Journal of Artificial Intelligence and Emerging Technologies
Volume 3, Issue 4, pp 1-7, April 2026
ISSN (online): 3049-1967
DOI: https://doi.org/10.47001/JAIET/2026.304001
Available Online at https://www.jaiet.com

Smart Voting System Using Face Recognition Technology and AI-Driven Database Management for Secure Elections

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Abstract: The Smart Voting System using Facial Recognition is designed to improve the security, accuracy, and efficiency of modern electoral systems. Traditional voting methods are vulnerable to issues such as voter impersonation, fraud, and manual verification errors. To overcome these challenges, this system integrates facial recognition technology with machine learning techniques. The proposed system utilizes OpenCV for real-time image processing and Histogram of Oriented Gradients (HOG) for extracting distinctive facial features. These features are then classified using a Support Vector Machine (SVM) algorithm to verify the identity of voters. During the voting process, the voter's face is captured using a webcam, pre-processed, and analyzed to extract HOG descriptors. The extracted features are compared with a pre-registered voter database using the trained SVM classifier. If the facial features match the stored records, the voter is authenticated and allowed to cast the vote. This approach reduces the chances of voter impersonation and improves the overall transparency of the voting process. The system is designed to be cost-effective, scalable, and suitable for real-time deployment in polling environments, making it a reliable alternative to traditional voting systems.

Keywords: Smart Voting System, Facial Recognition, OpenCV, SVM, HOG, Electronic Voting.

I. INTRODUCTION

In recent years, ensuring the security and integrity of voting systems has become a major concern. Traditional voting methods such as paper ballots and manual verification are prone to problems like voter impersonation, fraud, and human errors. These issues can affect the transparency and credibility of elections. Therefore, there is a growing need for a more secure and efficient voting mechanism.

Facial recognition technology combined with machine learning provides a promising solution for secure voter authentication. By using biometric facial features, the system can verify the identity of voters accurately and prevent unauthorized voting. Technologies such as OpenCV, Histogram of Oriented Gradients (HOG), and Support Vector Machine (SVM) are used to detect and recognize faces effectively.

In India, two main methods are currently used for voting. The first method is the secret ballot paper, which requires a large amount of paper and manual counting. The second method is the Electronic Voting Machine (EVM), which has been widely used since 2003. Although EVMs improved the voting process, the authentication of voters still mainly depends on voter ID cards, which can sometimes lead to misuse or impersonation.

To address these issues, this project proposes a Smart Voting System using Facial Recognition. In this system, a voter's face is captured and compared with the registered image stored in the database. If the captured image matches the stored data, the voter is allowed to cast their vote.

This approach enhances security, reduces fraud, and ensures that only authorized voters participate in the election. By integrating facial recognition with machine learning techniques, the proposed system aims to make the voting process more secure, efficient, and reliable, thereby strengthening the overall election system.

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II. RELATED WORK

Viola and Jones introduced a real-time face detection algorithm based on Haar-like features and the AdaBoost learning algorithm. Their approach enabled efficient face detection in images and video streams and became widely used in many computer vision applications. However, the method is sensitive to lighting conditions and pose variations. Turk and Pentland proposed the Eigenfaces method for face recognition using Principal Component Analysis (PCA). This method represents facial images in a lower-dimensional feature space and was one of the earliest successful approaches to automated face recognition. Despite its effectiveness, the method performs poorly when there are changes in illumination or facial expressions.

Ahonen et al. presented a face recognition technique using Local Binary Patterns (LBP) for extracting local texture features from facial images. This method improved recognition performance and showed robustness against certain lighting variations. However, its performance decreases when handling large datasets or uncontrolled environments. Dalal and Triggs introduced the Histogram of Oriented Gradients (HOG) descriptor for object detection. HOG extracts gradient orientation information from images and is particularly effective in detecting human shapes and faces. When combined with Support Vector Machine (SVM) classifiers, this approach significantly improves recognition accuracy. King developed the Dlib machine learning toolkit that integrates HOG- based feature extraction with SVM classifiers for reliable and efficient face detection and recognition. This framework has been widely used in real-time applications such as surveillance systems, biometric authentication, and identity verification systems.

III. PROPOSED SYSTEM

In this proposed system, a webcam captures real-time video frames of the voter's face. The captured frames are processed to detect the face using a face detection algorithm. Once the face is detected, the Region of Interest (ROI) representing the facial region is extracted from the image. This region is then processed to extract meaningful facial features required for identity verification.

Before feature extraction, the captured images undergo pre-processing steps such as resizing, noise removal, and RGB-to-grayscale conversion. These operations improve image quality and reduce computational complexity. After preprocessing, the system extracts facial features using the Histogram of Oriented Gradients (HOG) technique.

The extracted features are then passed to a Support Vector Machine (SVM) classifier, which compares the features with those stored in the voter database. The classifier determines whether the detected face belongs to a registered voter. If the identity matches the stored database, the voter is authenticated and allowed to cast the vote. Otherwise, the system denies access.

