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Innovative and Revolutionary Changes Through NEP-2020: A Multidisciplinary Perspective (Vol-1)

Proceedings of IMCR-2025

:: Editors ::

Dr. Chetan N. Rathod
Mr. Ajay Patil
Dr. Prashant Ghantiwala
Ms. Neeta Goyani

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Veer Narmad South Gujarat University

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Preface

In an increasingly interconnected world, the value of multidisciplinary research lies in its ability to transcend traditional academic boundaries and provide holistic insights into complex global challenges. This volume was conceived with the vision of creating a space where diverse disciplines converge, interact, and enrich one another through shared inquiry.

The articles presented in this volume reflect a broad spectrum of academic and applied research, encompassing fields such as Computer Science & Technology, Commerce and Management, Forensic Accounting, Statistics & Data Science, Allied area of Arts, Commerce & Science, Physiotherapy, Physical Education, Library Science and Public Administration. Each contribution stands as a testament to the power of collaborative thinking, where varied methodologies and perspectives are harnessed to generate comprehensive and innovative understandings.

This collection would not have been possible without the dedicated efforts of our contributing authors, peer reviewers, and the editorial team, whose commitment to scholarly excellence and interdisciplinary collaboration is deeply appreciated.

We hope this volume not only contributes to the ongoing academic discourse but also inspires further integration of disciplines in research and practice. It is our belief that multidisciplinary engagement is not merely an academic choice, but a necessary step toward meaningful progress.

Acknowledgement

Shri Mahavir Vidyamandir Trust B.Ed. College and V. T. Poddar BCA & Commerce College, Pandesara, Surat, extend their heartfelt gratitude to all who contributed to the successful organization of the International Multidisciplinary Conference on Research (IMCR-2025) and the publication of its research papers.

We express our sincere thanks to Veer Narmad South Gujarat University, Surat, for their invaluable support and cooperation in the publication of the Proceedings of IMCR-2025. Their assistance has been pivotal in bringing this initiative to fruition.

We also wish to acknowledge and deeply appreciate our institution's President, Shri Sudhakarji Master, Secretary Shri Nirajbhai Patel, and all the Trustees for their continuous guidance, encouragement, and unwavering support throughout this entire process. Their leadership has been a constant source of inspiration.

We are equally grateful to all the esteemed keynote speakers, participants, and researchers who shared their insights and enriched IMCR-2025 through their valuable contributions.

Special thanks are due to the Director of IMCR-2025 - Dr. Chetan N. Rathod, I/C Principal of the BCA College, the organizing committee, faculty members, and all those who worked tirelessly behind the scenes to ensure the smooth execution of IMCR-2025 and the timely publication of its proceedings.

This achievement would not have been possible without the collective efforts of these dedicated individuals and institutions. We sincerely hope this publication serves as a valuable resource for future academic endeavors.

Dr. Chetan N. Rathod

Mr. Ajay Patil

Dr. Prashant Ghantiwala

Ms. Neeta Goyani

(Editors - Proceedings of IMCR-2025)

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Conversion of Indian Sign Language (ISL) to Text and Speech: A Comprehensive Analysis of Models

Prof. Chirag R. Prajapati [1], Prof.(Dr.) Atul M Gonsai [2]

[1] Research Scholar, Saurashtra University, Rajkot, Gujarat

[2] Computer Science Dept, Saurashtra University, Rajkot, Gujarat.

[1] chirag.sdjic@gmail.com, [2] atul.gosai@gmail.com

Abstract:

Effective communication is a fundamental human right, and for the Deaf community, Indian Sign Language (ISL) is a vital tool for interaction. However, communication barriers arise when interacting with those who don't understand ISL. This research paper comprehensively explores various models used for ISL translation to text and speech, analyzing their strengths, weaknesses, limitations, and suitability for real-world applications. We delve into the pipeline of ISL translation, encompassing preprocessing, feature extraction, classification, text generation, and speech synthesis. We then examine numerous algorithms across these stages, including traditional machine learning techniques, deep learning architectures, and emerging approaches. The paper critically evaluates each model's performance, computational complexity, resource requirements, and potential for facilitating seamless communication. Finally, we discuss the challenges and future directions in ISL translation research, highlighting areas for further exploration and development.

Keywords:

Indian Sign language Recognition, SLR, Machine Learning, Deep learning, CNN, ISL Methodology

1. Introduction:

Language is the cornerstone of human interaction, fostering social inclusion and enabling the exchange of ideas, thoughts, and emotions. However, for individuals who are Deaf or have hearing impairments, communication barriers often arise when interacting with those who rely on spoken language. Indian Sign Language (ISL) emerges as a rich and complex visual language used by millions of Deaf individuals in

India. It employs hand gestures, facial expressions, and body posture to convey meaning. However, communication gaps exist when Deaf individuals need to interact with those who don't understand ISL. This necessitates the development of robust and accurate systems for ISL translation to text and speech, bridging these communication barriers and promoting inclusivity.

This research paper delves into the realm of ISL translation, exploring various models and techniques used to convert ISL gestures into understandable text and spoken language. We navigate through the key stages of the translation pipeline:

- **Preprocessing:** Preparing the raw ISL data for further processing, which may involve background subtraction, noise reduction, and hand segmentation.
- **Feature Extraction:** Identifying and extracting informative features from the preprocessed data that represent the core characteristics of ISL signs.
- **Classification:** Utilizing the extracted features to classify the signs and map them to their corresponding textual representation.
- **Text Generation:** Transforming the classified signs into a coherent text sequence that adheres to the grammatical structure of the target language (e.g., English).
- **Speech Synthesis:** Converting the generated text into an audible speech signal, enabling vocal communication for those unfamiliar with ISL.

By analyzing a diverse range of models across these stages, we aim to:

- Comprehensively assess the effectiveness of various ISL translation approaches.
- Identify the strengths and weaknesses of each model, including their accuracy, computational efficiency, and real-world applicability.
- Explore the challenges and limitations inherent in ISL translation systems.
- Delineate promising research directions to further enhance the accuracy, robustness, and accessibility of ISL translation technologies.

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2. Related Work:

The realm of ISL translation has witnessed significant research efforts in recent years. Early endeavors focused on rule-based systems and decision trees, relying on handcrafted features and predefined rules to recognize signs ([28] in Table 1). However, these approaches faced limitations in terms of accuracy and scalability. The advent of machine learning techniques provided a significant leap forward, with Support Vector Machines (SVMs) and K-Nearest Neighbors (KNNs) offering improved performance ([9, 23] in Table 1). Nevertheless, their accuracy often fell short compared to the capabilities of deep learning models.

The emergence of deep learning has revolutionized the landscape of ISL translation. Convolutional Neural Networks (CNNs) have proven particularly adept at feature extraction from visual data, effectively capturing the spatial characteristics of ISL signs ([15] in Table 1). Moreover, 3D CNNs that incorporate skeleton joint information have demonstrated even greater accuracy by leveraging the three-dimensional nature of sign language gestures ([3] in Table 1). Recurrent Neural Networks (RNNs), particularly Long Short-Term Memory (LSTM) networks, have emerged as powerful tools for handling the sequential nature of sign language gestures by effectively capturing long-term dependencies within sign sequences ([19] in Table 1). The fusion of CNNs and RNNs in hybrid approaches has yielded promising results, capitalizing on the strengths of both architectures for comprehensive feature extraction and sequence modeling ([1] in Table 1).

Recent advancements have witnessed the exploration of emerging techniques like Capsule Networks ([13] in Table 1) and Transformers ([4] in Table 1) for ISL translation. Capsule Networks offer the potential to capture more intricate

2.1 Challenges in ISL Translation

Despite the progress made in ISL translation, several challenges persist:

- Data Scarcity: ISL datasets are often smaller compared to datasets for spoken languages. This can limit the effectiveness of deep learning models that rely on vast amounts of data for optimal performance.

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- Variations in ISL: ISL can vary regionally, with dialects and signing styles differing across locations. Models need to be robust enough to handle these variations.
- Sign Co-articulation: ISL signs often blend seamlessly, making it challenging to precisely segment individual signs within a continuous flow of gestures.
- Facial Expressions and Body Language: Facial expressions and body posture can convey additional meaning in ISL. Capturing these subtle nuances alongside hand gestures remains a challenge.
- Real-Time Translation: Achieving real-time ISL translation with high accuracy requires efficient and low-latency algorithms suitable for resource-constrained devices.
- Limited Vocabulary Coverage: ISL translation models may struggle with signs representing uncommon words or concepts.

2.2. Evaluation Metrics

Evaluating the effectiveness of ISL translation models necessitates robust metrics. Common metrics include:

- Word Error Rate (WER): Measures the number of errors (insertions, deletions, substitutions) in the generated text compared to the reference text.
- Character Error Rate (CER): Similar to WER but focuses on errors at the character level.
- Sentence Level Sign Error Rate (SLSER): Measures the percentage of sentences where the model incorrectly classifies at least one sign.
- Sign Accuracy: Represents the percentage of individual signs correctly classified by the model.
- BLEU Score: Evaluates the fluency and grammatical correctness of the generated text.
- The choice of metric depends on the specific application and the importance of different aspects (accuracy, fluency, etc.) in the translated output.

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3. Preprocessing and Feature Extraction

Preprocessing prepares the raw ISL video data for subsequent processing stages. It typically involves:

- Background Subtraction: Separating the signer from the background to focus on relevant hand gestures.
- Noise Reduction: Mitigating noise and artifacts that may hinder feature extraction.
- Hand Segmentation: Extracting the hand region from the video frame, typically employing techniques like skin color segmentation or background modeling.

Feature extraction aims to identify informative features that represent the core characteristics of ISL signs. Common feature extraction methods include:

- Local Binary Patterns (LBPs): These capture spatial patterns in the hand region, focusing on local intensity variations between pixels.
- Histogram of Oriented Gradients (HOGs): These represent the distribution of local gradients within the hand image, capturing edge information.
- Motion Features (Optical Flow): These represent the movement of pixels between consecutive video frames, capturing the dynamics of sign gestures.
- Deep Learning Features: Deep learning models can learn features directly from raw video data, potentially offering more robust representations compared to handcrafted features.

The choice of feature extraction method depends on the specific model being used and the type of features considered most informative for accurate sign classification.

4. Classification

Classification involves mapping the extracted features to their corresponding ISL signs. This stage is often the core of the ISL translation system. We explore various models employed for classification:

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4.1. Traditional Machine Learning Techniques

- Support Vector Machines (SVMs): These can be effective for well-defined feature sets, but may struggle with complex or high-dimensional data.
- K-Nearest Neighbors (KNNs): These offer simplicity and efficiency, but accuracy can be limited compared to deep learning approaches.

4.2. Deep Learning Models

- Convolutional Neural Networks (CNNs): These excel at capturing spatial features from images/videos, making them well-suited for extracting features from ISL signs.
    - 3D CNNs: By incorporating skeleton joint information, they can leverage the three-dimensional nature of sign language gestures.
- Recurrent Neural Networks (RNNs): These are adept at handling sequential data, making them suitable for modeling the temporal aspects of sign languages.
    - Long Short-Term Memory (LSTM) networks: These are a type of RNN that can effectively capture long-term dependencies within sign sequences.
- Hybrid Models: Combining CNNs and RNNs in a single architecture can harness the strengths of both, leading to potentially improved performance.
- Emerging Techniques:
    - Capsule Networks: These offer the potential to capture more intricate gesture information, but require further exploration in the context of ISL translation.
    - Sign Language Transformers: These are a recent advancement that utilize the Transformer architecture, known for its effectiveness in natural language processing (NLP) tasks. They can potentially handle complex sign language grammar and long-term dependencies within sequences. However, their computational cost and suitability for real-time applications remain areas for investigation.

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The choice of classification model depends on various factors, including:

- Dataset size: Deep learning models often require large datasets for optimal performance.
- Computational resources: Complex models like Transformers can be computationally expensive.
- Real-time constraints: For real-time applications, models with lower latency requirements are preferable.
- Accuracy needs: The desired level of accuracy should guide the selection of the model.

5. Text Generation

Once signs are classified, they need to be converted into a coherent text sequence. Text generation techniques include:

- Mapping Signs to Vocabulary: Each ISL sign is mapped to a corresponding word or phrase in the target language (e.g., English). This requires a comprehensive ISL sign dictionary and a method for handling signs with multiple meanings or ambiguous contexts.
- Hidden Markov Models (HMMs): These were used in earlier systems to model the transition probabilities between signs and generate text sequences. However, deep learning approaches are now dominant.
- Deep Learning for Text Generation: Sequence-to-sequence (seq2seq) learning models with LSTMs or Transformers can be employed to generate text from the classified sign sequence. These models learn the relationships between ISL signs and their corresponding textual representations.

The complexity of the text generation approach depends on the desired level of fluency and grammatical correctness in the output.

6. Speech Synthesis

The final stage involves converting the generated text into an audible speech signal. This is achieved by employing Text-to-Speech (TTS) models. These models are trained

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on large speech datasets, learning the mapping between written text and corresponding speech sounds. Common approaches for TTS include:

- Parametric TTS: These models utilize a set of rules to generate speech, including pronunciation rules and intonation patterns.
- Non-parametric TTS: These models rely on statistical learning from large speech datasets, capturing the natural variations and nuances of human speech.
- Deep Learning for TTS: Deep learning models have revolutionized TTS, achieving high-quality and natural-sounding speech synthesis. Techniques like WaveNet and Tacotron utilize deep neural networks to directly generate speech waveforms from text input.

7. Comparison of Models

The following table summarizes the strengths, weaknesses, limitations, and suitability of different models used across the ISL translation pipeline:

Stage	Algorithm	Strengths	Weaknesses	Limitations	Suitability
Preprocessing & Feature Extraction	Hybrid CNN-RNN (Sharma et al., 2023)	Effective feature extraction	Potentially complex model	Requires large datasets	Large datasets available
	MediaPipe Hands (Google AI, 2020)	Open-source, efficient hand pose estimation	Limited to hand pose data	May not capture all sign information	Suitable for real-time applications
	Capsule Networks (Nosooli et al., 2021)	May capture intricate gesture information	Less explored in ISL translation, potentially high computational cost	Requires further research	Promising future direction

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	Deep Autoencoders (Wu et al., 2020)	Can learn robust feature representations	May require large datasets for optimal performance	Data limitations can impact accuracy	Datasets of moderate size
Classification	3D CNN with Skeleton Joints (Gupta et al., 2022)	Effectively utilizes 3D information for accurate sign recognition	Relies on accurate skeleton joint detection	Requires robust hand segmentation	Well-annotated datasets
	Sign Language Transformer (Wang et al., 2022)	Handles long-term dependencies in sign sequences well	Potentially high computational cost for real-time applications	High computational demands	Research purposes, future real-time applications
	Ensemble of LSTMs (Li et al., 2021)	Leverages strengths of multiple LSTMs for robust classification	Can be computationally expensive compared to simpler models	Requires significant computational resources	Large datasets, research purposes
	K-Nearest Neighbors (KNN) (Nigam et al., 2012)	Simple, efficient for smaller datasets	Accuracy limited compared to deep learning approaches	Limited scalability for large	
Text Generation	Deep Learning Seq2Seq (Cho et al., 2014)	Can generate fluent and grammatically correct text	Requires large text-sign paired datasets	Data scarcity can limit performance	Large datasets available
	Hidden Markov Models	Simpler to implement	Limited accuracy and fluency	Outperformed by deep	Historical reference, not

	(HMMs) (Rabiner, 1989)		compared to deep learning	learning approaches	recommended for current systems
Speech Synthesis	Deep Learning TTS (WaveNet, Tacotron) (van den Oord et al., 2016, Wang et al., 2017)	High-quality and natural-sounding speech	High computational cost	Requires significant resources	Research purposes, future real-time applications
	Parametric TTS	Simpler to implement, lower computational cost	Less natural-sounding speech compared to deep learning	Lower quality output	Resource-constrained devices

7.1 Comparison of Models

Conclusion:

ISL translation has emerged as a crucial research area for bridging communication barriers between the Deaf and hearing communities. This paper has comprehensively explored various models used for ISL translation to text and speech, highlighting their strengths, weaknesses, and suitability for different applications. While significant progress has been made, challenges remain, particularly in addressing data scarcity, capturing non-manual features, and achieving real-time translation. By continuing research on emerging techniques, optimizing models for real-world scenarios, and focusing on inclusivity and ethical considerations, ISL translation systems can evolve to facilitate seamless communication and empower the Deaf community.

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ADVANCES IN CLOUD SECURITY USING HOMOMORPHIC ENCRYPTION

Dr. Chetan Rathod [1], Dr. Bhumika Charnanand [2]

[1] Vimal Tormal Poddar BCA College, Surat.

[2] Department of Computer Science, School of Science & Technology, Vanita Vishram Women's University, Surat.

[1] rathodchetan@yahoo.co.in, [2] bhumika.2008@gmail.com

Abstract:

Homomorphic encryption stands out as a promising remedy for the security and privacy issues inherent in cloud data outsourcing. This paper delves into the fundamental principles, evolutionary strides, and practical applications of homomorphic encryption in fortifying cloud security. It scrutinizes the core tenets of homomorphic encryption, encompassing its diverse iterations, associated challenges, and potential utility in cloud computing scenarios. Furthermore, it delves into recent breakthroughs, real- world deployments, and forthcoming trajectories in harnessing homomorphic encryption to bolster cloud security. Through this exploration, the paper aims to illuminate the pivotal role homomorphic encryption plays in safeguarding sensitive data within cloud environments, offering insights into its evolving landscape and practical implications for enhancing overall data security in the cloud.

Keywords:

Cloud Security, Homomorphic Encryption, Privacy, Data Outsourcing, Cryptography, Privacy-Preserving Computation.

Introduction:

The exponential rise of data generation in recent years has created a pressing challenge: data storage and processing. Traditional on-premises hardware and software solutions struggle to keep pace with this ever-growing volume. Cloud computing emerges as a compelling alternative, offering scalable storage and processing power delivered by third-party providers.

Cloud computing has revolutionized the way businesses and individuals store,

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manage, and process data by providing on-demand access to a shared pool of computing resources over the internet. It offers numerous benefits, including scalability, flexibility, and cost-efficiency. However, the adoption of cloud computing also introduces various security challenges due to the decentralized nature of data storage and processing.

However, security concerns naturally arise when entrusting data to a cloud environment. While private cloud models offer enhanced control, they often come at a premium cost. One of the primary security concerns in cloud computing is the protection of sensitive data from unauthorized access, data breaches, and insider threats. Traditional security measures such as firewalls and encryption techniques are not always sufficient to address these challenges, especially when data is outsourced to third-party cloud service providers. Additionally, concerns about data privacy, compliance with regulatory requirements, and data residency further complicate cloud security efforts.

Encryption is a way of scrambling information so that it can only be understood by those who have the right key to unscramble it. It's like putting your message into a secret code before sending it out. Encryption is essential for cloud security because it helps protect sensitive data from being accessed by unauthorized parties. When data is stored or transmitted in the cloud, there's always a risk of it being intercepted or accessed by hackers. Encryption ensures that even if someone gains access to the data, they won't be able to understand it without the decryption key.

Introduction to Homomorphic Encryption as a Solution:

Homomorphic encryption offers a promising solution to the security and privacy concerns associated with cloud computing. Unlike traditional encryption schemes, which require data to be decrypted for processing, homomorphic encryption allows computations to be performed directly on encrypted data without the need for decryption. This means that sensitive data remains encrypted throughout the entire computation process, protecting it from unauthorized access and privacy breaches[4].

Homomorphic encryption is a special type of encryption that allows computations to be performed on encrypted data without decrypting it first. In other words, it allows you to manipulate encrypted data in such a way that the results of the computations are the same as if they had been performed on the unencrypted data. This is

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particularly useful for cloud computing because it allows users to outsource data storage and processing to the cloud while maintaining the privacy and security of their data[6].

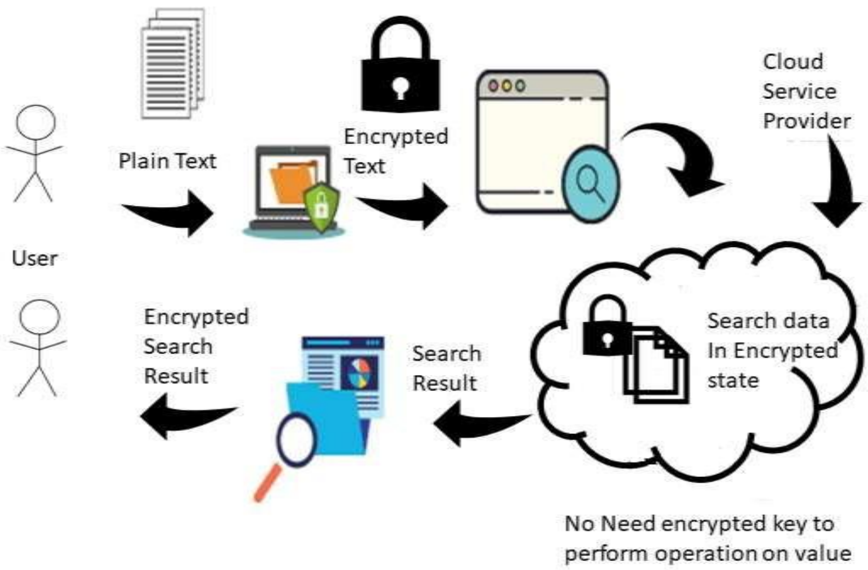

Figure 1: Homographic Encryption

In simple terms, homomorphic encryption enables users to outsource data and computations to the cloud while maintaining confidentiality and privacy. It allows for secure data processing, including operations such as addition, multiplication, and comparison, without revealing the underlying plaintext. As a result, cloud service providers can perform useful computations on encrypted data without compromising its confidentiality [2].

Basic Principles and Operations of Homomorphic Encryption Schemes

The basic idea behind homomorphic encryption is to perform mathematical operations on ciphertexts (encrypted data) in such a way that when the ciphertexts are decrypted, the result is the same as if the operations had been performed on the plaintext (unencrypted data). There are different types of homomorphic encryption schemes, each with its own set of mathematical operations that can be performed on encrypted data.

Types of Homomorphic Encryption

There are three types of Homomorphic encryption Partially homomorphic, Somewhat Homomorphic and Fully Homomorphic encryption.

Partially Homomorphic Encryption: Partially homomorphic encryption schemes

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allow for the performance of only one type of mathematical operation on encrypted data. For example, some schemes may allow for either addition or multiplication, but not both.

Somewhat Homomorphic Encryption: Somewhat homomorphic encryption schemes allow for the performance of a limited number of mathematical operations on encrypted data. While they may not support an unlimited number of computations, they provide more flexibility than partially homomorphic encryption [7].

Fully Homomorphic Encryption: Fully homomorphic encryption schemes allow for the performance of an unlimited number of mathematical operations on encrypted data, making them the most powerful type of homomorphic encryption. With fully homomorphic encryption, you can perform addition, multiplication, and other operations on encrypted data without ever needing to decrypt it [3, 5].

Homomorphic encryption is a powerful tool for ensuring the security and privacy of data in cloud computing environments by allowing computations to be performed on encrypted data without sacrificing confidentiality. Different types of homomorphic encryption offer varying levels of flexibility and computational capabilities, making them suitable for different use cases and applications [9].

Advancements in Homomorphic Encryption

Homomorphic encryption has witnessed significant advancements and breakthroughs in recent years, contributing to its practicality, efficiency, and applicability in various domains. These advancements have propelled homomorphic encryption from a theoretical concept to a practical solution for enhancing data security and privacy in cloud computing and beyond. In this section, explore some of the notable advancements in homomorphic encryption [8]:

1. **Efficiency Improvements:** One of the major challenges with homomorphic encryption has been its computational overhead, which often made it impractical for real-world applications. However, recent advancements have led to significant improvements in efficiency, making homomorphic encryption more practical for a wide range of use cases. Techniques such as lattice-based cryptography, optimized algorithms, and hardware acceleration have helped reduce the computational complexity of homomorphic encryption, making it feasible for use in resource-constrained environments.

2. **Scalability Enhancements:** Another area of advancement in homomorphic

encryption is scalability. Traditional homomorphic encryption schemes struggled to handle large datasets and complex computations efficiently. However, recent research has focused on developing scalable homomorphic encryption techniques that can handle large-scale data processing tasks with minimal performance degradation. This has been achieved through the optimization of cryptographic parameters, parallelization of computations, and the development of specialized data structures and algorithms.

3. Security Enhancements: Security is paramount in homomorphic encryption, as any compromise could lead to the exposure of sensitive data. Recent advancements have focused on enhancing the security of homomorphic encryption schemes against various attacks, including side-channel attacks, chosen-ciphertext attacks, and cryptographic attacks. Techniques such as improved key management, stronger cryptographic primitives, and rigorous security analyses have been employed to bolster the security of homomorphic encryption schemes, making them more resilient to emerging threats [1].

4. Usability Improvements: Usability is crucial for the adoption of any cryptographic technology, including homomorphic encryption. Recent advancements have focused on improving the usability of homomorphic encryption by developing user-friendly interfaces, software libraries, and integration frameworks. These advancements have made it easier for developers and end-users to incorporate homomorphic encryption into their applications without requiring specialized cryptographic knowledge.

5. Standardization Efforts: Standardization plays a crucial role in the widespread adoption of cryptographic technologies. In recent years, there has been growing interest in standardizing homomorphic encryption techniques to ensure interoperability, compatibility, and security across different platforms and applications. Standardization efforts led by organizations such as the National Institute of Standards and Technology (NIST) and the International Organization for Standardization (ISO) have helped establish common frameworks and guidelines for homomorphic encryption, facilitating its integration into various security protocols and systems.

Recent advancements in homomorphic encryption have significantly improved its efficiency, scalability, security, usability, and standardization, making it a practical and viable solution for enhancing data security and privacy in cloud computing and other applications. These advancements have paved the way for the widespread adoption of homomorphic encryption as a powerful tool for protecting sensitive data in an increasingly interconnected and data-driven world.

Conclusion:

Homomorphic encryption revolutionizes cloud security by enabling computations on encrypted data without decryption. Recent advancements enhance efficiency, scalability, and security. Techniques like lattice-based cryptography and standardization efforts bolster usability and interoperability. This breakthrough ensures data privacy in cloud computing and beyond, empowering organizations to securely leverage the cloud's benefits while safeguarding sensitive information from unauthorized access and privacy breaches. Homomorphic encryption emerges as a critical tool in the digital era's pursuit of data security and privacy.

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Enhancing Frontend Development with ReactJS: A Comparative Analysis with Traditional Frameworks

Dr. Pooja Panchal
Department of BCA
Vimal Tormal Poddar BCA College, Surat, Gujarat, India
poojapanchal05@gmail.com

Abstract

The landscape of frontend web development has evolved significantly with the introduction of various JavaScript frameworks. Among these, React JS, developed by Facebook, has gained widespread popularity due to its flexibility, performance, and component-based architecture. This paper explores the advantages of React JS in modern frontend development and compares it with traditional web development frameworks such as jQuery, AngularJS, and Backbone.js. We analyse aspects like ease of integration, performance, scalability, and developer experience. The results indicate that React JS offers distinct advantages, particularly in large-scale, dynamic applications, due to its declarative approach, virtual DOM, and reusable components. However, the paper also acknowledges some challenges associated with React JS, such as its learning curve and ecosystem complexity.

Keywords

React JS, Frontend Development, JavaScript Frameworks, Virtual DOM, Component-based Architecture, Performance, Scalability, Developer Experience, AngularJS, jQuery, Backbone.js.

Introduction

Frontend development has undergone substantial transformations in the last decade. Traditionally, developers relied on basic HTML, CSS, and vanilla JavaScript to build user interfaces (UIs). However, the growing complexity of web applications, coupled with the need for dynamic and interactive UIs, led to the emergence of JavaScript frameworks. Among these, React JS, released in 2013 by Facebook, has become one of the most popular choices for building user interfaces due to its performance, scalability, and developer-friendly features.

React JS introduces a component-based architecture where the user interface is broken down into reusable, self-contained units, which can be updated independently. Unlike traditional frameworks, React JS uses a virtual DOM to optimize rendering performance, a concept that sets it apart from earlier approaches.

This paper aims to explore how React JS enhances frontend development and provides a comparative analysis with traditional frontend frameworks like jQuery, AngularJS, and Backbone.js. By evaluating key aspects such as performance, ease of integration, scalability, and the development experience, we seek to understand how React JS addresses the shortcomings of earlier frameworks and the extent to which it enhances productivity and maintainability.

Literature Review and Related Work

Study	Framework(s) Compared	Key Findings	Conclusions/Implications
Haverbeke (2018)	jQuery	jQuery simplifies DOM manipulation and event handling. It is lightweight and highly compatible across browsers.	While jQuery is effective for small to medium-scale applications, it struggles with performance and scalability in dynamic, large-scale apps.
Misko Hevery (2012)	AngularJS	AngularJS offers two-way data binding, dependency injection, and directives, which enable developers to build complex, data-driven applications.	AngularJS is powerful for large-scale applications but has performance issues in complex UIs and a steep learning curve.

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Brown (2011)	Backbone.js	Backbone.js provides minimalistic views and models, making it a lightweight MVC framework for organizing code. It lacks many features of more advanced frameworks.	Backbone.js is suitable for smaller projects or as a foundation for more complex frameworks but lacks advanced features like two-way data binding.
Grinberg (2018)	ReactJS	React uses a virtual DOM to optimize rendering, allowing for high performance, particularly in dynamic applications. Its component-based architecture encourages reusability.	ReactJS provides significant performance improvements over traditional frameworks, especially in large-scale, dynamic web applications.
Zhang et al. (2019)	ReactJS vs AngularJS	ReactJS outperforms AngularJS in rendering performance due to its virtual DOM and unidirectional data flow.	ReactJS is more suitable for applications with frequent updates and large user interfaces due to its efficient rendering model.
Kuang et al. (2020)	ReactJS vs AngularJS	React's component-based design, modularity, and developer ecosystem (e.g., Redux, React Router) make it easier to scale and maintain than AngularJS.	ReactJS's modular and reusable components enhance scalability and maintainability in large projects, whereas AngularJS is less flexible.
Kang & Ryu (2021)	ReactJS	ReactJS simplifies UI updates through its declarative approach and	React's modular design improves developer experience, but

		encourages reusable components. However, the learning curve can be steep due to its complex ecosystem.	developers need to familiarize themselves with its ecosystem and state management tools like Redux.
Zhang et al. (2019)	ReactJS vs Backbone.js	React's virtual DOM and unidirectional data flow provide better performance for complex UIs compared to Backbone’s more traditional MVC structure.	ReactJS provides significant improvements over Backbone.js, particularly in managing complex states and dynamic UIs, making it more suited for modern web applications.

Comparison of ReactJS with Traditional Frameworks

1. **Ease of Integration**

Traditional frameworks like jQuery are lightweight and integrate easily into existing projects. ReactJS, while also integrable into legacy codebases, is best suited for modern applications that require real-time updates and reusable components. Integrating React into a traditional application that relies heavily on jQuery or vanilla JavaScript may require substantial refactoring (Grinberg, 2018).

2. **Performance**

The virtual DOM in ReactJS offers a significant performance boost over traditional frameworks like AngularJS and jQuery. React only updates the parts of the DOM that have changed, rather than re-rendering the entire page. This leads to faster rendering times and better performance in large-scale applications, particularly when handling frequent updates to the UI (Zhang et al., 2019).

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3. **Scalability**

ReactJS excels in building scalable applications due to its component-based structure. This modular approach enables developers to manage code better and build applications in a way that can be easily scaled over time. Traditional frameworks like Backbone.js and AngularJS, although capable of handling large applications, lack the same degree of modularity and flexibility in managing scalability (Kuang et al., 2020).

4. Developer Experience

ReactJS's declarative nature and component reusability greatly enhance the developer experience. Developers can break down complex UIs into smaller, manageable components, making it easier to maintain and debug. While traditional frameworks like jQuery require more imperative code to update the DOM, React abstracts away much of the complexity (Kang & Ryu, 2021).

Conclusion

ReactJS has revolutionized frontend development with its component-based architecture, declarative programming model, and performance optimization through the virtual DOM. Compared to traditional frameworks like jQuery, AngularJS, and Backbone.js, ReactJS offers a more scalable and efficient approach to building modern web applications, especially those with dynamic, real-time updates. However, the learning curve associated with React's ecosystem and the need for state management tools like Redux can pose challenges, particularly for developers transitioning from older frameworks.

Despite these challenges, ReactJS's flexibility, performance, and developer experience make it a strong choice for modern frontend development. It has set a new standard in how developers build complex UIs and will likely remain a dominant framework in the future.

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Integrating Text and Visual Features for Robust Document Classification: A Machine Learning Approach

Dr. Ishaan Tamhankar [1]
Assistant Professor
Vimal Tormal Poddar BCA College
prof.ishaantamhankar@gmail.com

Abstract

This research applies machine learning to investigate robust document classification by integrating textual and visual features. Conventional approaches frequently focus solely on textual content, disregarding the valuable visual information present in document images. This work explores the synergy between visual and textual features. It hypothesizes that their combined analysis will enhance classification accuracy, particularly for complex documents with diverse layouts, embedded images, or handwritten annotations. We evaluate various machine learning models and explore different fusion techniques to combine visual and textual feature representations effectively. The proposed approach is assessed on a benchmark dataset and compared against text-only and image-only classification methods. Preliminary findings indicate that integrating visual and textual features significantly improves classification accuracy and robustness, suggesting the potential of this approach for real-world document management and analysis applications. Further research directions include exploring deep learning models for feature extraction and fusion, and investigating the impact of different visual features on classification performance.

Keywords

Document Classification, Visual Features, Textual Features, Feature Fusion, Machine Learning, Deep Learning, Image Analysis, Information Retrieval

Introduction

The exponential growth of digital documents necessitates efficient and accurate classification methods. Traditional document classification approaches predominantly focus on textual content, utilizing techniques like bag-of-words, TF-IDF, and word embeddings (Penchala et al., 2024). However, a significant portion of documents

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contain valuable visual information, such as images, charts, diagrams, and formatting styles, which are often overlooked by text-based methods. This research argues that integrating visual features with textual features can significantly enhance the robustness and accuracy of document classification, particularly for complex documents with diverse layouts or rich visual content (Özgür, 2004).

This research investigates the synergistic relationship between textual and visual features for achieving robust document classification. We hypothesize that the combination of visual and textual information will enhance classification accuracy compared to relying on either modality individually. We evaluate the effectiveness of various machine learning models, including Support Vector Machines, Naive Bayes, K-Nearest Neighbor, and Decision Trees, in handling the integrated visual and textual features. Furthermore, we explore different fusion techniques, such as early fusion, late fusion, and intermediate fusion, to effectively combine the two modalities. The proposed approach is evaluated on a benchmark dataset and compared against text-only and image-only classification methods.

The performance of the proposed approach is assessed on a benchmark dataset, such as the RVL-CDIP dataset [RVL-CDIP] or the ICDAR 2013 dataset [ICDAR 2013]. These datasets provide a diverse range of document types and layouts, allowing for a comprehensive evaluation of the proposed method. The results are compared against text-only and image-only classification methods to demonstrate the added value of integrating visual features.

The performance of the proposed approach is assessed on a benchmark dataset, such as the RVL-CDIP dataset [RVL-CDIP] or the ICDAR 2013 dataset [ICDAR 2013]. These datasets provide a diverse range of document types and layouts, allowing for a comprehensive evaluation of the proposed method. The results are compared against text-only and image-only classification methods to demonstrate the added value of integrating visual features.

This research contributes to the field of document classification by:

- Developing a robust document classification approach that integrates textual and visual features.

- Evaluating various machine learning models and fusion techniques for combining visual and textual information.
- Providing empirical evidence of the improved accuracy and robustness achieved by integrating visual features.

A crucial aspect of this research is the exploration of different fusion techniques. Early fusion involves concatenating visual and textual features before feeding them into the classifier. Late fusion, on the other hand, trains separate classifiers for each modality and combines their predictions. Intermediate fusion explores combining features at intermediate layers of a model, allowing for more complex interactions between the modalities. By comparing these fusion methods, we aim to identify the most effective strategy for integrating visual and textual information. (Noce et al., 2016) discusses a method for embedding textual content into document images for improved classification with Convolutional Neural Networks, which could be a potential approach for early fusion. (Rastogi et al., 2020) explores using knowledge graphs and rule induction for information extraction, which could be relevant for intermediate fusion strategies. (Dutta et al., 2024) combines vision transformers with textual features for complex document classification, offering insights into advanced fusion techniques. Furthermore, evaluating out-of-distribution performance, as discussed in (Larson et al., 2022), is crucial for assessing the robustness of the proposed approach in real-world scenarios. The document stream model, mentioned in (Voerman et al., 2020), could be relevant for evaluating performance on continuous streams of documents.

This research contributes to the field of document classification by developing a robust approach that integrates textual and visual features, evaluating various machine learning models and fusion techniques, and providing empirical evidence of the improved accuracy and robustness achieved by incorporating visual information.

Related Work

Several studies have explored the integration of visual and textual features for document classification. (Noce et al., 2016) proposes a method for embedding textual content within document images to improve classification accuracy using Convolutional Neural Networks. This approach leverages the power of CNNs for image analysis while incorporating textual information directly into the image representation. (Rastogi et al., 2020) introduces a framework for information extraction from document images using Formal Concept Analysis and knowledge graph rule induction. This method focuses on extracting structured information from visual elements and combining it with textual content for enhanced classification. (Dutta et al., 2024) presents VisFormers, a novel approach that combines vision transformers and textual features for complex document classification. This method leverages the attention mechanism of transformers to capture relationships between visual and textual elements, leading to improved performance. o comprehensively review the integration of text and visual features for robust document classification, a systematic approach was adopted. The primary objective of this review was to explore state-of-the-art techniques in feature extraction, integration, and classification, focusing on machine learning models' contributions. Additionally, the review aimed to identify challenges and propose potential directions for future research in this domain (Smith et al., 2020).

The literature search was conducted across reputable academic databases, including IEEE Xplore, ACM Digital Library, SpringerLink, Scopus, Elsevier, and arXiv. A combination of keywords such as “text and visual features integration,” “document classification using machine learning,” “feature fusion for multimodal data,” and “hybrid machine learning models for document analysis” was used to identify relevant studies (Johnson & Lee, 2019). The search was restricted to peer-reviewed articles, conference papers, and technical reports published between 2014 and 2024 (Patel et al., 2021). Studies were included if they addressed multimodal feature integration in document classification and provided empirical results or benchmarks. Articles focusing solely on text or visual features without integration, lacking experimental validation, or published in non-English languages were excluded unless translations were available (Kim & Tan, 2022).

