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DEEPFAKE VIDEO DETECTION SYSTEM USING DEEP LEARNING

Mr. Sourabh Natu, Assistant Professor, Dept. Of Information Technology, International Institute of Information Technology, Pune, Savitribai Phule Pune University.
Mr. Rushikesh Jamnekar, Student, Dept. Of Information Technology, International Institute of Information Technology, Pune, Savitribai Phule Pune University.
Mr. Tushar Kamble, Student, Dept. Of Information Technology, International Institute of Information Technology, Pune, Savitribai Phule Pune University.
Mr. Navnit Amrutharaj, Student, Dept. Of Information Technology, International Institute of Information Technology, Pune, Savitribai Phule Pune University.
Mr. Aditya Gite, Student, Dept. Of Information Technology, International Institute of Information Technology, Pune, Savitribai Phule Pune University

ABSTRACT:
The rise of advanced deepfake technologies presents serious threats to the integrity of information, security measures, and individual privacy. As deepfake content becomes increasingly widespread, developing dependable detection systems is crucial. This paper surveys the current landscape of deepfake detection methods that employ deep learning techniques, particularly highlighting recent innovations involving Convolutional Neural Networks (CNNs), the ResNeXt architecture, and Long Short-Term Memory (LSTM) networks. We introduce a novel approach for a detection framework that adeptly integrates ResNeXt for spatial feature extraction alongside LSTMs for analysing temporal sequences.
Experimental findings reveal that our model demonstrates exceptional accuracy and generalization across various datasets. This research contributes to the expanding field aimed at creating robust deepfake detection solutions. In addition, the proposed model shows resilience against common manipulation artifacts by leveraging complementary strengths of both spatial and temporal features.
The architecture is designed to minimize false positives, making it suitable for deployment in sensitive domains such as digital forensics and media verification.

Keywords:
Deepfake Detection, CNN, ResNeXt, LSTM, GANs, Deep Learning, RNN.

I. INTRODUCTION

Deepfake technology, initially developed for applications in entertainment such as film editing and voice synthesis, has rapidly evolved into a powerful yet potentially dangerous tool. Its ability to create highly realistic but fabricated media has sparked serious ethical, legal, and security concerns. The widespread availability of deepfake tools through open-source platforms and apps has enabled even non-experts to generate deceptive content, often used for harmful purposes like political manipulation, cyberbullying, and misinformation—undermining public trust and digital integrity. Given these threats, effective detection methods have become increasingly vital.
Traditional forensic techniques often fall short as generative models grow more sophisticated. To address this, researchers have employed advanced machine learning and deep learning approaches. Given these threats, effective detection methods have become increasingly vital. Traditional forensic techniques often fall short as generative models grow more sophisticated. To address this, researchers have employed advanced machine learning and deep learning approaches.
This paper examines three notable contributions: A CNN-based method focusing on spatial inconsistencies, a hybrid CapsuleNet-LSTM model capturing both spatial and temporal features, and a systematic review of deep learning techniques in the field. By comparing these approaches, we analyze their strengths, limitations, and potential for future improvements in combating the misuse of deepfakes. The CNN-based approach offers high precision in detecting localized pixel anomalies, while

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the CapsuleNet-LSTM model excels at capturing motion patterns and temporal consistency. Meanwhile, the review provides a comprehensive overview of evolving techniques and highlights the importance of dataset diversity and model generalization. Through this multi-faceted analysis, we emphasize the need for more adaptive, explainable, and real-time detection systems. Furthermore, we advocate for interdisciplinary collaboration and standardized evaluation metrics to build resilient defenses against this growing technological threat.

II. LITERATURE SURVEY

Paper 1: DeepFakeDG: Leveraging Deep Learning for Detection and Creation of Deepfakes

- **Objective**: The primary objective of this project is to develop a comprehensive web application capable of both generating and detecting deepfakes. This dual-purpose platform aims to provide users with tools for understanding how deepfakes are created and how they can be identified. By integrating deep learning functionalities into a user- friendly interface, the app serves both educational and practical purposes. It also aims to raise awareness about the ethical implications of synthetic media.
- **Techniques Analyzed**: The system leverages Convolutional Neural Networks (CNNs) and VGG architectures for processing facial imagery. These models are employed for tasks such as face extraction, alignment, and classification to determine authenticity. CNNs are adept at identifying pixel-level irregularities, while VGG provides a deep feature hierarchy for robust learning.
- **Key Findings**: Experimental evaluations showed that the model achieved high accuracy in detecting deepfake videos across various test samples. Its effectiveness demonstrates strong potential for integration into tools used by law enforcement and judicial systems for evidence validation. The model's ability to generalize across diverse inputs highlights its practical applicability in real-world scenarios.

