# Comprehensive Study of Face Verification in Voting System

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***Abstract*—The study assesses the effectiveness of face verification techniques in verifying the identity of voters, aiming to prevent fraudulent activities during elections. Researchers analyze the benefits of incorporating face verification systems, such as improving voter authentication to ensure each voteis cast by the rightful individual, with the system achieving an accuracy of 98% and a validity of 90%. The paper also discusses the challenges and limitations faced in integrating face verification technology into the voting system, providinginsights into overcoming these obstacles. Through a detailed investigation, the research aims to offer valuable informationto policymakers and election officials on the feasibility and potential impact of adopting face verification in voting systems. The study also highlights how crucial it is to protect voter privacy and data security while putting face verification techniques in place to protect sensitive data and preserve the integrity of the election process. All things considered, the study offers a thorough examination of how face verification technology might improve the legitimacy, dependability, and overall effectivenessof the voting process.**

***Keywords - Face Verification, CNN, Voting System, Electoral Integrity, Proxy Voting, Multiple Voting***

## I. Introduction

Voting is a basic fundamental right and an essential component of civic participation in democracies. However, with the introduction of new technology and sophisticated types of electoral fraud, maintaining the security and integrity of the voting process has grown more difficult. Electoral integrity, which ensures free, fair, and transparent elections, is a crucial aspect of democratic governance. However, problems like as voting fraud, proxy voting, repeated voting, and voter impersonation threaten the integrity of elections everywhere.

Proxy voting, in which a legitimate voter casts a ballot on behalf of another voter who is unable to do so in person for a variety of reasons, including illness, impairment, or absence from the voting jurisdiction, is one area of concern [1]. Several incidents of bogus voting were reported in many Indian states during the general Lok Sabha elections of 2024 [2] [3] [4].

Malpractices like proxy voting, multiple voting, fake voter IDs, booth capturing, voter impersonation, technological manipulation, and voter intimidation, severely undermining the integrity of elections. Conventional voter verification techniques, which mostly rely on physical identification and manual inspections, are frequently insufficient to fully address these problems. For solving the problem there is a need for modern technology like face recognition.

In the 2019 Telangana municipal elections, the Indian state tested facial recognition technology as a means of authenticating voters. Estonia has investigated face recognition for safe online voting. Estonia is well-known for its e-governance projects. A few US states have also looked into using facial recognition technology during elections.

In order to prevent proxy and multiple voting, this research paper investigates the use of face recognition technology in the voting process. This article will look at the technology's accuracy, implementation challenges, and possible consequences on voting integrity.

## II. Literature Survey

B Singh, et.al.[5] proposed an International Direct Digital Election method using Android smartphones for voting and voter verification through face recognition proposed in previous research. They used techniques like face recognition, Aadhar number verification OTP verification with mobile numbers. Fatimah Dhaher, et.al.[6] proposed Face and fin-fingerprint identification through automated methods for voter authentication. They used DNN recognition for face matching and fingerprint training for validation.

Pratik Hopal et.al.[7] proposed Machine learning approaches for facial recognition using Recurrent Neural Networks and Non-parametric kernel smoothing and multi-output ridge regression for voting map construction. They have employed a 1024-bit Shamir's algorithm electronic voting security mechanism for voter authentication. Inggrid Fortuna, et.al.[8] proposed Face Recognition uses OCR with regex for ID card data extraction and face recognition with MT-CNN and Face-Net for voter verification.

Srushti Gunthe, et.al.[9] proposed a Client-server modelwith face recognition and OTP for online voting. They used theHaar Cascade Algorithm for face detection and recognition. It utilized Python, Tkinter, SQLite, and OpenCV for system development. Nadar Paulraj et.al.[10] proposed model on fingerprints and face recognition for voter verification.

