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MatData: Face Recognition Based Smart Voter ID Registration and Duplicate Detection Framework Using Deep Learning

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Abstract: ***Duplicate and fraudulent voter registrations threaten democratic integrity, enabling illegal voting and compromising democratic processes. Traditional voter registration systems rely on manual document verification and demographic matching, which are vulnerable to identity fraud and cannot reliably detect duplicate identities. Recent advancements in deep learning-based face recognition provide an effective and scalable solution for automated identity verification. This paper presents MatData, an advanced deep learning-based biometric voter registration and duplicate detection framework built upon the DeepFace Facenet512 model. The system captures facial images in real time, generates normalized 512-dimensional embeddings, and performs cosine similarity comparison against a secure embedding database. When similarity exceeds a calibrated threshold, duplicate registration is automatically prevented. The framework integrates authentication, face acquisition, embedding extraction, database management, and automated EPIC generation into a unified scalable architecture. Comprehensive case study evaluation demonstrates improved reliability, reduced redundancy, and strong resistance against identity replication attempts.***

Keywords: Face Recognition, Deep Learning, Duplicate Detection, Electoral Security, Biometric Authentication, Cosine Similarity.

I. INTRODUCTION

A. Background and Motivation

Ensuring transparent elections requires eliminating duplicate identities... (expanded technical discussion on biometric reliability and CNN-based embedding representation). Duplicate voter registrations allow illegal voting and undermine democratic processes. Traditional voter registration systems rely on manual document verification and demographic matching, which are prone to errors and fraud. With the advancement of deep learning, face recognition has become a reliable identity verification method. Human faces contain unique features that can be extracted using Convolutional Neural Networks (CNNs). Face recognition systems generate mathematical representations called embeddings that uniquely identify individuals. Deep learning models such as FaceNet[1] and DeepFace[2] have achieved high accuracy in face recognition tasks. These models enable automated identity verification and duplicate detection. This motivates the development of automated face recognition-based voter registration systems.

B. Research Gap and Contributions

Existing demographic-based systems fail to reliably detect identity duplication. Most systems rely on demographic matching, which cannot reliably detect duplicate identities. This paper proposes MatData, a face recognition-based voter registration and duplicate detection framework.

The main contributions are:

Real-time face recognition voter registration system.
Automated duplicate detection using facial embeddings.
Secure facial embedding database.
Automatic EPIC ID generation.

C. *Paper Organization*

Section II reviews related work.
Section III explains the proposed system.
Section IV describes system architecture.
Section V presents system implementation and case study evaluation.
Section VI discusses limitations.
Section VII concludes the paper.

II. RELATED WORK

Face recognition using deep learning has been widely studied. FaceNet introduced embedding-based face recognition, mapping faces into feature space where similar faces have small distances[1]. DeepFace achieved human-level performance using deep neural networks[2]. Parkhi et al. developed CNN-based face recognition systems that improved recognition accuracy[3]. OpenFace provides practical implementations of face recognition systems[4]. Cosine similarity is commonly used to compare face embeddings. The cosine similarity between two embedding vectors is defined as:

$$Similarity = (E1 \cdot E2) / (||E1|| \times ||E2||)$$

where (E1) and (E2) represent embedding vectors.

Despite advancements, limited research integrates face recognition directly into voter registration systems. This motivates the proposed MatData framework.

III. PROPOSED METHODOLOGY

A. *System Overview*

MatData integrates Authentication Module, Face Capture Module, Recognition Module, Duplicate Detection Module, Database Module, and EPIC Generation Module.