Paper 2: Explainable Deepfake video Detection Using CNN and CapsuleNet

- **Objective**: The paper's main aim is to provide a thorough review of deepfake detection methods leveraging deep learning techniques. It synthesizes existing literature to underscore the strengths and limitations of various approaches in the field.
- **Techniques Analyzed**: The focus is on significant methodologies, such as Convolutional Neural Networks, Generative Adversarial Networks, and discussion emphasizes the importance of both temporal and spatial feature extraction, with notable datasets like Face Forensics++ and Celeb-DF being examined for their contributions to model training and evaluation.
- **Key Insights**: The review concludes that CNNs are the most widely used techniques for deepfake detection, while Region- based CNNs (RCNNs) exhibit potential for enhanced temporal tracking. Additionally, the authors stress the necessity for diverse datasets to improve model generalization, reflecting a broader discourse in the research community about building robust training frameworks for deepfake detection.

Paper 3: Deepfake Detection Using Deep Learning Methods: An In-Depth and Thorough Review

- **Objective**: The paper aims to comprehensively review deepfake detection methods that utilize deep learning techniques, synthesizing existing research to highlight the advantages and disadvantages of different approaches.
- **Techniques Analyzed**: It focuses on key techniques, such as Convolutional Neural Networks, Generative Adversarial Networks, and Recurrent Neural Networks, emphasizing the role of temporal and spatial feature extraction. Prominent datasets like Face Forensics++ and Celeb- DF are also examined for their contributions to training and evaluation.

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Key Insights: The review finds that CNNs are predominant in deepfake detection, although Region-based CNNs (RCNNs) show promise for improved temporal tracking. The authors underline the need for diverse datasets to enhance model generalization, reflecting ongoing discussions in the field about developing robust training frameworks

Paper 4: Deepfake Detection: Examining Model Generalization Across Different Architectures, Datasets, and Pre-Training Approaches

- **Objective**: This study aims to evaluate how well various deep learning models generalize in detecting deepfakes. Generalization is crucial as it determines a model's performance on unseen data, which can differ significantly from training data.
- **Technique Analyzed:** The research shows notable performance differences across datasets, indicating that models trained on particular datasets may struggle to perform effectively on others. This variability highlights the need for diverse training data that represents various deepfake manipulations, as emphasized by Marra et al. (2020).
- **Key Insights**: The results underscore the importance of ongoing model enhancement and robustness to adapt to evolving deepfake technologies. Continuous research and the establishment of standardized benchmarks are vital for advancing detection methods, echoing the views of Zhou et al. (2020).

Datasets used:

Datasets	Description	Key Features	Links
Deepfake Detection Dataset	A collection of deepfake videos for training and evaluating detection algorithms.	Diverse video content varying manipulation techniques, labeled as real or fake.	Deepfake Detection Dataset
Celeb- DF	A comprehensive dataset created for deepfake detection, consisting of videos featuring celebrities.	High-resolution videos, realistic deepfakes, contains various facial manipulations	Celeb-DF
DFDC (Deepfake Detection Challenge)	Created for the Deepfake Detection Challenge, It contains diverse videos and fake content.	Contains a wide variety of deepfake techniques, large number of participants for diversity.	DFDC Dataset
FaceForensics++	A dataset designed for evaluating face manipulate ion methods, including deepfakes.	Includes original and manipulated videos, supports different manipulation algorithms.	FaceForenscs++

III. METHODOLOGY

To address the challenges associated with deepfake detection, we propose a hybrid framework that combines the advantages of ResNeXt, CNNs, and LSTMs. This portion outlines the approach used in the study, including data collection, model architecture, and evaluation metrics.

3.1 Data Collection and Preprocessing: Our framework utilizes publicly available datasets such as the Deepfake Detection Challenge Dataset and Face Forensics++. These datasets include a diverse range of manipulated and original videos, allowing for robust training and evaluation. Preprocessing steps involve:

i. **Frame Extraction:** Videos are segmented into individual frames for analysis.
ii. **Normalization:** Pixel values are scaled to a uniform range to enhance model performance.
iii. **Data Augmentation:** Approaches like rotating, resizing, and flipping are implemented to

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enhance the variety of training data and decrease the likelihood of overfitting.