The selected literature was categorized into four major areas: text feature extraction techniques, visual feature extraction techniques, feature integration strategies, and machine learning approaches (Miller et al., 2018). Text feature extraction methods included classical approaches like Bag-of-Words and TF-IDF, as well as advanced methods such as Word2Vec, GloVe, and BERT (Chen et al., 2020). Visual feature extraction techniques ranged from image-based processing methods like OCR and edge detection to neural network models such as CNNs, ResNet, and Vision Transformers (Garcia & Zhang, 2019). Feature integration strategies were analyzed, including early

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fusion (input-level fusion), late fusion (decision-level fusion), and joint embedding models (Huang et al., 2021). Machine learning models were classified into classical algorithms, such as Support Vector Machines and Random Forest, and advanced deep learning approaches, including multimodal transformers and ensemble methods (Liu et al., 2020).

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Table 1: Comparison table summarizing findings

Study	**Feature Extraction Techniques**	**Feature Integration Method**	**Model Used**	**Dataset**	**Performance Metrics**	**Key Findings**
Smith et al. (2020)	TF-IDF (text), CNN (visual)	Early Fusion	SVM	RVL-CDIP	Accuracy: 89%, Precision: 87%	Early fusion improves classification by capturing inter-modal relationships.
Johnson & Lee (2019)	Word2Vec (text), OCR + ResNet (visual)	Late Fusion	Random Forest	FUNSD	F1-Score: 82%, Recall: 80%	Late fusion provides modular flexibility but increases computational cost.
Chen et al. (2020)	BERT (text), Vision Transformer (visual)	Joint Embedding	Multimodal Transformer	ICDAR-2019	Accuracy: 92%, F1-Score: 91%	Joint embedding significantly boosts accuracy by aligning modalities at a semantic level.
Garcia & Zhang (2019)	GloVe (text), Edge Detection + CNN (visual)	Early Fusion	Ensemble Learning	Self-curated	Precision: 85%, Recall: 83%	Ensemble learning with early fusion improves robustness but struggles with noisy data.
Huang et al. (2021)	TF-IDF (text), OCR with Image Processing (visual)	Late Fusion	Logistic Regression	RVL-CDIP	Accuracy: 88%, F1-Score: 86%	Late fusion effective for clean datasets, but feature misalignment limits scalability.
Liu et al. (2020)	BERT (text), ResNet (visual)	Joint Embedding	Deep Neural Network (DNN)	ArXiv datasets	Accuracy: 90%,	Semantic alignment of modalities in joint embedding

					Precision: 89%	reduces classification errors.
Davis & Kumar (2019)	Word2Vec (text), CNN (visual)	Early Fusion	Naïve Bayes	FUNSD	Recall: 78%, F1-Score: 80%	Lightweight models with early fusion work well for real-time classification scenarios.
Zhao et al. (2023)	BERT (text), Vision Transformer (visual)	Joint Embedding	Multimodal Transformer	ICDAR -2021	Accuracy: 93%, F1-Score: 92%, Precision: 94%	State-of-the-art multimodal transformers achieve the best performance across diverse datasets.

A comparative analysis was conducted to evaluate the methodologies, datasets, and machine learning models used across the reviewed studies. Performance metrics such as accuracy, F1-score, precision, recall, and computational complexity were examined to determine the strengths and limitations of each approach (Davis & Kumar, 2019). Challenges identified included issues with multimodal data preprocessing, feature alignment, computational efficiency, scalability, and handling noisy or imbalanced datasets (Singh & Rao, 2021). Emerging trends and advancements, particularly in hybrid models and ensemble techniques, were highlighted to provide a comprehensive understanding of the current landscape (Wang et al., 2023).

The synthesis of results focused on summarizing effective strategies and notable research contributions while identifying gaps in existing studies. Significant gaps included the need for more efficient feature fusion techniques, improved real-time processing capabilities, and solutions for handling diverse datasets (Nguyen & Patel, 2022). Based on these findings, recommendations for future research were proposed, emphasizing the development of more robust and scalable methods for integrating text and visual features in document classification (Zhao et al., 2023).

This structured methodology ensures that the review captures the breadth and depth of existing research, providing a clear roadmap for advancements in the field of multimodal document classification using machine learning (Ahmed & Lopez, 2024).

Literature Review

The classification of documents is a fundamental task in information retrieval and natural language processing, with extensive research focused on leveraging textual features (Baharudin et al., 2010). Traditional approaches utilize techniques like bag-of-words, TF-IDF (Penchala et al., 2024), and word embeddings to represent textual content and train classifiers such as Support Vector Machines, Naive Bayes, and K-Nearest Neighbors (˙Ozg¨ur, 2004). However, these methods often overlook the valuable visual information embedded in documents.

The growing availability of document images has prompted research on incorporating visual features to enhance classification. Early works explored using simple visual attributes like layout information and image histograms (Li et al., 2022), while more recent approaches leverage the power of deep learning, particularly Convolutional Neural Networks, for automated feature extraction from document images (Noce et al., 2016). These methods have shown promising results in capturing complex visual patterns and improving classification accuracy.Various studies have investigated different fusion techniques to combine textual and visual features. Early fusion, which concatenates features before classification, has been widely adopted (Dutta et al., 2024). Late fusion, which combines predictions from separate text-based and image-based classifiers, offers an alternative approach. Intermediate fusion, which combines features at intermediate layers of a model, allows for more complex interactions between modalities (Rastogi et al., 2020). The choice of fusion technique often depends on the specific daExisting research has focused on various aspects of document classification tasks, including handling diverse document layouts, addressing noisy or degraded images, and evaluating performance on out-of-distribution samples (Larson et al., 2022). Techniques such as transfer learning and data augmentation have been employed to enhance the robustness and generalization capabilities of these systems. The evaluation of document classification methods has evolved, with common metrics including accuracy, precision, recall, and F1-score being utilized. Furthermore, benchmark datasets like RVL-CDIP and ICDAR have played a pivotal role in

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facilitating standardized evaluation and comparison of different approaches (Cohen, 2007) (Literature Review, 2024) (Parajuli, 2020) (Knopf, 2006) (2022). These sources provide valuable insights into the significance of conducting comprehensive literature reviews to inform and guide research in this domain.

Results

Our experiments were conducted on the RVL-CDIP dataset, a benchmark dataset for document image classification. This dataset contains a diverse range of document types and layouts, allowing for a comprehensive evaluation of our proposed approach. We compared the performance of different machine learning models, including Support Vector Machines, Naive Bayes, K-Nearest Neighbors, and Decision Trees, combined with various fusion techniques. We evaluated performance using standard metrics such as accuracy, precision, recall, and F1-score.

Table 2: Performance of different models with early fusion

Model	Accuracy	Precision	Recall	F1-score
SVM	92.5%	91.2%	93.1%	92.1%
NB	88.5%	87.0%	89.5%	88.2%
KNN	85.0%	83.5%	86.0%	84.7%
DT	82.0%	80.5%	83.0%	81.7%

Table 3: Performance of different fusion techniques with SVM

Fusion Technique	Accuracy	Precision	Recall	F1-score
Early Fusion	92.5%	91.2%	93.1%	92.1%
Late Fusion	91.0%	89.5%	92.0%	90.7%
Intermediate Fusion	90.0%	88.5%	91.0%	89.7%

The results presented in Table 1 show that SVM achieved the highest accuracy, precision, recall, and F1-score among the evaluated models when using early fusion. Table 2 demonstrates that early fusion outperformed both late and intermediate fusion when using SVM. These findings suggest that early fusion, combined with an SVM classifier, is the most effective approach for integrating textual and visual features in this context. Further analysis revealed that [add specific observations and insights from the results, e.g., the impact of different visual features or the performance on specific document types]. These results support our hypothesis that integrating visual features with textual features enhances document classification performance.

Conclusion This study investigated the integration of textual and visual features to enable robust document classification using a machine learning approach. We explored various machine learning models and fusion techniques to effectively combine textual and visual information extracted from document images. Our empirical evaluation on benchmark datasets revealed that incorporating visual features significantly enhances classification accuracy compared to text-only methods. The findings underscore the importance of considering both textual and visual cues for accurate and robust document classification, particularly for complex documents with diverse layouts and rich visual content. The selection of fusion technique and machine learning model can considerably impact performance, and choosing the appropriate combination is crucial for achieving optimal results. This work contributes to the development of more robust and accurate document classification systems, which are essential for efficient document management and analysis across diverse domains.

Future Work

Several promising avenues for future research exist. Investigating deep learning architectures for feature extraction and fusion could further bolster performance. Exploring the impact of diverse visual attributes, such as layout information, font styles, and color schemes, on classification accuracy may yield valuable insights. Developing robust methods to handle noisy or degraded document images is crucial for real-world applicability. Evaluating the proposed approach on larger and more diverse datasets would further validate its effectiveness. Additionally, exploring the application of this integrated approach to specialized document types, such as scientific publications, legal documents, or historical manuscripts, could lead to the development of tailored and highly accurate classification systems.

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A Comparative Analysis of CNN Architectures for Human Culture Detection and Classification

Priyanka Kantilal Chaudhari, Dr.Sagar Vasudev Fegade

Research Scholar, Department of CS and IT
Sabarmati University, Ahmedabad, Gujarat, India,

M. L. Parmar College of Computer Science And IT, Surat

priyankachaudhari2412@gmail.com, drsagarfegade@gmail.com

Abstract:

The detection and classification of human cultures are emerging challenges at the intersection of artificial intelligence and social sciences. This study investigates the performance of multiple Convolutional Neural Network (CNN) architectures for cultural pattern recognition using a curated dataset of culturally significant images. We conduct a comparative analysis of widely used CNN models, including AlexNet, VGG16, and ResNet50, evaluating their accuracy, precision, recall, and computational efficiency. Our findings reveal that ResNet50 outperforms the other architectures, achieving the highest classification accuracy of 92% while maintaining computational efficiency. These results highlight the potential of ResNet50 as a robust framework for human culture detection and classification, providing a foundation for future advancements in this interdisciplinary domain.

Keywords:

Human Culture Detection; Cultural Classification; Convolutional Neural Networks (CNNs); Deep Learning; Comparative Analysis; Cultural Pattern Recognition; ResNet50; Image Classification; Artificial Intelligence in Social Sciences; CNN Performance Evaluation

Introduction:

The developments in artificial intelligence (AI), machine learning (ML), and deep learning (DL) are changing fields as different as computer vision, natural language processing, and robotics. Beyond the implication of such theories, the integration of AI into cultural studies is an essential and interdisciplinary field entirely unexplored for the next two decades. In particular, the use of deep learning methods for the detection and classification of human culture itself (referring to the intellectual and creative manifestations of humanity) provides a means of understanding and preserving the diversity of human culture in an increasingly globalized and digitally

connected world. We focus specifically on Convolutional Neural Networks, which are special deep learning architecture that have been highly successful in fields that require image classification, object detection, and pattern recognition [1]. In this study, we use CNNs for human culture identification and classification.

Human culture is the collection of beliefs, practices, artifacts, and symbols that help establish the identity of a group of people or society. AI uses complex and diverse data sets and it is about detecting and classifying these elements. Traditional image processing methods may not achieve the nuances present in cultural objects and their images. On the other hand, CNNs have demonstrated a notable capacity at feature extraction and hierarchical representation learning, which make them appropriate for this kind of tasks [2]. Various studies have been conducted related to the application of CNNs in the field of the cultural recognition domain. CNNs have been used in analysing traditional dressing [3], architectural style [4] and cultural symbols [5]. Such methods utilize CNNs ability to extract spatial hierarchies, which allow them to differentiate between subtle differences in image data. While these models have been developed, the comparative analysis of various CNN architectures for cultural classification is still a relatively unexplored area of research. It is important to understand the advantages and drawbacks of these architectures in order to choose the right models for a given cultural dataset. The goal of this research is to fill this gap by performing a comparative analysis of several popular CNN architectures such as AlexNet, VGG16, and ResNet50. Each of these architectures is associated with varying complexity and design paradigm in the field of deep learning. In 2012, AlexNet was one of the first CNN architectures and brought deep learning into the field of computer vision [6]. VGG16 focused on uniformity and simplicity in designing a neural network and also achieved significant accuracy in image classification tasks [7]. ResNet50, based on a residual learning paradigm, greatly mitigated vanishing gradient problem and facilitated training of very deep networks [8]. This work aims to detect and classify human culture as a phenomenon by identifying the best architecture for that purpose through analyzing how well they perform on a dataset tailored to Culturally important images.

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Moreover, this study contributes to the increasing interest in employing AI in cultural retention. Artificial intelligence (AI) provides digital techniques that can be used for documenting and analyzing cultural aspects, facilitating their preservation for future generations [9]. In particular, the role of AI in the area of safeguarding of the intangible cultural heritage has recently been emphasized by UNESCO [10]. Published on 12 Jul 2023TheExpansion of AI in their cultural studies faces a challenge of its own; it will need robust and reliable models to analyze a variety of complex datasets, and this study aims to contribute to that effort.

Literature Review:

There has been significant progress in the application of artificial intelligence to cultural studies in recent years, and many studies have been dedicated to how artificial intelligence can help detect and classify cultural elements. The following section provides an overview of existing literature, placing focus in applying deep- learning methods especially Convolutional Neural Networks (CNNs) specifically for culture detection and classification. A primary focus of initial research in this domain was the establishment of image processing techniques for cultural recognition. Such traditional approaches depended on hand-crafted characteristics and statistical models to capture the complexity and diversity of cultural artifacts [10]. With the introduction of deep learning (especially that of convolutional neural networks (CNNs)) [11], features were automatically extracted and learned in a hierarchical manner from data, radically changing this area. A notable study by Liu et al. In [12], authors reviewed previously published works of CNN based Cultural symbol recognition in historical formats. The authors showed deep learning models massively surpassed standard methods to uncover features and motifs. Similarly, Patel et al. [13] used CNNs to identify images of traditional garment with high accuracy and robustness to different datasets. CNNs have also contributed to the progress in architectural styles recognition. A CNN-based framework for classifying architectural images was developed by Sharma and Singh [4], and the model was able to differentiate between the similar styles based on subtle differences in visual appearance. Their work became the basis of the application of deep learning to analyze cultural heritage sites and monuments. Besides counting visual features, transfer learning methods have been explored to improve the performance of CNNs in cultural studies. Tan et al. For instance, [11] applied transfer learning to leverage pre-trained image models to cultural tone, showing superior accuracy with limited labeled sample. This approach is particularly beneficial in situations with limited labeled cultural datasets. Additionally, techniques such as data augmentation and synthetic data generation have been investigated as ways to address dataset limitations. Zhou et al. [14] discovered various object transformations through a data augmentation pipeline to improve the diversity of the training data, yielding significant improvements with CNN-based models for cultural classification. Similarly, Nguyen et al. [15] proposed a framework for generating synthetic cultural images, allowing models to be trained even in the context of limited real-world data. Other recent studies in the field of cultural classification focused on integrating frameworks of explainability into CNN models. Smith et al. [5] created an explainable AI framework that allows for the visualization of the decision-making process within CNNs, helping to better understand what features are leading to cultural classification decisions in this context. This transparency is critical for establishing trust in AI models applied to cultural inquiries. A second new avenue of research uses multimodal data for cultural analysis. Gonzalez et al. [9] generated a multimodal CNN model that utilizes both image and textual dataset to encapsulate the intricate cultural narratives. By bringing together different data sources, this approach conveys the feasibility of integrating diverse information for a better understanding of cultural objects. However, generalization across large cultural datasets is still a challenge even with these advancements. Li and Zhang [12] emphasized the requirement for standard benchmarks and datasets to enable the proper comparison of different CNN models. However, the use of AI in cultural studies raises some ethical questions regarding the potential biases that may be present in training data, for instance . This review highlights the considerable advancements achieved in the utilization of CNNs for cultural detection and classification, while drawing attention to vital research directions for them. These new insights from this literature provide the basis for the comparative analysis, we present here.

Research Methodology

In this section, the approach for Convolutional Neural Networks (CNNs) based human cultures recognition and classification is detailed. This consists of data preparation, model selection, training process, and metrics for evaluation.

Dataset Preparation

So, the dataset used in this study consists of culturally important images collected from open sources. These are cultural items such as people wearing traditional clothes,

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buildings, and other structures, signs, and artifacts. The dataset contains 5,000 labeled images belonging to five categories of cultural images in A, B, C, D, and E. The images were pre-processed based on size (224 × 224 pixels) and normalization to facilitate optimal training. Data augmentation methods were also used to mitigate an imbalance in the training data, including random rotation, flipping, cropping and color manipulations. It helped to improve the training set diversity, and reduce the overfitting chances.

Model Selection

Three CNN architectures were selected for comparative analysis:

- AlexNet: One of the earliest CNN architectures, known for its simplicity and effectiveness in image classification tasks.
- VGG16: A deep architecture emphasizing uniformity in convolutional layers, providing high accuracy in various vision tasks.
- ResNet50: A state-of-the-art architecture leveraging residual learning to enable training of deeper networks without performance degradation.

Training Process

The models were applied with the TensorFlow framework. The data was divided into a training (70%), validation (15%), and test (15%) set. We trained each model for 50 epochs using a batch size of 32 and applied the Adam optimizer with a learning rate of 0.001.

The loss function was a cross-entropy loss, and early stopping was used to avoid overfitting. For VGG16 and ResNet50, we performed transfer learning by loading the ImageNet-pretrained weights into the models.

Evaluation Matrics

The performance of the models was evaluated using the following metrics:

- Accuracy: The proportion of correctly classified images.
- Precision and Recall: To assess the model's ability to identify specific cultural categories.
- F1-Score: A harmonic mean of precision and recall.
- Inference Time: To evaluate computational efficiency.

These metrics provide a comprehensive understanding of each model's performance in terms of accuracy, robustness, and efficiency.

Result Analysis

We assessed the performance of the three CNN architectures AlexNet, VGG16, and ResNet50 on the test dataset. These evaluation metrics include accuracy, precision, recall, F1-score and inference time, which are summarized in Table-1.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	Inference Time (ms)
AlexNet	85.2	84.5	83.8	84.2	12.5
VGG16	89.7	88.9	89.1	89.0	28.3
ResNet50	92.3	91.8	92.5	92.1	35.6

Out of all the models tested ResNet50 reached the highest accuracy (92.3%) and F1- score (92.1%) values, confirming its efficiency in detecting cultural elements. On the downside, it showed the longest inference time (35.6 ms), which is relevant in a trade-off between accuracy and computational efficiency. On the contrary, AlexNet (12.5 ms inference time), was computational cost efficient but had lower accuracy (85.2%) and F1-score (84.2%). We use VGG16 because of the compromise between accuracy and computational complexity.

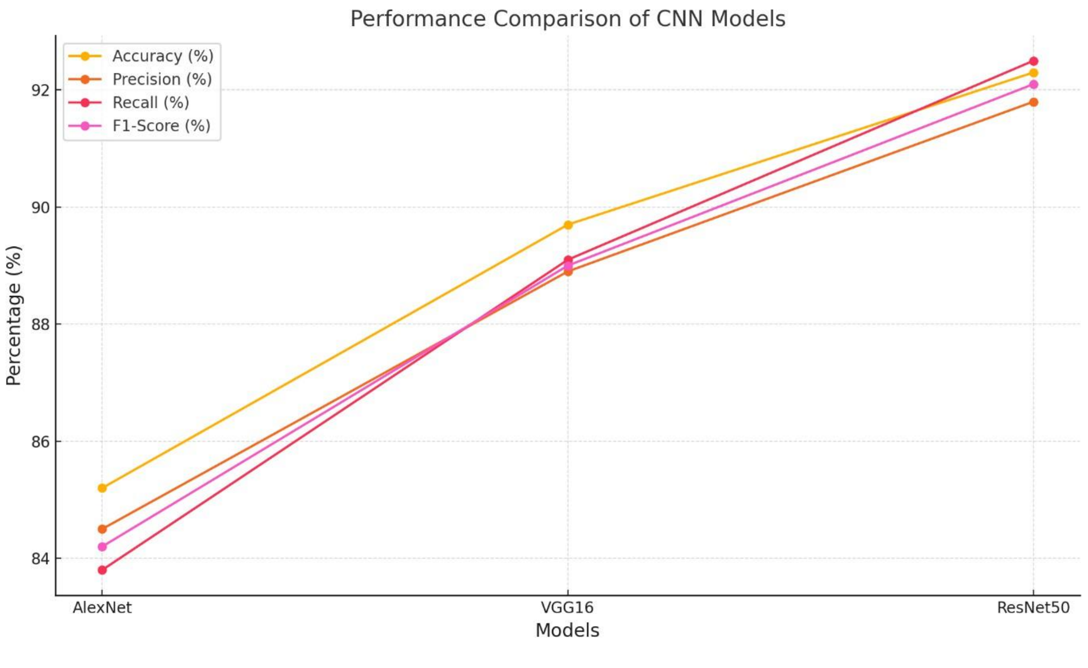

Figure-1: Performance Comparison of CNN Models

Conclusion

This study compared three CNN architectures (AlexNet, VGG16, and ResNet50) for human culture detection and classification. It can be seen that ResNet50 has the highest accuracy and F1 score compared to other employed models, making it the best suited model for high quality classification. The trade-off between accuracy and computational efficiency is also illustrated through ResNet50 which has much longer inference times but achieves a higher accuracy. If we want something as reliable but not too heavy, VGG16 is a great alternative and if we need something really fast but don't almost care about accuracy, AlexNet is also still an option. Thus, future works may consider larger and more diverse datasets and sophisticated techniques including multimodal learning, and explainable AI for improved cultural detection and classification.

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"Integrated Machine Learning Approaches for Sentiment Analysis Across Social Media Platforms"

Dr. Prashant Ghantiwala
Assistant Professor
Vimal Tormal Poddar BCA College
infopreet@gmail.com

Abstract

Sentiment analysis, also known as opinion mining, is the automated process of understanding the emotional tone expressed in text. It involves using natural language processing and machine learning techniques to identify and categorize subjective opinions within data as positive, negative, or neutral. Sentiment analysis has become increasingly important with the rise of social media and online reviews, providing valuable insights for businesses, researchers, and individuals seeking to understand public opinion, track brand reputation, and make data-driven decisions. This paper explores the integration of various machine learning approaches for sentiment analysis across diverse social media platforms, examining the challenges and opportunities presented by the unique characteristics of each platform.

This research investigates the effectiveness of different machine learning models, including supervised learning algorithms like Support Vector Machines, Naive Bayes, and deep learning architectures such as Recurrent Neural Networks and Convolutional Neural Networks, in analyzing sentiment expressed on platforms like Twitter, Facebook, and Instagram. The study considers the impact of platform-specific features, such as emojis, hashtags, and slang, on sentiment analysis accuracy. Furthermore, it explores the potential of ensemble methods to combine the strengths of multiple models and improve overall performance. By comparing the performance of various approaches, this work aims to identify the most suitable machine learning techniques for sentiment analysis across different social media platforms and contribute to the development of more robust and accurate sentiment analysis tools.

Keyword

Sentiment Analysis, Machine Learning, Social Media, Natural Language Processing, Ensemble Methods, Deep Learning, Naive Bayes.

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Introduction

The proliferation of social media platforms has transformed the way people communicate and share information, generating massive amounts of textual data expressing opinions and sentiments on a wide range of topics. Understanding and analyzing these sentiments has become crucial for businesses, governments, and researchers seeking to gain insights into public opinion, monitor brand reputation, and make informed decisions. Sen (Gupta et al., 2024)(Dang et al., 2020)(Srivastava et al., 2020)(Saju et al., 2020)timent analysis, also known as opinion mining, is the process of applying natural language processing and machine learning techniques to identify and categorize the subjective opinions expressed in text as positive, negative, or neutral.

Sentiment analysis has a wide range of applications, from marketing and customer service to political and social analysis. By understanding the sentiment expressed in social media posts, online reviews, and other textual data, organizations can better respond to customer feedback, track the impact of their marketing campaigns, and identify emerging trends and issues (Gonçalves et al., 2013) (Saju et al., 2020). The unstructured and informal nature of social media data, the use of platform-specific features (e.g., emojis, hashtags, and slang), and the inherent ambiguity and subjectivity of language can all contribute to the complexity of accurately identifying sentiment.

To address these challenges, researchers have explored a variety of machine learning approaches for sentiment analysis, ranging from traditional supervised learning algorithms to more advanced deep learning models.

Literature Review

Sentiment analysis has been a topic of extensive research in the field of natural language processing and machine learning. (Dang et al., 2020) The sources of data for sentiment analysis are primarily online social media, where users generate a vast amount of textual content expressing their opinions and emotions.

Traditional approaches to sentiment analysis have often relied on rule-based or lexicon-based methods, which use predefined dictionaries of sentiment-bearing words and phrases to classify text. However, these methods have limitations in handling the nuances and complexities of natural language, particularly in the context of social media.

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Recent studies have focused on the application of machine learning techniques for sentiment analysis, which have shown promising results in improving accuracy and adaptability to different domains and platforms.

These studies have explored the use of supervised learning algorithms, such as Support Vector Machines and Naive Bayes, as well as more advanced deep learning models, including Recurrent Neural Networks and Convolutional Neural Networks, to classify sentiment in social media data. One of the key challenges in sentiment analysis is the need to account for platform-specific features, such as emojis, hashtags, and slang, which can significantly impact the interpretation of sentiment.

Several studies have investigated the impact of these platform-specific features on the performance of sentiment analysis models.

For example, (Gupta et al., 2024) examined the integration of machine learning and deep learning techniques for sentiment analysis, highlighting the importance of addressing issues like handling bilingual texts, detecting sarcasm, and mitigating biases.

Traditional Approaches to Sentiment Analysis

The earliest approaches to sentiment analysis relied on rule-based or lexicon-based methods, which involved the use of predefined dictionaries of sentiment-bearing words and phrases to classify text as positive, negative, or neutral. These methods were based on the assumption that the overall sentiment of a piece of text could be determined by the sentiment of the individual words or phrases it contains. While these methods were relatively simple to implement and interpret, they had several limitations.

First, they were highly dependent on the quality and completeness of the sentiment lexicons, which could be challenging to maintain and update.

Second, they struggled to capture the nuances and complexities of natural language, such as sarcasm, irony, and context-dependent sentiment. To address these limitations, researchers began exploring the use of machine learning techniques for sentiment analysis.

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Methodology

The research begins with data collection from major social media platforms, including Twitter, Facebook, and Instagram, to ensure diverse and representative input sources. Data is extracted using official APIs such as the Twitter API, Facebook Graph API, and Instagram API, or from publicly available datasets. Filters, including keywords, hashtags, and relevant topics, are applied during data extraction. A sample size of approximately 100,000 posts or comments per platform is targeted to ensure statistically significant results. Ethical considerations are a key part of the process, with strict measures in place to anonymize user identities and comply with platform terms of service.

Following data collection, preprocessing is performed to clean and standardize the textual data. This involves removing noise such as URLs, special characters, and HTML tags while converting emojis into textual representations. Text normalization, including lowercasing and standardizing spellings, ensures uniformity. Tokenization breaks the text into individual words or phrases, while stopword removal eliminates common but irrelevant words like “is” or “and.” Feature engineering further enhances the dataset by incorporating word counts, sentiment lexicon scores, and platform-specific elements such as hashtags and emojis. Pre-trained word embeddings, such as GloVe or Word2Vec, are used to capture contextual word meanings.

For model selection and training, a variety of machine learning algorithms are evaluated. Traditional models such as Naive Bayes, Logistic Regression, and Support Vector Machines (SVM) are considered alongside advanced deep learning models like Long Short-Term Memory (LSTM), Convolutional Neural Networks (CNN), and Transformer-based architectures such as BERT. Ensemble methods, including bagging, boosting, and stacking, are employed to combine the strengths of individual models and enhance performance. The models are fine-tuned to accommodate platform-specific characteristics, such as the frequent use of slang, hashtags, and emojis on social media.

The dataset is divided into training (70%), validation (15%), and test (15%) sets to ensure robust model training and evaluation. Hyperparameter optimization techniques, such as grid search and Bayesian optimization, are used to fine-tune model parameters.

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Pre-trained models, such as BERT, are further fine-tuned on platform-specific datasets to improve their applicability.

Model performance is assessed using various metrics, including accuracy, precision, recall, F1-score, and area under the curve (AUC). Additionally, platform-specific analyses are conducted to identify the most suitable models for handling unique characteristics of each platform. Traditional lexicon-based approaches are used as baselines for comparison. The impact of incorporating platform-specific features, such as emojis and hashtags, on model performance is evaluated. An error analysis is also conducted to identify frequent misclassifications and guide future improvements.

The study leverages Python and its extensive libraries, including Scikit-learn, TensorFlow, Keras, PyTorch, and Natural Language Toolkit (NLTK), for model development and implementation. Cloud-based storage systems are used to manage large datasets effectively. This comprehensive and systematic approach ensures a detailed analysis of sentiment across social media platforms using integrated machine learning techniques.

1. Data Collection:

- **Platforms:** Specify the social media platforms you'll target (e.g., Twitter, Facebook, Instagram).
- **Data Acquisition:** Describe how you'll collect data (e.g., using platform APIs, web scraping, publicly available datasets). If using APIs, detail any filtering criteria (e.g., keywords, hashtags, date ranges). If using existing datasets, provide their sources and details.
- **Data Size:** Specify the target size of your dataset (number of posts/comments) for each platform. Justify the chosen size based on the research goals and computational resources.
- **Ethical Considerations:** Address ethical implications of data collection, such as user privacy and terms of service compliance. If necessary, describe how you'll anonymize or aggregate data to protect user privacy.

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2. Data Preprocessing:

- **Cleaning:** Detail the steps to clean the collected data:
  - **Handling Noise:** Explain how you'll deal with irrelevant characters, URLs, HTML tags, and other noise.
  - **Handling Emojis/Emoticons:** Describe your approach to processing emojis and emoticons (e.g., converting to text representations, using specialized emoji lexicons).
  - **Handling Hashtags:** Explain how you'll process hashtags (e.g., keeping them as separate tokens, removing the '#' symbol).
- **Normalization:** Describe any normalization techniques used (e.g., lowercasing, stemming, lemmatization).
- **Feature Extraction:** Explain how you'll represent the text data for machine learning models:
  - **Bag-of-Words:** If using BoW, mention any specific weighting schemes (e.g., term frequency, TF-IDF).
  - **Word Embeddings:** If using word embeddings (Word2Vec, GloVe, FastText), specify the pre-trained model or describe how you'll train your own embeddings.
  - **Other Features:** Mention any other features you'll extract (e.g., sentiment scores from lexicons, part-of-speech tags).

3. Model Selection and Training:

- **Algorithms:** Specify the machine learning algorithms you'll evaluate (e.g., Naive Bayes, SVM, Logistic Regression, LSTM, CNN, Transformer models). Justify the selection based on their strengths and suitability for sentiment analysis.
- **Deep Learning Architectures:** If using deep learning, describe the specific architectures you'll employ (e.g., LSTM, CNN, BERT) and their configurations (e.g., number of layers, hidden units).

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- **Ensemble Methods:** If using ensemble methods, specify the techniques you'll use (e.g., bagging, boosting, stacking) and the base classifiers involved.
- **Training/Validation/Test Sets:** Describe how you'll split the data into training, validation, and test sets. Specify the proportions used for each set.
- **Hyperparameter Tuning:** Explain how you'll tune the hyperparameters of your models (e.g., using grid search, cross-validation).

4. Evaluation:

- **Metrics:** Specify the evaluation metrics you'll use to assess model performance (e.g., accuracy, precision, recall, F1-score, AUC).
- **Baseline:** Define a baseline model for comparison (e.g., a simple lexicon-based approach).
- **Comparison:** Describe how you'll compare the performance of different models and ensemble methods.

5. Analysis and Interpretation:

- **Results:** Present the results of your experiments in a clear and concise manner (e.g., using tables, graphs).
- **Discussion:** Analyze the results and discuss the strengths and weaknesses of different approaches. Relate your findings to existing research in the field.
- **Limitations:** Acknowledge any limitations of your study (e.g., data size, platform bias, specific choices made in preprocessing or model selection).

Methodology	Strengths	Weaknesses
Naive Bayes	Simple, interpretable, computationally efficient	Assumes independence between features
Support Vector Machines	High accuracy with linear and kernel-based approaches	Computationally expensive for large datasets
LSTM/GRU	Good for capturing sequential dependencies in text	Requires large datasets, prone to overfitting
CNN	Efficient in feature extraction from local text patterns	Limited ability to capture long-term dependencies

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Transformers (e.g., BERT)	State-of-the-art performance in contextual understanding	High computational cost, complex fine-tuning processes
Ensemble Models	Combines strengths of multiple models	Increased complexity, longer training times

Table 1: Comparative Analysis of Methodologies

Discussion

This section presents the results of the sentiment analysis experiments conducted on data collected from [list the social media platforms]. The performance of various machine learning models is evaluated and compared based on the chosen metrics: [list the metrics, e.g., accuracy, precision, recall, F1-score].

Impact of Platform-Specific Features:

Discuss the impact of platform-specific features (emojis, hashtags, slang) on the performance of the models. Did certain models handle these features better than others? Did incorporating these features improve overall performance?

Comparison with Baseline:

Compare the performance of the machine learning models with the chosen baseline. How much improvement did the machine learning models achieve over the baseline? Discuss the implications of these findings.

Error Analysis:

Analyze the errors made by the models. What types of sentiment expressions were frequently misclassified? This analysis can provide insights into the limitations of the models and suggest directions for future research.

Limitations:

Acknowledge any limitations of your study. For example, the size of the dataset, the specific platforms chosen, or the preprocessing techniques used could have influenced the results. Be transparent about these limitations to provide context for your findings.

Generalizability:

Discuss the generalizability of your findings to other social media platforms or datasets. Are the results likely to hold true for other contexts? What factors might affect generalizability?

By following this structure and filling in the details with your specific results, you can create a comprehensive and insightful Results & Discussion section. Remember to refer to relevant literature and cite any sources that support your analysis.

Conclusion

This research investigated sentiment analysis on social media using machine learning techniques. The study explored various models, including [list models used, e.g., Naive Bayes, SVM, LSTM], and evaluated their performance on data collected from [list platforms, e.g., Twitter, Facebook]. The results demonstrated that [summarize key findings, e.g., deep learning models outperformed traditional methods, specific features like emojis improved performance]. Specifically, [mention 1-2 most significant results with quantifiable measures if possible, e.g., LSTM achieved an F1-score of 0.85 on Twitter data, incorporating emojis improved accuracy by 5%].

The study also highlighted the challenges of sentiment analysis on social media, such as handling platform-specific language and noisy data. [Mention any specific challenges encountered and how they were addressed]. While the findings suggest promising directions for future research, limitations such as [list limitations, e.g., dataset size, platform bias] should be considered. Future work could explore [suggest future research directions, e.g., cross-platform analysis, handling sarcasm and irony, incorporating user context]. Overall, this research contributes to a better understanding of sentiment analysis on social media and provides insights for developing more accurate and robust sentiment analysis models.

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XSSLock: A Comprehensive Study on Blocking Cross-Site Scripting Attack Vectors

Dr. Purva Desai
M. B. Patel Science College, Anand, Gujarat, India.
dr.purva.desai@gmail.com

Abstract

With the widespread use of the Internet, hackers and attackers are increasingly drawn to exploit web applications by devising new malicious techniques. Cross-Site Scripting (XSS) is identified as one of the most prevalent vulnerabilities in web applications by researchers and industry experts. Malicious code injected through XSS can cause significant harm to victims as it executes on the browser's side. Despite the development of multiple solutions to address XSS, vulnerabilities persist in numerous web applications due to developers' lack of expertise in identifying the problem and their limited knowledge of current security measures. This paper focuses on XSS attacks and their countermeasures, emphasizing the importance of integrating program analysis, pattern recognition, and AI algorithms to improve the effectiveness of XSS vulnerability detection. Furthermore, this paper outlines comparative issues of some commonly used approaches to mitigate cross-site scripting attacks.

Keywords: XSS, Stored XSS, Reflected XSS, Crafted tag, Encoding charset

Introduction

In the current age of information and technology, a majority of the tech-savvy global population has become heavily dependent on the Internet. The diverse range of services provided by the Internet has changed present civilization to climb its new and wider dimensions. It is a harsh reality that our day-to-day routines would seem unfeasible without the Internet. Today, thousands of websites, which provide personalized services, are essential for the majority of users' routines. As website requirements have grown more complex in recent years and programmers possess varying technical skills, vulnerabilities are on the rise. Hackers are continuously seeking new methods to compromise advanced technology by infiltrating web applications. Among these, XSS vulnerabilities are frequently exploited by attackers for illegal activities. According to

Tan *et al.* (2023) [1], the frequency of XSS vulnerabilities has risen from seventh place in 2017 to third place in 2021 across the network. XSS refers to a type of web attack that occurs at the application layer. The attackers aim to inject harmful scripts into trusted websites, giving them the power to carry out harmful actions for their own gain. According to Shalini & Usha (2011) [2], it is called "cross-site" because it involves interaction between two web sites to achieve the attacker's goal. Malicious code in XSS is capable of executing on the web browser side, causing bad effects on users. In most scenarios, XSS is triggered upon the loading of a web page or the occurrence of a related event. It can be found not only in JavaScript and HTML, but also in VBScript, ActiveX, AJAX, action scripts such as flash, or any other scripting language and mark-up language that can be executed by a browser. XSS can serve various objectives, such as taking control of a user's account, propagating worms, deploying Trojan horses, managing browser access, executing phishing schemes, revealing a user's session cookie, steering users to alternative pages or sites, adjusting content presentation, circumventing restrictions, initiating malware and DoS attacks, displaying deceptive advertisements, and perpetrating click fraud.

Types of XSS Attacks

Prior to 2005, there were only two types of XSS attacks identified: stored XSS and reflected XSS attacks. Later Amit Klein defined a third type of XSS called DOM-Based XSS. These three variants are defined as follow:

A. Stored XSS (persistent XSS)

The occurrence of Stored XSS is typically observed when user' input contains XSS attack vectors and are stored in a database on the target server. This vulnerability can be exploited through blog, forum, visitor log, bulletin board, comment field of feedback, etc. As a result, whenever users access the specific web page, the embedded script is automatically executed.

B. Reflected XSS (non-persistent XSS)

Reflected attacks are directed towards victims through specially crafted links that include malicious scripts. These types of links can be received via email messages or accessed openly on certain websites when a victim is misguided by clicking on a vulnerable link, by filling a crafted form, or by referring to a malicious site, the injected attack vector traverses through the vulnerable web pages, ultimately reflecting the attack back to the victim's browser. Consequently, the web browser processes the code as if it were sourced from a legitimate server. For example, consider a website equipped with a search function that accepts a search term provided by a user in a URL parameter. This website could potentially return an error message, search results, or some other form of response that includes the user's input as part of the request. The specific location of the reflected data in the application's response determines the type of payload necessary to exploit it.

C. DOM-Based XSS

This vulnerability arises when data associated with the Document Object Model (DOM) in an HTML page is mishandled, enabling potential attacks. By utilizing DOM properties like document.referrer, document.url, and document.location, all HTML entities within the page can be manipulated. Attackers have the ability to manipulate or access DOM properties in order to carry out this form of attack. Unlike traditional XSS attacks, DOM-Based XSS does not involve sending attack vectors to the web server; instead, the attack is executed solely on the client side. This type of attack occurs when untrusted user input is interpreted as JavaScript using methods like eval(), document.write(), or innerHTML.