Sowrirajan, et.al.[11] proposed a voting system that uses facial recognition algorithms like Eigenface, FisherFace, and SURF and they used Eigenvectors for facial recognition, classifying faces based on patterns. Shahram Syed, et.al.[12] proposed a hybrid model that uses Fingerprint and facial recognition for voter identification and the Viola-Jones algorithm for facial feature extraction. They used generalized PCAand K-NN for identity verification.

Anukar Sahitya, et.al.[13] proposed face recognition technology for eliminating fake voting and a system to detect facialexpressions and poses for voting. They used Geometric and Feature-based face recognition approaches and an SVM for classification and regression analysis. Voram Bhavan, et.al.[14]proposed an online voting system functionality and user experience. They used a web-based voting system with online voting privilege and the development of an online voting platform with security requirements.

## III. Proposed Methodology

In order to improve security and dependability, this study looks into the integration of facial verification technologies into voting systems. It evaluates the security of the system against spoofing, looks at privacy issues, rates the accuracy of facial recognition algorithms in confirming voter IDs, and talks about the moral and legal ramifications of using biometric data in elections. The paper intends to provide insights into the viability and limitations of adopting facial verification to support democratic integrity by synthesizing empirical data and current research. In order to guarantee fair and transparent electoral procedures, recommendations are made for further study and policy development in the conclusion. **Figure 1** shows the flow of methodology which includes collection, pre-processing, and capturing facial data, applying sophisticated algorithms to extract features, and carefully evaluating system performance and ethical considerations to guarantee reliable and secure implementation in various applications, including access control and digital identity management.

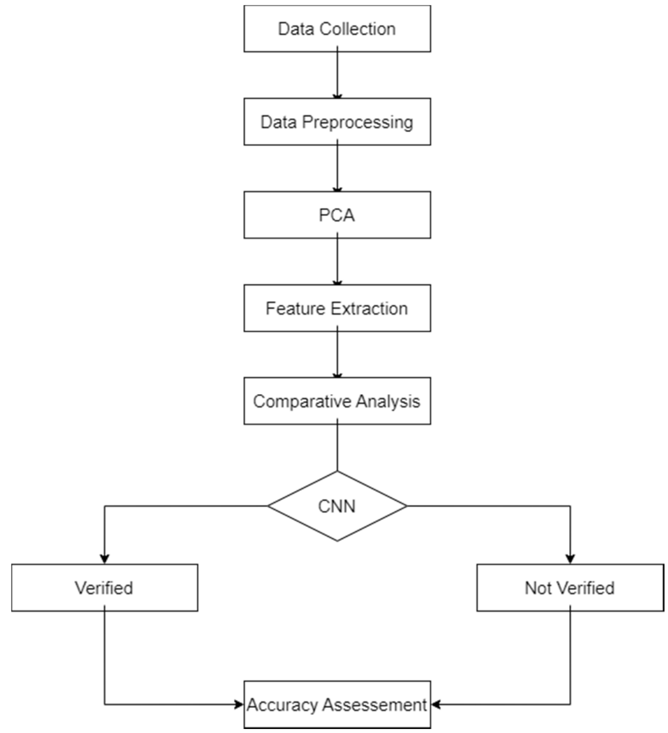


Fig. 1. Overview of Methodology

### A. Data Collection

Data collection for face recognition involves gathering a diverse and representative set of facial images to train and evaluate face recognition models. The dataset is taken from Kaggle and comprises images from different perspectives, with different lighting, backgrounds, and expressions.

The Olivetti dataset is a series of face photos taken in a span of two years. There are ten different photographs for each of the forty people, for a total of 400 images. These face photos were taken in a variety of settings and offer a broad and varied dataset for facial identification and analysis. The resolution of every image is 64x64 pixels where faces are displayed in grayscale.

### B. Data Preprocessing

Preprocessing data is essential for increasing the precision and efficiency of the model. It entails a number of steps for improving the consistency and quality of the data. Firstly, standardize the input data for the model, the images are first normalized to a constant size and resolution.

