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ENHANCING FINGERPRINT-BASED ATM SYSTEMS USING DEEP LEARNING AND NEURAL NETWORKS

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ABSTRACT- In the paper, deep learning methodology is enhanced for fingerprint-based ATM systems using Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and Siamese networks. In CNNs, automatic features are extracted directly from raw fingerprint images with a layered architecture that can increase classification accuracy and robustness in the case of pattern variation. SVMs depend solely on manually extracted features based on Histogram of Oriented Gradients (HOG). On the other side, Siamese focuses on learning similarity embeddings between images for one-to-one verification. Accuracy and F1 score are the metrics measured to evaluate the techniques while CNNs outperform by virtue of efficiency and good effectiveness in real-time use, making them potential alternatives for secure ATM authentication.

Keywords: CNN, SVM, Siamese network, fingerprint identification, ATM systems, backpropagation, downsampling, neural networks, deep learning.

I. INTRODUCTION

Automated Teller Machines (ATMs) which are essential to contemporary banking, financial services are now accessible anywhere in the world. Secured authentication is desperately needed since traditional PIN-based authentications are still vulnerable to fraud. Because fingerprint recognition technology offers a distinct biometric identity, it may be a potential option. Recent advancements in deep learning, such as Convolutional Neural Networks, SVMs, and Siamese networks, have demonstrated promising potential for enhancing fingerprint-based verification.

CNNs successfully extract difficult fingerprint patterns, SVMs provide decent classification, and Siamese networks verify fingerprint pairings well. Nevertheless, actual problems like poor image quality and incomplete fingerprints, in addition to computational limitations, impact its functionality in ATMs. This study demonstrates the capabilities of CNNs, SVMs, and Siamese networks for real-time ATM authentication, identifying the most effective method for safe, effective biometric systems. The findings so help to improve biometric security in the banking industry.

II. LITERATURE REVIEW

Deep learning has really enhanced fingerprint recognition in ATMs for secure and quick verification of users. The challenging features such as poor-quality fingerprints can be well dealt with by CNNs, SVMs, and Siamese networks. CNNs, particularly the architectures like ResNet and MobileNet, give an impressive accuracy and speed, but they may demand some hardware optimization for use in ATMs. SVMs improve classification when used in conjunction with feature extraction from CNN but are resource-intensive if applied alone. It turns out that Siamese networks work great for fingerprint verification when doing one-shot learning but perhaps are less scalable. In conclusion, CNNs seem to provide an optimal balance of efficiency and accuracy, so the research for hybrid models should aim to improve effective ATM authentication.

III. DATA COLLECTION

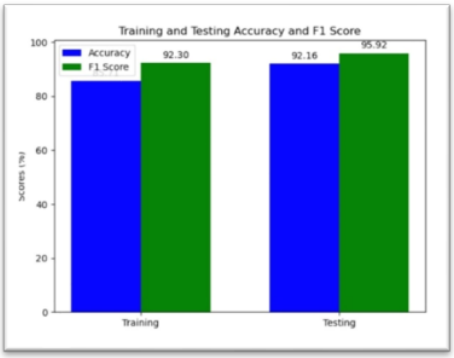
The FVC 2002 and Crossmatch datasets were the two publicly accessible GitHub sources from which the data for this study was obtained. Because they offer a variety of samples with differences in fingerprint quality, orientation, and unique fingerprint traits, these datasets are highly valued in the field of fingerprint research. Such variety is necessary to train a robust identification model

since it guarantees that the model will function consistently over a broad spectrum of fingerprint patterns and situations, which is in line with ATM systems' accuracy and dependability criteria.

IV. METHODOLOGY USED

Three cutting-edge methods are used in this study to assess fingerprint recognition for ATM systems: Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and Siamese Networks. Public databases like FVC or NIST are the source of fingerprint pictures. By using convolutional and pooling layers to collect fingerprint patterns like ridges and minutiae, a CNN is created to automate feature extraction and categorization. CNNs are perfect for fingerprint recognition because of their capacity to learn extensive feature hierarchies.
Using minutiae-based methodologies and features collected using Histogram of Oriented Gradients (HOG), an SVM model offers a comparison baseline. Although it typically necessitates extensive feature engineering, SVM's kernel-based classification works well with lower-dimensional features. Furthermore, to learn similarity scores across fingerprint pairs, a Siamese network with shared CNN weights is built. It uses contrastive loss during training to differentiate between photos that match and those that don't. In situations involving direct verification, this model is especially helpful.