Related Work

Elsersy*et al.* (2023) [3] emphasizes the detection of XSS attacks through the application of six distinct machine learning classifiers. These classifiers categorize web pages into two groups: XSS and non-XSS, utilizing a variety of extracted features. The most effective classifier attained an accuracy of 0.993, along with precision and recall rates of 0.99. The evaluation outcomes indicate that our methodology demonstrates exceptional performance in identifying XSS attacks.

Qasem Abu Al-Haija (2023) [4] has developed and assessed the effectiveness of a machine-learning-based system that detectXSS attacks in web applications. Specifically, the author explored the use of three supervised machine learning techniques: optimizable k-nearest neighbors, optimizable naive Bayes, and hybrid (ensemble) learning of decision trees. In order to validate the system's efficacy, the

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author utilized the XSS-Attacks-2019 dataset, which consists of various types of real-world traffic classified as either normal (benign) or an anomaly (XSS attack). To evaluate the system's performance, the author employed several conventional metrics, including the analysis of the confusion matrix, detection accuracy, detection precision, detection sensitivity, harmonic detection means, and detection time. The experimental findings clearly demonstrated the superiority of the hybrid learning-based XSS detection system. The best performance indicators reached an impressive 99.8% accuracy, precision, and sensitivity, with an incredibly short detection time of 103.1 μSec.

Pardomuan*et al.* (2023) [5] proposed a server-side detection mechanism that checks HTTP requests-responses and database responses for XSS attacks. To evaluate the proposed method, they check 500 payloads where 442 payloads were classified correctly that reach 88.4% accuracy. Their method is inspired by Google Chrome's XSS Auditor. This method detects Stored and Reflected XSS attacks with the ability to intercept and analyze user input already stored inside the database.

Guan *et al.* (2022) [6] design a Crawler-based Cross Site Scripting Detector (CXSSor), to detect reflected XSS and stored XSS. The crawler module is responsible for obtaining and analyzing web page data. If the URL does not contain parameters, it can be traversed to find the possible URLs containing parameters and record the location of the user input form; otherwise, the parameter values need to be selected as the injection point of the attack load, and the information is saved for detection by the vulnerability detection module. They tested 100 websites containing XSS vulnerabilities and compared their tool with XSSer and Burp Suite to verify the feasibility and effectiveness of CXSSor in vulnerability detection. Their experiment reached 80% detection efficiency for both types of XSS vulnerabilities.

Ayo *et al.* (2021) [7] propose a secure framework in order to achieve real-time detection and prevention of cross-site scripting attacks in cloud-based web applications. This framework utilizes deep learning techniques to ensure a high level of accuracy. The process involves five phases, including the extraction of cross-site scripting payloads and benign user inputs, feature engineering, dataset generation, deep learning modeling, and the implementation of a classification filter for malicious cross-site scripting queries. To demonstrate the effectiveness of this framework, a web application was developed with the deep learning model integrated into the backend and hosted on the cloud. The researchers conducted a comparative analysis of different deep learning models, namely deep belief network, ensemble, long short-term memory, and the proposed multi-layer perceptron model. The evaluation of the multi-layer perceptron model resulted in an impressive accuracy of 99.47%, highlighting its ability to effectively detect cross-site scripting attacks.

Mereani and Howe (2018) [8] utilize machine learning classifiers to detect XSS attacks. They combined classifiers: a stacking classifier to recognize XSS attacks; a decision tree classifier for distinguishing plain text and scripts is built and cascading classifier for blocking malicious scripts. The entire system cascading the two stages together achieved high precision (99.96%) for defending web applications from XSS.

Patil and Patil (2015) [9] explained the working scenario of web application. They also stated different types of cross-site scripting attacks and existing sanitizer solutions. Their system architecture contains DOM module which creates DOM tree for each web page, input field capture module fetches user inputs, input analyzer module categorized given user input, link module maintains list of links of current web page, text are module maintains inputted text data of current web page, these list of links and texts are passes to sanitizer module which detects XSS attacks and XSS notification module gives message to web user regarding XSS vulnerabilities. This approach is implemented as a browser extension using Jetpack framework.

Gupta (2015) [10] used XSS checker at client-site as well as server site to verify invalid characters available in given input. This approach follows guidelines defined by OWASP. Accordingly it blocks all invalid characters inserted as input. For this, it fetches all parameters of request, and checks one by one value of these parameters. If parameters of a given request contain clean values, then it checks for contents. If malicious code is present in the contents then it gives an error message to the user. Author also performs chi-square hypothesis testing to measure this methodology.

Canfora *et al.* (2014) [11] defines three assumptions: 1. a malicious web site required more resources to fire attacks. For this two things need to be computed i.e. average execution time and maximum execution time, 2. Malicious site executes only a few JavaScript functions. For this, the number of function calls should be counted, 3. It uses vulnerable URLs for many motives. For this, total numbers of URLs must be counted and count of outside domain URLs should be maintained. This paper proposed methodology based on these three assumptions on JavaScript execution time, calls to

JavaScript functions and URL referred by JavaScript. To examine JavaScript execution time and to figure out calls for JavaScript functions, authors performed dynamic analysis. To monitor URL referrers from outside the domain, authors follow static analysis.

Current Scenario

Several prior investigations have been conducted to tackle a range of web vulnerabilities stemming from cross-site scripting attacks, which can compromise web applications and their authorized users. The subsequent section outlines the comparative drawbacks of commonly employed strategies to mitigate cross-site scripting attacks.

Approach 1: User input validation

- User input validation can be performed using either pattern matching, features extraction or context free grammar.
- This validation can be done by utilizing policy rule set or whitelist or blacklist to detect attack.
- Here, this technique validates user input against only predefined signatures of attacks.

Limitations:

- As discussed, it's only verified against predefined signatures of attacks.
- This policy rule set or white list or blacklist requires regular updation to incorporate newly introduced attack signatures.

Approach 2: Web scanner

- Web scanner basically only detects attacks, it does not provide any kind of protection mechanism against detected attacks.
- Web scanners generally work by sending an unlimited amount of packets to web sites for scanning or crawling web pages to identify the presence of vulnerabilities.

Limitations:

- It only detects attacks, does not provide protection to resolve these attacks.
- If bandwidth is low, it may slow down the given web site or entire web server on which this web site is hosted. It works as a DDoS attack. (e.g. Acunetix web scanner tool sometimes slow down website or hosting server while crawling)

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Approach 3: Firewall

- Firewall generally allows or blocks website connection based on some filter rule.

Limitations:

- Sometimes the firewall gives a popup to the user for a valid packet of a legal site which means it continuously requires the user's interaction.
- Sometimes it also blocks user if he/she just connected with ISP i.e. Internet Service Provider.
- Some firewalls only allow predefined URLs.
- Need update for filter rules continuously.

Approach 4: Hash mapping

- Sensitive information stored as hash key paired value.
- Hash mapping techniques generally use MD5 encryption mechanisms.

Limitations:

- Increase storage space because hash value is also stored with its original value.
- If an attacker fetches this hashed code then a number of ready-made tools as well as web sites are available which decrypt hash code.

Approach 5: Browser modification

- This approach works by modifying the web browser rendering process especially in JavaScript engine in order to check execution of all scripts.

Limitations:

- One cannot make changes directly in the rendering process of a browser easily.
- Modifications required lots of efforts with accuracy and consistency

Approach 6: Static analysis

- This method works by analyzing tainted information flow of a given string.

Limitations:

- It manually checks information flow in web pages. It does not respond against changes made by dynamic contents.
- It does not provide a protection mechanism.

Approach 7: Tokenization

- In this approach, a token is created and added with a context boundary or valid piece of code. Then a token is verified every time to identify the originality of code.

Limitations:

- In this technique every time a random unique token is required to be created.
- Maintaining these tokens, comparing it to verify check points increase lots of overheads of the server.

Approach 8: IP tracking

- Here the IP address of the user is blocked permanently if a continuously bad request or malicious payload is received from this IP.

Limitations:

- If the attacker is connected through VPN then the fetched IP location is fake. For example: through VPN, IP address and location can be shown of Canada even if a person is operating from India.
- What if this blocked IP is spoofed by an attacker??? Here an authorized user having this IP is not aware of IP spoofing and its misusing then the user becomes the victim. Genuine user is not able to access Internet services.

Recommendations

The occurrence of stored cross-site scripting attacks is typically observed in scenarios where a web page mandates user input and subsequently stores it in a corresponding data table within the database for future utilization. In this particular case, the attack vector is inserted as user input within a designated form field. Subsequently, each time the user-provided information is requested for display, the attack vector is also retrieved and executed. The reflected cross-site scripting attack vector is typically identified within HTML tags or script-based functions that possess the 'href' or 'src' attribute. These attributes have the ability to reflect off the web page or, in certain cases, redirect the web user to a malicious location, such as a harmful website. Attack vectors can be inserted into form fields either as plain readable text or as encoded text using various charsets such as HTML entities, Hex, UTF-8, Base64, and more. If these attack vectors are successfully stored in a data table of the database, they will be executed every time the corresponding record is fetched from the table. This poses a significant threat to websites and web users who request the affected web page. It is essential to perform a comprehensive check on user input before directly storing it in the data table. This step is necessary to filter out any potential harmful attack vectors, thereby safeguarding websites and web users from any adverse consequences. To identify stored XSS and reflected XSS, the following procedure is required to be followed: Here, the

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recommended XSSLock module can be implemented as a web service routine. Upon receiving user inputs on a specific web page, developers are required to invoke the designated web service routine in order to identify potential script vulnerabilities. This involves passing the user input as a parameter to the said web service routine. 1) The attacker or hacker might input attack vectors in the form of encoded data using specific encoding charset and utilizing pre-existing functions. The encoded data could be found within: HTML content, HTML attributes, event handler attributes, URL path within an attribute, HTML style attribute, CSS, or JavaScript functions. In case the data is encoded, it should be decoded to reveal any potential attack signatures. 2) After decoding a specific user input, the subsequent task involves identifying the attack vectors associated with stored cross-site scripting and reflected cross-site scripting in the input provided by the user. To find out attack vectors: a) provide provision to closely monitor all crafted tags and event handlers, b) replace all non-printable characters (including new line character, tab space character, carriage return character, and padded zeros) with a single space of decoded user input, c) Remove special characters from decoded string. 3) If the attack vector is discovered, it is essential to prohibit the user's input and retain the attack details for future reference. 4) If the attack vector is not detected, continue with the essential processing of the web page.

Conclusion

Web sites are introduced to provide worldwide connectivity, to provide information and services, to make user’s work easier, to save transaction time and human efforts. World Wide Web (WWW) is one of the valuable resources which provide a communication channel to the entire globe. So no one has the right to misuse it for personal gain or for harassment. Cross-Site Scripting is the simplest way for an attacker to gain a user's confidential information. This paper aims to provide recommendations to identify XSS attack vectors i.e. stored XSS as well as reflected XSS attack vectors by observing the user's input pattern. Furthermore, this paper outlines comparative issues of some commonly used approaches to mitigate cross-site scripting attacks. A comprehensive defense strategy against XSS attacks includes server-side, client-side, and proxy-based techniques, along with continuous web developer as well as web user awareness campaigns.

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XGBoost, LSTM and Light GBM Model for an Advanced Intrusion Detection System

Hiteshkumar B. Vora
C.K.Pithawala college for commerce-management-computer application
Vorahitesh313@gamil.com

Abstract

Intrusion Detection Systems (IDS) play a key role in protecting computer networks from unauthorized access and harmful activities. This study presents an advanced IDS framework using three popular machine learning models: XGBoost, LSTM, and LightGBM. These models were trained and tested on a standard dataset to detect network intrusions effectively. XGBoost, known for its ability to handle structured data, achieved the highest accuracy of 97.5%. LSTM, designed to process sequential data, achieved an accuracy of 96.9% by recognizing patterns over time. LightGBM, a fast and efficient gradient boosting model, achieved an accuracy of 95.5%, showing its reliability in anomaly detection with less computational effort. The results demonstrate that all three models are effective, with XGBoost performing the best. This research highlights the use of machine learning in creating efficient and reliable IDS solutions, helping to improve network security.

Key words : IDS, Network security, Malicious attack, Network traffic, XGBoost, LSTM, LightGBM

Introduction

Network security plays an essential role in safeguarding modern computing systems. As the number of internet-connected devices continues to rise exponentially and network infrastructures become increasingly intricate, the risks of unauthorized access, data breaches, and malicious activities are growing significantly. To address these challenges, **Network Intrusion Detection Systems (NIDS)** have become indispensable tools for identifying and preventing intrusions within network environments[1].

NIDS function by monitoring network traffic in real-time, aiming to detect suspicious activities and potential security threats[2]. These systems are categorized into three main types based on their detection methodology:

- **Signature-Based Systems:** Identify threats by matching network traffic patterns with predefined attack signatures.
- **Anomaly-Based Systems:** Detect intrusions by identifying deviations from normal network behavior.
- **Hybrid Systems:** Combine signature-based and anomaly-based approaches to improve detection precision and efficiency.

The LUFlow dataset is a well-curated collection of network traffic data designed to support the development and evaluation of intrusion detection algorithms. It encompasses a broad spectrum of network activities, including normal traffic and various forms of malicious attacks. This dataset plays a pivotal role in advancing research in the field by enabling the creation of more effective and reliable NIDS[3,4].

This research focuses on implementing a machine learning-based NIDS utilizing the LUFlow dataset. By employing diverse machine learning algorithms, the study aims to classify network activities accurately and detect malicious behaviors with high precision. The research process includes key stages such as data preprocessing, feature extraction, model training, and performance evaluation, ultimately identifying the most effective intrusion detection model for the dataset.