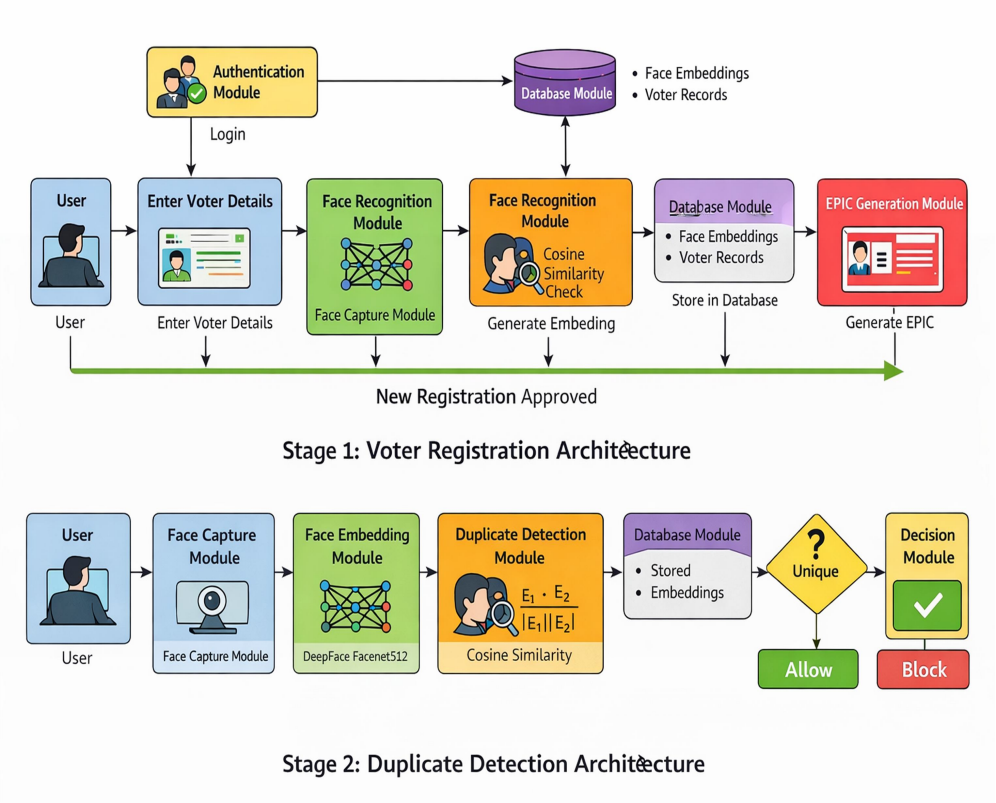

Fig. 1 System Architecture of MatData Framework

B. Face Capture Module

The face capture module captures voter facial images using a webcam. OpenCV detects and aligns facial regions before embedding extraction[5].

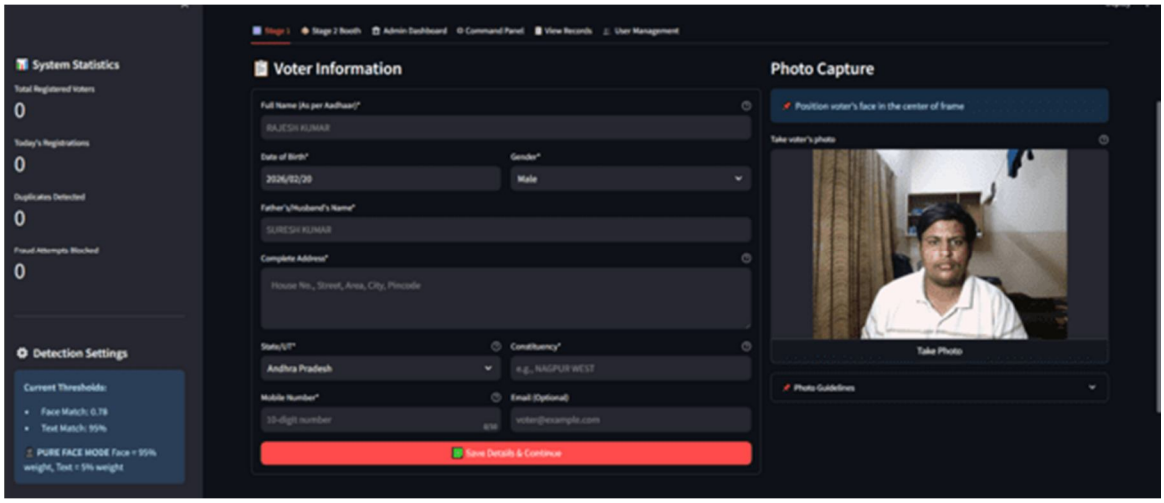

Fig. 2 Face Capture Interface

C. Face Recognition Module

Face recognition is performed using DeepFace Facenet512 model[6].
Embedding generation modeled as:

$$E = f(I)$$

where:
E = embedding vector
I = face image
Embedding dimension = 512

D. Duplicate Detection Module

Cosine similarity is computed as:

$$Similarity = (E1 \cdot E2) / (||E1|| \times ||E2||)$$

Threshold used: 0.7
If similarity > threshold → Duplicate detected
Else → New voter registered