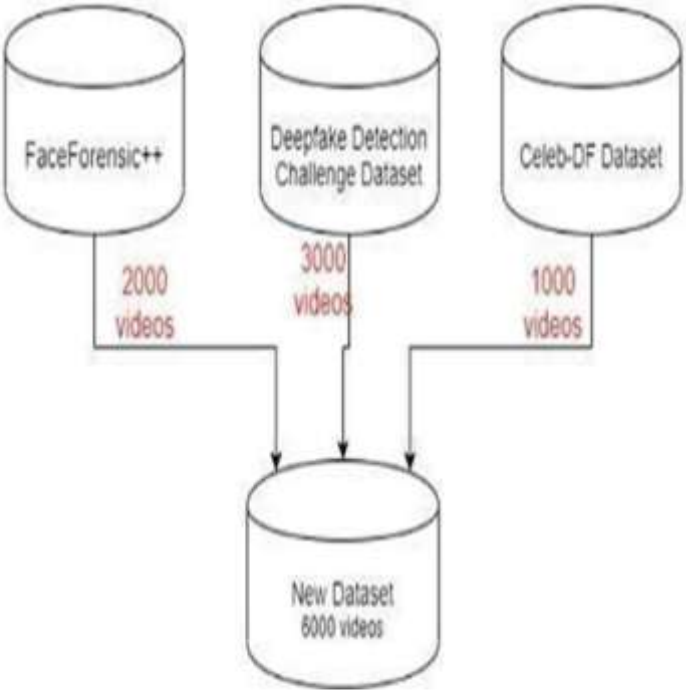

Diagram 1. Dataset collection.

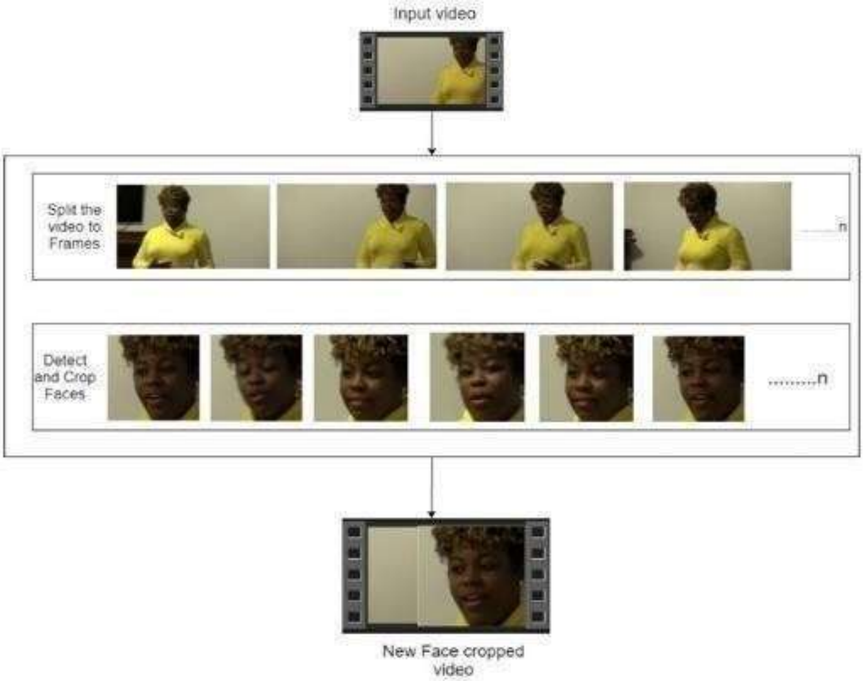

Diagram 2. Preprocessing of video.

3.2 Model Architecture:

The proposed model consists of three main components:

- **ResNeXt Module:** ResNeXt is an advanced deep learning architecture that employs a split-transform-merge strategy, enhancing feature extraction by utilizing multiple paths within the network. This architecture allows for better representation learning and improved robustness against variations in the data. The ResNeXt module processes input frames to extract rich spatial features, capturing complex patterns indicative of manipulations.
- **CNN Module:** Following the ResNeXt processing, additional CNN layers can be integrated to further refine the spatial feature extraction. This module is designed to capture complex visual patterns indicative of manipulation.

- **LSTM Module:** Following feature extraction, the output from ResNeXt and CNN is input into an LSTM network, which examines the temporal dependencies across frames. This enables the model to identify inconsistencies that may arise from deepfake manipulation, such as unnatural movement or timing discrepancies.