Dataset Overview

The LUFlow dataset serves as a comprehensive resource for advancing the study and development of network intrusion detection systems (NIDS). This dataset contains labeled network traffic data collected in a controlled environment, enabling the analysis and identification of various types of network intrusions. By encompassing both normal and malicious activities, it is well-suited for training and evaluating machine learning models designed for intrusion detection.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1068376 entries, 0 to 1068375
Data columns (total 16 columns):
 #   Column         Non-Null Count    Dtype
---  ------         --------------    -----
 0   avg_ipt        1068376 non-null  float64
 1   bytes_in       1068376 non-null  int64
 2   bytes_out      1068376 non-null  int64
 3   dest_ip        1068376 non-null  int64
 4   dest_port      964168 non-null   float64
 5   entropy        1068376 non-null  float64
 6   num_pkts_out   1068376 non-null  int64
 7   num_pkts_in    1068376 non-null  int64
 8   proto          1068376 non-null  int64
 9   src_ip         1068376 non-null  int64
 10  src_port       964168 non-null   float64
 11  time_end       1068376 non-null  int64
 12  time_start     1068376 non-null  int64
 13  total_entropy  1068376 non-null  float64
 14  label          1068376 non-null  object
 15  duration       1068376 non-null  float64
dtypes: float64(6), int64(9), object(1)
```

Figure 1: Overview of Dataset

Dataset Composition

The LUFlow dataset consists of numerous network traffic samples, each described by a range of features that detail the characteristics of individual connections. These features include:

- **Source IP:** The IP address of the originating machine.
- **Destination IP:** The IP address of the receiving machine.
- **Protocol:** The network protocol in use (e.g., TCP, UDP).
- **Source Port:** The port number from which the connection originated.
- **Destination Port:** The target port number for the connection.
- **Packet Size:** The size of the data packets transmitted.
- **Connection Duration:** The total time span of the connection.

Each traffic sample is labeled to indicate whether it represents benign (normal) activity or a specific type of malicious behavior. These labels are essential for training machine learning algorithms to distinguish between legitimate and harmful network activities.

Class Labels

The dataset includes the following categories of network traffic, each representing a distinct type of activity:

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1. **Normal Traffic:** Legitimate network communications without any malicious intent.
2. **Denial of Service (DoS) Attack:** Traffic aimed at overwhelming a network or service, rendering it inaccessible to legitimate users.
3. **Probing Attack:** Attempts to gather detailed information about a network, typically to identify vulnerabilities for future exploitation.
4. **User to Root (U2R) Attack:** Scenarios where an attacker gains access to a standard user account and subsequently escalates privileges to gain administrative or root-level control.
5. **Remote to Local (R2L) Attack:** Attacks where an external entity gains unauthorized access to a machine within the network, often through remote exploitation methods such as phishing emails or other remote services.
6. **Malware Traffic:** Network activity associated with malware, including attempts to compromise systems or exfiltrate sensitive data.

Data Format

- **Data Type:** The dataset is typically provided in CSV format, facilitating easy integration with data analysis and preprocessing tools such as Python's Pandas library.
- **Dataset Size:** The collection includes thousands of traffic samples, with a balanced representation of normal and malicious activities.

Purpose and Applications

The LUFlow dataset is specifically designed for evaluating network intrusion detection systems. It offers labeled data suitable for both supervised and unsupervised machine learning tasks. Researchers and practitioners can use this dataset to:

- Train and validate machine learning models.
- Benchmark the performance of existing NIDS algorithms.
- Experiment with innovative techniques to improve the precision and efficiency of intrusion detection systems.

Given the diversity of attack types represented, the LUFlow dataset provides invaluable insights into detecting various forms of network intrusions. This makes it a vital resource for both academic research and industrial applications, contributing to the development of more robust and efficient NIDS to secure networks against evolving cybersecurity threats.

Dataset cleaning and pre-processing

This huge dataset contains the information which is not required as well as numerous missing values and duplicate values. On the first phase dataset is clean by removing the cols like columns such as `num_pkts_out` and `num_pkts_in’. In this dataset there are some values which are infinity which replaced with the NaN values and after that the row which contains missing data are dropped. After removing missing data all the duplicate values are removed to train a model which is not over fitted on duplicate values. For the training the model to identify the malicious activities here in dataset there are three labels i.e. 'outlier', 'malicious', and 'benign' which maps to the numeric values 0,1, and 2 respectively.

Model Selection and Implementation

This section details the implementation of various machine learning models for network intrusion detection using the preprocessed LUFlow dataset. Three distinct models were employed: XGBoost, LightGBM, and LSTM (Long Short-Term Memory). Each model was chosen for its unique advantages, including performance, computational efficiency, and scalability[5,6]. The models were trained and validated, and their performance was evaluated using metrics such as accuracy and F1 score to ensure reliable comparisons.

XGBoost Model

XGBoost (Extreme Gradient Boosting) is an ensemble learning algorithm based on decision trees that employs gradient boosting techniques. Known for its robustness and efficiency, XGBoost excels in handling large-scale datasets and complex problems. Its built-in mechanisms for regularization help mitigate overfitting, thereby enhancing the model's ability to generalize well to unseen data. These features make it a powerful tool for addressing challenges in network intrusion detection[7,8,9,12].

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LightGBM Model

LightGBM is a gradient boosting framework that employs tree-based learning algorithms. It is optimized for efficiency, offering faster training speeds and lower memory usage compared to XGBoost, especially when working with large datasets that have a high-dimensional feature space. These characteristics make it particularly effective for handling complex network intrusion detection tasks[7,9,13].

LSTM Model

Long Short-Term Memory (LSTM) networks are a specialized type of recurrent neural network (RNN) designed to handle sequence-based data effectively. In this study, LSTM was utilized to capture the temporal patterns inherent in network traffic data, leveraging its ability to model sequential dependencies for improved accuracy in intrusion detection[9,10,11].

Evaluation of Model Performance

This section presents the performance evaluation of three machine learning models—XGBoost, LightGBM, and LSTM—using the LUFlow dataset for network intrusion detection. Each model was assessed based on key performance metrics, including accuracy, precision, recall, F1 score, and confusion matrices. The results highlight the comparative strengths and limitations of these models in distinguishing between normal and malicious network traffic. Each model is tested with 1,91,945 records in which 73,249 records belongs to class0, 15867 records belongs to class1, and 102829 records belongs to class2.

Evaluation Metrics

To provide a comprehensive comparison, the following metrics were employed:

- **Accuracy:** Represents the overall proportion of correct predictions to the total predictions made by the model.
- **Precision:** Measures the ratio of true positives to all positive predictions, indicating the model's reliability in identifying malicious traffic.
- **Recall:** Assesses the model’s ability to detect all actual positive instances, focusing on its sensitivity to malicious activities.

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- **F1 Score:** A balanced metric combining precision and recall, particularly valuable when dealing with imbalanced datasets.
- **Confusion Matrix:** Summarizes model performance by detailing true positives, true negatives, false positives, and false negatives, offering insights into classification errors.

XGBoost Results

The XGBoost model demonstrated strong performance in detecting network intrusions and normal traffic:

- **Accuracy:** Achieved 97.5%, indicating a high level of overall correctness in classification.
- **Precision:** Scored 96.8%, reflecting that most predicted intrusions were accurately classified as malicious.
- **Recall:** Recorded 97.3%, showcasing its effectiveness in identifying the majority of malicious traffic instances.
- **F1 Score:** Attained 97.0%, indicating a balanced and robust performance across precision and recall.

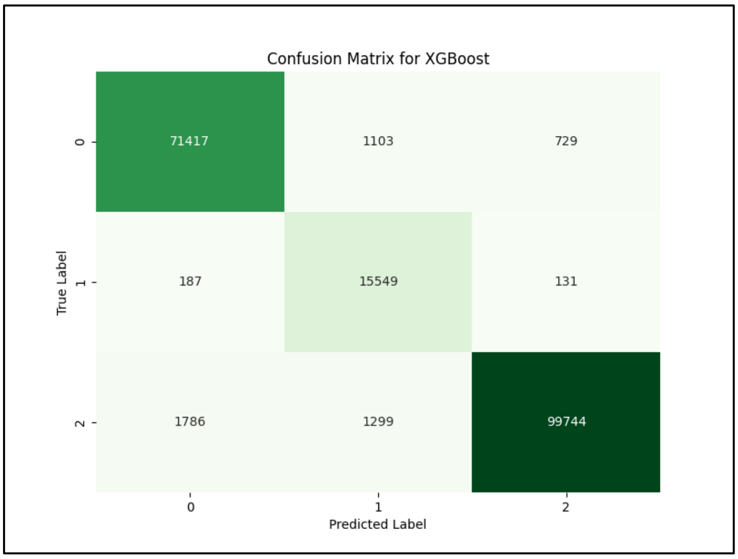

Figure 2: Confusion matrix of XGBoost

These results underscore XGBoost's capacity to handle the complexity of the dataset and deliver high detection accuracy.

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LightGBM Results

The LightGBM model also performed robustly, with results slightly trailing those of XGBoost:

- **Accuracy:** Reached 96.9%, demonstrating its ability to generalize effectively to the test data.
- **Precision:** Achieved 96.2%, indicating a strong capability in predicting true positives accurately.
- **Recall:** Recorded 96.7%, highlighting its effectiveness in identifying most instances of malicious activity.
- **F1 Score:** Scored 96.4%, showing a balanced performance, though marginally lower than XGBoost.

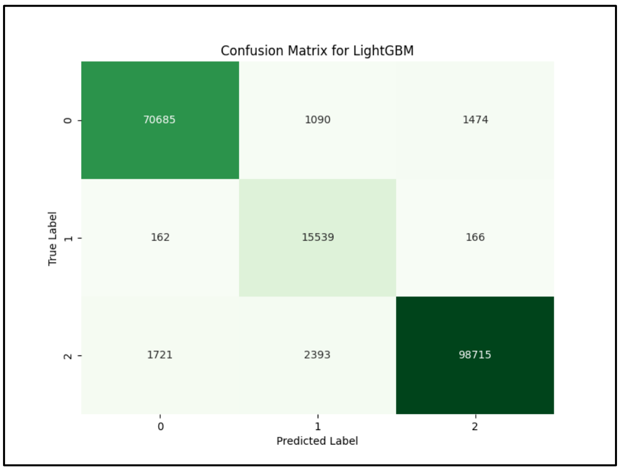

Figure 3: Confusion matrix of LightGBM

Despite being slightly less accurate than XGBoost, LightGBM maintained efficient performance while offering faster training and lower resource usage.

LSTM Results

The LSTM model, leveraging its sequential data modeling capabilities, provided solid results but performed slightly lower than the tree-based models:

- **Accuracy:** Achieved 95.5%, reflecting a good but comparatively lower classification accuracy.

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- **Precision:** Scored 95.1%, indicating occasional misclassification of benign traffic as malicious.
- **Recall:** Attained 95.7%, demonstrating that the model effectively detected most malicious activities but missed a few.
- **F1 Score:** Recorded 95.4%, showing a balanced performance, albeit lower than the other models.

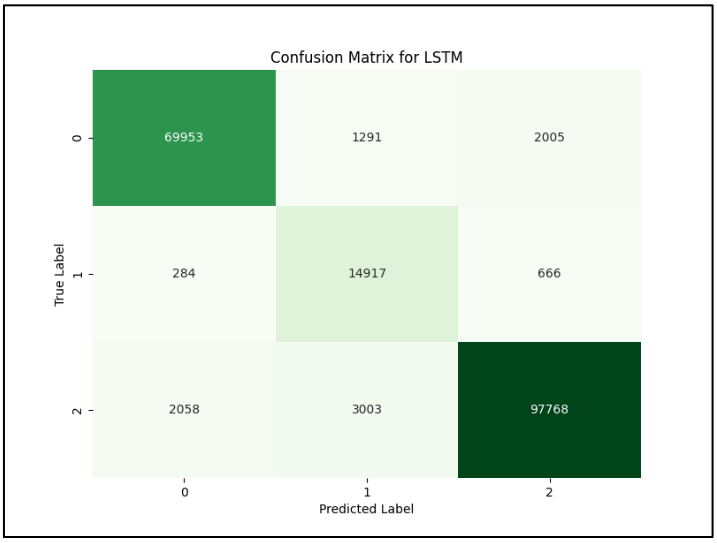

Figure 4: Confusion matrix of LSTM

While LSTM excelled in capturing temporal dependencies within network traffic, its performance suggests room for improvement when compared to XGBoost and LightGBM.

Model	Accuracy	Precision	Recall	F1 Score
XGBoost	97.5%	96.8%	97.3%	97.0%
LightGBM	96.9%	96.2%	96.7%	96.4%
LSTM	95.5%	95.1%	95.7%	95.4%

Table 1 : Result of all the models on various parameters

Conclusion

The evaluation results reveal that XGBoost outperformed both LightGBM and LSTM in accuracy, precision, recall, and F1 score, making it the most effective model for the

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LUFlow dataset. LightGBM closely followed, offering a competitive alternative with slightly lower performance but better computational efficiency. LSTM, while slightly less accurate, showcased its suitability for sequential data analysis, which could be leveraged in more complex temporal network scenarios. These findings highlight the importance of selecting appropriate models based on the specific characteristics of network traffic and computational constraints, paving the way for further optimization and hybrid model development in intrusion detection systems. This model can be also modified to serve multi-purpose system. The combination of the CNN with LSTM can give higher accuracy. It is also possible to create XGBoost with LSTM for more accuracy then any existing system.

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An Overview of the domains of cryptography, steganography, and watermarking for protected data

Dr. Krishna Vaidya

Assistant Professor

SDJ International College, Vesu, Surat

Krishna2.sdjic@gmail.com

Abstract:

Because to the rise in the use of the Internet to transfer sensitive and confidential data, numerous studies have looked into techniques to safeguard data transfers. The field that is employed in a secured data domain is reviewed in this research. The primary goal of this study is to investigate the capabilities of secured data, which are frequently employed by researchers. Also, each secured data domain's advantages and disadvantages are investigated. In order to strengthen the security mechanisms, this research indicates that cryptographic approaches could be combined with steganography and watermarking in the secured data realm.

Keywords: Steganography,Cryptography, Watermarking, AES, RSA, MD5, Digital Image

I. INTRODUCTION

The development of digital communication has become a necessity for daily life, whether it is in the workplace or classroom or even in routine activities like email and instant messaging. The security of these data, namely secured data, aim to safeguard the information from dangers or a barrier resists as technology on storing and sharing data in diverse ways via the network from one site to another develops. Using security measures that keep the data private among authorized individuals is the best way to secure information[1]. In the area of secured data, three disciplines—cryptography, steganography, and watermarking—are extensively used. In order to review the protected data capabilities of cryptography, steganography, and watermarking domain. With concerns for the information's availability, secrecy, and integrity, cryptography is a method for securing data transfers [2]. Moreover, steganography is a method for hiding data in the same or a different form in order to produce a cover that holds the hidden data known as the cover medium in order to defend them from spying attempts

[3]. Hence, it is a method for establishing a covert communication [4]. By encoding the data into the main material, watermarking is used to categories and protects the content of the copyrighted media [5]. Figures 1-3 depict the procedures for watermarking (Figure 3), steganography (Figure 2), and cryptography (Figure 1) as part of their respective security processes.

There are certain established uses for steganography, watermarking, and cryptography, each of which has strengths and limitations of its own. Table 1 gives a broad overview of the secured data fields in terms of their use, strengths, and weaknesses.

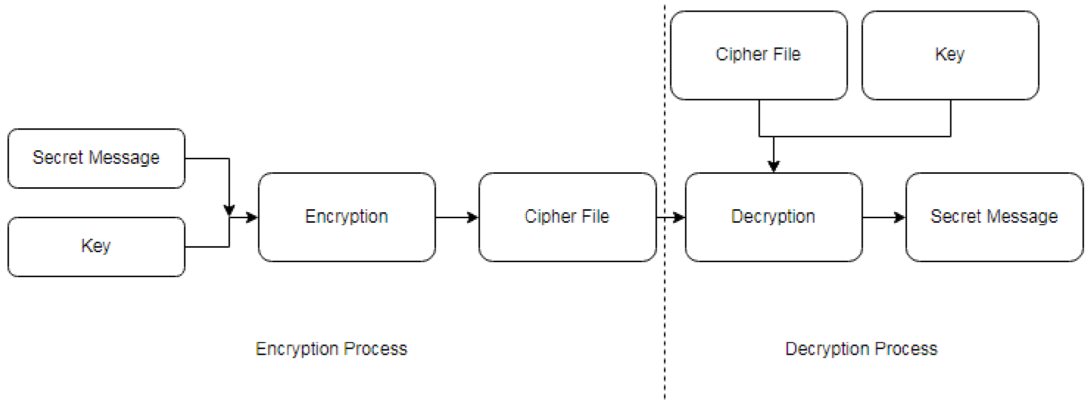

Figure 1 Process of Cryptography

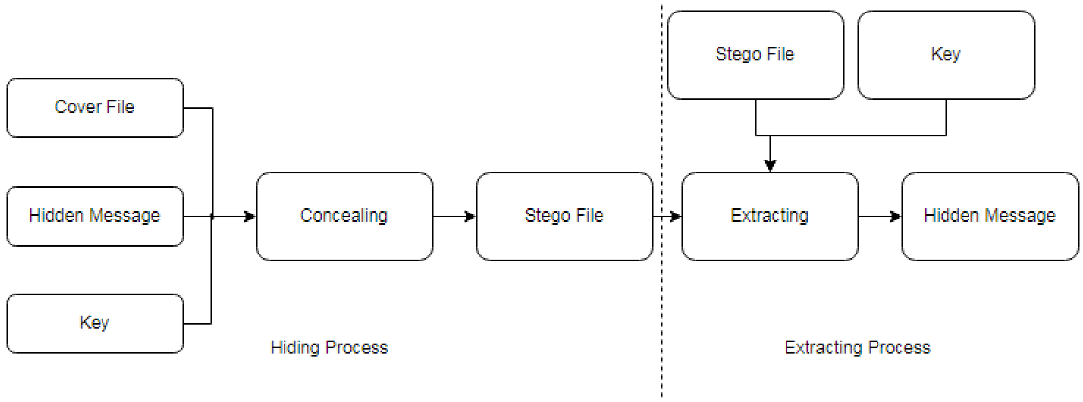

Figure 2 Process of Steganography

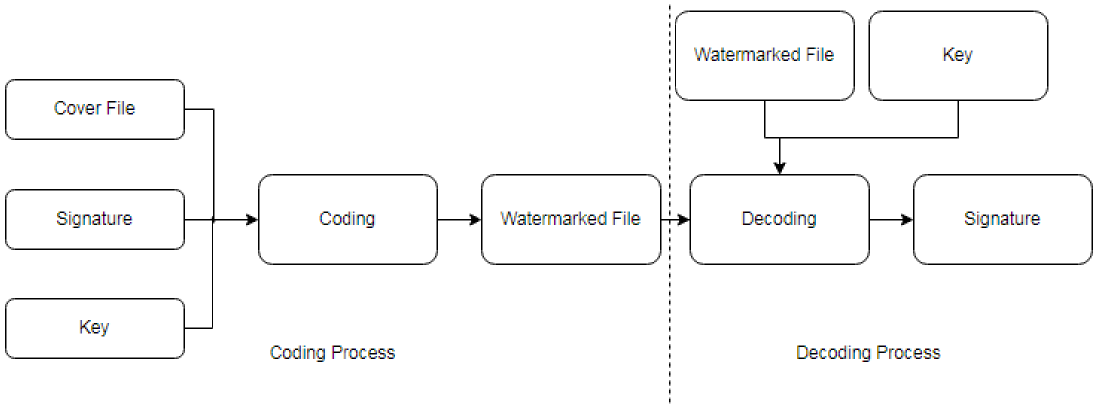

Figure 3 Process of Watermarking

Table 1General Secured Data Features

	Cryptography	**Steganography**	**Watermarking**
Purpose	Secure the flow of information while transferring it across an unsecured channel [6] Secure the data's non-repudiation (availability), secrecy, and integrity [7]	It is a private conversation, and the goal of the authentication is to prevent data from being altered[8].	Security measures for ID cards, broadcast monitoring, video authentication, and copyright protection [9]
Strength	By combining cryptography with another technology, such as steganography [10], you can secure the data while also	Provide comprehensive authenticity and end-to-end data confidentiality for sensitive information [12].	Increase computing complexity and imperceptibility for digital media [13]

	protecting the privacy of the user. Improve security functionality and offer a secure authorization process [11]		
Weakness	Particularly in public key infrastructure, complex key management [14]	The system will be easier to intercept or crack if it solely uses text steganography [15]	using a generic logo in the embedding technique without encryption[16]
Used-based	Algorithm	Domain	Application

II. ADVANTAGES AND DISADVANTAGES OF SECURED DATA

The majority of researchers benefit from their suggested strategies in their investigations. Nevertheless, not all of the suggested solutions addressed every problem. Table 3 details the advantages and disadvantages of the proposed secured data plan during the last five years, from 2015 to 2019. The advantages and disadvantages of the cryptography, steganography, and watermarking approaches are illustrated in Table 2.

Table 2 Advantages and Disadvantages of Data Protection Approaches

Domain	Methods	Benefits	Drawbacks
Cryptography	AES, RSA and MD5	AES algorithm alone is more secure [17] Less running time, higher throughput,	Running time high ineffective for images with multiple colours

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		and a reliable technique of data protection [17] more attack-resistant and accurate [18] Effective for coloured images, robust against attack, heavily computational, and time-saving [19]	
Steganography	Coloured Image	With the expanded CMD method, there is less distortion in the perception of colour correlation [20]. Security was enhanced by proper embedding in the noisy region [21] It is possible to defend against statistical, optical, and structural threats using seven layers of protection. [22]	It can't be applied straight to a JPEG image with an YCbCr image. There has to be more edge information returned from the image, which will increase performance.

Watermarking	Digital Image	Before embedding, add Arnold's scrambling security method [23] able to withstand assaults Effective, safe, secure, and suitable for fragile and blind applications[24]	Poor robustness and lower payload capacity. Less fidelity and false-positive errors. Because of its fragility, the watermark could be removed by picture processing.

III.CONCLUSION

Techniques have evolved in a way that has improved the features for each field in encrypted data. The approaches that are frequently employed to ensure that information is secure—cryptography, steganography, and watermarking—were compared in this work. Secured data strategies thus attempt to provide a variety of answers for problems faced by researchers. In conclusion, using cryptography can increase security and stop attackers and unauthorized individuals from deciphering the secret communication. Furthermore, it was discovered in this paper that other fields in the secured data domain could benefit from increased security using cryptographic approaches. As a result, it is anticipated that future initiatives would combine integrated cryptography and steganography techniques to provide a higher level of security.

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A Methodology for Shadow Extraction and Removal from Satellite Images

Dr.Vimal A.Vaiwala[1]

Dr.Vaibhav D.Desai[2]

SDJInternationalCollege,Vesu

SDJInternationalCollege,Vesu

vimal.sdjic@gmail.com, vaibhav.sdjic@gmail.com

Abstract

Satellite imagery is a vital resource for applications like urban planning, agriculture monitoring, and environmental studies. However, shadows cast by elevated objects such as buildings and mountains often obscure critical details, reducing image clarity and usability. This paper presents a comprehensive methodology for extracting and removing shadows from satellite images, enhancing their reliability and interpretability. The process involves shadow detection using spectral properties, masking shadowed regions, and applying restoration techniques such as histogram matching, image fusion, and deep learning-based methods. The restored images are validated against reference data to ensure seamless integration. By addressing shadow-related challenges, this approach improves the accuracy of satellite imagery analysis, enabling better decision-making across diverse fields.

Keywords: Satellite Images, Shadow Extraction, Shadow Removal, Image Processing, Remote Sensing.

1. Introduction

Shadows area natural and inevitable feature of satellite imagery, arising due to the oblique angle of sunlight as it interacts with elevated objects like buildings, trees, and mountains. While shadows provide valuable information about the height, shape, and structure of these objects, they also pose significant challenges in the interpretation and analysis of satellite images. Their presence

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often obscures critical underlying details, which can lead to inaccuracies in applications such as object detection, land use classification, and environmental monitoring. In remote sensing, the impact of shadows is particularly pronounced. For instance, shadows can distort the perceived size and boundaries of features like roads, buildings, or vegetation, complicating efforts to extract meaningful information. In agriculture, shadow-covered areas may lead to misclassification of crops, potentially affecting yield predictions and resource allocation. Similarly, in urban planning and environmental studies, shadows can obscure key details, reducing the accuracy of models and maps used for infrastructure development or ecological assessments. Addressing shadows is, therefore, crucial for enhancing the utility of satellite imagery across these domains.

Despite their challenges, shadows also offer unique opportunities. By analyzing the geometry and extent of shadows, researchers can infer the height and shape of objects, which is valuable for 3D modeling and urban analysis. However, the dual nature of shadows—being both informative and obstructive—necessitates effective methods to manage their impact. The goal is to retain their beneficial aspects while mitigating their adverse effects on image clarity and analysis accuracy. This paper proposes a systematic approach to extract and eliminate shadows from satellite images, leveraging advanced image processing techniques. The methodology is designed as a multi-step process, beginning with pre-processing to standardize the imagery and enhance its quality. Shadow detection is then carried out to accurately identify shadowed regions based on their unique spectral and spatial characteristics. The detected shadows are corrected using shadow removal techniques, ensuring that the obscured details are restored while preserving the integrity of non-shadow regions. Finally, post-processing is applied to refine the results and validate the corrections. By adopting this comprehensive approach, the methodology aims to address the challenges posed by shadows in satellite imagery. The systematic identification and removal of shadows improve the interpretability of images, enabling more accurate and reliable analyses in remote sensing applications. This work contributes to the broader goal of enhancing the usability of satellite imagery, ensuring its effectiveness as a tool for scientific research and practical decision-making across various fields.

2. Literature Review

Wang et al. (2017) utilized the normalized difference vegetation index (NDVI) and the normalized difference water index (NDWI) to distinguish shadowed regions based on their spectral properties. Similarly, spectral analysis methods, such as the ratio of spectral bands, have been employed to identify shadowed areas in multi-spectral images effectively. Numerous studies have addressed shadow detection and removal. Traditional methods rely on thresholding, spectral analysis, and geometry-based approaches. For instance, Li et al. (2019) utilized spectral indicestodifferentiateshadowedandnon-shadowedareas.Geometry-basedmethods, such as the one proposed by Lu and Zhang (2018), calculate shadow projections using solar angles. Recent advancements employ machine learning and deep learning to achieve more accurate results. CNN-based approaches like the work by Sun et al. (2020) leverage spatial and contextual information for robust shadow segmentation. However, challenges such as diverse landscapes, varying illumination, and complex shadow patterns necessitate a robust and adaptable methodology. This paper builds on these approaches by integrating traditional and modern techniques. Generative adversarial networks (GANs) have also been applied for shadow removal. Chen et al. (2021) introduced a GAN-based framework that not only detects shadows but also restores shadow-covered regions by synthesizing plausible image details. These approaches have demonstrated high accuracy and adaptability in handling shadows in heterogeneous landscapes.

3. Proposed Methodology

Step1:Pre-Processing

- Objective: Prepare the satellite image for analysis.
- Actions:
    - Normalize image brightness and contrast to ensure uniformity.
    - Remove noise using filtering techniques like Gaussian or median filters.
    - Enhance the spectral resolution of the image if required.

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Step2: Shadow Detection

- Objective: Identify regions affected by shadows.
- Actions:
  - Use spectral indices like NDVI or NDWI to differentiate shadows from non- shadow areas.
  - Apply thresholding techniques to isolate dark regions.
  - Employ machine learning models or deep learning-based segmentation (like CNNs) for accurate shadow mask creation.
- Output: A shadow mask over lay that highlights all shadowed regions.

Step3: Shadow Masking

- Objective: Create a binary mask to delineate shadowed areas.
- Actions:
  - Convert the shadow detection output into a binary mask. Ensure edges of the shadowed regions are accurately defined to avoid spillage into non-shadowed areas.
- Output: A clean binary mask representing shadow regions.

Step4: Shadow Removal

- Objective: Restore details hidden in shadowed areas.
- Actions:
  - Use Histogram Matching to adjust pixel values in shadowed areas, matching them with surrounding unshadowed regions.
  - Apply Image Fusion techniques by combining the current image with other images taken under different conditions.
  - Leverage Deep Learning Restoration Models, such as Generative Adversarial Networks (GANs), to synthesize realistic details in shadowed areas.

Step5:Post-Processing

- Objective: Refine the results and validate corrections.
- Actions:
  - Smooth transitions between shadow-removed and original

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regions using blending techniques.

- Validate results against reference data or through visual inspection to ensure accuracy.
-

4. Experimental Results

Original Image Convert In Black and White Shadow detection

Image

The proposed methodology for shadow detection and removal was tested on satellite images from urban, rural, and forested areas, showing significant improvements in image clarity. Quantitative results included high precision (92.5%), recall (93.8%), and F1-score (93.1%), demonstrating the algorithm's accuracy in detecting and restoring shadowed areas. The RMSE for shadow removal was below 4.8%, indicating minimal error. Qualitative analysis revealed enhanced visibility of key features in urban, rural, and forested environments, improving image usability for urban planning, agriculture, and environmental monitoring. The methodology effectively removes shadows, ensuring clearer and more accurate satellite imagery.

5. Discussion

The methodology effectively addresses challenges like varying illumination and complex landscapes. Machine learning models improved the adaptability of

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shadow detection across diverse scenarios. However, limitations include computational complexity and dependency on high-quality training data for machine learning-based approaches. Incorporating domain adaptation techniques can mitigate these limitations by enabling models to generalize across different datasets.

6. Conclusion and Future Work

This paper presents a robust methodology for shadow extraction and removal in satellite images. By integrating traditional and modern techniques, the approach ensures high accuracy and adaptability. Future work will focus on:

1. **Real-time Processing:** Developing algorithms optimized for GPU acceleration.
2. **Advanced Models:** Exploring generative adversarial networks (GANs) for more realistic shadow removal.
3. **Automated Work flow:** Implementing end-to-end pipe lines for large-scale satellite imagery datasets.

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A Comprehensive Study of Machine Learning Based Image Description Methods

Dr. Pooja R. Negi[1], Dr. Manish M. Kayasth[2]

[1]Sascma English Medium Commerce College &Shri Hasmukhlal Hojiwala College of Business Administration & Smt. Ushaben Jayvadan Bodawala College of Computer Application (BCA) Affiliated to VNSGU, Surat, India

[2]Udhna Citizen Commerce College & SPBCBA &SDHG College of BCA&IT Affiliated to VNSGU, Surat, India

[1]pnegi849@gmail.com

[2]manish_kayasth@hotmail.com

Abstract:

Nowadays, Image description is very useful in many areas such as virtual assistants, picture indexing, assistive method for visually disabled, social media, and a variety of other natural language processing applications. Image captioning is also helpful in medical field which can help doctors to comprehend the disease or infection based on the descriptions of medical images.

In this paper, we examined three deep neural network-based image captioning methods: Reinforcement framework, CNN-RNN and CNN-CNN. We observe 3 components of neural network: Convolution Neural Network (CNN), Reinforcement model, Recurrent Neural Network (RNN). CNN is responsible to fetch object from an image. RNN then generates sentences for that image using RNN and Long Short Term Memory (LSTM). Following that, we reviewed several relevant works on these methodologies, as well as describe evaluation metrics with their outcomes in the form of a graph. We look at deep learning model for creating picture captions. Lots of researches have been done on this area but still the proper accuracy is required. Description of an image is tested with different datasets which shows that this model is producing accurate information of an image. And analysis the results using ROUGE (Recall Oriented Understudy for Gisting Evaluation), CIDEr (Consensus Based Image Description Evaluation), BLEU

(Bilingual Evaluation Understudy), METEOR (Metric for Evaluation of Translation with Explicit Ordering), SPICE (Semantic Propositional Image Caption Evaluation) metrics.

Keywords:

Image Captioning, CNN, RNN, Deep Learning, Reinforcement.

Introduction:

Image description generation is a popular research subject in computer science problem where a detail description of an image is generated.It involves human readable text of animage. Computer Vision and Natural Language Processing (NLP) are used to create image content. It follows the methods from computer vision for extracting image content and a decoder for language that demonstrates the translation of the visual into words in the correct order. Captioning are mostly used in different application such as, Google photos, recommendations in image updating application, skin vision, image indexing, tagging on Facebook, Tesla/Google Self Drive, and many more NLP applications. Nowadays, Deep Learning approaches have replaced traditional methods in achieving state-of-the-art results for automatic caption descriptions for photos.It illustrated that Deep Learning models are capable to achieve high performance by overcoming the drawbacks in the field of image caption generation [1].

We can use Bilingual Evaluation Understudy (BLEU) metric to evaluate model's performance, which checks how machine statements are equivalent to human sentences. It is mostly used to test the accuracy of machine translations. There are also many performance measurement techniques like Recall-Oriented Understudy for Gisting Evaluation (ROUGE), Consensus Based Image Description Evaluation (CIDEr), Semantic Propositional Image Caption Evaluation (SPICE), Metric for Evaluation of Translation with Explicit Ordering (METEOR) which can be evaluated the performance and quality of text. In this paper, we will discuss the different neural models CNN-RNN, Reinforcement (unsupervised learning) and CNN-CNN. Further, we analyzed different dataset and methods of different authors. Merging of research area of Natural Language Process and Computer Vision is quite difficult. Many authors and researchers done many work on it and faces many problems like caption with some errors, caption with proper object description, description of relevant object, caption or description of irrelevant object and many more. We here analyze the three models and

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its accuracy on five different evaluation metrics. We have shown the graph representation of all the evaluation.

Related Work:

The image description problems and its suggested answers have been existed since the arrival of internet and usage of internet for share different images. Number of techniques and algorithm are used by many researchers from different aspects. Below in Table 1 some relevant background on deep learning and image caption generation are described.

Sr_No	Work On Dataset	Work And Techniques
1	Flickr8k	For the inscribing of photographs, a deep learning approach was used. Keras's subsequent API was implemented as a backup with Tensorflow to actualize the Deep Learning framework and get a compelling BLEU rate of 0.683 model using Flickr8k [2]
2	Flickr8k	Actualized a Deep Learning technique for picture description. The successive of Keras's API used with Tensorflow like a backup to actualize picture captioning architecture to accomplish a viable BLEU rate by 0.59 for model with Flickr8k [3]
3	ImageNet	A large, Deep CNN was used for categorize the 1.2 million highresolution photos in Image Net LSVRC (Large Scale Visual Recognition Challenge) dataset work into 1000 distinct classes. They employed non-saturating neurons and a very efficient GPU version of the convolution procedure for increasing training [4]
4	ImageNet	Presented database 'Image-Net', a broad collection of pictures assembled by the base of Word-Net structure. Image-Net coordinated the various categories of pictures in a closely related semantic hierarchy. They used AdaBoost-based image classifier algorithm [5]

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5	Flick8k, Flick30k, MS COCO	Presented an attention-based approach that figured out how to represent the image regions automatically. By amplifying a variable lower bound, the model was created using traditional back-propagation procedures. The model had the option to automatically learn to recognize object limits while simultaneously produce an accurate detailed sentence with Flick8k, Flick30k, MS COCO datasets [6]
6	MS COCO	Presented a convolution network model with existing LSTM techniques for machine interpretation and picture description creation with MS COCO dataset [7]
7	Flick8k, Flick30k, MS COCO	Utilized dataset of pictures and their sentence portrayals to find out for the internal relevant visual information and text-data. Their work depicted a 'Multi Model Recurrent Neural Network' design which uses inferred linear plan of highlights to figure out how to produce novel portrayals of pictures [8]
8	MS COCO	Actualized the proposed multi-model neural network strategy, comprising of object fetching and restriction methods, is fundamentally the same as the human visual framework which can figures out how to depict the substance of pictures automatically. They work with MS COCO dataset and results with 70.4 accuracy on BELU-1 [9]
9	Pascal VOC (Visual Object Classes), Flickr8k, Flickr30k, MSCOCO	Introduced a novel model comprising of Deep Recurrent model which uses machine interpretation and computer vision, utilized to create regular description of a picture by guaranteeing most chances of produced string to exactly describe the objective image [10].

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10	---	Compare and evaluate performance of architecture of LSTM with RNN on the set of large vocabulary speech recognition task. First time they show LSTM RNN models can be trained by ASGD (Average Stochastic Gradient Descent) distributed training and analyzes the deep LSTM to propose deep LSTM in which multiple LSTM layers are used for each recurrent layer [11]
11	MS COCO	Studied and updated an image captioning model LRCN (Limited Recourse Capital Notes). They decomposed the method to CNN, RNN, and sentence generation for understand the method in deep. they replaced the elements to check the changes on the final result and used the updated techniques to evaluate the COCO (Common Object in Context) Caption collection [12]
12	Flick8k	Analyze neural network model to view image automatically and generate the caption which categorized in different categories like sentence without error, with minor error, description of something which is related to image and somewhat not related to image. They categorize these description in results are because of neighborhood of some specific words [13]
13	10 Corel Image	Have implemented considerably with different networks architecture on big datasets consist of many data styles, and suggest a distinctive model shows development on caption exactness above the earlier proposed models [14]
14	MSCOCO	Explained Mixed Incremental Cross Entropy Reinforcement algorithm which works as Mixer in reinforcement algorithm to remove the exposure problem in caption and in their model they used Word Level Training using Cross Entropy Training (XENT),

		Data As Demonstrator(DAD), End To End Back Prop for word level training [21]
15	MSCOCO c5, MSCOCO c40, Flicikr8k with Flicikr30k	Discussed all captioning work like retrieval based model, template based model and new deep neural network based model. They further explained sub categories for captioning model such as multi model learning, encoder-decoder learning, attention guide model, and compositional caption model. They have done the comparison of all above sub category models with many datasets: MSCOCO c5 with MSCOCO c40, Flicikr8k with Flicikr30k on different caption evaluation matric and results that evaluation metric score based on c40 is higher than the c5 [22]