The system is implemented using Python with OpenCV, Dlib, and Scikit-learn libraries, enabling efficient image processing, face detection, and machine learning classification. The overall architecture of the system supports real-time operation and can be deployed effectively in polling stations.

IV. SYSTEM ARCHITECTURE

The system architecture of the proposed smart voting system describes the overall structure and flow of the facial recognition process used to authenticate voters. The system begins with a camera that captures the voter's face in real time. The captured image is first processed through a face detection module, which identifies the facial region from the input frame. After detecting the face, the image undergoes pre-processing, where operations such as resizing and converting the image to grayscale are performed to improve image quality and prepare it for further analysis.

Next, the processed image is sent to the feature extraction stage, where the Histogram of Oriented Gradients (HOG) algorithm extracts important facial features such as edges, contours, and gradient patterns. These features are converted into a feature vector representing the unique structure of the face. The extracted features are then given to the Support Vector Machine (SVM) classifier, which compares them with the stored facial features of registered voters in the voter database.

If the extracted features match the stored data, the system successfully authenticates the voter and allows access to the voting

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interface. Otherwise, the system denies access to prevent unauthorized voting. This architecture ensures a secure, efficient, and automated voter verification process, reducing the chances of impersonation and improving the reliability of the voting system.

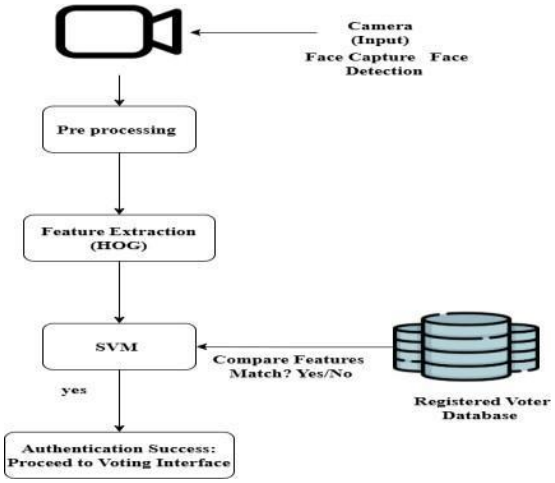

Figure 1: System Architecture

HOG (Histogram of Oriented Gradients)

The Histogram of Oriented Gradients (HOG) method is widely used for feature extraction in computer vision applications such as face detection and recognition. In this project, HOG is applied to extract important facial features from the detected face image before classification. The HOG algorithm works by analyzing the gradient direction and magnitude of pixel intensities in localized regions of an image. These gradients help in identifying important structural information such as edges, contours, and shapes of facial components. The extracted gradient information is grouped into histograms, which together form a feature vector representing the facial structure.

This feature vector is then passed to a classifier such as Support Vector Machine (SVM) to identify whether the detected face matches a registered voter in the database.

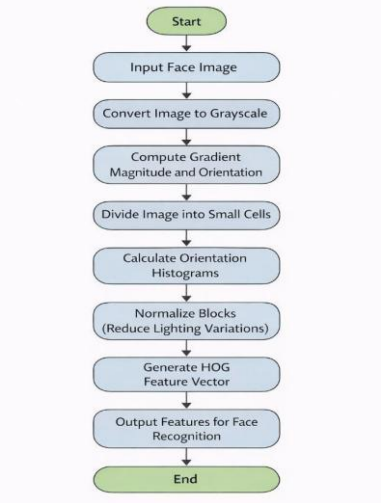

Fig 2: HOG Feature Extraction Process

The HOG feature extraction process begins by converting the input image into a grayscale image to simplify the processing and

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reduce computational complexity. The grayscale image is then divided into small regions called cells, typically of size 8×8 pixels. For each cell, the algorithm calculates the gradient magnitude and orientation for every pixel. The gradient magnitude represents the strength of the edge, while the orientation indicates the direction of the edge. Next, the gradient directions within each cell are grouped into orientation bins to form a histogram. These histograms represent the distribution of edge directions within that particular region of the image. By capturing these gradient patterns, HOG effectively describes the local shape and structure of the face.

SVM (support vector machine)

The Support Vector Machine (SVM) is a supervised machine learning algorithm used for classification tasks.

In this project, SVM is used to classify the extracted facial features and determine whether they match the registered voter database. The SVM algorithm works by finding an optimal hyperplane that separates different classes of data points. In the case of facial recognition, each class represents a registered voter. During training, the SVM model learns the boundaries between different facial feature vectors. During testing, the extracted features from the input image are compared with the trained model to determine the identity of the voter.