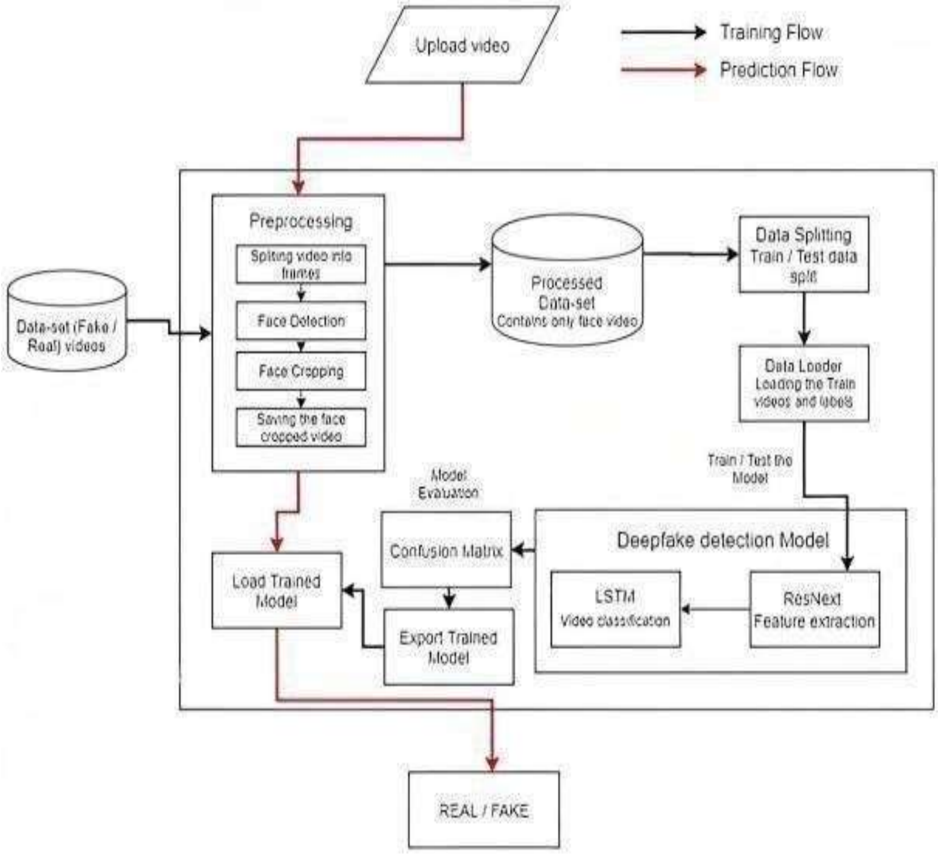

Diagram 3. Abstract diagram of the proposed method.

3.3 Training and Evaluation

The model is trained employing a supervised learning method with a binary cross-entropy loss function. A validation set is utilized to track performance and avoid overfitting. The assessment parameter include:

- **Accuracy:** The ratio of accurately identified instances.
- **Precision and Recall:** Metrics that assess the accuracy of positive predictions.
- **F1-Score:** The Harmonic Mean of precision and recall, providing a balanced evaluation.

IV. RESULTS

- The system successfully detected deepfake videos using a hybrid model combining ResNeXt for spatial feature extraction and LSTM for temporal analysis.
- The model showed promising detection ability during testing, identifying inconsistencies in facial movements and features across frames.
- Preprocessing techniques such as face detection and frame extraction improved the quality of input fed to the model.
- The system could distinguish between real and fake videos with a noticeable level of visual and behavioral anomaly identification.
- Integration of the system into a user-friendly interface was achieved for testing video inputs and showing prediction results.
- The system maintained efficient processing time, enabling near real-time deepfake detection for short video clips.