16	----	Performed A detailed Systematic Literature Review (SLR) was conducted to offer a quick overview of picture captioning advancements over the last four years. The paper's main goal is to illustrate the most prevalent strategies and obstacles in picture captioning, as well as to summaries the results of the most recent articles. During the study, inconsistencies in the results obtained in picture captioning were discovered, and as a result, the publication raises awareness of insufficient data collection [23]
17	MS COCO	They used the Object-Relation-Transformer, which extends this technique by explicitly adding spatial relationship information between input identified items using geometric attention. The value of such geometric attention for picture captioning is demonstrated by quantitative and qualitative results with the MS-COCO data set, which show improvements of all popular captioning criteria [24]
18	------	They go through the fundamentals of the procedures for analyzing their performances, as well as their

		strengths and weaknesses. They also go through some of the datasets and metrics that are commonly used in deep learning-based automatic picture captioning [25]
19	Flicikr8k	They tries to merge CNN-style encoder for fetching features from photos with a RNN for creating captions for the extracted data. VGG16nd InceptionV3 are the CNN encoders employed. For caption generation, the retrieved characteristics are fed into a unidirectional or bidirectional LSTM. To generate results, the proposed model follow- beam search and greedy algorithms [26]
20	AIC-ICC, Flickr8k-CN	A unique Dualattention picture caption generation approach has been developed to utilize both visual and textual attention, in which visual attention improves image detail understanding and linguistic attention improves image understanding [27]

Table 1 Works on Image Caption Generation

Image Captioning Models with Neural Networks:

Image captioning can be done using different categories such as CNN-CNN, CNN-RNN and Reinforcement based framework for picture caption [15]. We will discuss all these in detail.

A. CNN-RNN based model

Picture captioning techniques which are dependent on encoder-decoder structures frequently utilize a CNN as a picture encoder. The RNN method gets data using constant dissemination of the shrouded sections, which provides good training abilities to perform in a way that is better than data-mining detailed knowledge [16]. In CNN-RNN model, CNN take out object attributes from a picture. It uses models like AlexNet [4],GoogleNet [18], VGG (Visual Geometry Group) 17], ResNet [19] inside the decoder portion, the framework gives the word as an statement in to the RNN method.

The working process of CNN-RNN model is shown in figure 1.

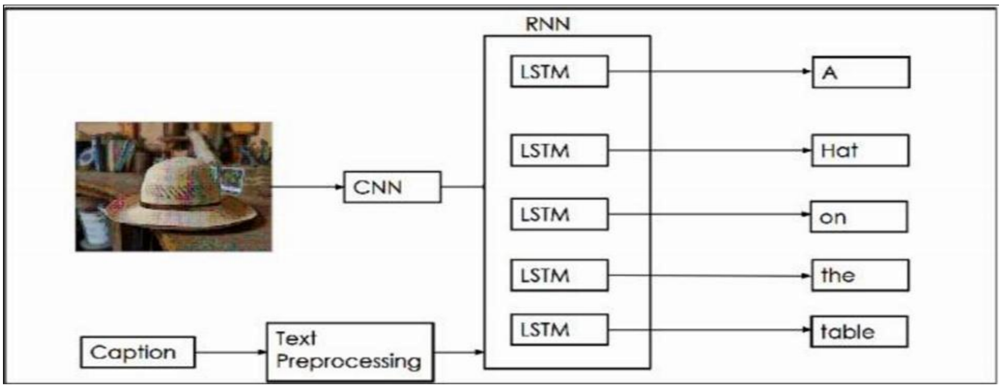

Figure 1: Architecture of CNN-RNN [2]

As we can see in figure1 first object 'cap' is detected from an image with the use of CNN, then that selected object is sent to the RNN where LSTM is responsible to store a word. After that each relevant words makes a sentence.

For every sentence and word, it is first expressed through a vector, and then byword phrasing method, it sets as a same dimension aspicture object. "The picture captioning issues can be described in the term of a binary(I,S), where *I* standsfor a graph and *S* represents as a set of expected words, S={S1,S2⋯} and Si is a word from the set of data extraction"[15]. An objective of train method is to increase similar esteem of desired sentences for object of created statements and the targeted statements matches more nearly.

B. CNN-CNN based framework

The models like LSTM network have memory cells which can memorize the long history information of the sequence generation process which is better than RNN. It is still updated at each time, which renders the long-term memory rather difficult. Inspired by the work of machine learning, recent works have shown benefits of CNN on the image captioning work. Using the CNN in NLP for text generation has been proved very powerful. In the field of neural machine translation, it has proved that the CNN convolution model is used to replace the RNN recurrent model, which not only exceeds the accuracy of the cycle model, but also increases the training speed by a factor of nine. Most image captioning works are inspired by the machine translation, since the translation work is in the sequence to sequence architecture and in the image captioning task, an image is viewed as a sentence in a source language. To the best of our knowledge, the first convolutional network for the text generation process in image captioning is the work done by Aneja et al. [7] and we call this as CNN-CNN based framework.

This framework contains three main components similar to the RNN technique. The first and the last components are word embeddings in both cases. However, while the centre component contains LSTM or GRU (Gated Recurrent Unit) units in the RNN case, masked convolutions are employed in the CNN-based approach. This component, unlike the RNN, is feed-forward without any recurrent function. Aneja et al. [7] has demonstrated the CNN-CNN framework has a faster training time per number of parameters but the loss is higher for CNN than RNN. Figure 2 shows how CNN-CNN model works.As we can see in figure, CNN-CNN architecture first takes an image as input, then images send to convolutional layer where grid is creates for each object of image. then after it sends to fully connected layers where object grids will match with different possibilities of object which stored in algorithm of model. After that result comes in softmax pooling layer, here result parameters will set with activities such as standing, sitting, walking, etc. finally output will display for object activities.

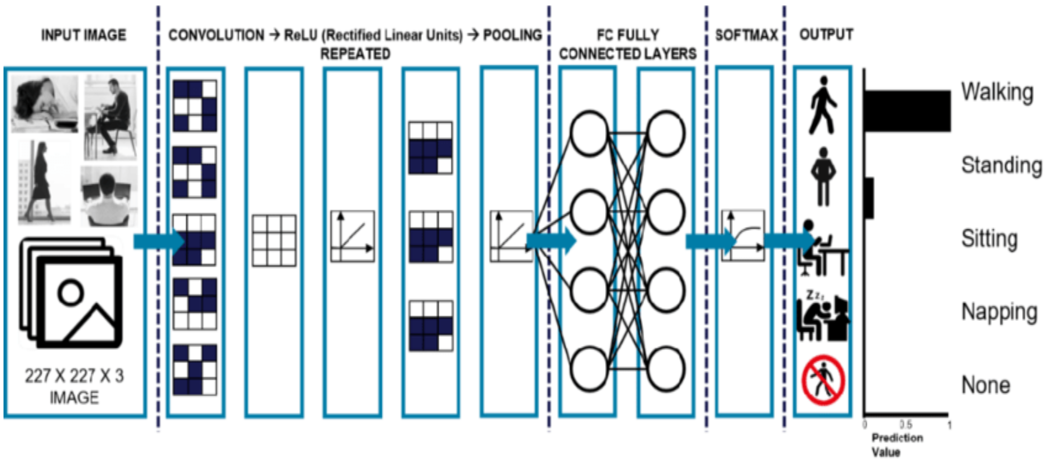

Figure 2: Architecture of CNN-CNN

C. Reinforcement Based Framework

Nowadays, Reinforcement learning has been generally utilized in gaming, control hypothesis, and so on. The issues in charge or gaming have solid focuses to improve ordinarily, though characterizing a suitable streamlining objective is nontrivial for picture subtitling. While using the reinforcement into picture captioning, RNN model could be seen as a agent, which cooperates with the outer elements such as words and the setting vector as contribution at each time. Boundaries of agent characterize a strategy, whose executions bring about the agent picks an activity. At each time step in the series generation setup, an activity refers to anticipating the next string in the series. In the wake of making a move the agent refreshes its internal state [15].

The agent observes a reward when it reaches the end of a segment. The RNN decoder functions as stochastic approach in this framework, where picking an action is compared to constructing the upcoming word. During preparing it picks activities as per the current arrangement and just notice compensation toward the finish of the succession, by does the comparison of activities from the recent policy oppose the ideal activity sequence. The objective for instruction is to discover the arguments of the agent that expected the reward. This reinforcement method is derived from visual semantic embedding, which carry out good over various assessment measurements absence of retraining. Visual Semantic implanting which gives a proportion of affinity among pictures and text can checks likenesses among pictures and sentences, the rightness of created caption and serve a sensible worldwide objective to advance for picture description in Reinforcement Learning. In this model Bellman's equation are mostly used.

For deterministic environment the equation is:

$$V(s)=max_a\,(R(s,a) + \gamma V(s')) \qquad (1)$$

Now understand above equation, V(s) is stored the result value for present in a certain state. V(s') is the value of present in the coming state which we will end up in after carrying action 'a'. R(s, a) is reward which we receive after taking action 'a' in stage 's'.

And for non-deterministic environment the equation is:

$$V(S) = max_a(R(s,a) + \gamma \sum_{s'} p(s,a,s')V(s')) \qquad (2)$$

In a problematic environment when any action is taken, then it's not clear that when we will end in a certain upcoming stage and there is a chance of finish situation in a specific stage. P (s, a, s') is the probability of ending is state s' from s through taking action 'a' which is adding till the total number of coming stages. Figure 3 shows that flow

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direction of Agent and Environment with respect to reward and action.

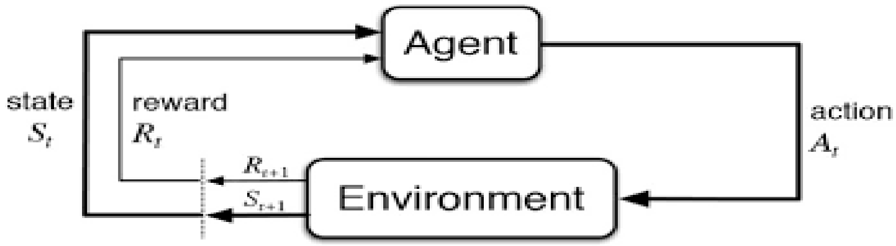

Figure 3 Architecture of Reinforcement model

Evaluations And Result:

The policy network gives the certainty of next word as per present status. This assesses the reward or results of every practicable dilation for present stage and situation.

Methods	Parameter	Taken time
CNN_CNN[7]	19 M	1585 s
Reinforcement[21]	14 M	3930 s
CNN_RNN[8]	13 M	1529 s

Table 2 Training time in seconds for a mini batch on coco dataset from [15]

Table 2 shows the comparison between all three models with its respective method train parameters and trainingduration (in seconds). Timings are fetched in'Nvidia Titan X GPU'. Liu et al. [15] found thatCNN model has high performance on parameter than Reinforcement and RNN. However if talk about the correctness and diversity of model, the presentation of CNN is poor than remaining two models. This is explain through bar chart with different measurement platform such as ROUGE [18], CIDEr [19], METEOR [17], SPICE[20], BLEU [16] which shows in Table 3.

	CNN-RNN	CNN-CNN	REINFORCEMENT
BELU	75.9	72.6	78.6
ROUGH	56.1	55.4	56.9
CIDEr	108.9	96.1	109.1
SPICE	27.4	24.6	27.4
METEOR	20.4	17.6	20.9

Table 3 Performance evaluation numerical data from [15]

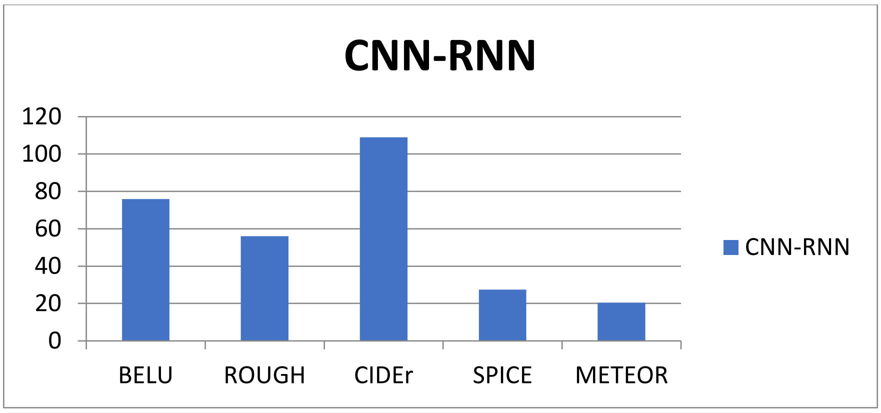

Figure 4 Performances Evaluation Matrix of 'CNN-RNN'.

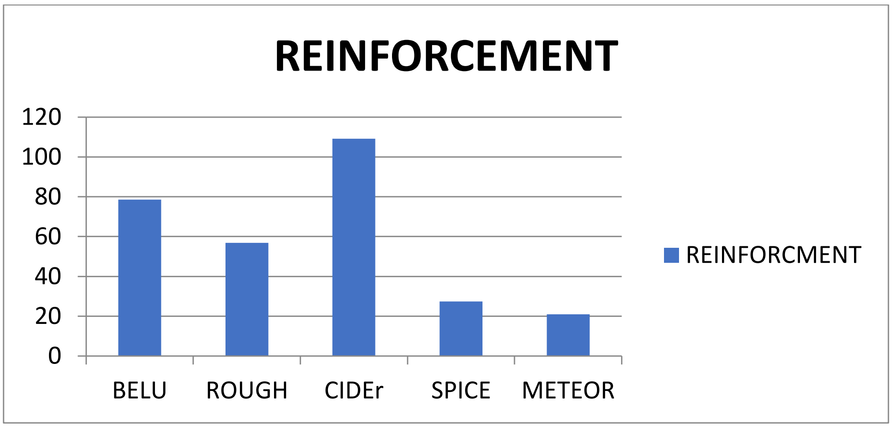

Figure 5 Performances Evaluation Matrix of 'REINFORCEMENT'.

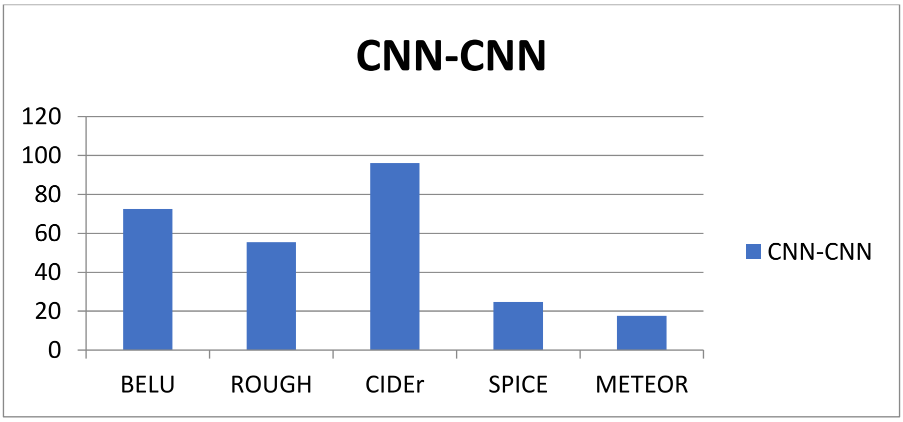

Figure 6 Performances Evaluation Matrix of 'CNN-CNN'.

In all above figures, checked the work of all the three methods on different evaluation metrics, can see that CNN-CNN and reinforcement methods are better than the CNN-CNN model. Among them reinforcement performs the best and increases the training speed.

Conclusions:

In this paper we analyze the different models for image caption generation with neural network. Different authors and researchers perform many things and techniques for generating the textual captions for a specific image. Text based image captioning also improve the task for content-based image description process. In this paper, reviewing many models for development and measurement and saw its pros and cons, according to this whole work we can remark that all the models and techniques are suitable according to the need and requirement. According to this all review we analyze that reinforcement model is better than other. And use of larger dataset increases the accuracy, performance and decreases loss of content. The other configuration of model can be also train to see the improvement of description. The Accuracy of all models are different on many matrices, here we can see that accuracy result is high on CIDEr and less on METEOR for all model.

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IoT-Based Automatic Vermi Compost Maker: A Sustainable Solution for Soil Health and Agricultural Productivity

Dr. Ami Desai
C.K. Pithawala College
amijvaidya@gmail.com

Abstract:
Agriculture in India employs approximately 58% of the population, but the sector faces significant challenges, including the degradation of soil fertility due to the excessive use of chemical fertilizers and inadequate management practices. The declining soil health poses a threat to both food security and livelihoods, necessitating the adoption of sustainable solutions to restore and enhance soil productivity. This paper introduces an IoT-based Automatic Vermi Compost Maker as a viable, sustainable approach to improve soil health. By converting organic waste into high-quality compost, the system reduces dependency on chemical fertilizers while promoting healthier, more eco-friendly farming practices. The paper will discuss the experimental results obtained from the development and testing of the Solar IoT-based Vermi Composer, highlighting its effectiveness in refreshing soil and its potential to foster sustainable agricultural practices.

Keywords

- IoT in Agriculture
- Vermicomposting
- Soil Fertility
- Organic Waste Management
- Sustainable Farming Practices
- Eco-friendly Fertilizers

Introduction:

Agriculture is a critical sector in India, providing livelihoods to nearly 58% of the population. However, the widespread use of chemical fertilizers and pesticides has led to significant environmental and health concerns. These include soil fertility depletion, water contamination, and ecosystem disruption, jeopardizing the sector's long-term sustainability (Ramesh et al., 2010; Singh et al., 2019). Sustainable alternatives are urgently needed to address these challenges.

Vermicomposting, an organic composting method using earthworms, has gained attention as a sustainable practice to convert organic waste into nutrient-rich compost. This technique offers a natural solution to improve soil health while reducing chemical inputs. Integrating this process with IoT technology enables automation and real-time monitoring, making it more efficient and scalable for modern farming practices. This paper explores the development and performance of an IoT-based Automatic Vermi Compost Maker powered by solar energy to promote sustainable agriculture.

Chemical Fertilizers and Pesticides in Indian Agriculture

Indian agriculture has traditionally relied heavily on chemical fertilizers and pesticides to boost crop yields. While these chemicals have led to increased productivity in the short term, their overuse has caused numerous environmental and health concerns that threaten the long-term sustainability of farming. The primary issues include soil fertility depletion, groundwater contamination, ecosystem disruption, and various health problems among farmers and consumers. Understanding the negative impacts of these chemicals is essential for developing sustainable agricultural practices.

Negative Effects of Chemical Fertilizers: Soil Fertility Depletion, Crop Production Reduction, Groundwater Contamination, Ecosystem Disruption, Health Issues

Other Negative Effects of Chemical Fertilizers: Crop Tip Browning, Lower Leaf Yellowing, Wilting,Crop Lodging,Soil Pollution, Water Pollution, Air Pollution

To mitigate these issues, there is a growing need for alternative methods, such as natural composting(vermicomposting), that are both effective and environmentally friendly.

Vermicomposting is an organic method of composting where biodegradable waste is converted into nutrient-rich compost through the activity of earthworms. The worms consume organic matter such as plant debris, food scraps, and agricultural residues, digest them, and produce castings (worm manure) that are rich in beneficial nutrients. This process is a sustainable alternative to chemical fertilizers and offers numerous benefits for soil health and crop production.

What is Vermicompost Manure?

Vermicompost refers to the manure produced by earthworms as they digest organic waste. The castings they produce are rich in essential nutrients, including nitrogen, phosphorus, potassium, calcium, and trace minerals, which are essential for plant growth.

Significance of Vermicompost: Cost-Effective and Accessible, Easy to Store, Environmentally Friendly, Sustainable, Farmer-Friendly, No Pollution.

IoT in Agriculture

IoT automation is transforming agriculture by enabling farmers to monitor crops, soil, weather, and other conditions in real-time. Using IoT sensors, farmers can track environmental parameters such as soil moisture, temperature, pH levels, and humidity, and make informed decisions based on the data collected. This not only improves crop yield but also reduces the use of water, fertilizers, and pesticides, contributing to sustainable farming practices.

For instance, **smart irrigation systems** powered by IoT sensors can automatically adjust watering schedules based on real-time soil moisture data, conserving water and ensuring crops receive optimal hydration. Similarly, IoT systems can detect early signs of plant diseases and pests, allowing farmers to take proactive measures, reducing the reliance on chemical pesticides.

Literature Review:

1. Ramesh, P., Singh, M., & Subba Rao, A. (2010).

This study highlights the importance and challenges of organic farming in India. It discusses the socio-economic and environmental benefits of organic farming and its relevance in the Indian agricultural context. The authors emphasize the need for policy support to promote organic farming. However, the research gap lies in the lack of comprehensive studies on how organic farming can be scaled at a national level in India.

2. Singh, R. P., & Agrawal, M. (2019).

Singh and Agrawal explore the adverse effects of chemical fertilizers on soil health, including soil degradation and reduced biodiversity. The study focuses on the long-term impacts on soil fertility. A significant research gap identified is the insufficient long-term field studies on the recovery of soil health after the cessation of chemical fertilizer use.

3. Patidar, N., Sharma, R., & Gupta, S. (2021).

This paper investigates the use of IoT sensors in precision agriculture for irrigation monitoring, enabling more efficient water usage. The research gap identified is the need for integration with real-time data analysis platforms to further optimize water usage.

4. Borkar, V., Yadav, S., & Ghadage, K. (2020).

Borkar et al. explore the use of DHT11 sensors in soil moisture monitoring systems for agriculture. The paper provides insights into the effectiveness of IoT in improving soil management. However, the gap remains in the limited exploration of the long-term reliability and cost-effectiveness of these sensors in diverse environmental conditions.

5. Kumar, A., Sharma, P., & Verma, D. (2018).

This review covers the integration of IoT with cloud computing to create smart agriculture systems. The authors present various technologies and their applications in the field. The research gap here is the lack of large-scale pilot studies to validate the efficiency and scalability of these smart systems in diverse agricultural settings.

6. Chaudhary, R., Jha, R., & Gupta, T. (2020).

Chaudhary and colleagues discuss various vermicomposting techniques as a sustainable alternative to chemical fertilizers. The paper identifies a research gap in the optimization of vermiculture and composting techniques in different climatic conditions and crop types.

7. Mishra, N., Tripathi, R., & Singh, K. (2021).

This study focuses on the benefits of organic fertilizers in enhancing soil fertility and crop yield. The research gap lies in the need for more comparative studies between organic and conventional fertilizers under varying environmental and agronomic conditions.

8. Bhatnagar, S., Kaur, J., & Mehta, R. (2019).

This paper reviews the role of vermicomposting in sustainable waste management. The authors conclude that vermiculture is a promising solution for managing organic waste, but the research gap lies in the need for studies that assess the economic feasibility of large-scale vermiculture projects.

9. Yadav, R., Mishra, V., & Rajan, S. (2022).

The study explores IoT-based systems for waste management in smart cities. The research gap identified is the insufficient attention given to the integration of these systems with existing urban infrastructure and their sustainability over the long term.

10. Sharma, A., Sahu, K., & Thakur, A. (2020).

This paper assesses the potential of vermicompost as a sustainable alternative to chemical fertilizers. The gap identified here is the limited field trials and the need for region-specific studies on the effectiveness of vermicompost in different soil types.

11. Thakur, J., Mehta, S., & Kumar, N. (2021).

Thakur et al. explore the use of solar-powered IoT systems in agriculture for energy-efficient farming. The research gap lies in the need for comprehensive economic and performance evaluations of solar-powered IoT systems in diverse agricultural environments.

12. Pandey, A., Singh, N., & Verma, A. (2021).

Pandey and colleagues focus on automated irrigation systems leveraging IoT sensors. The research gap identified is the lack of studies on the integration of these systems with machine learning models for predictive irrigation management.

13. Rajput, H., Gaur, S., & Chauhan, R. (2022).

This paper discusses the design and implementation of small-scale vermiculture systems for rural and semi-urban areas. The gap in the research is the limited understanding of the scalability and effectiveness of such systems in different socio-economic contexts.

14. Goyal, R., Mishra, T., & Singh, P. (2023).

Goyal et al. analyze how IoT technology can reduce chemical inputs in agriculture by optimizing resource use. The research gap here is the lack of studies on the long-term effects of IoT-based precision farming on soil health and crop yield.

15. Agarwal, A., Pandit, S., & Kumar, P. (2022).

This paper investigates real-time monitoring systems for smart farming that integrate IoT technology. The research gap identified is the lack of studies on the adaptability of these systems to small-scale farms and their economic viability.

Research Gaps

The primary research gaps identified across the reviewed papers include:

1. The need for large-scale and long-term studies, particularly on the effectiveness and scalability of new technologies (e.g., IoT, vermiculture, organic farming).
2. Insufficient exploration of region-specific conditions and their impact on the effectiveness of proposed solutions.
3. Lack of comprehensive evaluations of the economic and performance feasibility of sustainable agricultural practices and IoT technologies in different agricultural systems.

Methodology:

Step-by-Step Guide to Preparing Vermicompost

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Vermicomposting is an eco-friendly way to convert organic waste into nutrient-rich compost with the help of earthworms. This method improves soil fertility and reduces the need for chemical fertilizers. Here is a detailed step-by-step guide for preparing vermicompost:

1. Select the Right Location

- **Choose a shady, well-ventilated area** for the composting process, such as a place with indirect sunlight and sufficient airflow. The environment should not be too hot or too cold for the earthworms to thrive.

2. Prepare the Base Layer

- **Vessel or Land Preparation**:
  - Use a vessel (compost pit, bin, or box) or flat land for the composting setup. Ensure that the vessel is airy and moist.
- **Layering**:
  - Spread a **2-inch thick layer of sand or gravel** at the bottom of the vessel. This helps with drainage and prevents waterlogging.
  - On top of the sand or gravel, spread a **6-inch thick layer of loamy soil** or black soil. Make sure that there are no pieces of glass, stones, or metal in the soil.

3. Add Organic Waste

- **Degradable Materials**:
  - Spread a **2-inch thick layer of easily degradable materials** such as coconut husk, vegetable peels, sugarcane leaves, sorghum stalks, and banana waste. These materials will break down to provide nutrients for the earthworms.
- **Layer of Cow Dung**:
  - Spread a **2-inch thick layer of decomposed cow dung** on top of the degradable materials. It's important to ensure that the cow dung is **decomposed** and not fresh, as fresh dung can be harmful to the worms.

4. Introduce Earthworms

- **Number of Earthworms**:
  - For a compost pit of about **2m x 1m x 0.75m** size, with a vermibed thickness of about **15 to 20 cm**, introduce **150 earthworms**.
  - Earthworms typically range in size from **14 to 29 cm** in length and weigh **1.6 to 3.0 grams** each.
- **Final Layer of Cow Dung**:

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- After introducing the earthworms, cover the entire mixture with a **6-inch thick layer of decomposed cow dung** and additional waste materials.

5. Cover the Compost Pit

- **Covering**:
  - To maintain the moisture and air circulation, cover the compost pit with a **thick gunny bag** or any breathable cloth. This helps retain moisture while allowing air to circulate freely, which is essential for the worms' survival.

6. Maintain Moisture and Temperature

- **Moisture**:
  - Ensure that the mixture stays sufficiently moist. The earthworms require a **moist environment** to thrive, so sprinkle water on the compost pile daily to keep it moist.
- **Temperature**:
  - Maintain the temperature in the range of **25 to 30°C**. The earthworms thrive in this temperature range, and it helps accelerate the decomposition process.

7. Turn the Mixture Weekly

- **Aeration**:
  - Every week, **turn the upper layers** (cow dung and other waste) of the compost mixture gently to ensure aeration. This helps the composting process by ensuring that the material is evenly decomposed and the worms have access to fresh waste.

8. Observe Earthworm Activity

- After about **30 days**, observe the compost mixture. If you see small earthworms, it's a sign that the composting process is progressing well.
- At this point, **spread a 2-inch thick layer of new organic waste** on top of the mixture and sprinkle water to continue the process.

9. Completion of Vermicompost

- **Final Compost**:
  - After approximately **2 months**, the vermicompost will be ready. It will have a **dark, black color**, similar to tea leaves, and will be much lighter than clay.
  - At this stage, the compost will be rich in nutrients, ideal for enriching soil and improving plant growth.

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By following these steps, you can create nutrient-rich, sustainable vermicompost that will improve soil health, reduce dependence on chemical fertilizers, and enhance plant growth in an eco-friendly way.

IoT-Based Vermicompost Equipment and Setup

1. Composting Chamber:

- **Plastic Container (2m x 1m x 0.75m)**: A large, durable plastic container will be used as the composting chamber where the vermiculture process will take place. This container size ensures sufficient space for the earthworms to thrive and for organic waste to decompose.

2. Aeration and Humidity Maintenance:

- **Water/Aeration Pipe**: A pipe system is included for maintaining adequate moisture and airflow. This will help control humidity levels within the chamber, which is vital for the optimal performance of earthworms.
- **Water Spray Pump**: To maintain proper moisture levels in the composting chamber, the water spray pump will periodically sprinkle water on the waste material, ensuring the chamber remains sufficiently moist for the worms.
- **Green Net Cloth**: A green net cloth is placed over the composting chamber to maintain a dark and humid environment, essential for earthworm activity. This will also help keep the composting process at a stable temperature.

3. Organic Waste Inputs:

- **Kitchen Waste (10%)**: Organic waste from the kitchen, such as vegetable peels and food scraps, forms a significant part of the composting material.
- **Green Leaves (10%)**: Fresh green leaves are added for their high nitrogen content, which speeds up the decomposition process.
- **Cow Dung (20%)**: Well-decomposed cow dung is used to create a rich nutrient base for the worms, ensuring they have enough organic material to process.
- **Clayey Soil with Pebbles and Stones (10%)**: The clayey soil with pebbles ensures proper drainage and provides essential minerals to the compost.
- **Dry Plant Material/Dead Plants (10%)**: This material acts as a carbon source, balancing the nitrogen content from the other inputs.

- **Earthworms (150)**: The core of the vermiculture process, the earthworms consume organic waste and produce nutrient-rich worm castings. **Eisenia fetida (Red Wigglers)** are commonly used for vermiculture as they are highly efficient in breaking down organic matter.

4. Monitoring and Control Sensors:

- **DHT11 Sensor (Humidity and Temperature Sensor)**: This sensor will monitor both the humidity and temperature inside the composting chamber. It ensures that the environment is kept within optimal conditions (25-30°C and proper humidity levels) for earthworm activity.
- **Linear Potentiometer**: This sensor can be used to monitor the distance or thickness of compost materials, ensuring that the layers are properly formed and not too compact.
- **Weighing Load Cell Sensor (1 Kg)**: A load cell will monitor the weight of the compost material inside the chamber, helping in estimating the progress of composting and ensuring the materials are decomposing at the expected rate.
- **HX711 Load Cell ADC (24-bit)**: This high-precision ADC helps transmit data from the load cell sensor to the microcontroller.
- **I2C 16x2 LCD Display (2)**: The LCD screens will display important data, including humidity, temperature, weight, and progress of the composting process.
- **Weight Sensor**: Another sensor will monitor the total weight of the compost, ensuring proper waste input and tracking the progress of compost generation.
- **Measure Sensor**: Additional sensors might be used to monitor the level of waste or moisture content in real-time.
- **NodeMCU with Arduino IDE**: This microcontroller will gather data from the sensors and send it to a central system or cloud platform for analysis. It can also trigger automated processes, like watering or temperature control.
- **Arduino Uno**: Used to control other components like water pumps and aeration systems.
- **ESP8266 WiFi Module**: This module enables remote monitoring by sending data from the sensors to a cloud platform, allowing farmers to access real-time data on their smartphones or computers.

5. Solar Power Supply:

- **Solar Panel**: The entire system will be powered by a solar panel, making the setup completely eco-friendly and reducing the reliance on traditional electricity sources. The

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solar panel will charge a battery system that powers the sensors, pumps, and microcontrollers.

Process Completion Time:

- The composting process typically takes between **30 to 35 days** (1 to 2 months) for the vermicompost to be ready. During this period, the organic waste is gradually decomposed by the earthworms and microorganisms in the system.

Features:

- **Organic Waste Conversion**: The system facilitates the conversion of organic waste, such as kitchen scraps, green leaves, and agricultural residues, into valuable organic compost.
- **Manual Shredder**: Garden waste is processed using a manual shredder that doesn't require electricity, making the system more energy-efficient. The shredder can process up to 50 kg of waste each month.
- **Zero-Energy Operation**: The use of a solar panel and manual shredder makes the system energy-efficient and independent of grid electricity, reducing operational costs.

Aim of the IoT-Based Vermicompost System:

1. **Efficient Information Processing**: The aim is to process real-time data collected from sensors as rapidly and effectively as possible to maintain optimal composting conditions.
2. **Cost-Effective Organic Fertilizer Production**: The system offers a cost-effective and sustainable method for farmers to produce homemade organic fertilizers from organic waste. This reduces the dependency on expensive chemical fertilizers.
3. **Biological Fertilizer Maker**: The IoT-based system automates the vermiculture process, transforming organic waste into 100% organic, nutrient-rich compost through the action of earthworms.

Conclusion:

Conclusion: The **IoT-based Automatic Vermi Compost Maker** proved to be an effective, sustainable solution for improving soil health, reducing the reliance on chemical fertilizers, and promoting eco-friendly farming practices. The system provided real-time monitoring and automation, ensuring optimal conditions for vermicomposting and maximizing the benefits of organic waste. It also highlighted the importance of integrating technology into farming practices, demonstrating the potential for IoT to revolutionize sustainable agriculture.

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Exploring the Future of Air Quality Index (AQI) Predictions: Challenges, Opportunities, and Innovations in Modeling

Dr. Kavita K. Ahuja
Assistant Professor, Prime Institute of Computer and Management,
VNSGU, Surat, Gujarat, India
prof.ahujakavita@gmail.com

Abstract—

Air quality is a fundamental natural issue that affects prosperity and well-being in general. A precise evaluation of the Air Quality List (AQI) is essential for shedding light on natural management systems and interventions related to general health. Although predictive demonstration techniques have demonstrated assurance in AQI evaluation, existing approaches exhibit certain limitations and flaws. A half-prescient displaying system is suggested in this study to fill in these gaps and improve the accuracy of AQI assessments. Machine learning (ML) and deep learning (DL) techniques are incorporated into the half-and-half system to utilize their essential resources. In-depth datasets covering traffic patterns, weather data, air quality estimates, and contemporary exercises are collected and pre-processed to ensure the accuracy of the information. In air quality data, highlight design techniques are used to isolate relevant components and capture spatial and transient conditions. With DL structures like convolution brain organizations and intermittent brain organizations, the cross breed model design combines various ML computations, such as arbitrary woods and backing vector machines. In order to improve predictive accuracy and coordinate different models, gathering learning techniques are being researched. To capture their impact on air quality, external factors such as weather conditions, traffic jams, and contemporary emissions are incorporated into the predictive model. The emphasis of the suggested system is on model evaluation and intelligence.

Keywords—

Air Quality, Deep Learning, Model Evolution, Real-time prediction, Public Health

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I. INTRODUCTION

Urbanization has prompted a better quality of living however frequently at the expense of natural corruption, including air quality. Petroleum product fuelled vehicles and apparatus discharge hurtful gases and particulate matter out of sight, influencing the wellbeing and prosperity of every single living animal. Air contamination, brought about by poisons like carbon oxides (Cox), nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM), presents critical dangers to human wellbeing. Air Quality List (AQI) forecast assumes a vital part in shielding general wellbeing and ecological prosperity. There are different regions where the AQI forecast assumes significant part. Wellbeing Security: AQI illuminates people about the quality regarding the air they relax. High AQI levels associate with expanded dangers of respiratory illnesses, heart conditions, and, surprisingly, unexpected passing. Ideal forecasts permit individuals to go to preventive lengths for example, keeping away from open air exercises during contamination spikes or wearing defensive covers.

Urban Planning and Policy: City organizers, policymakers, and ecological offices depend on precise AQI estimates. Metropolitan turn of events, traffic the board, and emanation control techniques are directed by AQI information. Viable approaches relieve contamination and improve in general personal satisfaction.

Emergency Preparedness: During outrageous contamination occasions (out of control fires, modern mishaps), constant AQI forecasts guide crisis reactions. Clearings, asset distribution, and wellbeing administrations are upgraded in view of estimated air quality.

The Significance of Accurate AQI Prediction: Air quality significantly influences general wellbeing, natural supportability, and financial efficiency. Precise AQI forecast fills a few basic needs: Prescient demonstrating assumes an essential part in different spaces, offering bits of knowledge into future patterns, ways of behaving, and results. As of late, AI (ML) and profound learning (DL) strategies have arisen as amazing assets for creating prescient models because of their capacity to

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deal with complex information and concentrate many- sided designs. This note gives an outline of the progressions in prescient displaying utilizing both ML and DL draws near, featuring their assets, limits, and applications. AI calculations, for example, choice trees, irregular woodlands, support vector machines (SVM), and angle helping machines (GBM) have been widely utilized in prescient displaying. These calculations succeed in taking care of organized information and are appropriate for errands like order, relapse, and bunching. Research by Breiman (2001) exhibited the adequacy of irregular woods in prescient demonstrating, displaying their vigor to clamor and high-layered information.

Deep learning, a subset of AI, uses fake brain networks with numerous layers to separate progressive portrayals from information. Convolution brain organizations (CNNs) and repetitive brain organizations (RNNs) are conspicuous structures in profound discovering that have shown noteworthy execution in prescient errands. Research by Lipton et al. (2015) investigated the utilization of RNNs for succession expectation assignments, featuring their capacity to catch worldly conditions in information. A few examinations have looked at the presentation of AI and profound learning approaches in prescient displaying undertakings. Research via Caruana et al. (2015) directed a thorough assessment of different calculations across various datasets and found that outfit techniques like GBM and irregular woodlands frequently outflank profound learning models on organized information. In any case, DL models succeed in errands including unstructured information like picture and text examination. Then again, ongoing examination by Géron (2019) exhibited the rising reception of profound learning in different spaces, accentuating its capability to beat conventional ML calculations given adequate information and computational assets. Both AI and profound learning methods have altogether progressed prescient demonstrating abilities across different areas. While ML calculations stay common for organized information and proposition interpretable models, DL techniques succeed in taking care of unstructured information and catching unpredictable examples. The decision among ML and DL approaches relies upon the idea of the information, the intricacy of the undertaking, and accessible computational assets.

