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A Hybrid Fake Logo Detection Using Machine Learning and Deep Learning

P.Sugavaneshwari
Department of Computer Science and Engineering
Government College of Engineering
Dharmapuri, India
suga.eshwari@gmail.com

Dr.K.G.Saranya
Department of Computer Science and Engineering,
PSG College of Technology
Coimbatore, India
kgs@psgtech.edu.in

Abstract: The rapid growth of e-commerce and digital marketplaces has significantly increased the circulation of counterfeit products, where fake logos are widely used to deceive consumers and exploit brand reputation. To address this issue, this project proposes a hybrid fake logo detection system that combines Machine Learning (ML) and Deep Learning (DL) techniques to achieve accurate and efficient classification of logos as real or fake. The proposed system integrates deep learning and machine learning techniques such as Convolutional Neural Networks (CNN) for feature extraction and Support Vector Machines (SVM) for classification respectively. This hybrid approach leverages the strengths of both deep learning and traditional machine learning, resulting in improved accuracy and reduced computational cost compared to stand alone deep learning models.

Keywords: Fake logo detection, CNN algorithm, SVM, feature extraction.

I.INTRODUCTION

The proposed system is developed to identify whether a given logo is real or fake using a combination of techniques. Nowadays, fake logos are becoming very common, especially in online shopping platforms and digital marketplaces, where many sellers use logos that look similar to original brands to attract customers. This creates confusion among users, reduces trust, and also causes financial loss to companies. Checking logos manually is not practical because there are a large number of products, and sometimes the difference between real and fake logos is very small. Human verification can also lead to mistakes and inconsistency. Because of these issues, there is a need for an automated system that can quickly and accurately detect fake logos. The system works by analyzing important features such as shape, color, and texture from logo images and uses them to classify

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whether the logo is real or fake The main goal is to build a reliable, cost-effective, and efficient system that can be used in real-world applications such as e-commerce and brand protection, making the process of logo verification faster, easier, and more accurate, precision, recall and F1-score. A scalable, efficient and easy to use tool to be integrated as part of online market places, brand protection systems or standalone applications for businesses and consumers is the future. The challenge in counterfeit detection worsens mean while counterfeiters innovate by integrating machine learning techniques such as Convolutional Neural Networks(CNNs) into counterfeit detection systems in order to preserve brand integrity and consumer safety.

II. LITERATURESURVEY

G. Zhu and D. Doermann proposed a logo matching technique for document image retrieval. Their approach focuses on identifying and matching logos from document images using feature-based methods, which helps in detecting similar and counterfeit logos in large datasets. C.-H. Wei, Y. Li, W.-Y. Chau, and C.-T. Li introduced a trademark image retrieval system using synthetic features that describe both global shape and internal structure. This method improves logo recognition accuracy by capturing detailed visual characteristics, making it useful for distinguishing real and fake logos. H. Sahbi and L. Ballan developed a context-dependent logo matching and recognition approach. Their method considers the surrounding context and visual relationships within images, which enhances the detection of logos even in complex backgrounds and improves overall recognition performance. A. Bianco, M. Buzzelli, D. Mazzini, and R. Schettini presented a deep learning approach for logo recognition. Their work highlights how deep neural networks can automatically learn complex visual features, improving the accuracy and efficiency of logo classification tasks.

In addition, the research “Fake Logo Detection Using Convolutional Neural Networks” published in IEEE explores the use of CNN models for automatic feature extraction and classification. This method improves the system’s ability to identify subtle differences between real and fake logo.

III. PROPOSED METHODOLOGY

The proposed system follows a step-by-step approach to detect whether a logo is real or fake. The method mainly focuses on extracting useful information from the logo image and then classifying it accurately. The process is divided into two main parts: feature extraction and classification. By combining these two stages, the system achieves better performance with less complexity.

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A. Data Source and Dataset Description

The dataset used in this project is collected from online sources such as Kaggle and other image repositories, which provide a wide variety of logo images for both training and testing purposes. The dataset is divided into two main categories, namely real logos and fake logos, which help the system, learn the differences between authentic and counterfeit images effectively. All the images are organized in structured folders with proper labels, making it easier for the system to process and understand the data during training. A well-balanced and diverse dataset plays an important role in improving the overall performance of the system, as it helps in better learning and ensures that the model can generalize well when handling new and unseen logo images.

B. Data Preprocessing

In this stage, all images are resized to a fixed size to maintain uniformity, which helps the systemprocessthemefficiently.Anyunwantednoisepresentintheimagesisremovedusing filtering techniques, improving the clarity and making feature extraction more accurate. The pixel values are then normalized to a standard range, which helps in improving the stability and speed of the training process. Additionally, all images are converted into a consistent format such as RGB to ensure uniformity across the dataset. Overall, these preprocessing steps make sure that the input data is clean, consistent, and suitable for further processing.