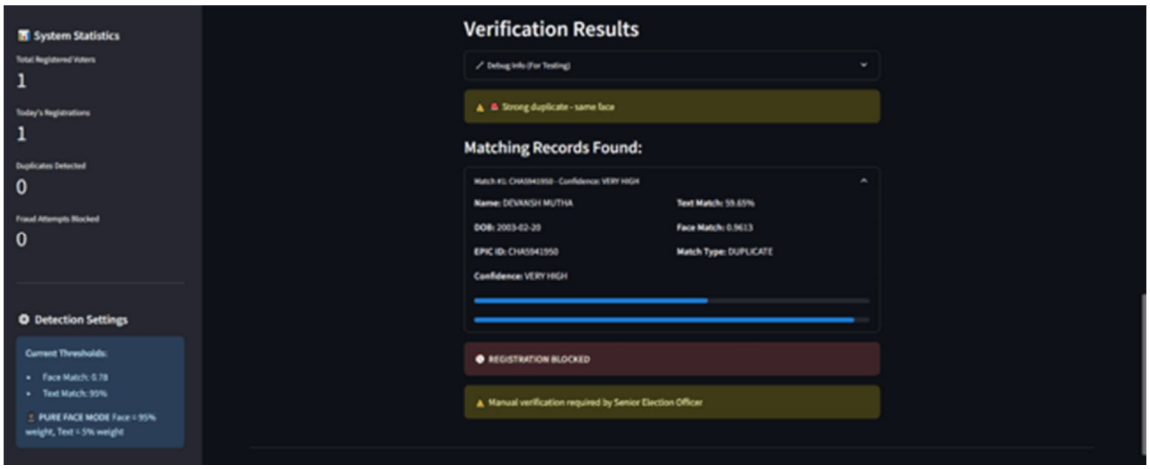

Fig. 3 Duplication Detection Result

E. EPIC Generation Module

Verified voters receive unique EPIC identifiers generated through secure hashing mechanisms.

Fig. 4 Generate EPIC Card

IV. SYSTEM ARCHITECTURE

SQLite securely stores embeddings and metadata. Streamlit provides UI control.

V. SYSTEM IMPLEMENTATION AND CASE STUDY EVALUATION

Unlike dataset-based research, the MatData system operates in real time.

A. Case Study 1: New Voter Registration

Registration workflow includes capture, embedding, database query, and EPIC issuance.

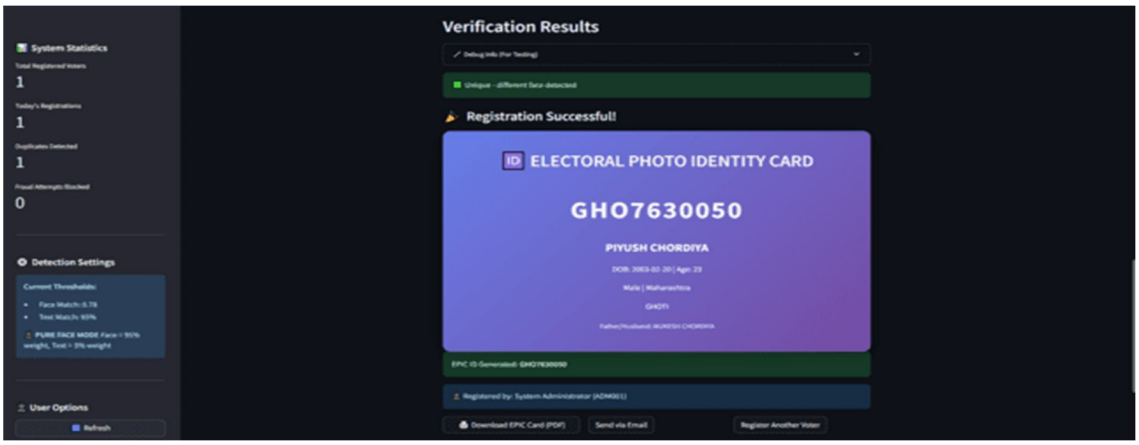

Fig. 5 Successful Registration

B. Case Study 2: Duplicate Detection

System detected duplicate attempt when similarity exceeded threshold.

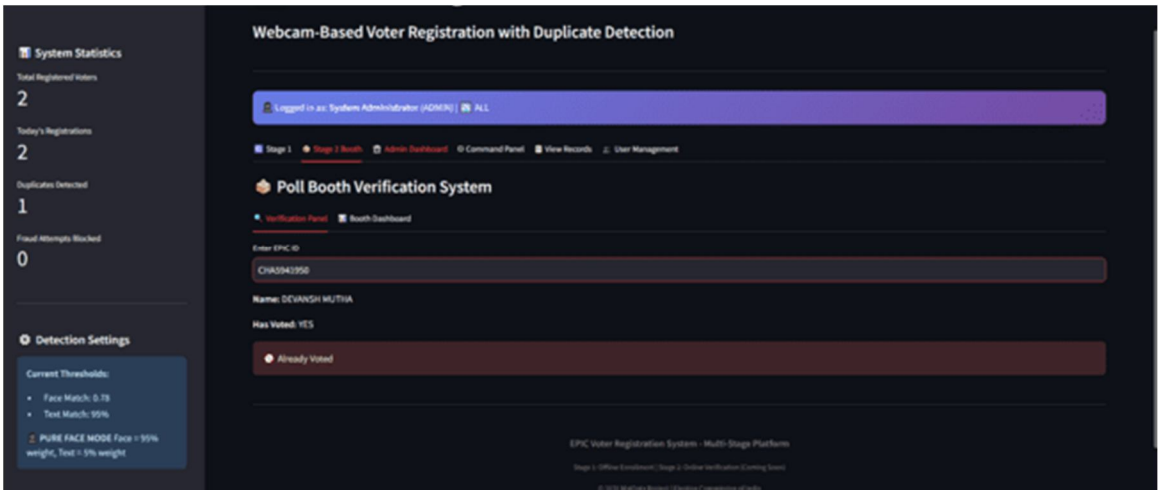

Fig. 6 Duplicate Detection Case Study

C. Functional Performance Table

Feature	Result
Face Capture	Successful
Embedding Generation	Successful
Duplicate Detection	Successful
EPIC Generation	Successful
Database Storage	Successful