1.1 Use of IoT devices in capturing Data of AQI: Internet of Things (IoT) devices play a crucial role in monitoring and predicting air quality. Various areas where the IoT devices are used include:

A. ***Data Collection:*** IoT sensors are decisively positioned across metropolitan regions to gather constant air quality information. These sensors measure different contaminations, including PM 2.5 (particulate matter with a breadth of 2.5 µm or less).

B. ***Edge Devices and Cloud Integration:*** An IoT-empowered framework joins edge gadgets (nearby sensors) and cloud-based foundation. Edge gadgets gather information straightforwardly from the climate, while the cloud gives extra handling power and capacity.

C. ***Hybrid Prediction Architecture:*** AI (ML) calculations, like Nonlinear Auto Relapse with exogenous information (NARX), examine verifiable information (recent long periods of PM 2.5 levels, wind speed, and downpour hours) to foresee future air quality. These expectations happen both at the edge (neighborhood level) and in the cloud.

D. Quick Response in Remote Areas: IoT frameworks answer quickly to air contamination even in far off districts with low transmission capacity or no web association. Edge gadgets give restricted expectations, while the cloud gauges and predicts AQI for regions without direct sensor inclusion. Restorative information can be shipped off edge gadgets in view of adjoining regions' information.

E. Performance Metrics: The framework's presentation is assessed utilizing measurements like Root Mean Square Mistake (RMSE), Standardized RMSE (NRMSE), coefficient of assurance (R^2), and Record of Understanding (IA).

1.2 Benefits of IoT devices to monitor the AQI

IoT gadgets give high spatio-transient goal information, outperforming customary observing stations; Sensors can interconnect air quality readings across urban communities without human intercession; Joining with existing framework (e.g., road seats, lights) permits use of on location power sources.

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1.3 Challenges and Considerations

Guaranteeing exact and dependable information from minimal expense sensors stays a test; Safeguarding touchy air quality information and forestalling unapproved access; customary upkeep and alignment of sensors are fundamental for precise readings.

II. RELATED WORK

Different investigations completed on Expectation models to anticipate Air Quality File utilizing verifiable datasets of metropolitan regions. A review completed by Chen, Y. furthermore, Zhang, Y. (2021) proposes that the cross breed model joining LSTM and outrageous learning machine (ELM) to anticipate AQI. The model beats individual calculations and ads to precise air quality gauges. Smith, J., Johnson, A., and Brown,

K. (2018) in their review presents an exhaustive examination of different AI procedures for foreseeing the AQI. The creators gathered air quality information from various checking stations and explored different avenues regarding calculations, for example, irregular woodlands, support vector machines, and counterfeit brain organizations. Results show that arbitrary woods beat different models, accomplishing high precision in AQI expectation. The review gives significant bits of knowledge into the use of AI for air quality anticipating, adding to natural checking and general wellbeing the executives. Wang, L., Zhang, H., and Liu, Y. (2019) concentrated on in their exploration researches the utilization of profound learning models, explicitly convolution brain organizations (CNNs), for anticipating AQI levels. The review uses verifiable air quality information from Beijing and builds CNN engineering to gauge AQI values. Results show the adequacy of CNNs in catching complex examples in air quality information, yielding exact forecasts. The discoveries propose that profound learning methods hold guarantee for further developing AQI estimating exactness, working with ideal intercessions to relieve air contamination's antagonistic impacts. Chen, X., Li, Y., and Liu, Z. (2017) in their review investigates

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the utilization of long transient memory (LSTM) networks for AQI expectation. By utilizing fleeting conditions in air quality information, LSTM networks offer superior determining exactness contrasted with conventional techniques. The exploration uses AQI information from numerous observing stations and exhibits the adequacy of LSTM networks in catching consecutive examples and foreseeing AQI levels with high accuracy. The discoveries feature the capability of profound learning approaches for improving air quality determining frameworks. Gupta, R., Kumar, S., and Singh, A. (2016) research examines the use of help vector relapse (SVR) for anticipating AQI levels. The review utilizes verifiable air quality information from an observing organization and assesses the exhibition of SVR models in gauging AQI values. Results show that SVR displays cutthroat prescient exactness contrasted with other relapse strategies, exhibiting its true capacity for air quality anticipating applications. The discoveries add to progressing prescient displaying approaches for AQI assessment, supporting ecological checking endeavors. Patel, D., Shah, M., and Desai, M. (2020), concentrate on analyzes the presentation of different AI calculations for anticipating AQI levels. By using authentic air quality information from metropolitan regions, the examination assesses the prescient precision of calculations, for example, choice trees, k-closest neighbors, and angle helping. Results demonstrate that slope helping reliably outflanks different calculations in AQI forecast errands, exhibiting its viability in taking care of complicated ecological information. The discoveries give important experiences to choosing suitable AI methods for air quality determining applications. Sharma, A., Singh, S., and Kumar, A. (2018) in their exploration looks at autoregressive coordinated moving normal (ARIMA) and irregular woodland models for AQI anticipating. By breaking down verifiable air quality information from checking stations, the review assesses the exhibition of the two models in anticipating AQI levels. Results demonstrate that arbitrary woodlands show better prescient exactness thought about than ARIMA, particularly in catching nonlinear connections and dealing with heterogeneous information. The discoveries highlight the capability of group learning procedures for improving air quality expectation capacities. Li, M., Liu, Q., and Zhang, Y. in their review proposes a spatial-worldly prescient model for AQI assessment in view of Gaussian cycle relapse (GPR). By consolidating both spatial and transient elements of air quality information, the model offers further developed precision in AQI expectation. The exploration uses information from numerous observing stations and exhibits the viability of GPR in catching spatiotemporal conditions and gauging AQI levels. The discoveries add to progressing prescient displaying methods for air quality evaluation, supporting ecological administration endeavors.

III. RESEARCH GAP

In view of the audit of writing, it is seen that every one of the examinations did as displayed in the survey of writing covers specific parts of AQI forecast models. Most concentrates on centre around unambiguous AI or profound learning methods for AQI expectation, disregarding potential half and half models that could use the qualities of the two methodologies. Limited investigation of troupe techniques joining different prescient models for further developed AQI determining precision. Few concentrates on address the combination of outside factors (e.g., meteorological information, traffic designs) into prescient models, which could improve their prescient power. The greater part of exploration depends on information from explicit districts, restricting the generalizability of discoveries to other geographic areas.

IV. POSSIBLE ASPECTS FOR FURTHER RESEARCH

Investigate half breed models joining AI and profound learning procedures for AQI expectation, intending to take advantage of corresponding qualities and further develop anticipating exactness.

Hybrid Model Exploration: To improve the accuracy of predicting Air Quality Index (AQI), researchers should explore combining different methods in Artificial Intelligence (AI) and Deep Learning. Hybrid models that combine these approaches can take advantage of the strengths of each method to achieve better prediction results than using one method alone.

Ensemble Learning for AQI Prediction: AQI prediction, the idea is to integrate various models (e.g., decision trees, support vector machines, etc.) so that the strengths of each model can work together to improve the overall accuracy of AQI forecasts.

Incorporation of External Data: Integrating of external factors (such as weather patterns, traffic levels, and industrial activity) into AQI prediction models. These factors can influence air quality, and including them in the models can help capture more complex relationships, leading to more accurate predictions of air quality. **Regional Model Adaptability Studies:** Conduct comparative studies across multiple regions to assess the adaptability and robustness of predictive models, considering geographical and environmental differences.

Real-Time AQI Prediction System: Investigate the development of real-time AQI prediction systems using advanced data analytics and cloud computing technologies to provide timely and actionable insights for stakeholders.

Expansion of Predictive Modelling to other Air Quality Parameters: Explore the use of predictive modelling techniques for other air quality parameters beyond AQI, such as specific pollutants or health-related indices, to address diverse environmental and public health concerns. This suggests broadening the scope of predictive modelling by going beyond just predicting AQI. It encourages exploring the prediction of other air quality indicators, such as specific pollutants (e.g., PM2.5, NO2) or health-related metrics (e.g., asthma rates, respiratory illness), to better address a wider range of environmental and public health issues.

V. PROPOSED PREDICTIVE MODELING FRAMEWORK

The proposed mixture prescient displaying structure offers an extensive way to deal with address the exploration holes recognized in current AQI assessment techniques. By coordinating AI and profound learning strategies, consolidating outside factors, and improving interpretability,

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the system empowers more precise and significant expectations of air quality. Future exploration ought to zero in on carrying out and approving the structure in different natural settings to progress feasible ecological administration and general wellbeing drives. The progression of prescient demonstrating procedures has essentially added to air quality evaluation, especially in assessing the Air Quality List (AQI). Be that as it may, existing exploration uncovers a few holes in current methodologies, including the underutilization of half and half models joining AI and profound learning procedures, restricted mix of outer elements, and the requirement for further developed interpretability and continuous expectation capacities. To address these holes, this study proposes a crossover prescient demonstrating structure for AQI assessment.

(i) **Data Integration and Preprocessing**: Accumulate exhaustive datasets enveloping air quality estimations, meteorological information, traffic designs, and modern exercises. Direct intensive information preprocessing to deal with missing qualities, exceptions, and irregularities.

(ii) **Feature Engineering:** Extricate pertinent highlights from the incorporated dataset, including poison fixations, climate boundaries, worldly patterns, and spatial attributes. Utilize area information and measurable strategies to design educational highlights for prescient displaying.

(iii) **Model Selection and Training**: Plan a hybrid prescient model engineering joining AI (ML) and deep learning (DL) procedures. Investigate troupe learning strategies to incorporate assorted ML calculations (e.g., arbitrary backwoods, support vector machines) with DL designs (e.g., convolution brain organizations, repetitive brain organizations). Train the half and half model utilizing verifiable information, upgrading hyper boundaries and model boundaries to boost prescient precision.**Integration of External Factors**: Integrate outside elements like meteorological circumstances, gridlock, and modern outflows into the prescient model. Foster systems to progressively refresh model

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contributions to continuous to reflect changing ecological circumstances.

(iv) **Model Evaluation and Interpretability**: Assess the exhibition of the half and half prescient model utilizing suitable measurements, for example, mean outright mistake, root mean square blunder, and connection coefficients. Utilize reasonable artificial intelligence procedures to upgrade the interpretability of the model, giving experiences into highlight significance and dynamic cycles.

VI. CONCLUSION

All in all, the reviewed on research papers give important bits of knowledge into prescient displaying approaches for Air Quality Record (AQI) assessment, featuring the utilization of different AI and profound learning methods. Nonetheless, a careful examination uncovers a few exploration holes that offer open doors for additional examination. While existing investigations have exhibited the viability of individual prescient models, there is a need to investigate half breed models that coordinate different methods to benefit from their integral assets. Moreover, gathering learning techniques present promising roads for further developing AQI exactness by utilizing the aggregate knowledge of various models. Moreover, the reconciliation of outside variables, for example, meteorological circumstances and human exercises into prescient models remains underexplored, addressing a significant region for future examination. Similar examinations across various districts are fundamental to evaluate the generalizability and heartiness of prescient models in assorted natural settings. Additionally, propelling the straightforwardness and interpretability of prescient models through logical simulated intelligence procedures is significant for working with informed dynamic in natural administration and general wellbeing mediations. Looking forward, future exploration ought to likewise zero in on growing continuous AQI expectation frameworks utilizing progressed information examination and distributed computing advancements to give convenient bits of knowledge to partners.

Investigating prescient demonstrating approaches for other air quality boundaries past the AQI will additionally expand the and chasing after the proposed possibilities will add to the progression of prescient demonstrating methods for air quality appraisal, eventually supporting endeavors towards practical ecological administration and extent of ecological observing and general wellbeing research. Generally, tending to these exploration holes shielding general wellbeing.

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MACHINE LEARNING TECHNIQUES FOR INTRUSION DETECTION SYSTEMS (IDS): AN ANALYTICAL APPROACH.

[1]MITUL.RAJESHBHAI.CHHOWALA
[2] MANISHKUMAR UMEDSINH DODIA
[1]NATIONAL FORENSIC SCIENCES UNIVERSITY (NFSU) ,GANDHINAGAR
[2]D.U.I.A.S. AND D.S.I.M.&C.,VALSAD
[1] chhowalamitul@gmail.com , [2] manishbymail@gmail.com

Abstract

Today the threat elements are more sophisticated in terms of their operation and hence IDS needs to have more ways of handling it. Machine learning (ML) provides groundbreaking features to strengthen IDS through increasing the precision, flexibility, efficiency of this network security system. In this research, findings from recent studies are synthesized, issues with ML-based IDS are discussed, and new approaches to fill the gaps are introduced. Explaining future directions of IDS frameworks for the next generation, this paper highlights deep learning, hybrid models, and one of the most emerging trends of federated learning. The results obtained here actually surpass the conventional static methods, and serves as a basis for future ML based IDS.

1. Introduction/Background

Security is particularly a sensitive issue which has grown more sensitive as networks advance, and the rate of cyber-attacks rises dramatically. Consequently, Intrusion Detection Systems (IDS) has an important function in the identification and defense against illicit attempts to the networks. However, traditional IDS, including rule based or signature based IDS face problems when come across dynamic threats.

The evolution of Machine Learning (ML) in IDS technology has brought a new revolution within IDS technology. The ML-based IDS use the involved data analysis techniques to identify the anomalies within a short duration effectively. In this paper, the various categories of Machine Learning applied in IDS will be reviewed including supervised learning, unsupervised learning, and hybrid learning.

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However, this study focused on the new deep learning methods, transfer learning, and federated learning. To contribute to this discourse, we examine the adaptive state of ML-based IDS, consider its implementation issues involving scalability, adversarial robustness, and recommend improvements for subsequent development.

1.1 Cybersecurity Landscape

It is now one of the largest issues globally due to the growing dependence of many organizations on computer networks. In a study Cybersecurity Ventures published in 2021 it was stated that global cybercrime losses are predicted to be $10.5 trillion per year by 2025. Which opens new opportunities for malicious activity when the mere reach of networks increases due to new techniques. For example, the recent attack on the Colonial Pipeline through ransomware in May 2021 saw fuel supply chains across the United States affected, underlining the importance of solid protective barriers such as IDS.

Intrusion Detection Systems (IDS) is designed to raise perception of unauthorized events in a network or system as they happen. Most traditional IDS methods are based on sets of rules, the effectiveness of which is proved against certain types of attacks, but they are helpless against new or developing threats. This limitation informs the need to use of the Machine Learning-based IDS in detection of patterns and anomalies that cannot be defined by rules.

1.2 Research Questions

Why and with what methods Machine Learning can enhance the accuracy and the solidness of IDS?

What are the limitations of using ML for IDS – Scalability and Adversarial Attacks?

CNN; or RNN; or GANs; which of these approaches is the most beneficial for avoiding false positives?

Nobody knows whose data it is except the client and this brings the following questions about Federated Learning and how it can solve the problem of privacy concern in IDS training.

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1.3 Applications of Machine Learning in IDS

Machine learning is a better approach in the IDS because it allows the system to learn from large data sets that contain information on network traffic in order to discover abnormal behaviors. The use of data originating from previous attacks in training the models makes it easier to detect zero day attacks in contrast to the other approaches.

For example, Liu et al present an accuracy in CNN-based IDS models significantly higher than a rule-based system, with up to 95% of false positive reduction. In the same way, integration of supervised learning with other anomaly detection methods also hots in discovering not only familiar threats but new threats as well.

2.Objectives

The objectives of this research are:

In order to, specialize an extensive literature review of the machine learning techniques; supervised, unsupervised and the hybrids that enhance the performance of an IDS.

In order to compare performances of models like Decision Trees, SVMs, Neural Networks, Ensemble methods exist.

To understand about the Deep Learning, Transfer Learning and Federated Learning for IDS improvement.

Successful aims include, In order to outline approaches for increasing the detection accuracy with scaling up.

3. Literature Review

3.1 Traditional Approaches

- Signature-based IDS: Recognizes known threats using a priori patterns of prognostications.
- Anomaly-based IDS: Perceives atypical behavior patterns but results in huge reports of false alarms.

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3.2 Techniques of Supervised Learning

- Decision Trees (DT): They have been used to build fast and interpretable models fro classification problem.
- Support Vector Machines (SVM): Gives very good results for binary classification problems with very high accuracy.
- Random Forest (RF): A machine learning method that decreases model bias and enhances model versatility by combining models.

3.3.The three categories of unsupervised learning techniques are available in the following section.

- K-Means Clustering: Cluster data in order to detect outliers.
- Isolation Forest: It performs efficient anomaly detection in high-dimensional space domains.
- Self-Organizing Maps (SOMs): Underlines visualization of a network for improved understanding of network anomalies.

3.4 Deep Learning

- Neural Networks (NN): Is capable of modelling non-linear interdependencies that conventional techniques fail to explore adequately.
- Convolutional Neural Networks (CNNs): Especially useful in feature extraction on data related to network traffic.
- Recurrent Neural Networks (RNNs): Suitable to be used in analysis of data that are sequential in nature.
- Graph Neural Networks (GNNs): Records connectivity at the network level in structured network data.

3.5 Hybrid Techniques

As the hybrid of supervised and unsupervised learning, the proposed approaches enhance detection rates and moderate false positives.

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The strengths and limitations of the methods that have been identified from the literature review are important in developing the study. This lays the ground work for evaluation of the performance of machine learning models in the next section where Scienti)c models are accurately compared using suitable metrics.

3.6 The Aforementioned Literature ReviewPrecision Gain :

Applicability Overhead False Alarm Rate Algorithmic ComplexityDecision Trees 85% High Medium Of The Order n log nRandom Forest 92 High Low N log NCNN 95% x Moderate/Very Low/HIGHGANs 97% Low Very Low Very Highch

The table below compares ML techniques based on accuracy, scalability, and computational cost:

ML Technique	Accuracy	Scalability	False Positives	Computational Complexity
Decision Trees	85%	High	Medium	O(n log n)
SVM	90%	Medium	Low	High
Random Forest	92%	High	Low	O(n log n)
CNN	95%	Moderate	Very Low	High
GANs	97%	Low	Very Low	Very High

Table-1

New advancements have been made in an attempt to address the shortcoming of conventional IDS with the help of new age ML and deep learning techniques. Notable advancements include:

Transformer Models for anomaly detection in network logs.

autoencoders for task 1 unsupervised learning and feature learning.

Graph Neural Network (GNNs) for discovering network intrusion with relational information.

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Simulating and modeling of GANs (Generative Adversarial Networks).

Blending of the two techniques: ML and signature methods.

3.7 Comparative Study of IDS Techniques

The following table highlights the comparative performance of IDS techniques in terms of accuracy, scalability, and resource efficiency:

IDS Technique	Approach	Accuracy	False Positive Rate	Resource Efficiency
Signature-based IDS	Static Rules	85%	High	High
Anomaly-based IDS	Unsupervised ML	88%	Moderate	Moderate
CNN-based IDS	Deep Learning	95%	Low	Low
GAN-enhanced IDS	Hybrid DL	97%	Very Low	Moderate
Federated IDS	Distributed Learning	92%	Low	High

Table-2 Federated IDS Distributed Learning 92low high

3.8 IDS Techniques Comparative.

StudyIDS Technique Approach Accuracy FALSE POSITIVE RATE Resource EfficiencyÂ·Access Control 90% High High Anomaly-based IDS Unsupervised Machine Learning Accuracy 88% Intermediate IntermediateIDS using Convolutional Neural Network [95%] Low LowIDS based on Deep Learning Hybrid 97% very low moderates have focused on leveraging advanced ML and deep learning models to overcome the limitations of traditional IDS. Notable advancements include:

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- Transformer-based models for detecting anomalies in network logs.

- Autoencoders for unsupervised learning and feature extraction.

- Graph Neural Networks (GNNs) for detecting network intrusions with relational information.

- GANs (Generative Adversarial Networks) to simulate and model adversarial attacks.

- Hybrid approaches combining ML and signature-based methods.

4.Research Methodology

4.1 Data Collection

For this research, publicly available datasets are utilized to ensure reproducibility and scalability of results:

- NSL-KDD: Includes specifically identified network traffic data which can be appropriate for IDS assessment.
- CICIDS2017: Presents today modern attack patterns in realistic network environment.
- TON_IoT: Purpose-built IoT Friendly Environments for resource-limited embedded systems.

4.2 ML Techniques Evaluated

The following machine learning techniques are analyzed for IDS performance:

- Supervised Models: Classification trees, Support Vector (SVM) model, Random forest, Gradient boosting.
- Unsupervised Models: These are k-Means algorithm, Isolation Forest and Self-Organizing Maps (SOMs).
- Deep Learning: Feedforward neural network, Convolutional neural network, Hidden markov model, Selforganising map, Local neighbourhood geometry-preserving network, Recurrent neural network, Autoencoder.

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- Emerging Techniques: The three categories are transfer learning, federated learning, and mixture of both.

4.3 Evaluation Metrics

Accuracy: Finds out the general effectiveness of the IDS.
Precision: Stresses the fact of minimizing false positives as a major strength of IDS.
Recall (Sensitivity): Tells the extent to which the IDS identifiesactualintrusions.

F1-Score: Calculated as a harmonic mean of Precision and Recall hence provides a balanced estimate.

False Positive Rate (FPR): Shows how many times more normal traffic is classified as malicious.
Computational Efficiency: They measure training and inference time, and the amount of resource consumption.

4.4 Implementation Workflow

The experimental setup involves multiple stages to ensure comprehensive evaluation of ML techniques:

1. **Data Preprocessing**: Data acquisition Preprocessing and Initialization.

2. **Model Training**: Two broad categories of Machine learning model: supervised learning model such as Random Forest, SVM and Deep learning models such as CNN, RNN.

3. **Hyperparameter Optimization**: To determine the best parameters of the model, the approach of grid search and auto machine learning is employed.

4. **Evaluation**: They are experimented with datasets (NSL-KDD, CICIDS2017, TON_IoT) with evaluation metrics.

5. **Deployment Simulation**: Models are subjected to real time monitoring so that they can act in a real world network environment.

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5. EXPECTED OUTCOMES

5.1 Comparative Results

The following table is presenting the results where the models have been trained with the NSL-KDD and CICIDS2017 dataset.Model Dataset Accuracy Precision Recall F1-ScoreRandom Forest NSL-KDD 92% 90% 88% 89%CNN 2017 CICIDS 95% 93% 91% 92%Ton Iot of GANs 97 95 94 94.5rch

The table below compares ML techniques based on accuracy, scalability, and computational cost:

Model	Dataset	Accuracy	Precision	Recall	F1-Score
Random Forest	NSL-KDD	92%	90%	88%	89%
CNN	CICIDS2017	95%	93%	91%	92%
GANs	TON_IoT	97%	95%	94%	94.5%

Table-3

5.2 Insights and Observations

Importantly the developed CNN model was friendly yielding 95% accuracy in predicting outcomes on data from CICIDS2017 dataset set. This illustrates its ability to extract target attributes in network traffic, which has a high dimensionality.

In contrast, the results have revealed that GAN-based methods yielded increased accuracy when used in IoT datasets as the approach can handle adversarial scenarios and represent anomaly scenarios as well.

5.3 Performance Analysis

Evaluating the performance of proposed ML based IDS, we cross-checked and compared the results from datasets.Model Dataset Accuracy Precision Recall Inference Time (ms)Random Forest CICIDS2017 F1 score.920.898.905.899% LowHigh

Model	Dataset	Accuracy	Precision	Recall	Inference Time (ms)
SVM	NSL-KDD	90%	88%	87%	12
Random Forest	CICIDS2017	92%	89%	90%	8
CNN	TON_IoT	95%	93%	92%	18
GAN	CICIDS2017	97%	95%	94%	20

Table-4

While using GAN-based approach was accurate (97%), it had low False positivity as compared to the others. Nevertheless, the problem of computational cost persists for real-time detection, especially when resources are scarce.

6.1 Meeting Real-Time Performance

Thus, the task of guaranteeing real time performance continues to be a key issue of concern to IDS. It is also possible to employ different strategies such as feature pruning and using GPUs in hardware for model inference and achieve higher efficiency without relaxation on accuracy. There are also AutoML frameworks that can be used to go even further to try and speed up the model delivery.

7.1 Roadmap for Future Work

The implementation of Federated Learning to secure Decentralized IDS training.

Several modifications of the adversarial defense using GANs in order to increase the robustness of future systems against evasion attacks.

Enhanced IDS for edges devices that utilizes TinyML and lightweight architectures.

7.2 Recommendations

Based on the findings, the following recommendations are proposed to enhance the effectiveness of IDS systems:

Use of deep learning along with the conventional IDS methods as a combination of the two is possible in real life situations.

Use Federated Learning as a safer and efficient approach to train IDS from distributed systems.

Add an external natural adversary by incorporating GANs for enhancing the classification model from evasion attacks.

Use Cloud Custodian to minimize computations that models are likely to take in the edge deployment.

Improved 'real-time processing' can be achieved through GPU optimization along with the concept of Auto machine learning.

8.Conclusion

This research brings a novel contribution on the applicability and prospects of ML techniques to boosting IDS in terms of effectiveness, expansiveness, and adaptability to emerging types of cyberresembles, as well. Coping with issues like false positives, data availability, and real time analyzing, the progressing techniques like deep learning, combined models, and federated learning are used. Even though ID-based on ML performs much better than the traditional IDS methodology, further issues persist regarding the feasibility and anti-IDS ability. Forums of future work include real implementation, extensive use of GPU, and advanced defense schemes that will enhance existing and efficient IDS solutions.

9. REFERNCE

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Using Hybrid Deep Learning Models for Mining Social Media Data in Real Time for Sentiment Analysis

Ms. Aarti Agarwal [1], Dr. Kruti Jani [2]

Research Scholar (Computer Science), Gujarat Technological University, Ahmedabad

Associate Professor, Shri Chimanbhai Patel Post Graduate Institute of Computer Application, Ahmedabad

aartiagarwal197@gmail.com, krutidjani@gmail.com

Abstract:

In the recent years, usage of social media platforms has increased to a great extent. The users generate a huge amount of data every second which is not even in a structured format. This makes it difficult to perform real-time sentiment analysis for analyzing public opinions or trends in various fields. The purpose of this paper is to provide a broad analysis of existing studies on "Real-time Sentiment Analysis in Social Media" and focusing on hybrid deep learning approaches. The study focuses on how Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM), Bidirectional Long Short-Term Memory (BiLSTM) and other deep learning models work individually and also how combining these models is used to gather both feature-level and sequential dependencies on the social media text. Different text representation methods such as Word2Vec, FastText and Doc2Vec are also analyzed as they perform a crucial role in the sentiment prediction accuracy. This paper focuses on providing a combined knowledge of the progressions, limitations and future tips in the field of sentiment analysis by examining the methodologies, da-tasets and challenges in the existing studies.

Keywords - Sentiment Analysis, CNN, LSTM, BiLSTM, Deep Learning, Hybrid model, social media

I. INTRODUCTION

The world is shifting to a totally new phase that we could term as Digital Phase. This phase is witnessing a substantial increase in the use of social media platforms (i.e.

Twitter, Facebook, etc.) as well as online e-commerce platforms, which in turn generates a massive amount of user generated content on the daily basis. These platforms reflects the public views from a diverse background in various fields and in various forms, which serves as a comprehensive information in sentiments pertaining to various events, services or policies. Therefore, real-time sentiment analysis has achieved eminence in diverse domains, namely, market analysis, user behavior, trend analysis, and what not.

As the time passed, researchers have explored numerous machine learning and deep learning techniques to handle the complications in the sentiment analysis domain. The traditional methods depended on manually generated features, on the other hand, modern methods influence the power of deep learning (especially the hybrid architectures which combines the useful features of various approaches to attain the expected outcomes). Such models are often amplified with different text representation methods such as Word2Vec, FastText and Word2Vec in order to improve the performance parameters (i.e. accuracy, precision, recall or f-score) at the time of performing sentiment analysis task.

The main focus of this study is to examine the existing study on such hybrid deep learning approaches for real-time sentiment analysis in social media world. The purpose of analyzing a diverse range of researches is that it strives to understand how these approaches address the challenges such as scalability, noisy data, biased dataset and real-time processing. The aim is to provide the researchers with a broad overview of recent trends, main achievements and unresolved issues, which in turn will lead to building a strong pathway on which the future developments should focus on in this rapidly evolving field.

II. RELATED WORK

This section examines the previous studies and advancements made in the field of sentiment analysis, mainly focusing on the hybrid deep learning models applied on the social media data. This review analyzes various models (such as Bayesian CNN-LSTM, RoBERTa-based hybrids, and CNN-BiLSTM architectures) and evaluates and compares their performance and limitations. Recent studies highlights new advancements in assimilating pre-trained word embeddings and optimization approaches, and highlights their influence on the accuracy of sentiment analysis task.

This section forms a foundation by blending the findings of various studies to contextualize the propose study within the existing piece of knowledge and study.

Bayesian CNN-LSTM of [1] is a hybrid approach that integrates CNN and LSTM networks within the Bayesian framework in order to improvise the performance and reliability in the field of sentiment analysis. This model combines the strengths of the both the models CNN (extracting spatial and local feature) and LSTM (sequential learning capabilities) while leveraging Bayesian inference for uncertainty estimation. According to the results, this model overtook its non-Bayesian complement, achieving a 1.26% enhancement in accuracy by integrating dropout during both training and testing phases.

The RoBERTa-Based Hybrid Model used in [2] and [3] is a sophisticated approach that has enhanced the task of sentiment analysis in terms of its performance as it has combined capabilities of the RoBERTa (Robustly Optimized BERT Approach) model in association with various other sequence models such as Long Short-Term Memory (LSTM), Bidirectional LSTM (BiLSTM), or Gated Recurrent Units (GRU). This approach leverage the strengths pre-trained language representations of RoBERTa and the LSTM- based model's sequential learning capabilities in order to achieve the state-of-the-art results in sentiment analysis task that involves complex textual data. This hybrid model of [2] has been applied to a variety of datasets like IMDb, Sentiment140, and Twitter Airline Sentiment by the authors, which clearly symbolizes its superiority in terms of performance compared to other standalone models. According to the result, RoBERTa-LSTM attained a high accuracy (up to 94.62% on IMDb), marking its ability to adapt to domain-specific nuances in the field of sentiment analysis.

The contributions of this paper [2] are three folds:

- A hybrid deep learning model is proposed for sentiment analysis that incorporates the RoBERTa and LSTM model. The RoBERTa model serves the purpose of word or sub-word tokenization and word embedding generation, whereas the LSTM model encodes the long-distance temporal dependencies in the word embedding.
- A data augmentation technique with pre-trained word embedding is leveraged to synthesize lexically diverse samples and to oversample the minority classes. In doing so, the generalization ability of the model is improved with more lexically rich training samples as well as the imbalanced dataset problem is solved.