C. Feature Extraction

In this stage, the input logo image is first processed to extract important visual details. The system analyzes features such as edges, shapes, textures, and color patterns, which are useful in identifying differences between real and fake logos. The extraction process is done automatically, so the system can learn patterns from different types of logos without manual effort. It also handles variations like noise, blur, resizing, and slight distortions in the image. These extracted features act as a compact representation of the logo, which helps in making accurate decisions in the next stage.

D. Classification

After extracting the features, the next step is to classify the logo as real or fake. In this stage, the system uses the extracted information to learn the difference between genuine and counterfeit logos. The classifier separates the logos based on learned patterns and identifies whether the given inputbelongstotherealorfakecategory.Thisapproachimprovesaccuracybecausethe classification is based on meaningful features rather than raw images. It also reduces errors and provides more consistent results.

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E. Model Evaluation and Explanation

The performance of the system is evaluated using important metrics such as Accuracy, Precision, recall, and confusion matrix. Accuracy measures the overall correctness of the model by calculating the percentage of correct predictions. Precision indicates how many of the logos predicted as fake are actually fake, while recall measures how many of the actual fake logos are correctly identified by the system. The confusion matrix provides a detailed view of correct and incorrect classifications, helping to better understand the model's performance. In addition to evaluation, the system also explains its predictions by showing why a particular decision was made. It highlights the important regions of the image that influenced the result and works by modifying parts of the image to observe changes in prediction. This helps in identifying which features are most important for classification and improves user understanding by making the decision process more clear and transparent.

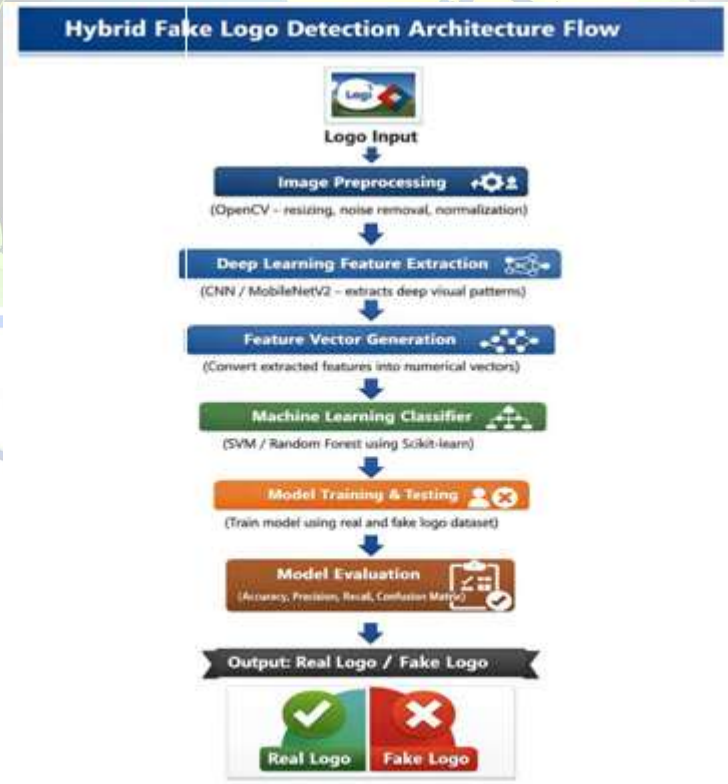

Figure1: System Architecture

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IV. RESULTS AND DISCUSSION

The system performs well in different conditions by correctly detecting logos even when they appear on various backgrounds like product images, packaging, and online listings. It can handle different types of variations such as changes in color, size, distortions, and partially visible logos. The system is easy to use, where users can upload images and get results quickly without any difficulty. It also gives results in a short time, making it suitable for real-time use. The performance remains consistent for different inputs, and the system provides reliable outputs. Overall, it is practical and can be effectively used in real-world applications like e-commerce etc,