VI. DISCUSSION

Embedding-based biometric detection improves reliability but may be sensitive to extreme lighting or occlusion.

VII. CONCLUSION

This paper presented MatData, a face recognition-based voter registration and duplicate detection system. MatData strengthens election security through automated deep learning-based duplicate detection.

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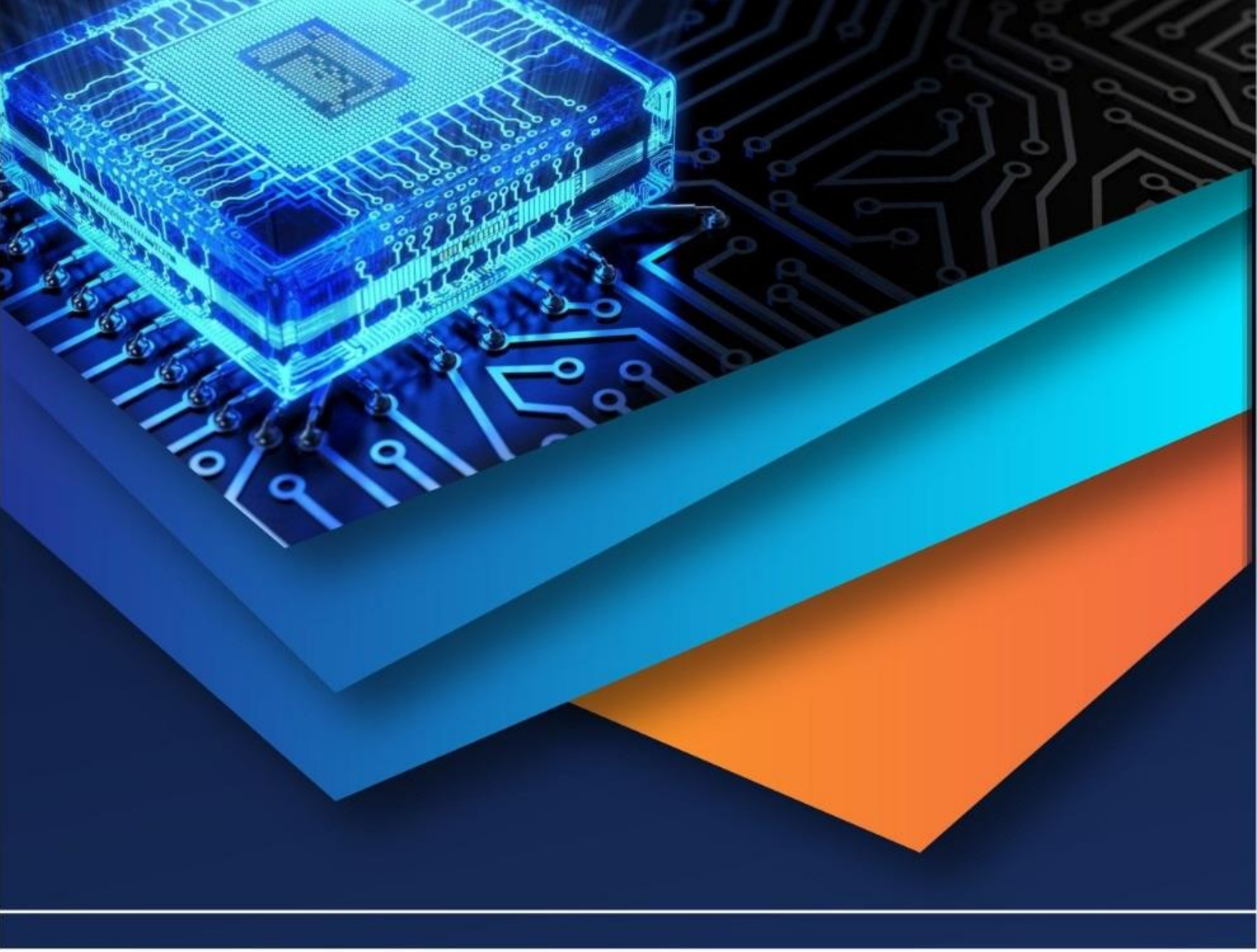

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