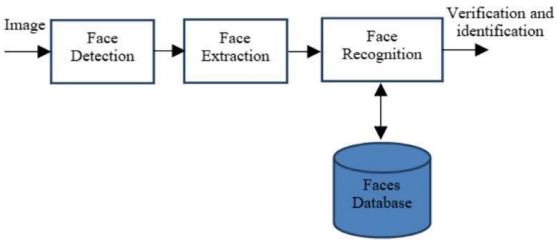

Fig 3: SVM classification process

The main advantages of SVM include: High accuracy in classification. Ability to handle high- dimensional data. Effective performance with limited training samples. By combining HOG feature extraction with SVM classification, the system achieves accurate and reliable facial recognition.

V. RESULTS

The proposed Smart Voting System using Face Recognition Technology and AI-Driven Database Management was successfully implemented and tested. The system authenticates voters using facial recognition before allowing them to cast their vote. The implementation includes modules such as user registration, login authentication, face detection, feature extraction, and voter verification.

Home Page Interface

When the application starts, the home page of the Smart Voting System is displayed as shown in Fig. 4.

Fig 4: Home Page

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The interface provides two options: Sign Up and Login. The Sign Up option allows new users to register in the system, while the Login option allows registered users to access the voting platform.

VI. VOTER REGISTRATION

When the user clicks the Sign Up button, the registration form is displayed as shown in Fig.5 The user must provide details such as:

- Name
- Email
- Phone Number
- Aadhaar Number
- Password
- Upload Face Image

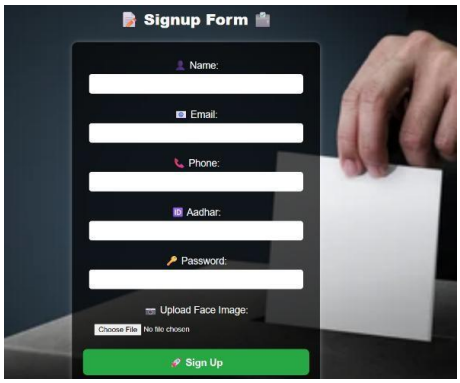

Fig 5: Voter Registration

The uploaded face image is stored in the system database and later used for facial recognition during authentication.

USER LOGIN

After successful registration, the user can log in using the Login page shown in Fig. 6

Fig 6: User Login

The user must enter their Aadhaar number and password. The system verifies the login credentials with the stored database information.

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VII. FACE VERIFICATION

Face verification is an important part of the proposed smart voting system because it confirms whether the person trying to vote is a registered voter. After the user logs into the system, the webcam turns on and captures the voter's face in real time. The system first uses the Haar Cascade algorithm to detect the face from the camera frame. This step helps the system locate the exact facial region in the captured image.

Once the face is detected, the system extracts the important facial features using the Histogram of Oriented Gradients (HOG) technique. These features describe the unique structure of the person's face, such as edges and contours. The extracted features are then given to the Support Vector Machine (SVM) classifier, which compares them with the facial data stored in the registered voter database.

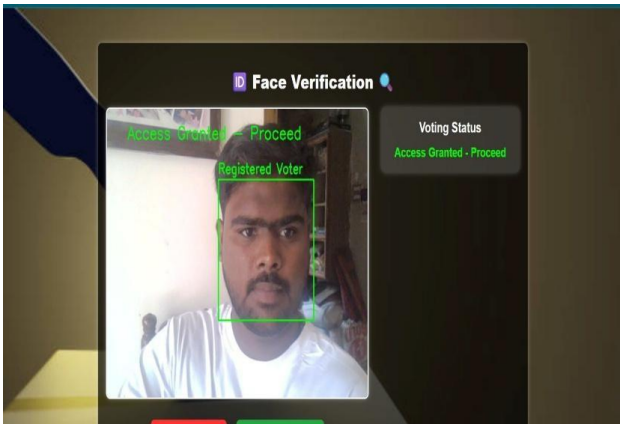

Fig 7: Face Verification

If the features match the stored data, the system recognizes the person as a registered voter and displays the message "Access Granted – Proceed", allowing the user to continue to the voting interface. If the features do not match, access is denied. This process helps ensure that only authorized voters are allowed to vote.

VIII. VOTING ACCESS

At this stage, the voter is allowed to move to the voting page, where they can view the available candidates and cast their vote. The system ensures that only verified voters can reach this stage, which helps prevent unauthorized voting. If the facial verification fails, the system blocks access and does not allow the user to continue to the voting interface.

IX. CONCLUSION

The proposed smart voting system uses face recognition technology to improve the security and efficiency of the voting process. Traditional voting methods may face problems such as human errors, long verification procedures, and the possibility of fraudulent voting. To address these issues, the system integrates Haar Cascade for face detection, HOG for feature extraction, and SVM for classification to verify voters automatically.

The system captures the voter's face using a webcam and compares the extracted facial features with the stored data in the registered voter database.

If the features match, the voter is authenticated and allowed to vote. This approach helps prevent unauthorized voting and ensures a more reliable and transparent election process.

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