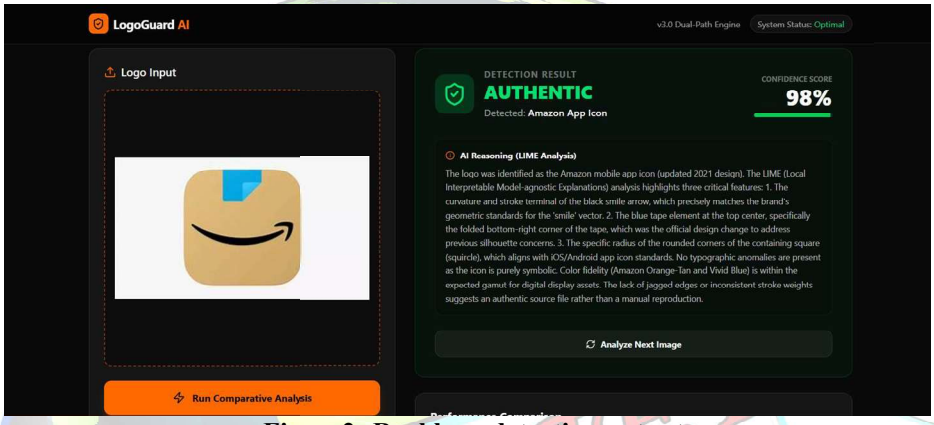

Figure2: Real logo detection output

The image shows the result of the logo analysis where the system identifies the uploaded logo as "AUTHENTIC." It confirms that the logo is original based on its internal evaluation.

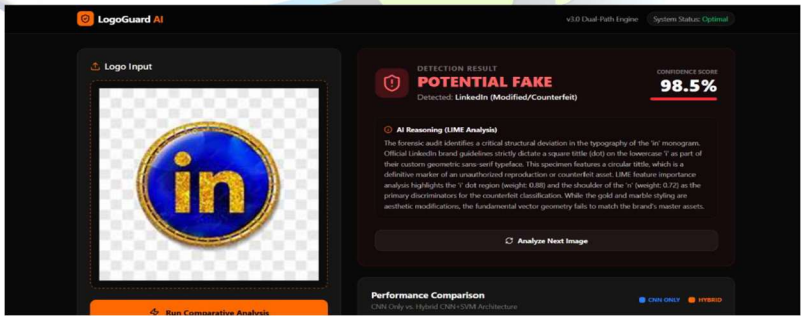

Figure3: Fake logo detection output

The system provides a brief explanation indicating that the logo is detected as fake. This decision is based on AI analysis, identifying inconsistencies or mismatched features in the logo.

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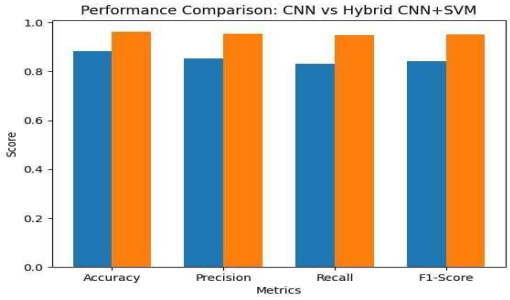

Figure4: Performance Metrics

The experimental results show that the Hybrid CNN-SVM model outperforms the CNN-only model in all evaluation metrics. The system achieved 96.2% accuracy, 95.5% precision, 94.8% recall, and 95.1% F1-score, which is significantly higher than the CNN-only approach. This proves that combining CNN for feature extraction and SVM for classification improves the overall performance of fake logo detection.

Metrics	CNNonly	Hybrid(CNN+SVM)
Accuracy	0.884	0.962
Precision	0.852	0.955
Recall	0.831	0.948
F1-Score	0.841	0.951

Table 1:Metrics Comparison

V.CONCLUSION

The Fake Logo Detection System has been developed as an effective solution to identify whether a given logo is real or counterfeit using a hybrid approach of Machine Learning and Deep Learning. The system integrates Convolutional Neural Networks (CNN) for feature extraction. The system performance is evaluated using accuracy, precision, recall, and F1-score, showing clear improvement in the hybrid approach. While using CNN alone for feature extraction, the model achieves an accuracy of 88.4%, indicating good but limited classification performance. In contrast, while using a combination approach for feature extraction and classification, the system reaches a higher accuracy of 96.2%, showing

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improved overall results. Precision increases from 85.2% to 95.5%, reducing false detections, and recall improves from 83.1% to 94.8%, ensuring more fake logos are correctly identified. The F1-score also rises from 84.1% to 95.1%, proving that the combined approach provides a more balanced and reliable performance

VI. FUTURE SCOPE

While the current system provides an efficient solution for fake logo detection, there are several enhancements that can further improve its performance and applicability. One possible enhancement is the development of a real-time detection system that can analyze logos instantly through live camera input or mobile applications Improving precision can help reduce false detections, especially in cases where real and fake logos are visually very similar. Enhancing recall will ensure that even subtle fake logos are detected without being overlooked. To further enhance transparency and trust in the system, Explainable Artificial Intelligence (XAI) can be incorporated using Local Interpretable Model-Agnostic Explanations (LIME) for better understanding.

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