Models are assessed using F1 score to guarantee balanced performance across possibly unbalanced classes and accuracy to gauge overall correctness. Comparative investigation reveals that whereas SVM mainly depends on high-quality feature engineering and Siamese networks require higher processing resources, CNNs are anticipated to perform well because to their robust automated feature extraction capabilities. According to the results, CNNs are the most effective option for ATM systems as they strike a compromise between functionality and performance.



V. DATASET

Our dataset comes from two GitHub sources: DB1_B (FVC) with 78 photos and Crossmatch_sample with 510 images. Training was done on the DB1_B dataset, while testing was done on the Crossmatch_sample dataset. Additionally, three photos from each dataset have been included in the sample.

VI. DATA PROCESSING

This paper presents a CNN-based fingerprint authentication system for ATMs, based on free fingerprint databases from FVC and NIST. The preprocessing includes size normalization and data augmentation by scaling and rotating. For achieving maximum accuracy, the comprehensive backpropagation system with categorical cross-entropy loss was used to fine-tune a new CNN design comprising convolution and pooling layers. Accuracy and F1 score measures the efficiency, and for accuracy measure fingerprints identification correct while, on the other hand F1 score relates to positive and negative which is most appropriate when it comes with an imbalance scenario. Hence

effective feature extraction of the CNNs guarantees fast safe recognition of the fingerprint to operate banking sectors.

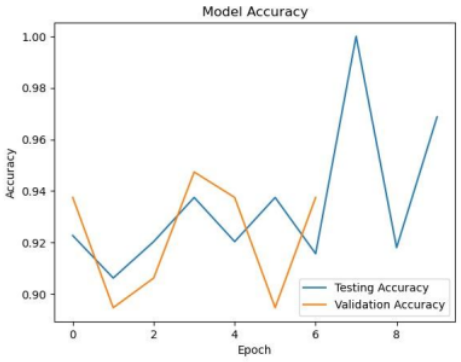
VII. COMPARATIVE ANALYSIS

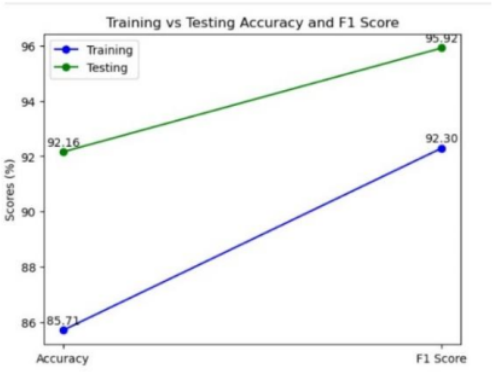
All of CNN, SVM, and Siamese networks have benefits that make them suitable for various purposes. The CNN networks are more beneficial for image pixels from which complex features can be extracted automatically to make it more robust when dealing with large datasets as well as varying patterns; hence the CNNs would be ideal in ATM systems of high accuracy. SVM is useful for much smaller datasets where engineered features like Histogram of Oriented Gradients are used and are not scalable. Siamese networks are very effective for the purpose of one-to-one verification via learned embeddings but are indeed very computationally intensive that reduces the possibility of practical application in real time. CNNs provide the balance best accuracy, efficiency, and scalability in ATM fingerprinting.

METHOD	APPLICATION	ACCURACY
CONVOLUTIONAL NEURAL NETWORK(CNN)	frequently employed for image tasks such as fingerprint, face, and object recognition	85% - 98%
SUPPORT VECTOR MACHINE(SVM)	frequently applied to low-class or binary jobs involving small to medium picture collections.	75% - 90%
SIAMESE NETWORKS	commonly used in one-shot learning problems requiring pairwise comparison, like face, signature, and biometric matching.	85% - 95%

VIII. CONCLUSION

This work demonstrates that CNNs are significantly superior in fingerprint-based ATM systems when compared to traditional machine learning methods like SVMs and other alternative neural network architectures, namely Siamese networks. The fact that CNNs can automatically learn and extract complex fingerprint features directly from raw images, along with their optimization using backpropagation, especially makes them suitable for real-time, high-accuracy applications required in ATMs. As clearly shown by this comparative analysis, though SVMs prove to be pretty efficient, especially if there is care in designing good features and a Siamese network finds extensive proficiency within similarity-based matching, such methods prove rather difficult regarding scalability and the overall complexity of the algorithms. Systems relying on CNN represent an optimum solution with balanced accuracy and adaptability speed needed to be safely used and, therefore, in ATM authentication systems. This work points out the possibility of CNNs in leading to an advancement in biometric security, which should lead to more reliable, accessible, and secure ATM systems.





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