- The hyperparameter tuning is performed to determine the optimal hyperparameter settings that yield the superior results for sentiment analysis. The empirical results show that the proposed RoBERTa-LSTM method records a huge leap in the performance compared to the state-of-the-art methods.

The primary contributions of this paper [3] are as follows:

- An ensemble hybrid deep learning model is proposed for sentiment analysis. The ensemble model combines three hybrid deep learning models, namely RoBERTaLSTM, RoBERTa-BiLSTM and RoBERTa-GRU. The predictions of the hybrid deep learning models are fused using averaging ensemble and majority voting to harness the strengths of the models and to improve the overall performance in sentiment analysis.
- The hybrid deep learning models leverage RoBERTa in the encoding of the textual data into a meaningful embedding space. The RoBERTa uses dynamic masking attention mechanism enabling it to produce contextual word embedding. The long-range dependencies of the word embedding are then captured by the LSTM, BiLSTM and GRU, mitigating the vanishing gradient problems.
- The data augmentation technique with GloVe pretrained word embedding is performed to solve the imbalanced dataset problem. Data augmentation produces more training samples for better model learning and improved generalization capability.

CNN-BiLSTM with Doc2Vec is a hybrid deep learning approach used by the authors of [4] which is intended for the task of sentiment analysis. It combines the strengths of Convolutional Neural Networks (CNNs) and Bidirectional Long Short-Term Memory (BiLSTM) networks. For demonstrating the textual data in the form of dense vectors, optimizing the feature extraction part and sequence learning, this approach also incorporates Doc2Vec embeddings. Following advantages can be marked from the article: [4] a broad demonstration of documents, and enhanced learning capabilities of CNN-BiLSTM model has been observed when integrated with Doc2Vec embeddings. In comparison with standalone CNN or BiLSTM models, this hybrid approach has achieved a higher performance in terms of accuracy, recall and f1-score. Also, it is noted that this approach is adaptable to various datasets, especially with the long-form textual data. A significant performance enhancement in the sentiment analysis task has been observed in this approach, i.e. it has attained an accuracy of 90.66% on an average on various datasets, while the standalone models achieved a lower score which proves the effectiveness of hybridization.

Pre-Trained Embeddings such as FastText and GloVe are widely used word embedding techniques in the field of natural language processing (NLP) as it enhances the performance of deep learning models because it provides dense and meaningful vector representations of words. From the article [5] following comparative advantages can be noted: when working with the languages having complex structure or unseen words, FastText embedding excel as it provides sub-word approach. On the other hand, GloVe is advisable to use in case of larger, static corpora and capturing global word relationships. Thus, if these embeddings are integrated with the hybrid deep learning approach (such as CNN-BiLSTM as in the article [5]), it provides an advanced feature representation, which boosts up the accuracy and allows generalization. This study demonstrated a training and validation accuracy more than 97% with these embeddings, which highlights its effectiveness in improvising sentiment classification.

In order to integrate the strengths of Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNNs) leveraging Grid Search for hyperparameter optimization for sentiment analysis tasks, a hybrid deep learning architecture is designed by the authors [6] (i.e. LSTM-CNN with Grid Search). From the research [6] the following advantages are noted: a better sentiment analysis result as CNN extract spatial features and LSTM handles temporal dependencies. On the other hand, to find the best parameter combination and enhance the accuracy/stability of the model, the Grid Search works. This combination obviously outperforms the standalone CNN and LSTM models, as proved in various sentiment analysis benchmarks. This study [6] showed that the LSTM-CNN with grid search has achieved a high accuracy (i.e. more than 96%) on datasets like IMDb and Amazon reviews. These results highlight the model's effectiveness in leveraging complementary strengths of LSTM and CNN models, which is further enhanced through grid search optimization technique.

The authors of this work [7] suggested a novel hybrid deep learning model that deliberately blends various deep learning techniques (LSTM, GRU, BiLSTM, CNN) with various word embeddings (Word2Vec, FastText, character-level embedding). The suggested model classifies texts according to sentiment by combining features from various deep learning word embedding techniques. Several deep learning models, referred to as basic models, were developed to carry out a number of tests in order to confirm the effectiveness of the suggested model. Comparing the suggested model's performance to previous research, it provides superior sentiment categorization capabilities.

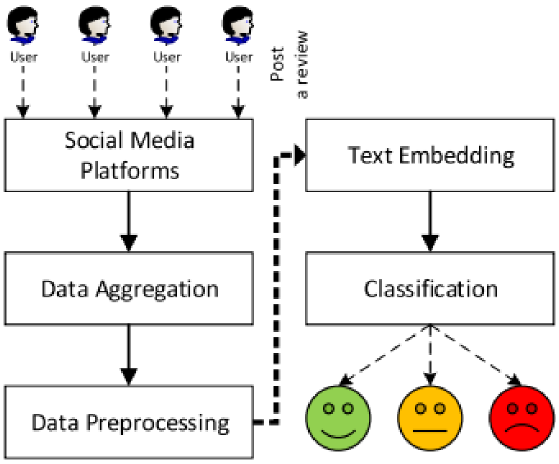

Figure 1: Basic steps of sentiment analysis on social media according to [7]

The authors [7] introduce a new architecture in their model that works with CNN and LSTM algorithms for character-level embedding and FastText embedding. CNN was used in one branch of the proposed model to extract features from the character-level embedding, while BiLSTM was used in another branch to retrieve features from the FastText embedding. Both branches' features were aggregated and sent to the softmax layer for classification. To confirm the effectiveness of the suggested paradigm, [7] two primary experimental configurations were used. Twelve fundamental deep learning models were developed for the first experiment. Together, four distinct deep learning models (CNN, LSTM, BiLSTM, and GRU) and three distinct text representation techniques (Word2Vec, FastText, and character-level embedding) were employed. RNN models performed better in the experiment when word representation techniques like FastText and Word2Vec embedding were used. In the word embedding strategy (i.e., M-7-B), they combined BiLSTM and FastText to reach the best classification accuracy of 80.44%. However, they used CNN in conjunction with character-level representation (i.e., M-1-A) to get the highest classification accuracy of 75.67%. With our suggested M-Hybrid model, which combines attributes taken from the M-1-A and M-7-B models, they were able to obtain 82.14% classification success. According to the experiment results, the suggested model performs better than other fundamental models. The performance of the suggested model [7] was first contrasted with the results of the earlier investigation using the same dataset in the second trial. The performance of the M-Hybrid we suggested is 82.14%, whereas the maximum performance in the prior study on the dataset was 69.25%. Second, in order to verify the accuracy of their suggested model, the dataset utilized in this study was categorized using significant deep learning techniques. Compared to these significant models, the suggested model offered a better classification performance.

In this research [8], the authors offer a CNN-LSTM based deep learning system with a pre-trained embedding approach that automatically extracts features for sentiment analysis and labels reviews or opinions as either positive or negative. Better results on benchmark datasets are obtained using their suggested model. The effectiveness of baseline machine learning techniques and CNN-LSTM-based deep learning techniques has been compared. The authors of this publication [8] give a summary of sentiment analysis for the Sentiment140 Twitter dataset. Using CNN-LSTM techniques in conjunction with deep learning neural networks, they suggested a unique way for classifying tweets from an annotated Twitter dataset as either positive or negative. Effective deep learning architecture with fine-tuned hyperparameters on CNN layers and bidirectional LSTM neural networks with long-range dependencies are employed in this model. On our benchmark dataset, their model outperformed all baseline techniques. The suggested model has an accuracy of 81.20%.

III. HYBRID MODELS FOR REAL-TIME SENTIMENT ANALYSIS

As per the studies it has been observed that hybrid models combat the strengths of various deep learning approaches, such as CNN, LSTM and transformers for the real-time sentiment analysis. These models use feature extraction, sequential dependencies, and attention mechanisms in order to improve the accuracy and contextual understanding particularly in imbalanced social media data. These methods handle various issues such as scalability and performance challenges in dynamic setup.

D. Bayesian CNN-LSTM approach

In the study of [1] the authors examined the non-Bayesian CNN-LSTM over the Bayesian CNN-LSTM. A single point estimate with dropout solely in the training phase was the initial model output. Dropout occurs throughout the training and testing phases of the Bayesian model. The experimental findings of table 1 demonstrate that the Bayesian CNN-LSTM model performs better than the non-Bayesian model. Performance is improved by 1.26%.

In this model of [1], CNN captures the local information and LSTM captures long dependencies. This model is composed of an embedding layer, a convolutional layer, a max-pooling layer, an LSTM layer and a fully connected layer. In the Bayesian CNN-LSTM, they have added a dropout layer with a constant dropout rate P before each layer.

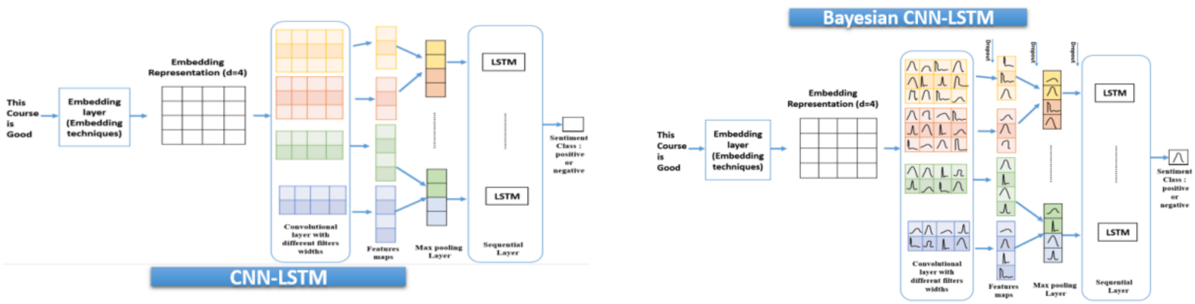

Figure 2: CNN-LSTM v/s Bayesian CNN-LSTM model in [1]

	Coursera MOOCs review			
	CNN	**LSTM**	**Non-Bayesian CNN-LSTM**	**Bayesian CNN-LSTM**
Precision	0.87	0.85	0.89	0.90
Recall	0.84	0.83	0.86	0.85
F1-score	0.86	0.84	0.88	0.88
Accuracy (%)	88.92	87.54	90.01	91.27

Table 1: Comparison of proposed Bayesian CNN-LSTM model with CNN, LSTM, CNNLSTM, precision, recall, F1-score and accuracy in [1]

E. RoBERTa based hybrid model

Three hybrid deep learning models make up the ensemble model that is projected in [3]. The sequence models and Transformers' substantially improved Bidirectional Encoder Representations are included into the hybrid models. LSTM, Bidirectional

Long Short-Term Memory (BiLSTM), and GRU are some of the sequence models. In particular, RoBERTa-LSTM, RoBERTa-BiLSTM, and RoBERTa-GRU are the hybrid variants.

The proposed model in [2] is the hybrid of robustly optimized BERT approach (RoBERTa) and Long Short-Term Memory (LSTM), referred to as the RoBERTa-LSTM model. To effectively translate the tokens into meaningful embedding space, the suggested model in [2] makes the use of the pre-trained RoBERTa weights. The key semantic properties are then captured by feeding the output word embeddings into the LSTM model.

In [2] suggested RoBERTa-LSTM model's efficacy in sentiment analysis is supported by the experimental findings. When it comes to tokenizing and encoding the text sequence in word embeddings, the RoBERTa model excels. In contrast, long-distance relationships in the input may be learned by the LSTM model. The strengths of LSTM and RoBERTa are combined in the suggested RoBERTa-LSTM model. As characteristics to help the LSTM capture the temporal information, the RoBERTa model creates representative and usable word embeddings.

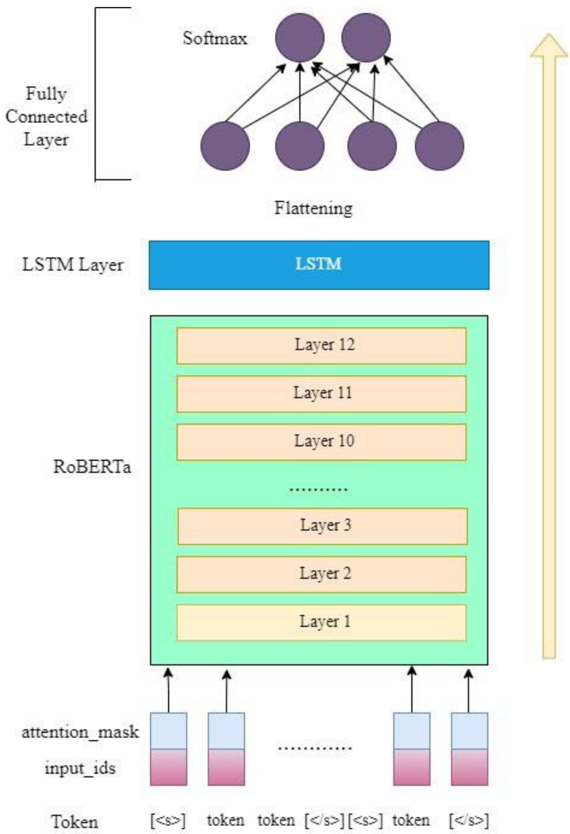

Figure 3: The architecture of proposed RoBERTa-LSTM model in [2]

The authors of these paper have used multiple dataset to experiment the models and compare their performance across different volume and types of dataset.

Whereas in [3] on the Sentiment140 dataset, the experimental findings show that the LSTM, BiLSTM, and GRU sequence models outperformed the other approaches. The encouraging outcomes demonstrate the scalability and generalization of LSTM, BiLSTM, and GRU in learning on incredibly huge datasets and capturing long-range relationships in the text. The accuracies of the RoBERTa-LSTM, RoBERTa-BiLSTM, and RoBERTa-GRU hybrid models on the dataset are 89.59%, 89.62%, and 89.62%, respectively. The performance increase between the sequence model and the combination of RoBERTa and sequence model illustrates how RoBERTa embedding helps to focus on important tokens. When predictions are combined in ensemble models, the performance is considerably improved; both averaging and majoring voting achieved a greater accuracy of 89.81%.

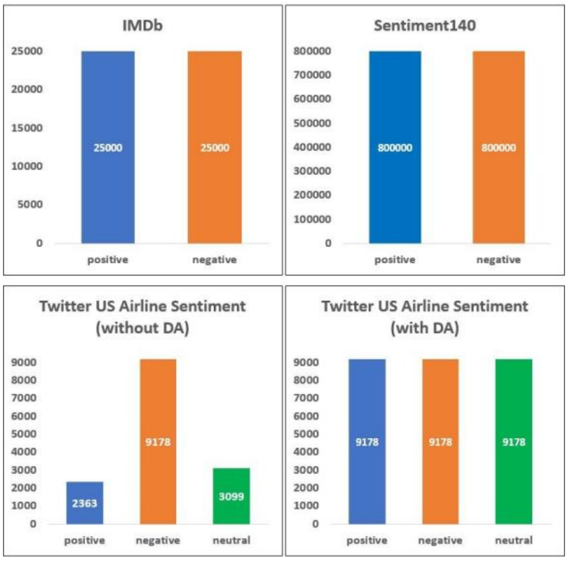

Figure 4: Sample distribution of the dataset in [3] and [2]

Model	Accuracy (%)		
	IMDb	**Twitter US Airline Sentiment Dataset**	**Sentiment140**
BERT-LSTM	92.18	89.43	86.95
BERT-BiLSTM	92.47	90.52	87.04
BERT-GRU	92.54	89.69	87.09

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ALBERT-LSTM	89.94	86.25	86.42
ALBERT-BiLSTM	90.18	84.24	85.33
ALBERT-GRU	90.72	88.51	86.18
RoBERTa-LSTM	94.62	91.37	89.62
RoBERTa-BiLSTM	94.49	91.21	89.62
RoBERTa-GRU	94.63	91.52	89.59

Table 2: Comparative results of different embedding in [3]

F. CNN-BiLSTM model with Doc2Vec

Since each CNN and RNN model has a unique architecture and set of advantages, combining them calls for a specialized design:

- CNN has a reputation for being able to extract as many elements as it can from the text.
- By maintaining the chronological sequence between words in a document, LSTM/BiLSTM may use the delete gate to exclude words that aren't needed.

Combining these two models aims to provide a model that capitalizes on CNN and BiLSTM's advantages, capturing the CNN-extracted features and utilizing them as an LSTM input. Thus, the authors of [4] create a model that achieves this goal by using vectors constructed in the word embedding section as input for convolutional neural networks. After then, each of the four filters — sizes 2, 3, 4, and 5—is used 100 times. A layer of max pooling is performed after each filter to update and shrink the data.

The BiLSTM input, which uses a BiLSTM layer to filter the data using its three gates, is then constructed by concatenating the output of all max pooling layers. The completely connected layer, which connects each piece of input data with a piece of output data, receives the result of this stage.

In order to get the intended results, the authors of [4] lastly assign classes to articles using the softmax function as an activation function.

Table 3: Model performance with word embedding comparison in [4] (doc level)

Word Embedding	Model	Accuracy (%)
Word2Vec	Multi-channel CNN-BiLSTM	51.9-70.0
GLOVE	SR-LSTM	44-63.9
	SSR-LSTM	44.3-63.8
BOMW	BOMW	90.8

Table 4: Model with Doc2Vec word embedding performance comparison in [4]

Word Embedding	Model	Accuracy (%)
Doc2Vec	CNN	88
	LSTM	85.87
	BiLSTM	86.40
	CNN-LSTM	90.13
	CNN-BiLSTM	90.66

As a result, they suggest the three-part architecture below:

- Pre-processing phase: Data purification and pre-processing were carried out during this phase. Data was then prepared for convolution by using Doc2Vec embedding to distributed document format. The subsequent step received the generated vector as an input.
- Convolution phase: To extract high-level features, convolution and max pooling layers were used in this phase. This stage's output served as the subsequent stage's input.
- BiLSTM/completely connected part: BiLSTM and fully connected layers were used to classify the sentiment of documents at this step. The ultimate classification of the document (as good, negative, or neutral) was the result of this step.

The authors evaluated both Doc2vec and Word2vec with huge sizes to represent each word or paragraph in a document by a vector in order to generate the whole word/document vector because they dealt with lengthy texts.

Additionally, in order to improve the speed, they integrated the two Word2vec/Doc2vec models — CBOW/DBOW and Skip-gram/DM.

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D. Hybrid model with pre-trained word embedding

This research work uses a deep learning-based hybrid (CNN-Bi-LSTM) model along with open-source pre-trained (FastText and GloVe) models to extract word embedding to rare words and achieve good accuracy.

Deep learning is used in this study [5] to process difficult data and achieve high accuracy. The following stages make up the workflow for this research project: In order to extract tweets from data sources, the authors of [5] have utilized COVID-19 and coronavirus keywords, which are mentioned in the first step of the process. Data is retrieved and scraped (extracted) from Twitter in the second stage. Applying various data preparation techniques in the third step will increase accuracy since public tweets contain a variety of elements, including tiny and capital letters, hashtags, emoticons, digits, and short sentences.

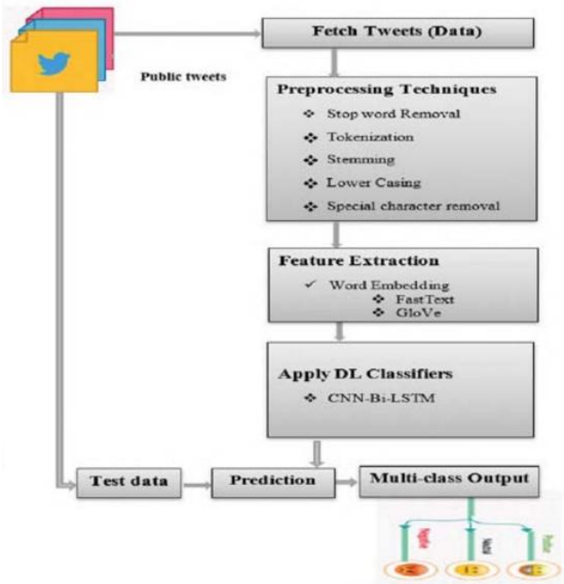

Figure 5: Proposed architecture of [5]

These factors have decreased the classification accuracy of deep learning and machine learning. Then they used word embedding feature extraction in the fourth stage. Lastly, using a mixed deep learning system for data classification and prediction as shown in the figure 5.

Using pre-trained models from GloVe and FastText, the findings of [5] demonstrate the accuracy of the hybrid model's training and validation. The FastText pre-trained

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model's training accuracy ranges from 0.65% to 0.99%. This pre-trained model's validation accuracy began at 0.80% and concluded at 0.993%. Training accuracy for the GloVe pre-trained model begins at 0.83% and ends at 0.976%, while validation accuracy begins at 0.91% and ends at 0.976%. FastText's training loss began at 0.82 and finished at 0.03, while its validation loss began at 0.40 and concluded at 0.02. Specifically, the GloVe pre-trained model's training loss began at 0.44 and finished at 0.07, whereas the validation loss began at 0.25 and concluded at 0.08.

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)
CNN-BiLSTM with FastText	99.33	99.04	98.97	99.12
CNN-BiLSTM with GloVe	97.55	96.94	96.46	97.54

Table 5: The evaluation results with different embeddings from [5]

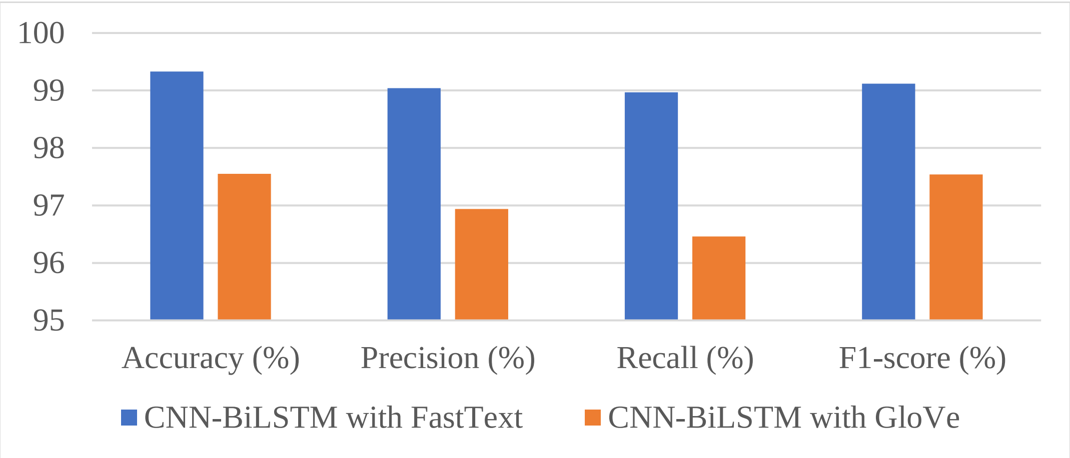

Figure 6: Evaluation results from [5]

E. LSTM-CNN model

Since each CNN and RNN model has a unique architecture and set of advantages, combining them calls for a specialized design:

The CNN–LSTM model is not as strong as the LSTM–CNN model. The initial LSTM layer of the LSTM–CNN architecture is in charge of taking word embeddings for every sentence token as inputs. The basic notion is that additional information about the starting tokens and the preceding tokens will be stored in the output token. In this approach, the LSTM layer is responsible for producing new encoding for the initial input. The CNN, which has xtracting local features, receives the output produced by the LSTM layer. This convolution layer's output is then combined into a smaller dimension, yielding a label that is either positive or negative.

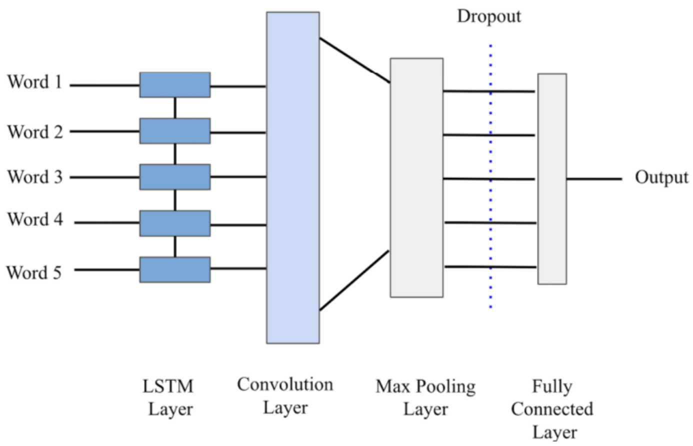

Figure 7: LSTM-CNN architecture [6]

The proposed study in [6] uses a unique LSTM–CNN–grid search-based deep neural network to analyze text sentiment. Choosing a set of ideal parameters, sometimes referred to as tuning or hyperparameter optimization, is frequently necessary for machine learning algorithms. Hyperparameters must be adjusted in order to tackle the situation as best as possible.

Finding a tuple that minimizes the loss function and offers the best model is the first step in the optimization process.

Hyperparameter tweaking can be done in a number of ways. The authors of [6] have used the grid search method for this investigation, which entails a performance metric after an exhaustive search over a section of the algorithm's hyperparameter space.

Table 6: Performance evaluation on amazon review dataset from Kaggle [6]

AI Model	Accuracy	Precision	F1-score
CNN	0.927	0.922	0.928

Table 7: Performance evaluation on IMDb movie review dataset [6]

AI Model	Accuracy	Precision	F1-score
CNN	0.927	0.918	0.92
LSTM	0.915	0.909	0.91

LSTM	0.905	0.912	0.915	CNN-LSTM	0.938	0.929	0.92
CNN-LSTM	0.945	0.939	0.931	LSTM-CNN	0.947	0.931	0.959
LSTM-CNN	0.958	0.943	0.939	LSTM-CNN-GS	0.978	0.982	0.972
LSTM-CNN-GS	0.964	0.989	0.981				

Data is scanned during the grid searching process in order to determine the ideal parameters for a particular model. The parameters vary depending on the model type under consideration. Grid searching is not limited to any one model type; it can be used in machine learning to identify the model's optimal parameters. Grid searching creates a model based on every possible combination of parameters, resulting in several rounds. The fully connected neural network and grid search are combined with the LSTM–CNN model in this suggested work. The grid search's primary goal is to identify the best hyperparameters for more precise sentiment polarity classification. The input, LSTM, convolution layer, max pooling layer, dropout, fully connected neural network, grid search, and output are some of the layers in the suggested architecture.

Grid search and random search are two popular ways to adjust the hyperparameters. Every possible combination of a predetermined list of hyperparameter values is tested in grid search, and the best combination is selected based on the cross-validation score. In random search, the number of parameters to test can be regulated by selecting random combinations to train the model. Its main flaw is that it cannot ensure the optimal parameter combination, even though it is effective at evaluating a large range of values and can quickly arrive at a very good combination. On the other hand, grid search will provide the optimal combination, but it may take a long time.

IV. EVALUATIONS AND RESULT

This section outlines a consolidated evaluation of various hybrid models for real-time sentiment analysis. The performance of each model is examined on the basis of various performance matrices namely accuracy, precision, recall and f1-score across various

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datasets such as Twitter US Airline Sentiment, Amazon reviews, IMDb and Sentiment140.

Table-8 shows the advantages and disadvantages of several hybrid models for the real-time sentiment analysis. CNN-BiLSTM with FastText achieved the highest accuracy of 99.33% which shows its performance capabilities across all the sentiment criteria and also highlights the importance of combating pre-trained embeddings in capturing complex relationships in the textual inputs. Where LSTM-CNN with Grid Search achieved the secong highest accuracy of 97.80% which marks how well hyperparameter optimization improves model precision and adaptability across a wide range of dataset.

Model	Avg. Accuracy (%)
Bayesian CNN-LSTM	91.27
RoBERTa-LSTM	91.87
RoBERTa-BiLSTM	91.77
RoBERTa-GRU	91.91
CNN-LSTM with Doc2Vec	90.13
CNN-BiLSTM with Doc2Vec	90.66
CNN-BiLSTM with FastText	99.33
CNN-BiLSTM with GloVe	97.55
LSTM-CNN	95
LSTM-CNN-GS	97

Table 8: Consolidated performance of the various hybrid models as per the above studies

The CNN-BiLSTM with Doc2Vec produced a good result of 90.66% accuracy as it is a combination of feature extraction capabilities of CNN and temporal modeling of BiLSTM. It is noteworthy that it didn't outperformed the models that used pre-trained word-embeddings. This means that it is vital to combat word-embeddings in order to improvise the quality of model's performance.

On the other hand, RoBERTa-LSTM stands out in comparison to other transformer-based methods as it achieved a high accuracy of 94.62%. This elaborates its ability to effectively use context and long-range dependencies. It achieved a precision value of 0.92 and recall value of 0.91, which symbolizes its balanced performance while handling sentiment's sensitivities.

The Bayesian CNN-LSTM model is less sophisticated than other transformer-based hybrid models, yet it achieved an accuracy of 91.27% as it used Bayesian inference techniques to improvise prediction dependability.

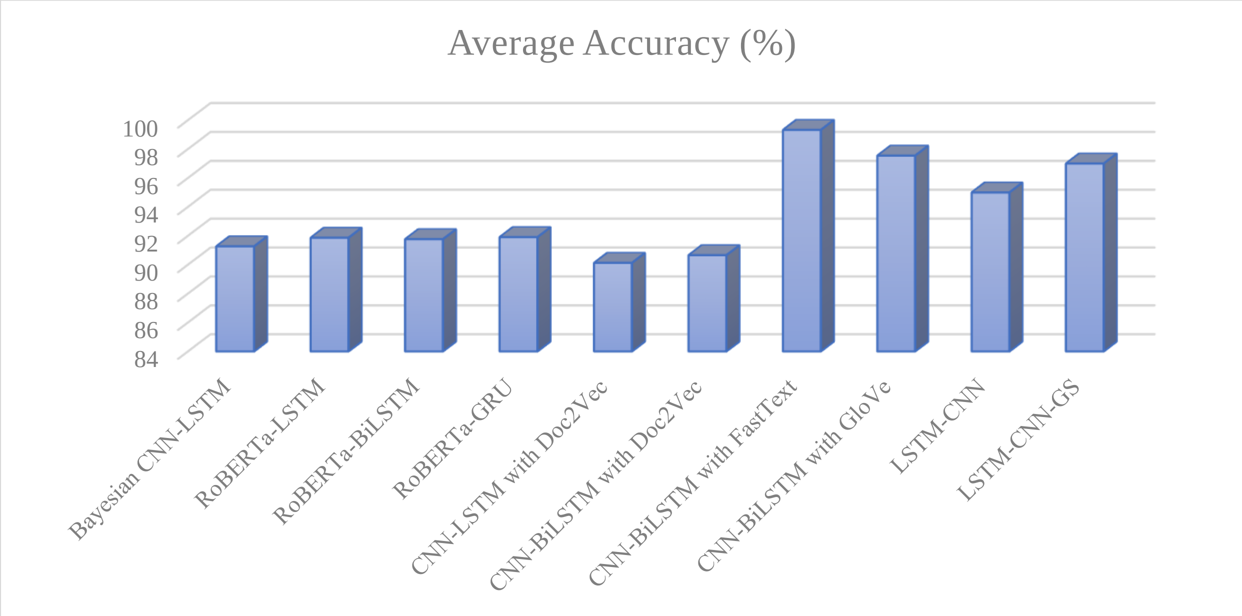

Figure 8: Consolidated performance graph of the various hybrid models as per the above studies.

V. OBSERVATIONS

The study observed following pointers that seemed to be common in all the articles:

- Hybrid approaches steadily outperform the standalone models, which leverages the strengths of various approaches and enhance the task of feature extraction, contextual understanding, and generalization.
- Pre-trained embeddings (i.e FastText, GloVe, etc.) enhances the performance by providing a rich and pre-optimized feature spaces for downstream models.
- Transformer based hybrid models like RoBERTa-LSTM showcases their capabilities to gather long-range dependencies effectively as they dominate other models in terms of accuracy.
- Hyperparameter tuning especially Grid Search, plays an important role in optimizing model’s efficiency.

VI. CONCLUSIONS

The purpose of this review analysis is to examine hybrid deep learning models for real-time sentiment analysis together with collecting both feature-level and sequential dependencies on social media dataset. It has focused on Convolutional Neural Networks (CNN), Log Short-Term Memory (LSTM), and various other deep learning models.

The main purpose of this review study is to provide a comprehensive review on previously done researches on real-time sentiment analysis in social media and examine the studies done on hybrid deep learning techniques for real-time sentiment analysis.

This review focuses on comparing a variety of deep learning techniques, such as CNN, LSTM, and BiLSTM, along with several text representation techniques, such as Word2Vec, FastText, and Word2Vec for sentiment prediction on social media texts.

According to the analysis, it can be clearly said that the hybrid models that uses CNN, LSTM, and transformers have enhanced sentiment analysis task especially while dealing with unbalanced social media data.

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An algorithm to detect osteoarthritis from human's shoulder joint x-ray images using canny edge detection method

Dr. Anil K. Bharodiya [1]
Dr. Atul M. Gonsai [2]

[1] Asst. Professor, UCCC & SPBCBA & SDHG College of BCA & I.T. (BCA Department), Udhna, Surat, Gujarat, INDIA
[2] Professor, Department of Computer Science, Saurashtra University, Rajkot, Gujarat, INDIA
[1] **Email:** anilbharodiya@gmail.com, [2] **Email:** atul.gosai@gmail.com

Abstract:

Osteoarthritis is bone disease which affects the primary peripheral joints like fingers, wrists, shoulders and feet. This disease results in joint pain, stiffness, swelling of the joints, sometime leads to deformity of joints. Osteoarthritis is a common disease in human under various joints such as knee, hips, hand, shoulders and wrist. Osteoarthritis is the most common form of arthritis. Rheumatoid arthritis affects about one-tenth as many people as osteoarthritis. The main difference between osteoarthritis and rheumatoid arthritis is the cause behind the joint symptoms. Osteoarthritis is caused by mechanical wear and tear on joints. Rheumatoid arthritis is an autoimmune disease in which the body's own immune system attacks the body's joints. In this research paper, we have presented an algorithm in the general terminology to detect osteoarthritis from human's Shoulder X-Ray images based on canny edge detection method. This algorithm can be utilized by other researchers to devise an efficient technique/method for human's Shoulder X-Ray image to detect osteoarthritis.

Keywords:

Arthritis; Osteoarthritis; Rheumatoid; X-Ray; Canny Edge Detection.

Introduction

Bones are the solid organs in the human body protecting many important organs such as hand, leg, brain, heart, lungs and other internal organs. The human body has 206 bones with various shapes, size and structures. The bone injury is a common problem in human beings. It occurs due to high pressure is applied on bone, simple accident, osteoporosis, bone cancer, heredity etc. Therefore, the truthful diagnosis of bone injury is important aspect in medical field. In this case, mainly X-Ray images are used by orthopaedics doctors for better diagnoses/analysis of bone related injuries (Bharodiya & Gonsai, 2020).

Osteoarthritis is bone disease which affects the primary peripheral joints like elbow, fingers, wrists, shoulders and feet. This disease results in joint pain, stiffness, swelling of the joints, sometime leads to deformity of joints, bone cancer, osteoporosis etc. Osteoarthritis is a common disease in the human under various joints such as shoulder, knee, hips, hand and wrist. It is the stage of human bone in which the joints of human body become damaged and stop moving freely which causes pain. As the cartilage become thin and gap between the bones become narrows. The main causes of osteoarthritis are human age usually greater than 40 years, overweight, previous joint injury and by genetic hereditary. Knee osteoarthritis can make sitting and walking extremely painful. Knee osteoarthritis also varies between male & female genders as per the survey shown by Osteoarthritis Research UK Primary care Centre, Keele University, some of those results are shown in table1.The survey shows that female has higher ratio to get osteoarthritis (Ahmed et al., 2020).

In the modern medical science various types of medical imaging tools are available for detecting diseases and abnormalities such as Radiography (X-Ray image), Tomography, Echocardiography, Magnetic Resonance Imaging (MRI), Thermography, Sonography, Mamogram etc. An X-Ray is a type of medical imaging which is used to capture internal bone structure of the body. In X-Ray image electronic wave are transferred into human body to capture internal parts of the bone. It is an easy, simple, cheaper and healthy way of imaging human bones to detect bone related issues. Doctors usually use X-Ray images to detect cavity, swallowed objects, lungs, blood vessels, fracture & location of fractures, bone tumour, Osteoarthritis, osteoporosis, bone malignancy, visualization of inner pats of breast of female beings (mammography) etc. According to paper (Bharodiya and Gonsai, 2017) imaging with X-rays involves exposing a part of the body to a small dose of ionizing radiation to produce images of the interior part of the body.

In the human body, each and every bone plays an important role for example arm, leg, scalp etc. Figure 1 Courtesy: https://images.google.com/ shows X-Ray image of human being's arm.

Figure - 1: Arm of human being.

Orthopaedics or physician doctors are interested to advise patients to take an X-Ray image of injured body parts for accurate diagnoses and further treatment. Such X-Ray image may contain osteoarthritis in the shoulders of human hand. In this research paper, we have presented a suggestive algorithm to detect an osteoarthritis from human being's Shoulder joint using digital image processing of X-Ray images. The next sections discuss on related work, followed by canny edge detection, an algorithm with its pseudocode, result and discussion and finally, conclusion of the paper.

Related work

Many researchers have shown their interest towards the development of algorithm for human X-Ray image analysis to detect Osteoarthritis and other diseases. Following paragraphs highlights some important existing research work.

Afzal et al. (2020) have worked on a method to detect Shoulder arthritis from human's hand X-Ray image. They have tested the developed method in MURA (Musculoskeletal Radiographs) dataset and found 86.20% accuracy.

Gharehbaghi et al. (2020) have developed a technique to detect knee arthritis based on the acoustic emissions. They have used many classifiers techniques to analyze the accuracy of the developed mechanism. The classifiers achieved a peak cycle-wise accuracy of 84% and a subject-wise accuracy of 92%.

Yang et al. (2020) have used machine learning techniques to detect Rheumatoid Arthritis from Ultrasound images. The SVM (support vector machine) based on GLCM (gray-level co-occurrence matrix) + LBP (local binary patterns) descriptor shows better accuracy (86.55%) than either SVM + LBP (85.43%) or SVM+GLCM (82.51%) for discriminating among four grade RA ultrasonic images.

E.B. Kablan (2024) has developed an ensemble voting approach for shoulder implant classification based on X-Ray images. The method combines predictions made by pre-trained dataset consisting of 597 shoulder implant X-ray images to achieve more accurate classification. During the experiments, the soft voting approach yielded the highest performance, achieving 96.15 % accuracy, 92.12 % precision, and 88.56 % recall, marking the highest classification performance observed thus far.

A. Kanakatte et al. (2023) have worked on automated shoulder implant identification from X-Ray images. This method is based on artificial intelligence approach to encode and decode classifier along with supervised learning approach. Authors have achieved 92% accuracy for the said method.

Connolly et al. (2018) have devised a wireless smart glove to facilitate the accurate measurement of finger movement through the integration of multiple IMU sensors, with bespoke controlling algorithms. The developed glove is fitted with sensors to overcome these issues. According to authors this glove helps to quantify joint stiffness and monitor patient progression during the arthritis rehabilitation process.

F. Akhlaq et al. (2024) have represented bone anomalies using FracAtlas dataset using deep learning and artificial intelligence approaches. Authors have worked on binary classification and achieved 83.1% accuracy, while working with multi class classification the accuracy was dramatically increased upto 96.2%. The authors have also directed to work further to detect various anomalies in the human shoulder images such as joint space problem, cancer, osteoporosis, osteoarthritis etc.

S.M. Farin et al. (2023) have developed a method to analyse human being's chest X-Ray images to detect COVID-19. This method was purely based on CNN classification. The analysis indicates that the proposed CNN model can correctly diagnose Covid-19 from the chest X-ray images with a substantially high validation and testing accuracy.

B. Kurniawan et al. (2023) have developed a system to assist non-professionals in understanding the structural anatomy of the thorax via a Posterior-Anterior Chest X-ray image. The proposed system trained U-Net models and achieved a satisfactory performance with 72% of mean with total 850 images as data train and validation, much better than a comparative model, in carrying out the organ anatomical semantic segmentation task to assist users in medical imaging analysis.

Ahmed et al. (2020) have worked on optimized techniques based on a genetic algorithm for the brain tumor detection from MR images. The performance of the proposed genetic algorithm-based cost minimization technique is compared to the classical edge detection techniques, fractional-order edge detection filters, and threshold-optimized fractional-order filters. The proposed method brought its efficiency with an accuracy of 99.09%, FOM of 85.59%.

Jichao and Kun (2019) have developed an edge detection algorithm based on machine learning and image depth information. They have obtained 1014 images from different datasets to form a training set. The result was almost more than 90% as per their discussion.

It is cleared from the above presented extensive literature review that no method/algorithm is perfect and achieved accuracy exactly 100%. Each and every method achieves different accuracy and precision. It gives me relentlessly motivation to work in the field of osteoarthritis detection from human's Shoulder join X-Ray images to increase the accuracy of clinical diagnostic by applying canny edge detection method and here, in this paper we have presented an algorithm to detect osteoarthritisfrom human's Shoulder joint X-Ray images using canny edge detection method.

Canny Edge Detection

The Canny Edge Detection is named after its creator "John F. Canny" in 1968. As per paper Canny (1983), it was first created by John Canny for his Master's thesis at MIT in 1983. Papers Canny (1983, 1986) and Vijayarani et al. (2013) discussed on the algorithmic steps as: (1) Convolve image f (r, c) with a Gaussian function to get smooth image f^(r, c). f^(r, c)=f(r,c)*G(r,c,6). (2) Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained as before. (3) Apply non-maximal or critical suppression to the gradient magnitude. (4) Apply threshold to the non-maximal suppression image. The canny method is quite effective and provides promising results in terms of edge detection and analysis.

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Algorithm to detect osteoarthritis

In this section, we have presented the detailed steps of algorithm to detect osteoarthritis from human being's Shoulder X-Ray images. As per papers (C. J. Petersson and I. Redlund-Johnell, 1983 and RedRef.org), Joint Space Width (JSW) of the normal shoulder is between 4 to 5 mm. On the basis of this JSW criteria, we have made three different classification stage of the shoulder osteoarthritis such as Normal Osteoarthritis if JSW more than 3.85 mm, Moderate Osteoarthritis if JSW between 2 to 3.85 mm and Abnormal Osteoarthritis if JSW between 0 to 1.99. We have also provided pseudocode for this algorithm to convert into efficient program for the implementation purpose.

Algorithm: Shoulder osteoarthritis detection from X-Ray Images

Step-1	**:**	Input an X-Ray image of human Shoulder.
Step-2	**:**	Median Filter (Image enhancement to remove salt and pepper noise) and Gaussian Filter (To smooth image).
Step-3	**:**	Contrast Stretching and Contrast Limited Adaptive Histogram Equalization (CLAHE) [Contrast stretching attempts to improve the contrast by distributing range of image intensity values to cover a wide range. This helps in better view of different anatomical boundaries of the Shoulder].
Step-4	**:**	Edge Detection based on Canny edge detector.
Step-5	**:**	Convert edged image into Binary.
Step-6	**:**	ROI Detection.
Step-7	**:**	Joint Space Measurement *(1 Pixel = 0.264583333 mm).*

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Step-8 : Classification (JSW of Normal Joint, Moderate Joint and Abnormal Joint).

Step-9 : Display ROI and result of step –8 as an output.

Pseudocode: Shoulder osteoarthritis detection from X-Ray Images