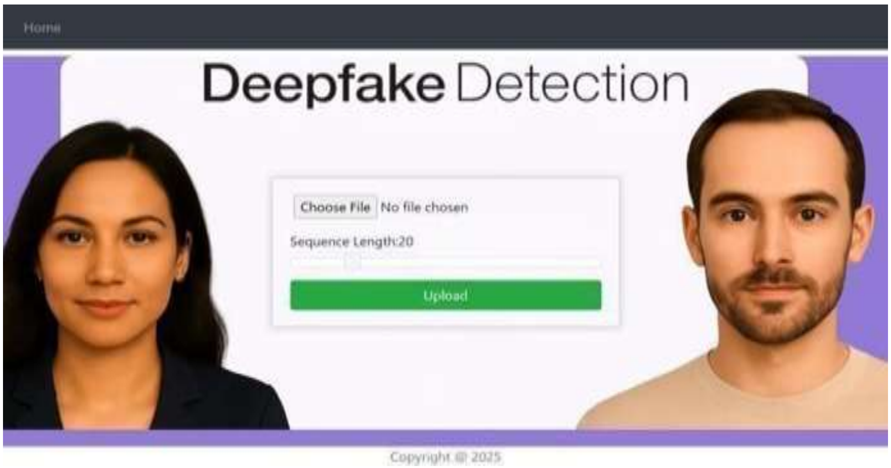

Diagram 4. Homepage

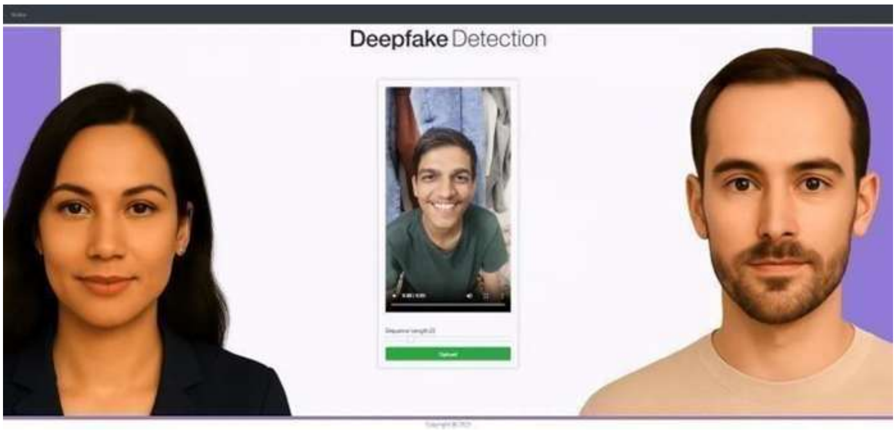

Diagram 5. Uploading a Video

Diagram 6. Prediction on a Real Video

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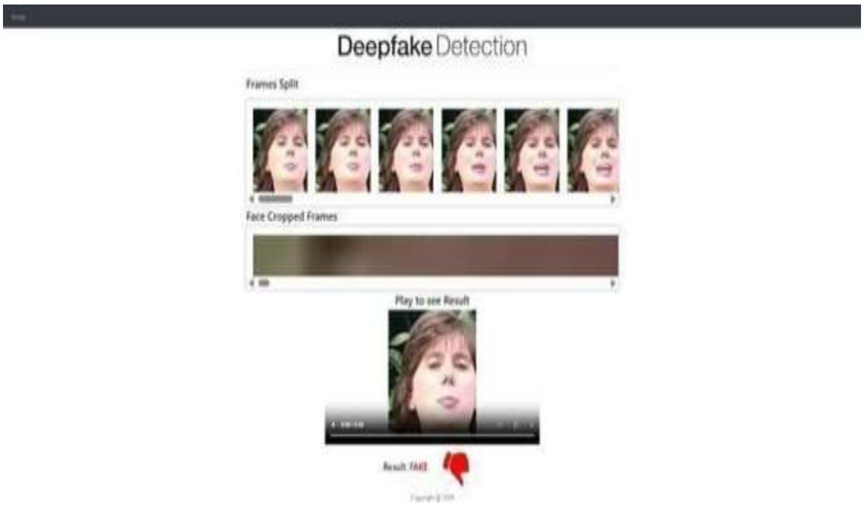

Diagram 7. Prediction on a Fake Video

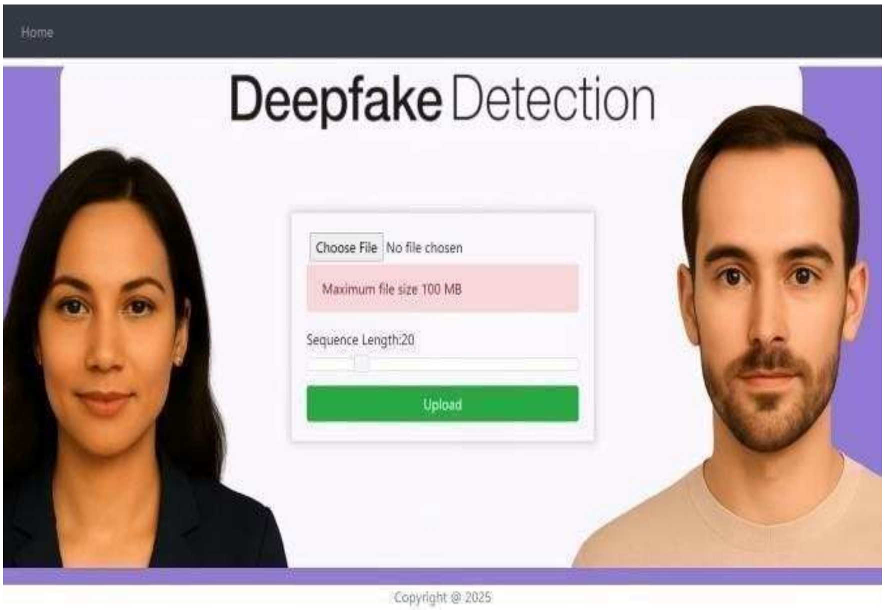

Diagram 8. Uploading video with size greater than 100 mb.

Diagram 9. Pressing upload button without uploading a video

V. LIMITATIONS

- **Dataset Bias**: The model is trained on DFDC and FaceForensics++, which may not capture all types of deepfakes, especially lower-quality or more advanced ones, limiting generalization to real- world data.
- **Computational Resources**: The ResNeXt-LSTM hybrid model is resource-intensive, requiring powerful GPUs for training and inference, which may hinder scalability for deployment in resource- constrained environments.
- **Real-Time Detection**: The model is not optimized for real-time detection due to sequential frame processing with LSTM, leading to latency in live applications like video streaming.
- **Overfitting on Smaller Datasets**: Despite data augmentation, the model may overfit on smaller or less diverse datasets, impacting its ability to detect new deepfakes not seen during training.
- **Limited Modalities**: The current system uses only visual and temporal features, excluding audio or other modalities, which could improve detection accuracy if incorporated.
- **Environmental Sensitivity**: The model was trained on controlled conditions and may underperform in low-light or noisy environments, affecting robustness in diverse real-world settings.

VI. FUTURE SCOPE

While the proposed deepfake detection framework leveraging ResNeXt for spatial feature extraction and LSTM for temporal analysis has shown commendable accuracy and robustness, there remains significant scope for further advancement. One of the most promising directions is the real-time deployment of the system on low-resource and energy- constrained devices such as smartphones, tablets, and embedded systems. Achieving efficient model compression and optimization techniques, such as quantization and pruning, could enable smooth operation on edge devices, thus widening the reach and usability of the system in real-world applications like mobile content moderation, video conferencing, etc.

Another important area of future research is enhancing cross- dataset generalization. While the current system performs well on the selected datasets, its effectiveness against entirely new datasets or unseen manipulation techniques must be assessed. Incorporating domain adaptation techniques and robust training methodologies can make the model more adaptable to real-world variability and emerging deepfake generation methods.

In addition, the integration of multimodal data presents a compelling opportunity to enhance detection accuracy. By incorporating complementary modalities such as speech patterns, voice consistency, lip-sync analysis, and micro-expressions, the detection model can make more informed decisions and identify inconsistencies that might be overlooked by visual analysis alone.

This multimodal fusion can significantly improve resilience against more sophisticated and hybrid deepfakes. Overall, by pursuing these future directions—real- time deployment, cross- dataset generalization, multimodal integration, and explainable AI—deepfake detection systems can become more robust and trustworthy.

VII. CONCLUSION

The emergence of deepfake technology presents significant challenges to media authenticity, individual privacy, and global security. By leveraging advanced machine learning techniques, deepfakes are capable of producing hyper-realistic synthetic media that can deceive viewers and disrupt trust in digital content. This paper provides a comprehensive review of the current landscape of deepfake detection systems that employ deep learning approaches and introduces a novel hybrid framework that combines ResNeXt for spatial feature extraction and Long Short- Term Memory (LSTM) networks for temporal sequence analysis. The proposed model demonstrates enhanced performance in detecting manipulated content by effectively capturing both spatial and temporal inconsistencies. Our experimental results underscore the effectiveness of deep learning techniques in improving the accuracy, robustness, and generalizability of deepfake detection models. However, as generative methods continue to evolve, it is imperative that detection systems also advance. Ongoing research and innovation in this domain are crucial to mitigating the threats posed by deepfakes and ensuring the integrity of digital information across platforms.

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