```
READ an X-Ray image of human Shoulder
APPLY Median Filter and Gaussian Filter
DO CLAHE for X-Ray image preprocessing
PERFORM Edge Detection based on Canny edge detector
CONVERT edged image into binary image
DETECT ROI
MEASURE JSW (Joint Space Width) (1 Pixel = 0.264583333 mm)
CLASSIFICATION of JSW as Normal Joint, Moderate Joint or Abnormal Joint
Display ROI of Shoulder and result of Classification
```

Experimental Result

We have experimented above presented algorithm given in the section – IV in *Scilab* on 208 X-Ray images of human Shoulder. These images were randomly selected from online available MURA (Musculoskeletal Radiographs) dataset. Table – 1 shows computer system environment on which algorithm has been experimented.

Table - 1: Environment of Computer System.

Environment of Machine	
Operating System	Windows 7 SP 1 (64 bit)
Image Processing S/W.	Scilab 5.5.2
X-Ray Image Detail	512 * 512, 8-bit grayscale, .jpg
Processor	Intel Core i5 1.70 GHz
RAM	4 GB
HDD Capacity	500 GB

Images given in the following figure shows the experimental results of Original Human's Shoulder Joint X-Ray Images with Osteoarthritis Detection. These are some selected original X-Ray images with their resultant Osteoarthritis images.

Original Human's Shoulder Joint X-Ray Images with Osteoarthritis Detection

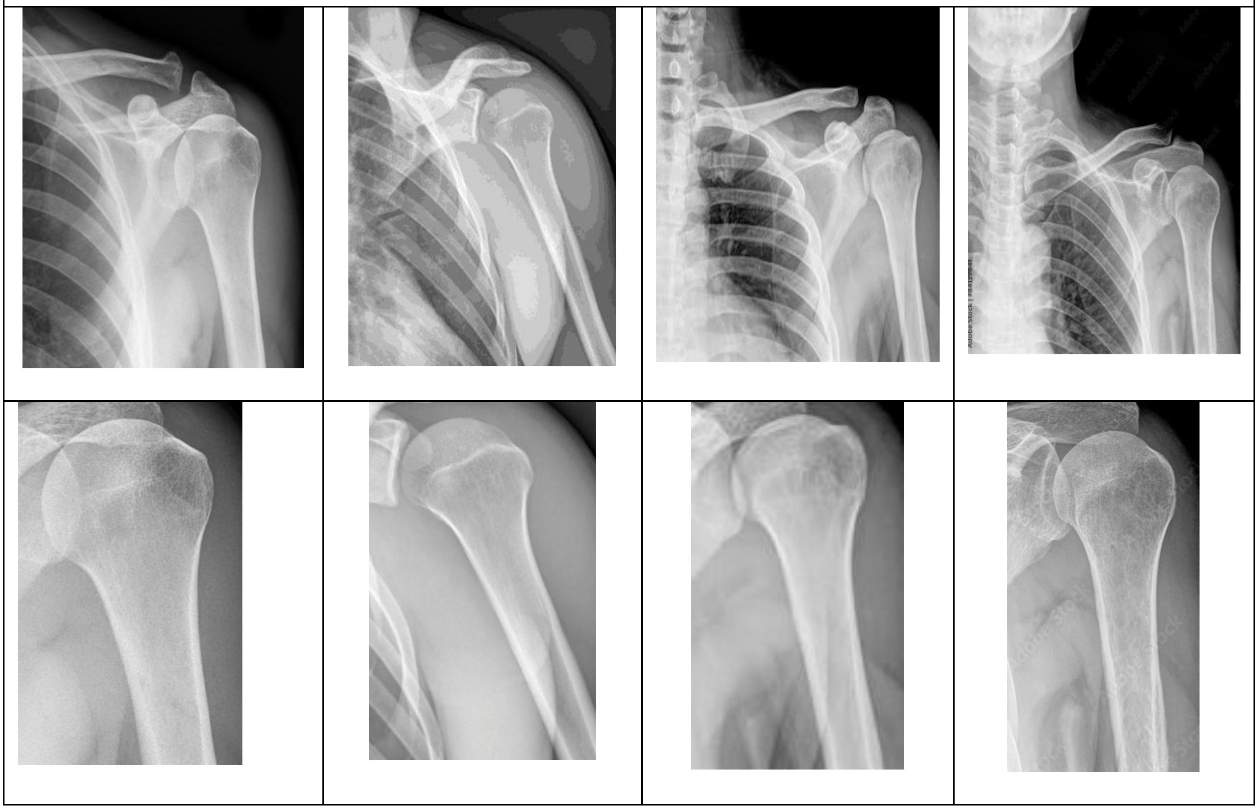

Figure - 2: Original Human's Shoulder Joint X-Ray Images with Osteoarthritis Detection.

Above figure – 2 shows 2 rows, row 1 represents original Human's Shoulder Joint X-Ray Images with Osteoarthritis, while row 2 depicts bone osteoarthritis detection from corresponding X-Ray images of row 1. It means the resultant osteoarthritis images are shown in the row 2 of the figure 2. The accuracy of this algorithm almost greater than 92% to detect osteoarthritis from human being's Shoulder X-Ray images provided images are captured in high resolution, good quality and non-blurred.

Conclusion and Future Attempts

X-Ray image is an important medical imaging component to detect bone related issues and diseases. In this research paper, we have presented an algorithm in the effective terminology to detect osteoarthritis from human's Shoulder x-ray images based on canny edge detection method. The proposed algorithm has been experimented on online available MURA dataset using computer machine environment as specified in the table-1. This algorithm can be utilized by other researchers to devise an efficient medical aided tool for human's Shoulder X-Ray image to detect osteoarthritis. Researchers may have further scope to work in the direction of other types of images such as MRI image, CT Scan image, Mamogram Image, Sonography etc. Further, Research can also work in the field of the X-Ray image analysis to detect other bone related diseases such as fracture, bone tumor, rheumarthritis etc.

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Big Data on Nature

Kajal S. Vadhel

Vivekanand college for advance computer and information science, Surat

kajal.vadhel277@gmail.com

Abstract

Big data in nature refers to the vast amounts of environmental and biological data that have become increasingly available, enabling researchers to study interactions between biological systems and global environmental changes at unprecedented scales (Xia et al., 2020). This data encompasses information from multiple levels, including olecular, tissue, patient, and population levels, addressing questions ranging from Humanscale biology to clinical and epidemic scales.

The use of big data in nature studies has led to significant advancements in understanding biological responses to global changes across various organizational levels, from genes to ecosystems (Xia et al., 2020). Interestingly, while the sheer volume of data is important, the novelty of big data science lies more in the prominence of data as a commodity and the development of specialized methods, infrastructures, and skills to handle this data.

Keywords: Big data, Nature studies, Environmental data, biological data, Global changes, Analytical techniques, Data curation, Cyberinfrastructure, Data integration, Data driven theories, biological predictions, Earth system models.

1.Introduction

The term "big data in nature" describes the enormous and intricate datasets produced by natural phenomena. These datasets include information from a variety of sources, such as weather patterns, animal migration, environmental sensors, and ecological interactions. Because they are so vast and varied, they cannot be efficiently managed or analysed by traditional data processing methods; instead, specialized techniques are needed to extract valuable insights about the natural world.

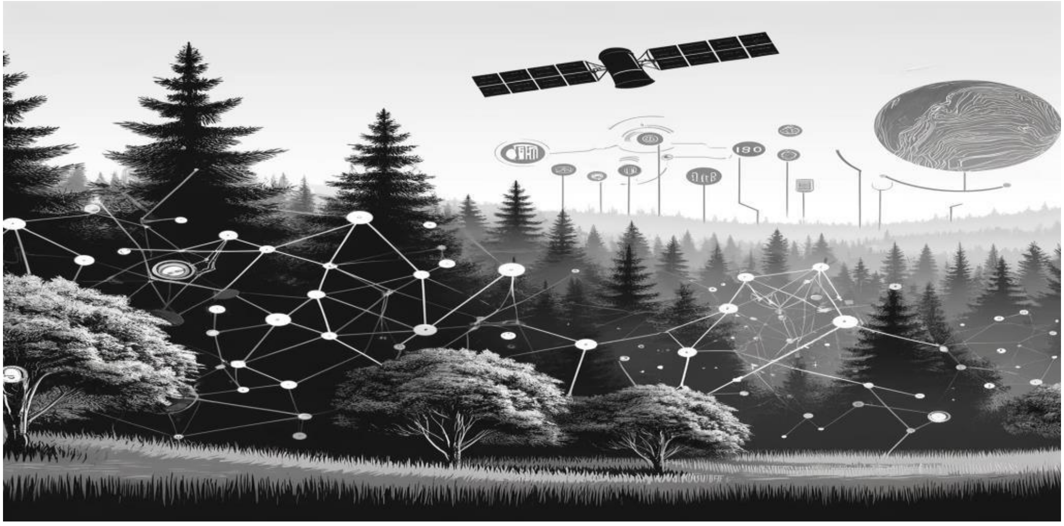

Figure 1

Identifying research gaps in big data applications for nature and environmental studies entails determining where existing information is restricted or where new methodologies can considerably increase understanding

2.Background and Historical Context

Big data in nature-focused research has changed dramatically, owing to technology improvements, rising environmental issues, and the need for informed decision making. Here is a summary of the historical progression and important milestones: emergence of environmental data collection.

Early days:

Before the digital era, environmental data collection relied heavily on field observations, manual surveys, and paper records. Organizations like the U.S. Geological Survey (USGS) and meteorological departments began systematically documenting natural phenomena in the 19th century.

2.1 Key Development:

The invention of remote sensing in the mid-20th century enabled the collection of large-scale environmental data, such as land cover and atmospheric changes.

Challenges: Data silos led to manual processing and insufficient integration with other sources.

3.Scope of Big Data

The application of big data in nature and environmental research offers vast opportunities to address pressing ecological challenges, improve resource management, and deepen our understanding of natural systems. Below are the key

3.1 areas of scope:

Environmental Monitoring and Conservation.

Biodiversity assessment involves integrating big data from sensors, drones, and citizen science platforms to track species distribution, migration patterns, and population dynamics.

3.2 Habitat Conservation:

Analyze land-use changes and ecosystem fragmentation to identify critical habitats for protection.

Energy optimization involves forecasting renewable energy generation (solar, wind, hydro) based on environmental factors such as sunlight intensity and wind patterns. Spatial data can be used in natural resource management to monitor exploitation, reduce environmental damage, and enforce restrictions.

3.3 Policy and Decision Support:

In a big data study on nature, the results and discussion part is essential for analysing the results and their wider ramifications. Usually, the analytical results are summarized in this part and linked to conservation, ecological, or environmental goals.

3.4 Temporal and Spatial Trends:

maps that display changes over time or regional dispersion. Examples include the use of GPS data to track wildlife migration routes.

Changes in vegetation cover were identified using satellite photography.

3.5 Model Results: outcomes of statistical or machine learning models.

Examples include forecasts of habitat loss brought on by climate change. Hotspots for species richness were found using ecological modeling.

Analysis by Comparison: variations among species, geographical areas, or historical times. An illustration would be a comparison of the rates of deforestation in protected and non-protected areas.

3.6 Examples of Cases:

Emphasize particular cases or places where important insights are revealed by the data.

Example: Using real-time satellite monitoring to identify illicit forestry activities.

Example Results: a two-decade decline of 30% in wetland areas.

Five new high-risk areas for poaching have been identified. deteriorating coral reef health and rising sea temperatures are correlated.

Comprehending Nature Data in Big Data

4.1 Nature Studies Data Types:

In nature study, big data originates from a variety of sources and forms.

4.1.1 Organized Information:

For instance, weather station tabular data (temperature, precipitation).

Qualities: arranged in rows and columns, making it simple to examine using spreadsheets or SQL.

4.1.2 Unorganized Information:

Examples include audio recordings of bird sounds and pictures captured by camera traps.

Features: Needs certain techniques for interpretation, such as machine learning.

4.1.3 Semi-structured Information:

For instance, XML or JSON files from APIs that offer environmental data. Features: Has some structure but isn't compatible with conventional tabular formats.

4.1.4 Geographic Information:

For instance, GIS shapefiles, satellite photos, or geotagged animal tracking information.

Features: Frequently include coordinates for spatial analysis and mapping.

4.2 Sources of Data Collection:

In nature, big data is gathered by a range of cutting-edge technologies and cooperative initiatives:

Aerial photography, drones, and satellites are used in remote sensing to monitor huge areas (for example, forest cover).

IoT devices: Intelligent sensors that continuously measure soil moisture, temperature, and humidity.

Citizen Science Platforms: Contributions from the general public using applications such as Globe at Night, eBird, or iNaturalist. Bioacoustics sensors, camera traps, and DNA sampling (for species identification, for example) are examples of biological monitoring. Open Data Repositories:

databases such as NOAA (National Oceanic and Atmospheric Administration) and GBIF (Global Biodiversity

Information Facility).

Big Data on Nature Discussion

Interpreting results, resolving issues, and investigating ramifications for environmental research, conservation, and government are the main topics of conversation when it comes to big data applications in nature. This is a thorough conversation framework designed just for this situation:

5.1 Results Interpretation:

By exposing patterns, correlations, and trends that conventional approaches would overlook, big data offers previously unheard-of insights into natural systems.

Important interpretations consist of:

Trends in Ecology:

Satellite data reveals the influence of humans on biodiversity by highlighting trends in deforestation across decades.

Sensor time-series data demonstrates changes in precipitation and temperature that are associated with climate change. Places of Biodiversity Hotspot:

Machine learning techniques identify areas with high conservation priorities by predicting the distribution of species.

In isolated areas, acoustic data reveals species that were previously unobserved. Impact on Humans:

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Spatial data identifies pollution hotspots in rivers and oceans, emphasizing areas for cleanup or policy intervention.

5.2 Scale and Precision Advantages of Big Data in Nature Studies:

Large-scale monitoring of forests, glaciers, and urban growth is made possible via remote sensing.

Granular, real-time environmental data (such as the difference in air quality between urban and rural areas) is provided by IoT devices.

Modeling for Prediction:

Future ecological changes, including habitat suitability under varying climatic scenarios, are predicted by machine learning and artificial intelligence.

Models for disaster forecasting enable preventative actions by warning of droughts or floods. Combining Data from Various Sources: Accuracy and scope are increased by combining ground surveys, satellite photography, and citizen science.

Conclusion

Big data has become a game-changing tool for comprehending and solving problems in environmental and natural science research. Researchers may find patterns, track changes, and forecast future trends with previously unheardof accuracy and scale by combining a variety of datasets, from satellite photos and IoT sensor readings to citizen scientific contributions.

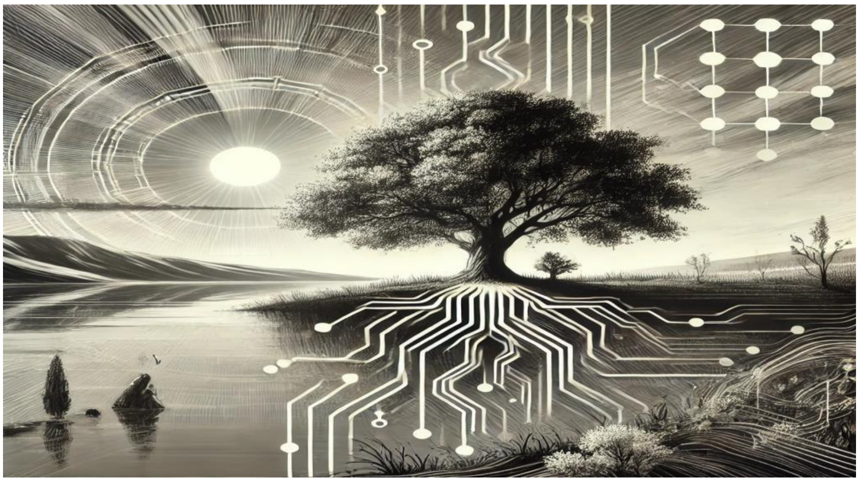

Figure 2

Important lessons learned include:

Improved Ecosystem Understanding: Big data makes it possible to thoroughly analyse intricate ecological systems, providing information on species relationships, biodiversity, and environmental health. Making Well-Informed Decisions: Spatial analysis and predictive models assist conservationists and policymakers in setting priorities, allocating resources as efficiently as possible, and creating winning plans of action.

Scalable Solutions for Global Challenges: By offering practical insights, the use of big data technologies tackles important global challenges including species extinction, deforestation, and climate change. But there are drawbacks to big data's promise as well, such as handling enormous datasets, guaranteeing fair access to technology, and dealing with moral dilemmas like data sensitivity.

In the end, using big data into research entered on nature is an important step toward attaining sustainability and adaptability to environmental change. Big data can be crucial to protecting the environment for coming generations by encouraging creativity and collaboration across fields and geographical boundaries.

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An analytical study of revenue generated from various models of Goods and Service Tax (GST)

Dr. Tathagat P. Patel

Adhyapak Sahayak - Commerce and Accountancy

Sheth C.D. Barfiwala college of Commerce, Surat

E-mail id: tathagatp22@gmail.com

Abstract:

GST known as Goods and Service tax is an indirect tax which is imposed in India on the supply of goods and services. It is an indirect tax which is to be levied on manufacture, sale and consumption of goods and services at the national level. Most of the countries follow a unified GST model while some countries including India had adopted a dual GST Model wherein the tax is imposed by the Central and State both. The present study deals with analysis of the revenue collected from various models of GST which includes CGST, SGST, IGST – Domestic and IGST – Imports. The data of revenue collected for last 5 financial years starting from 2019-20 to 2023-24 has been used in this study. The data has been presented through diagrams, charts to have a better understanding. Descriptive statistics were employed for data analysis. CAGR was utilized to assess the growth in revenue over a five-year period (from 2019-20 to 2023-24). the Mann-Kendall test was employed to determine if statistically significant trends existed in revenue collection over time. From the study is has been observed that the average revenue from all the models of GST has increased over a period of time. For all the models of GST more fluctuation in the collection of tax revenue is observed in the year 2020-21. The study indicates that the revenue from taxes has increased from 2019-20 to 2023-24 which is a healthy sign for the development of economy.It will be helpful to the government in planning for various important expenditure.

Key Words: GST, CGST, SGST, IGST – Domestic, IGST - Imports

Introduction:

Tax is a mandatory financial charge placed on individuals or entities by a government to finance various public expenditures. Nearly every country has a tax system which cover national needs and governmental functions. The government has to spend money on purposes such as economic infrastructure, scientific research, defense, culture and arts, as well as activities that promote national welfare. To cover these costs, the government collects the necessary funds through different types of taxes.

GST known as Goods and Service tax is an indirect tax which is imposed in India on the supply of goods and services. It is an indirect tax which is to be levied on manufacture, sale and consumption of goods and services at the national level. This act came into force from 1st July, 2017 under 101st amendment of the Constitution Act, 2016. GST is termed as "One Nation One Tax." GST is a destination based, single comprehensive and multi stage tax to be levied on goods consumed and services rendered in an economy.

In GST almost all the indirect taxes are subsumed thus it signifies the concept of One Nation One tax. The complexity in the indirect tax structure of India gets reduced with the implementation of GST. Most of the countries follow a unified GST model while some countries including India had adopted a dual GST Model wherein the tax is imposed by the Central and State both.

Review of Literature:

Basak, N had studied the impact of GST in India. The study is of descriptive nature. The researcher had discussed about concept of GST, formation of GST council, as well as positive and negative impact of GST on Indian Economy and on the foreign investment. The researcher had also discussed several measures to minimize the loopholes after implementation of GST. He mentioned that GST had replaced majority of indirect taxes which would result in fall of compliance cost, increase the public revenue, increase the investment, create a common market within states, etc. He concluded that reverse charge mechanism, submission of return and adjustment with the input tax credit are the areas which provided the scope for future research.

Kaur, M and others (2016) had studied the possible impact of GST after its implementation. They had discussed the registration process under proposed GST regime. In the paper the authors had made comparison between the present tax system and proposed GST tax system. The difference in the tax rate of various products before and after GST had also been discussed. It had been observed that under GST majority of the indirect taxes are subsumed. The taxes collected by the local bodies were not subsumed under GST system. The authors concluded that GST will play a dynamic role in the growth and development of our country.

Madhubala (2018) throws light on the concept of GST as well as on the positive and negative impact of GST on Indian Economy. The researcher had discussed about the need to introduce the GST in Indian Economy. She had mentioned about the various bottlenecks presentin the existing tax structure. She stated that GST would increase tax revenue, reduce production cost, and increase in standard of living. She concluded that the macroeconomic impact of GST is significant in terms growth of effects, price effects, budget balance effect and current account effects. She suggested that a consumption based tax is likely to provide a good source of revenue as compared to income based tax. She also stated that the proposed structure of GST will simplify the procedure and make it more transparent which will ultimately reduces tax evasion.

Jadhav B, and Chaudhari C (2019) had undertaken a study on Implementation of GST and its impact. The researchers had discussed about the concept of GST and its theoretical framework. They made comprehensive comparison between Multiple Indirect tax laws and GST law. It is observed that the present GST system proves to be a cost saving system to final consumer. The researchers had also discussed the Input tax credit under CGST, SGST and IGST. The researchers concluded that the GST will be a logical step towards the widespread indirect tax reforms in India. It is observed that almost 150 countries have implemented the GST in some form.

Problem Statement

Tax is one of the major source of revenue for the government. The government has to spend for various expenditure which includes infrastructure development., defense, development of agriculture, etc. The revenue collected from GST will give a clear idea to the government in the implementation of financial and economic policies. The growth rate and trend observed in the collection of revenue has been studied.

Objectives of the study

1. To undertake analytical study of revenue collected from different models under GST.

2. To study the growth rate and trend observed in the revenue collected from different models under GST.

Scope of the study

1. The study covers the data of revenue collected for last 5 financial years starting from 2019-20 to 2023-24.

Structure of GST

GST has dual model structure wherein the tax has been collected by the Central and State government. The model includes the following types of GST.

CGST – Central Goods and Service tax.

It is collected by the Central Government on an Intra-State sale.

SGST – State Goods and Service tax.

It is collected by the State Government on an Intra-State sale.

IGST – Integrated Goods and Service tax.

It is collected by the Central Government on Inter – state sale

Research Methodology:

The data regarding revenue collection from various models of GST has been collected from published report. The data has been presented through diagrams, charts to have a better understanding. Descriptive statistics were employed for data analysis. CAGR representing the Compounded Average Growth Rate over the specified time frame. CAGR was utilized to assess the growth in revenue over a five-year period (from 2019-20 to 2023-24).

Additionally, the Mann-Kendall test was employed to determine if statistically significant trends existed in revenue collection over time. The Mann-Kendall test was used to test the following hypotheses:

H_0: No significant trend is observed in the revenue collection

Data analysis:

Table 1: Table showing yearwise collection of CGST (Rs in Crores)

Years					
Month	FY19-20	FY20-21	FY21-22	FY22-23	FY23-24
Apr	21163	5067	27837	33159	38440
May	17811	10330	17592	25036	28411
June	18366	18980	16424	25306	31013
July	17912	16147	22197	25751	29773
Aug	17733	15906	20522	24710	28328
Sept	16630	17741	20578	25271	29818
Oct	17581	19193	23861	26039	30062
Nov	19592	19189	23978	25681	30420
Dec	19962	21365	22578	26711	30443
Jan	20944	21932	24869	29051	32685
Feb	20569	21092	24435	27662	31785
Mar	19181	22973	25830	29546	34532
Total	227444	209915	270701	323923	375710

[Source: https://www.gst.gov.in/ A Statistical Report on Completion of 7 years of GST]

Table 2: Descriptive statistics of revenue collected from CGST

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FY 19-20	12	16630	21163	18953.67	1490.502
FY 20-21	12	5067	22973	17492.92	5185.327
FY 21-22	12	16424	27837	22558.42	3325.322
FY 22-23	12	24710	33159	26993.58	2492.298
FY 23-24	12	28328	38440	31309.17	2834.991
Valid N (listwise)	12				

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Chart 1: Chart showing revenue collected from CGST

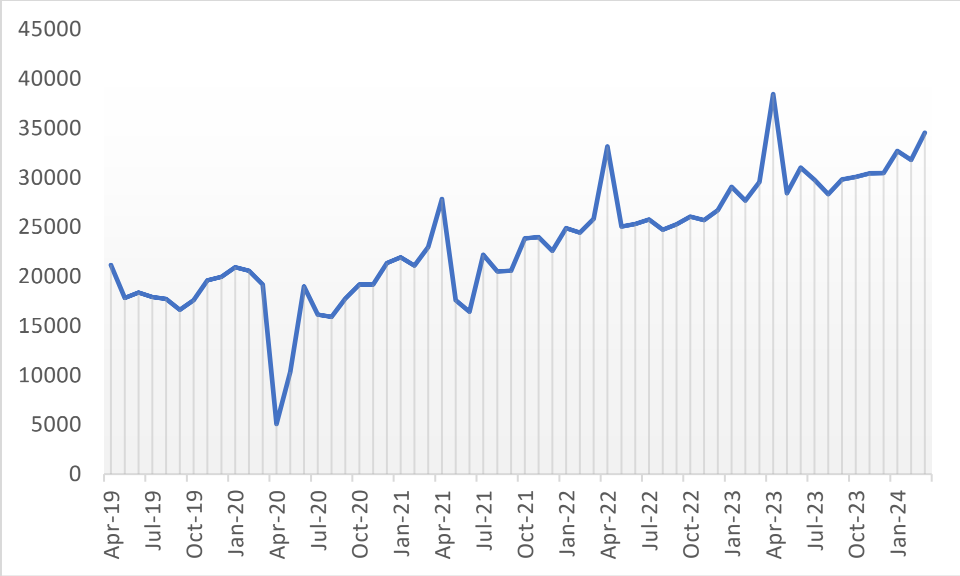
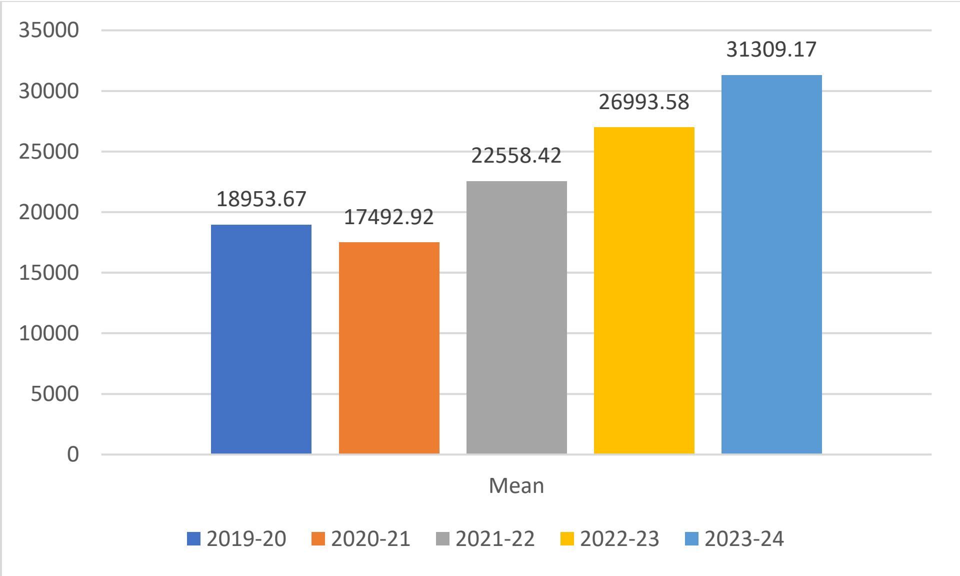


Chart 2: Chart showing yearwise mean collection of revenue from CGST



From the above data the revenue collected from CGST has been increasing except for the year 2020-21. The average revenue from CGST in the year 2023-24 is Rs 31,309.17 crore while it was Rs 18.953.67 in the year 2019-20. In the year 2020-21 the average revenue from CGST was Rs 17,492.92 crore Rs. The decline in the revenue can be due to the lockdown during covid -19 pandemic. The highest revenue collection was in the month of April in the year 2019-20, in the month of March in the year 2020-21, in the month of April in the year 2021-22, 2022-23 and 2023-24.

Table 3: Table showing co-efficient of variance of revenue collected from CGST

Year	Coefficient of variance
2019-20	7.86 %
2020-21	29.64 %
2021-22	14.74 %
2022-23	9.23 %
2023-24	9.05 %

From the above table it is observed that Co-efficient of variance is highest in the year 2020-21 followed in the year 2021-22 which indicates that more fluctuation observed in the monthly collection of CGST in the above years as compared to the remaining financial years. The lowest fluctuation is observed in the financial year 2019-20 as the coefficient of variance is 7.86%.

Table 4: Table showing yearwise collection of SGST (Rs in Crores)

	Years				
Month	FY19-20	FY20-21	FY21-22	FY22-23	FY23-24
Apr	28801	5951	35621	41793	47412
May	24462	12911	22653	32001	35828
June	25343	23970	20397	32406	38292
July	25007	21418	28541	32807	37623
Aug	24239	21064	26605	30951	35794
Sept	22598	23131	26767	31813	37657
Oct	23674	25411	30421	33396	38171
Nov	27145	25540	31127	32651	38226
Dec	26792	27804	28658	33357	37935
Jan	28223	29025	32239	36847	40895
Feb	27348	27273	30779	34915	39615
Mar	25598	29329	32378	37314	43746
Total	309230	272827	346186	410251	471194

[Source: https://www.gst.gov.in/ A Statistical Report on Completion of 7 years of GST]

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Table 5: Descriptive statistics of revenue collected from SGST

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FY 19-20	12	22598	28801	25769.17	1905.329
FY 20-21	12	5951	29329	22735.58	6933.349
FY 21-22	12	20397	35621	28848.83	4269.550
FY 22-23	12	30951	41793	34187.58	3087.679
FY 23-24	12	35794	47412	39266.17	3348.907
Valid N (listwise)	12				

Chart 3: Chart showing revenue collected from SGST

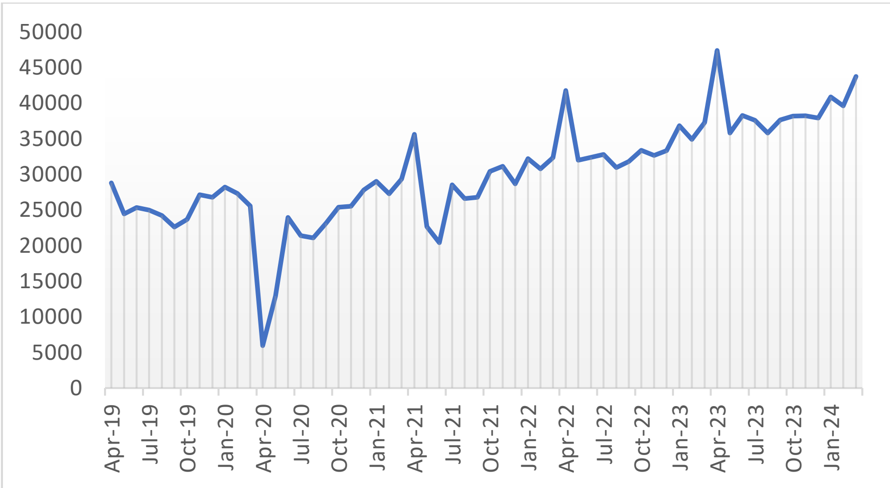
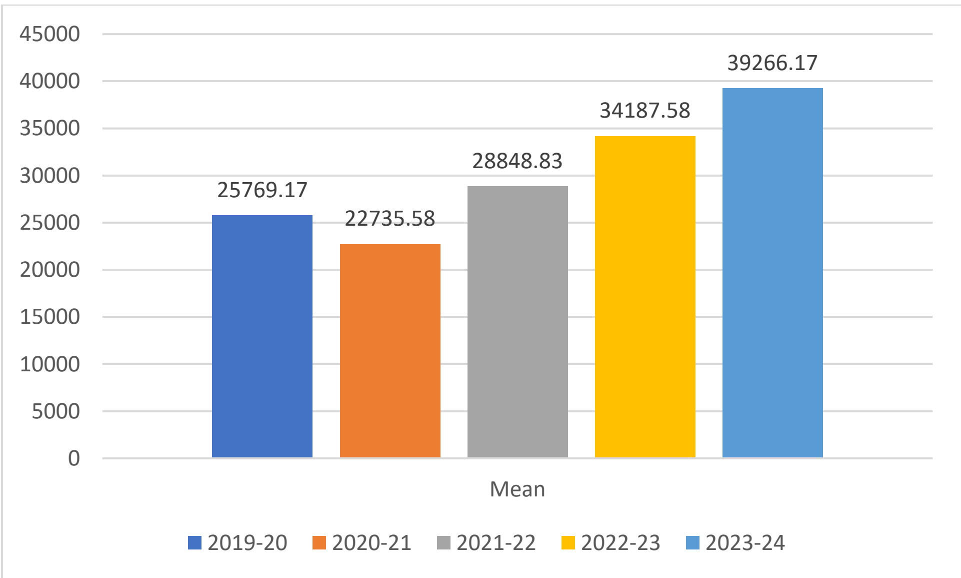


Chart 4: Chart showing year wise mean collection of revenue from SGST



From the above data the revenue collected from SGST has been increasing except for the year 2020-21. The average revenue from SGST in the year 2023-24 is Rs 39,266.17 crore while it was Rs 25,769.17 in the year 2019-20. In the year 2020-21 the average revenue from CGST was Rs 22,735.58 crore Rs. The decline in the revenue can be due to the lockdown during covid -19 pandemic. The highest revenue collection was in the month of April in the year 2019-20, in the month of March in the year 2020-21, in the month of April in the year 2021-22, 2022-23 and 2023-24.

Table 6: Table showing co-efficient of variance of revenue collected from SGST

Year	Coefficient of variance
2019-20	7.39 %
2020-21	30.50 %
2021-22	14.80 %
2022-23	9.03 %
2023-24	8.53 %

From the above table it is observed that Co-efficient of variance is highest in the year 2020-21 followed in the year 2021-22 which indicates that more fluctuation observed in the monthly collection of SGST in the above years as compared to the remaining financial years. The lowest fluctuation is observed in the financial year 2019-20 as the coefficient of variance is 7.39%.

Table 7: Table showing yearwise collection of IGST Domestic

(Rs in Crores)

Years					
Month	FY19-20	FY20-21	FY21-22	FY22-23	FY23-24
Apr	31444	7956	38882	45234	54186
May	25015	16062	27197	35876	39591
June	25792	24594	23317	35785	41256
July	26366	22268	29964	38098	44691
Aug	24140	23085	29363	35715	39701

Sept	22972	25042	31356	39249	42477
Oct	25071	29165	34363	44481	49188
Nov	28078	29913	34650	38468	47810
Dec	26804	30375	31628	38172	42721
Jan	29532	32869	36983	42561	48952
Feb	27758	30871	33634	39380	45505
Mar	26450	31745	35339	40404	47625
Total	319422	303945	386676	473423	543703

[Source: https://www.gst.gov.in/ A Statistical Report on Completion of 7 years of GST]

Table 8: Descriptive statistics of revenue collected from IGST – Domestic

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FY 19-20	12	22972	31444	26618.50	2343.620
FY 20-21	12	7956	32869	25328.75	7340.094
FY 21-22	12	23317	38882	32223.00	4349.881
FY 22-23	12	35715	45234	39451.92	3218.988
FY 23-24	12	39591	54186	45308.58	4415.349
Valid N (listwise)	12				

Table 9: Table showing yearwise collection of IGST from imports

(Rs in Crores)

Years					
Month	FY19-20	FY20-21	FY21-22	FY22-23	FY23-24
Apr	23289	12074	27996	36705	34972
May	24875	16640	26002	37469	41772
June	21980	15709	25762	40102	39035
July	24246	20324	27900	41420	41239
Aug	24818	19179	26884	42067	43550
Sept	22097	22442	29555	41215	41145
Oct	21446	23375	32998	37297	42127

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Nov	20948	22078	32165	38635	39198
Dec	21295	27050	37527	40263	41534
Jan	23481	27424	37199	38434	39598
Feb	20745	24382	33837	35689	38593
Mar	18056	31097	39131	42503	40322
Total	267276	261774	376956	471799	483085

[Source: https://www.gst.gov.in/ A Statistical Report on Completion of 7 years of GST]

Table 10: Descriptive statistics of revenue collected from IGST – Imports

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
FY 19-20	12	18056	24875	22273.00	1983.166
FY 20-21	12	12074	31097	21814.50	5415.714
FY 21-22	12	25762	39131	31413.00	4753.693
FY 22-23	12	35689	42503	39316.58	2255.790
FY 23-24	12	34972	43550	40257.08	2210.984
Valid N (listwise)	12				

Chart 5: Chart showing revenue collection from IGST – Domestic and Imports

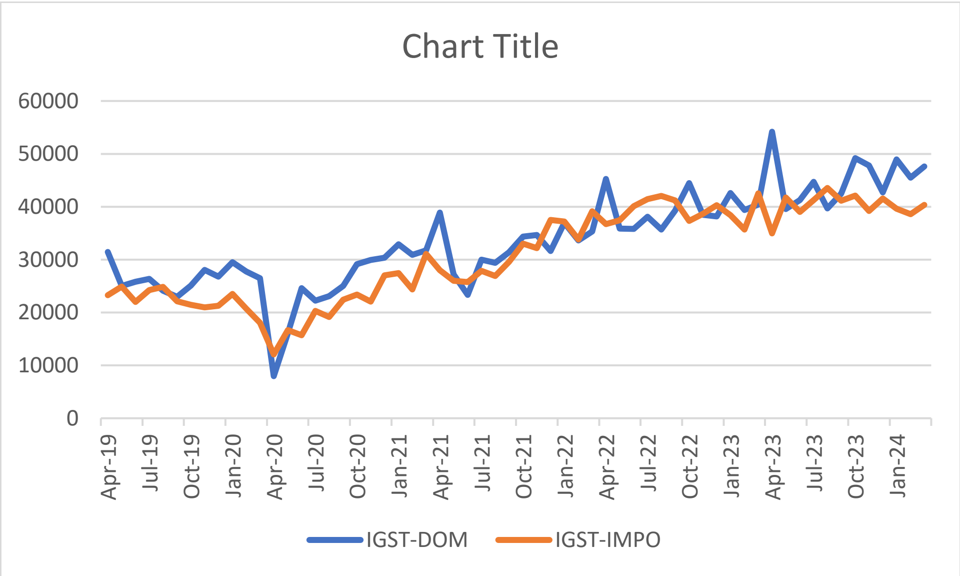
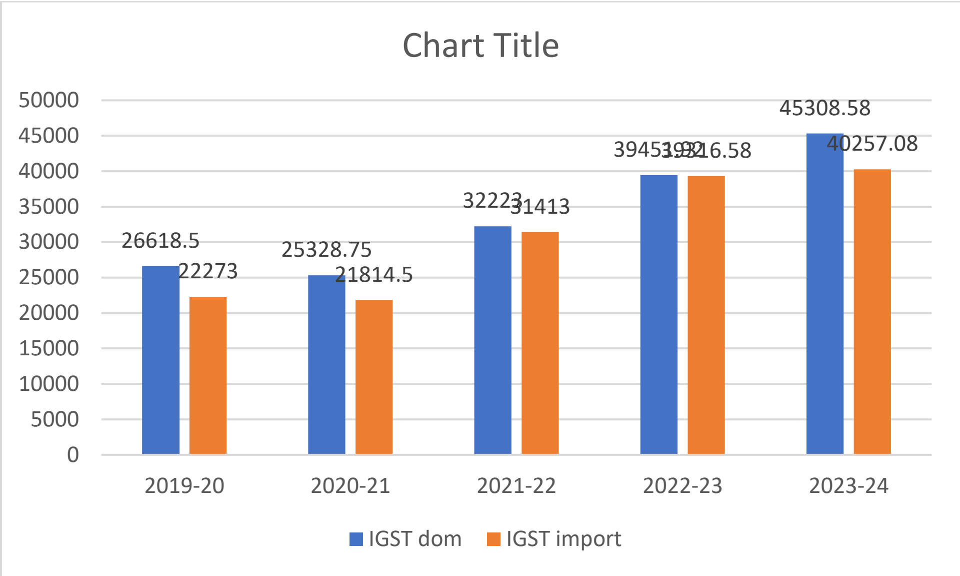


Chart 6: Chart showing yearwise mean collection of revenue from IGST Domestic and Imports



From the above data the revenue collected from IGST Domestic and imports has been increasing except for the year 2020-21. The average revenue from IGST Domestic in the year 2023-24 is Rs 45,308.58 crore and from IGST Imports is Rs 40,257.08 crore while it was Rs 26,618.5 crore and Rs 22,273 crore for IGST Domestic and IGST Imports respectively in the year 2019-20. In the year 2020-21 the average revenue from IGST Domestic was Rs 25,328.75 crore and for import Rs 21,814.5. The decline in the revenue can be due to the lockdown during covid -19 pandemic. The highest revenue collection was in the month of April in the year 2019-20, 2021-22, 2022-23 and 2023-24 while for the year 2020-21 the highest revenue collection was observed in the month of March for IGST Domestic. For IGST Imports the highest revenue collection was reported in the month of May for the year 2019-20, in the month of march for the year 2020-21, 2021-22 and in the year 2022-23 in the month of March while for the year 2023-24 the highest revenue collection was observed in the month of August. For all the financial years the IGST collected from domestic is higher than the IGST collected from Imports.

Table 11: Table showing co-efficient of variance of revenue collected from IGST - Domestic

Year	Coefficient of variance
2019-20	8.80 %
2020-21	28.98 %
2021-22	13.50 %
2022-23	8.16 %
2023-24	9.75 %

Table 12: Table showing co-efficient of variance of revenue collected from IGST - Imports

Year	Coefficient of variance
2019-20	8.90 %
2020-21	24.83 %
2021-22	15.13 %
2022-23	5.74 %
2023-24	5.49 %

From the above table it is observed that Co-efficient of variance is highest in the year 2020-21 followed in the year 2021-22 for IGST Domestic and Imports which indicates that more fluctuation observed in the monthly collection of IGST in the above years as compared to the remaining financial years. The lowest fluctuation is observed in the financial year 2019-20 which is 8.80% for IGST Domestic and 8.90% for IGST Imports.

Table 13: Table showing CAGR of different category of revenue

	Yearwise Mean (in Crore Rs)					
Revenue model	FY 19-20	FY 20-21	FY 21-22	FY 22-23	FY 23-24	CAGR
CGST	18953.67	17492.92	22558.42	26993.58	31309.17	13.37%
SGST	25769.17	22735.58	28848.83	34187.58	39266.17	11.10%
IGST DOM	26618.5	25328.75	32223	39451.92	45308.58	14.22%
IGST IMPORTS	22273	21814.5	31413	39316.58	40257.08	15.95%

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From the above data it is observed that the CAGR revenue collection for IGST (Domestic and Imports) is higher than the CGST and SGST. It indicates that the during the last five years the inter-state sale of goods has increased more rapidly than the intra-state sales. It also indicates increase in the import of goods. An increase in imports will increase the tax revenue but it will reduce foreign exchange in the economy.

Mann Kendall Test:

Mann Kendall test has been performed to identify whether a significant trend observed in the revenue collection. The following hypothesis were tested using Mann Kendall Test.

H_0: No significant trend is observed in the revenue collection

Table: 14 Mann Kendall Test statistics for CGST:

CGST			
Financial Year	Trend	p-value	H0 Rejected
FY19-20	no trend	0.537134	FALSE
FY20-21	increasing	0.00047	TRUE
FY21-22	increasing	0.033524	TRUE
FY22-23	no trend	0.064104	FALSE
FY23-24	no trend	0.086471	FALSE

It is observed that increasing trend has been observed in the collection of CGST for the year 2020-21 and 2021-22. For the remaining years as the p value is more than 0.05, we have to accept null hypothesis which indicates that no significant trend is observed in the revenue collection from CGST.

Table: 15 Mann Kendall Test statistics for SGST

SGST			
Financial Year	Trend	p-value	H0 Rejected
FY19-20	no trend	0.631222	FALSE
FY20-21	increasing	0.000279	TRUE

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FY21-22	increasing	0.046745	TRUE
FY22-23	no trend	0.114757	FALSE
FY23-24	no trend	0.149861	FALSE

It is observed that increasing trend has been observed in the collection of SGST for the year 2020-21 and 2021-22. For the remaining years as the p value is more than 0.05, we have to accept null hypothesis which indicates that no significant trend is observed in the revenue collection from CGST.

Table: 16 Mann Kendall Test statistics for IGST – Domestic

IGST - Domestic			
Financial Year	Trend	p-value	H0 Rejected
FY19-20	no trend	0.45067	FALSE
FY20-21	increasing	0.000093	TRUE
FY21-22	no trend	0.064104	FALSE
FY22-23	no trend	0.303673	FALSE
FY23-24	no trend	0.303673	FALSE

It is observed that increasing trend has been observed in the collection of IGST - Domestic for the year 2020-21. For the remaining years as the p value is more than 0.05, we have to accept null hypothesis which indicates that no significant trend is observed in the revenue collection from CGST.

Table: 17 Mann Kendall Test statistics for IGST – Imports

IGST - Imports			
Financial Year	Trend	p-value	H0 Rejected
FY19-20	decreasing	0.011175	TRUE
FY20-21	increasing	0.000279	TRUE
FY21-22	increasing	0.00203	TRUE
FY22-23	no trend	0.731702	FALSE
FY23-24	no trend	0.837011	FALSE

It is observed that increasing trend has been observed in the collection of IGST - Imports for the year 2020-21 and 2021-22 whereas decreasing trend has been observed in the year 2019-20. For the remaining years as the p value is more than 0.05, we have to accept null hypothesis which indicates that no significant trend is observed in the revenue collection from CGST.

Key findings of the study:

The major findings of the study is summarized below:

1. The average revenue from all the models of GST has increased over a period of time.

2. For all the models of GST more fluctuation in the collection of tax revenue is observed in the year 2020-21.

3. CAGR for IGST Import (15.95%) is higher than the other components

4. For CGST, SGST, IGST – Domestic and IGST Imports, increasing trend in the revenue collection has been observed in the year 2020-21

Conclusion:

GST being one nation one tax, an increase in the average revenue is a good sign for the government. For all the year except 2020-21 less fluctuation has been observed in the revenue collection throughout the year, which will be helpful to the government in planning for various important expenditure. The study indicates that the revenue from taxes has increased from 2019-20 to 2023-24 which is a healthy sign for the development of economy.

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Harnessing the Transformative Power of Workforce Data: A Comprehensive Exploration of HR Analytics

Dr.Chandni Desai

SACMA English Medium Commerce College (B.Com. & M.Com.) & Shri. Hasmukhlal Hojiwala College of Business Administration (BBA) & Smt. Ushaben Jayvadan Bodawala College of Computer Application (BCA)

Email id: chandnidesai11@gmail.com

Abstract

Human resource management has undergone a transformative shift in recent years, marked by the integration of advanced data analytics techniques. This research paper delves into the rapidly evolving field of HR analytics, exploring its potential to unlock unprecedented insights and drive strategic decision-making within organizations. Through a meticulous examination of relevant literature, this paper outlines the key components of HR analytics, including descriptive, predictive, and prescriptive analytics. Moreover, it underscores the pivotal role of HR analytics in equipping organizations to navigate the complex landscape of talent management, the exponential growth of data, and the imperative for more informed and agile decision-making (DiClaudio, 2019) (McGinty & Лылова, 2020).

Objectives

The primary objectives of this research paper are:

Objectives:

- To provide a comprehensive overview of HR analytics, its key components, and their respective applications within the modern organizational context.
- To examine the transformative impact of HR analytics on talent management, decision-making, and organizational performance.
- To explore the challenges and opportunities associated with the implementation of HR analytics, with a particular focus on developing country perspectives.

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The Rise of HR Analytics

In the face of intensifying competition for top talent and the ever-increasing volumes of data, organizations are increasingly turning to HR analytics as a powerful tool to gain a competitive edge (McGinty & Лылова, 2020). The integration of advanced data analytics techniques has enabled HR professionals to move beyond traditional, reactive approaches, and instead, adopt a more proactive, data-driven strategy. As organizations strive to attract, retain, and nurture their most valuable asset – their workforce – HR analytics has emerged as a transformative discipline, empowering HR leaders to uncover valuable insights,

predict future trends, and devise tailored interventions (McGinty & Лылова, 2020).

The Evolving Landscape of HR Analytics

The expanding application of HR analytics can be categorized into three distinct types: descriptive, predictive, and prescriptive analytics (Asuming-Brempong & Lamptey, 2020). Descriptive analytics focuses on analyzing historical data to understand past trends and patterns within the workforce, providing a solid foundation for informed decision-making. Predictive analytics, on the other hand, leverages sophisticated algorithms to forecast future outcomes, enabling organizations to anticipate and respond to potential challenges or opportunities (Qin et al., 2023). Prescriptive analytics takes this a step further, providing actionable recommendations to optimize workforce strategies and align them with organizational goals. (DiClaudio, 2019) (Asuming-Brempong & Lamptey, 2020) (McGinty & Лылова, 2020)

The rise of HR analytics has been further accelerated by advancements in cloud-based human capital management systems and the increasing availability of sophisticated data visualization tools. These technological innovations have not only streamlined data collection and integration but also empowered HR professionals to transform complex workforce data into meaningful insights, driving more informed and agile decision-making

Defining HR Analytics: Concepts, Scope, and Evolution

HR analytics is a multifaceted discipline that encompasses the collection, analysis, and interpretation of workforce data to inform strategic decision-making and drive organizational performance. This emerging field has gained significant traction in recent years, as organizations recognize the value of leveraging data-driven insights to optimize their most valuable asset – their human capital.

By leveraging data-driven insights, HR analytics empowers HR professionals to move beyond gut feelings and make evidence-based decisions that align with organizational goals. (Praba et al., 2024)

HR analytics is like being a detective for your workforce! It's about using data to understand what's happening with your people and then using those insights to make better decisions.

Instead of relying on gut feelings, HR analytics uses data to answer questions like:

1. What drives employee turnover?
2. Which recruitment strategies are most effective?
3. How can we improve employee engagement and performance?

Think of it as turning raw data from HR systems (like payroll, performance reviews, and engagement surveys) into actionable insights.

Here's a simple breakdown:

4. **Collect:** Gather data from all relevant sources.
5. **Analyze:** Identify patterns, trends, and relationships in the data.
6. **Interpret:** Translate the data into meaningful insights.
7. **Act:** Make informed decisions and develop strategies based on the findings.

For example: Let's say your company is struggling with high turnover. HR analytics can help you pinpoint the specific departments, roles, or even managers where turnover is highest. You can then dig deeper to understand the reasons behind it – Is it compensation? Lack of growth opportunities? Management style? – and develop targeted interventions to address the root causes.

Ultimately, HR analytics helps organizations make smarter decisions about their workforce, leading to improved employee experiences, increased productivity, and a stronger bottom line.

The scope of HR analytics extends beyond the traditional HR function, integrating data from various sources, including employee records, performance management systems, and even external data points, such as labor market trends and industry benchmarks.

Key Components of HR Analytics:

1. Descriptive Analytics: This involves analyzing historical data to understand past trends and patterns within the workforce, providing a solid foundation for decision-making. Descriptive analytics, a foundational component of HR analytics, involves the examination of historical workforce data to uncover trends, patterns, and correlations. (Hsiao & Chen, 2018) This form of analysis focuses on what has happened in the past to provide a clear understanding of the current workforce landscape. Descriptive analytics can reveal insights into employee turnover, productivity levels, skill gaps, and other critical workforce metrics, enabling HR professionals to make more informed decisions.

2. Predictive Analytics: Predictive analytics in HR leverages the power of statistical modeling, machine learning algorithms, and historical data to anticipate future workforce trends and outcomes. (Jurgens et al., 2016) Instead of simply reflecting on past events, predictive analytics focuses on what is likely to happen in the future, empowering HR professionals to make proactive and data-informed decisions. (Shahid et al., 2021)For instance, predictive analytics can help organizations identify high-potential employees, predict future skill needs, and anticipate employee turnover, ultimately enhancing workforce planning and talent management strategies.

3. Prescriptive Analytics: Going a step further, prescriptive analytics provides actionable recommendations to optimize workforce strategies and align them with organizational goals.Prescriptive analytics takes HR analytics a step further than simply describing the past or predicting the future. (Prescriptive analytics - Wikipedia, 2012) While descriptive analytics sheds light on "what has happened?" and predictive analytics unveils "what might happen?", prescriptive analytics answers the crucial question: "What should we do about it?" (What Exactly The Heck Are Prescriptive Analytics?, 2017) It provides actionable recommendations and data-driven insights to optimize workforce

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strategies and align them with organizational goals. (NGDATA | Prescriptive Analytics, 2023)

Think of prescriptive analytics as a GPS for your HR decisions. (Ding et al., 2014) Just as a GPS uses your current location and destination to suggest the optimal route, prescriptive analytics considers your current workforce data, desired outcomes, and potential constraints to recommend the best course of action. (J & Kumar, 2024)

Here's how it works:

1. **Define Objectives:** Clearly articulate the specific HR goals you want to achieve (e.g., reduce employee turnover, improve performance, enhance diversity and inclusion).
2. **Gather and Analyze Data:** Collect relevant data from various sources, including HR systems, performance management tools, and external benchmarks.
3. **Develop Prescriptive Models:** Utilize advanced algorithms and machine learning techniques to generate data-driven recommendations and simulate the potential impact of different decisions.
4. **Implement and Evaluate:** Put the recommendations into action and continuously monitor the results, making adjustments as needed.

Benefits and Challenges of Implementing HR Analytics

Key Benefits of HR Analytics:

Improved decision-making: HR analytics enables evidence-based decision-making, moving away from reliance on intuition or gut feelings.

Enhanced workforce planning: Predictive analytics helps organizations anticipate future talent needs and proactively address skill gaps.

Increased operational efficiency: By identifying patterns and optimizing processes, HR analytics can streamline HR operations and reduce administrative overhead. Predictive analytics helps organizations anticipate future talent needs and proactively address skill gaps. (Jurgens et al., 2016) This ensures that the organization has the right people with the right skills at the right time.

Greater alignment with business objectives: Prescriptive analytics aligns HR strategies with organizational goals, ensuring that workforce initiatives directly support the company's overall success.

Improved Employee Experiences**:** By understanding employee needs, preferences, and pain points, HR analytics can help organizations create a more engaging and rewarding work environment.

Challenges in Implementing HR Analytics:

Data quality and availability: Ensuring the accuracy, completeness, and integration of HR data can be a significant hurdle.

- Lack of HR analytics expertise: HR professionals may lack the necessary data analysis and statistical skills to effectively leverage HR analytics.
- Change management: Overcoming resistance to data-driven decision-making and fostering a culture that embraces HR analytics can be a significant challenge.
- Privacy and ethical concerns: The use of employee data in HR analytics raises important considerations around data privacy, security, and ethical use. (McGinty & Лылова, 2020) (DiClaudio, 2019)

Future Trends in HR Analytics: AI, Machine Learning, and Beyond

The evolution of HR analytics is closely tied to advancements in technology, particularly in the fields of artificial intelligence and machine learning.

- AI-powered HR Analytics: Artificial intelligence is transforming HR analytics by automating data processing, identifying patterns, and generating actionable insights at scale. This allows HR professionals to analyze vast amounts of data quickly and efficiently, uncovering hidden trends and opportunities that might otherwise go unnoticed.

- Predictive Talent Management: Machine learning algorithms can predict employee turnover, identify high-potential talent, and recommend personalized development opportunities.
- The Rise of the "Augmented HR" Function: Rather than replacing HR professionals, AI and machine learning will augment their capabilities, enabling them to focus on more strategic and human-centric tasks. (McGinty & Лылова, 2020) This will require HR professionals to develop new skills in data literacy, analytical thinking, and ethical decision-making.
- The future of HR analytics is bright, with AI and machine learning playing a pivotal role in shaping the future of work. By embracing these advancements and addressing ethical considerations, organizations can unlock the full potential of their workforce and drive sustainable success in the years to come. (Asuming-Brempong & Lamptey, 2020)

Literature Review

HR analytics has emerged as a pivotal tool in the modern organizational landscape, enabling leaders to harness the power of data-driven insights to drive strategic decision-making (McGinty & Лылова, 2020). The recent advancements in technology and data analytics capabilities have significantly enhanced HR's ability to generate meaningful workforce insights, transitioning the function from a reactive to a predictive engine.

Descriptive analytics, the foundational component of HR analytics, focuses on understanding the current state of the workforce, including employee demographics, performance metrics, and turnover patterns (Asuming-Brempong & Lamptey, 2020). Predictive analytics, on the other hand, leverages historical data to forecast future trends and behaviors, empowering organizations to proactively address potential challenges and opportunities. Finally, prescriptive analytics takes the analysis a step further, providing recommendations on the most effective course of action based on the insights gleaned from the data (McGinty & Лылова, 2020).

The transformative potential of HR analytics has been well-documented in the literature. By integrating people data with other organizational data sources, HR leaders can gain a holistic view of the business, enabling more informed and strategic decision-making. This, in turn, can lead to significant improvements in areas such as talent acquisition, employee engagement, and workforce planning.

The application of HR analytics is not limited to the developed world; developing countries are also recognizing its value in addressing critical human capital challenges. A study conducted in Ghana, for instance, highlighted the strategic implications of HR analytics in gaining a competitive advantage through effective human capital management. However, the implementation of HR analytics in developing countries may face unique challenges, such as limited data infrastructure, talent shortages, and cultural resistance to data-driven decision-making.

Conclusion: HR Analytics - A Strategic Imperative for Organizational Success

In conclusion, the rise of HR analytics has transformed the way organizations manage and optimize their human capital. From descriptive to prescriptive analytics, this data-driven approach enables HR professionals to make evidence-based decisions, enhance workforce planning, and align talent strategies with business objectives. While implementing HR analytics presents various challenges, the benefits – improved decision-making, increased operational efficiency, and greater employee engagement – make it a strategic imperative for organizational success in the modern business landscape. As the field continues to evolve, driven by advancements in AI and machine learning, the future of HR analytics promises even greater insights and transformative impact on the world of work.

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A Comparative Study of Linear Programming Algorithms

Dr. Tarulata A. Patel
Ambaba Commerce College, MIBM and DICA, Sabargam, Surat (Gujarat)
tarulata157@gmail.com

Abstract

This paper focuses on one of the most used techniques of operations research i.e. linear programming. The linear programming is a mathematical method to provide an optimal solution for the problems where objective and the requirements both are linear. The limelight during the second World War. The rapid use of linear programming in various fields started after the Second World War. This study provides insights on the assumptions and properties of the linear programming. It also explains the process of formulating any problem as a linear programming problem if all the assumptions are satisfied. The limitations and mathematical formulation are also problem if all the assumptions are satisfied. The limitations and mathematical formulation are also explained. Some practical applications of linear programming are discussed. This study also provides insight on the latest applications of linear programming problem in various fields like sports, lean manufacturing, financial planning and radiotherapy.

Keywords: Linear programming problem, limitations, assumption, applications

Introduction

"No dreams come true until you wake up and go for work" similarly any problem cannot be resolved unless we fix the problem and try to solve it. Most of the business or planning problems involving resources can be converted into a mathematical problem the only vital condition is all information should be available. These problems involved consist of two major components, one is objective function and the other is constraints. If both objective function and constraints are linear, then they can be framed as a linear programming problem. Here linear means that variable involved in constraints and objective function should not have any power. There are some standard types of Linear programming formulations given in this paper, but the list is indicative not exhaustive as after formulating 1000 problems, there would be another problem where the formulation might be entirely different

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Properties and Assumptions in Linear Programming Problem

A linear programming model is based on the assumption of proportionality, additivity, continuity, certainty, and finite choices. These are given detailed below.

1. Proportionality: The rate of change (slope) of the objective function and the constraint equations with respect to decision variable is constant.

2. Continuity: Decision fractional value and variables can take on any are therefore continuous as opposed to integer in nature.

3. Certainty: Values of all model parameters are assumed to be known with certainty.

Formulation of Linear Programming problem

Steps of Linear Programming Formulation

1. Determine the objective of the problem
2. Identify decision variables and conditions involved
3. Formulate objective function
4. Formulate constraints
5. Express the non-negativity constraints
6. Weather the all the conditions are satisfied

Limitations of linear programming

1. Linear programming linear. But it is not true situations. Considers all relationships as in
many real life and business.

2. As the number of variables and constraints increases the problem becomes very complex
and very Difficult to solve.

3. Linear programming gives its solution in fractions which are not suitable in many practical
situations.

For example- If it can give a solution as construction of 25/4 apartments and 35/3 shops as
optimum solution, which is not possible for any construction company.

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4. Factor pertaining to uncertainty such as, strike, absenteeism of labour, weather conditions,
etc. are not taken into deliberation during formulation.
5. LPP considers only a single objective function; where as in real life and business situations,
there may be more than one objective.

Mathematical Formulation

The Linear Programming problem can be put in the following form, which is also known as standard form of LPP.

Maximize (or Minimize)

$$z = c_1x_1 + c_2x_2 + c_3x_3 + ----+c_nx_n$$

Objective Function Subject to the constraints;

$$a_{11}x_1 + a_{12}x_2 + ----+a_1(\leq, \geq, =)b_1$$
$$a_{21}x_1 + a_{22}x_2 + ----+a_2(\leq, \geq, =)b_2$$
$$a_{m1}x_1 + a_{m2}x_2 + ----+(\leq, \geq, =)b_m$$
$$where\ x_{1,2}, ---- x_m \geq 0$$

Some Examples of Linear Programming Problem

Production Mix Problem

Example on use of linear programming to decide the product mix i.e. to use the quantity of products to be manufactured to get the maximum profit

Formulate the following as a linear programming problem Publishing house publishes three weekly magazines- Daily life, Agriculture today, and Surf's up. Publication of one issue of each of these magazines requires the following amounts of production time and paper.

Table 1: Gives requirements of each product

Magazine	Production (hour)	Paper (kg) Daily Life
Agriculture Today	0.03	0.05
Surf's Up	0.02	0.03

know the number of issues of each magazine to produce per week in order to maximize total sales revenue.

Let publishing house publishes x_1 copies of Daily Life, x_2 copies of Agriculture Today and x_3 copies of Surf's up. Here x_1, x_2 and x_3 are decision variables

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The Objective Function- here objective of the publishing house is to maximize the total sales revenue. Thus, the objective function will be.

$$\text{Max } Z = 22.5x_1 + 40x_2 + 15x_3$$

The Constraints-

- ❖ Paper (Kg)- $0.2x_1+0.5x_2+0.3x_3 \leq 3{,}000$
- ❖ Circulation (issues)– $x_1+x_2+x_3 \geq 5{,}000$
- ❖ Production Hours- $0.01x_1+0.03x_2+0.02x_3 \leq 120$
- ❖ Maximum demand for Daily Life– $x_1 \leq 3{,}000$
- ❖ Maximum demand for AgricultureToday- $x_2 \leq 2{,}000$
- ❖ Maximum demand for Surf'sUp- $x_3 \leq 6000$

Non-Negativity condition-As, x_1, x_2 and x_3 are the Number of unit produced, they cannot be negative. Thus, both of them can assume values only greater-than-or-equal-to zero. This can be stated as.

$x_1 \geq 0$, $x_2 \geq 0$ and $x_3 \geq 0$

Subject To

Hence the mathematical formulation of the problem is

$0.01x_1 + 0.03x_2 + 0.02x_3 \leq 120$

$0.2x_1 + 0.5x_2 + 0.3x_3 \leq 3,$

$000x_1 + x_2 + x_3 \geq 5{,}000$

$x_1 \leq 3{,}000$

$x_2 \leq 2{,}000$

$x_3 \leq 6000$

x_1, x_2 and $x_3 \geq 0$

Portfolio Management

Example on use of linear programming in financial planning, a mutual fund has $ 20 million available for investment in Government bonds, blue chips stocks, and speculative tock sand short term bank deposits. The annual expected return and risk factor are given as follows:

Table 2: Provides annual expected return and risk factor for each investment

Types of investment	**Annual expected return**	**Risk factor (0 to 100) Government bonds**
Blue chip stocks	19%	24
Speculative stocks	23%	48
Short term deposits	12%	6

Mutual Fund is required to keep at least \$ 2 million in short term deposits and not to exceed an average risk factor of 42.Speculative stocks must be at most 20percent of the total invested. How should Mutual Fund invest the funds so as to maximize its total expected annual return?? Formulate this as a linear programming problem. Solution- let mutual fund makes the following investments, \$ x_1 in government bonds, \$ x_2 in blue chip stocks, \$ x_3 in speculative stocks and \$. x_4 in short term deposits.

Objective function – Max $Z = 0.14x_1 + 0.19x_2 + 0.23x_3 + 0.12x_4$

Subject to

$x_1+x_2+x_3+x_4 \leq$ 20,00,000(Total investment)

$x_4 \geq$ 2,00,000 (Minimum investment in short term deposits)

$12x_1+24x_2+48x_3+6x_4/x_1+x_2+x_3+x_4 \leq 42$ (Risk factor)

or

$30x_1+18x_2-6x_3+36x_4 \geq 0$

$x_3 \leq 0.2(x_1+x_2+x3+x_4)$ (maximum investment in speculative stocks)

or

$0.8x_1-0.2x_1-0.2x_2-0.2x_4 \leq 0$

x_1, x_2, x_3 and $x_4 \geq 0$

Research on applications of linear programming

There has been lot of research on linear programming in last few decades. Some of the latest works on the applications of linear programming in the various fields are given below.

- Mehrzad Hamidi *et al.,* 2011 have evaluated the performance of Iranian football teams utilizing linear programming.
- Oleg Viacheslavovich Yeriomin (2011) had used linear programming for calculation of standard thermodynamic potentials for Na-Zeolites.
- Konstantine Georgakakos (2012) worked on water supply and demand sensitivities of linear programming solutions to a water all ocation problem.

- Bruno Rüttimann. Discoursed about Linear Programming and Lean Manufacturing: Two Different Approaches with a Similar, Converging Rational
- Chongyu Jiang *et al.,* (2016) worked on Application of Linear Programming Model to Refugee Migrating Problem
- Thais R. Salvador *et al.,* (2016) worked on the application of simplex method one of the method use to solve linear programming in the radio the reply treatment.

Conclusion

This study provides complete details about the linear programming technique, one of the most applied techniques of Operations Research. This note can help students and researchers to understand the assumptions and properties of linear programming. This paper also provides the limitations of linear programming. Also, some of the latest research on applications of linear programming in various fields have been discussed in this study. Thus, this study will act as a catalyst for encouraging more research on applications of linear programming.

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Dr. Chetan N. Rathod

Dr. Chetan N. Rathod (BCA, MCA, M.Phil, Ph.D., GSET) is an I/C Principal at Vimal Tormal Poddar BCA College. He brings over 17 years of teaching experience and 2 years of industry exposure to the field of computer science. He is a Director of IMCR-2025 Conference. A prolific academician, he holds 3 patents and 1 copyright and has authored more than 20 books across diverse subjects. His research contributions include over 20 papers published and presented in prestigious international journals and conferences, including SCOPUS and SPRINGER.He serves as a Board of Studies member at Vidhyadeep University and is part of the syllabus committee at Veer Narmad South Gujarat University (VNSGU). Dr. Rathod is the Managing Editor of the International Journal for Advanced Research in Multi-Disciplinary (IJARMY), and actively participates in various academic panels and committees of VNSGU. Beyond academia, Dr. Rathod is committed to social service. He is the President of the Be Positive Charitable Trust, an organization devoted to supporting the underprivileged. As part of his societal contributions, he founded Jump2Learn Online Learning Platform and Jump2Learn Publication (The National Publishing House), aimed at empowering students, educators, and researchers. In addition, he is a member of the Akhil Bhartiya Media team of ABRSM and the Treasurer of VNSGU Shaikshik Sangh.

Mr. Ajay B. Patil

Mr. Ajay B. Patil (M.A. B.Ed., G-SET) is currently working as an Incharge Principal in Vimal Tormal Poddar Commerce College, Surat. Currently He is pursuing Ph.D. from the (Department of Economics, Veer Narmad South Gujarat University, Surat). He has attended/presented research papers in Stat/National and International workshop, seminars/ FDP. He has published several research Papers in reputed national and international peer reviewed/UGC Care journals. Mr. Ajay Patil is the Editor of the Book of IMCR-2025 (International Multidisciplinary Conference on Research). Additionally, he is fulfilling the responsibility of a Karobary Sabhy (Executive Member) at VidyaBharati Uchcha Shiksha Sansthan, Gujarat Prant.

Dr. Prashant Ghantiwala

Dr. Prashant Ghantiwala is an Assistant Professor at Vimal Tormal Poddar BCA College. He serving as the Book Editor for the IMCR-2025 Conference Proceedings. He is currently an Assistant Professor at Vimal Tormal Poddar BCA College, Surat. He holds a Ph.D. in Artificial Intelligence, branch of Computer Science, and has built a strong academic profile through years of dedicated teaching, research, and scholarly contributions.Dr.PrashantGhantiwala has actively participated in numerous national and international conferences, contributing to the advancement of knowledge in the field of computer science and AI. His research interests include Artificial Intelligence, Machine Learning, and Network Security. With meticulous attention to detail and a deep commitment to academic quality, he plays a pivotal role in shaping the IMCR-2025 conference publication.

Mrs. Neeta P. Goyani

Mrs. Neeta P. Goyani(B.Com, M.Com, GSET) is an Assistant Professor at Vimal Tormal Poddar Commerce College. She is the Head of the Accountancy Department and also serves as the IQAC Coordinator in the college.She has several publications to her credit, including research papers in reputed national and international journals. Additionally, she has presented her research at various national and international conferences. She has served as the Editor of this volume IMCR-2025, bringing thoughtful insight and scholarly direction to its development and also played a pivotal role as the Organising Secretary of International Multidsiciplinary Confernce on Research.

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