Once the face has been identified, alignment techniques are used to adjust for changes in pose, size, and rotation. Further, Data cleaning process is used for removing unnecessary noise and variations to ensure that the model concentrates on the most important features for accurate identification and verification.

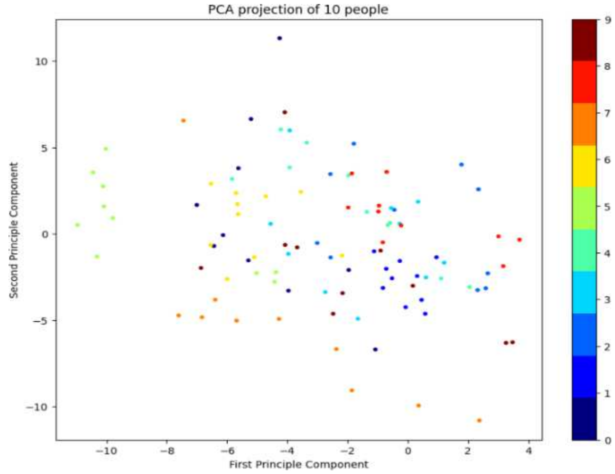


Fig. 2. PCA Projection

### *C. PCA*

Machine learning uses principal component analysis (PCA), a dimensionality reduction approach, to extract as much variance as possible from high-dimensional data and express it ina lower-dimensional format. Gathering facial images—which are represented as high-dimensional vectors—is the first step in PCA's face process. The mean face is then subtractedto center these vectors, and the principal components thatmaximize data variance are identified.

These can be discovered as the greatest eigenvectors of the covariance matrix, which indicates the principal components. These eigenfaces, or primary components, offer a productive means of comparing and representing faces. It is possible to express each face as a linear combination of eigenfaces, which makes comparisons easy and quick.

A fresh face is projected onto this lower-dimensional subspace in a face recognition system, and it is then contrasted with stored representations of well-known faces. This method concentrates on differentiating characteristics and maximizing computing efficiency, simplifying face recognition. In **Figure 2**, the PCA projection reduces data from 10 individuals to two principal components, capturing the largest variance in the dataset. Each point represents an individual, with distances between points indicating similarities or differences based on key features. The first and second principal components explain a significant portion of the variance, providing a simplified view of complex, multidimensional data.

$$Z = XW$$

where X is input data, W is the matrix of eigenvectors, and Z is the lower-dimensional representation. The eigenfaces are calculated as the eigenvectors of the covariance matrix:

$$C = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)(x_i - \mu)^T$$

where $x_i$ represents the individual data points, and $\mu$ is the mean vector of the data.

### *D. Feature Extraction*

The process of detecting and separating the most characteristic and useful elements of face photos is known as feature extraction, and it is essential to face recognition systems' accuracy and performance. Techniques like PCA decrease the dimensionality of data while maintaining variance and class information.

Convolutional Neural Networks (CNNs) extract hierarchical features straight from raw pixel data by automating feature learning through layers of convolutions and pooling. Convosolution and pooling layers are used along with activation layers for extracting features. To handle fluctuations in lighting, position, expression, and occlusion, robust feature extraction is necessary.

### *E. Comparative Analysis*

Comparative analysis is the rigorous assessment of different systems or algorithms to verify identity based on features of the face. The goal of research is to identify and choose thebest workable solution. The creation of a face verificationsystem that is more accurate, dependable, and effective. Table 1, shows that Convolutional Neural Networks (CNNs), is the most suitable algorithm with 98% accuracy and 90% validation score.

TABLE 1
Performance Comparison table

| **Algorithm** | **Accuracy** | **Validation** |
|---|---|---|
| LDA | 93% | 97% |
| Logistic Regression | 93% | 93% |
| Naïve Bayes | 86% | 79% |
| KNN | 69% | 68% |
| Decision Tree Classifier | 62% | 49% |
| SVM | 92% | 86% |
| Siamese Network | 94% | 87% |
| CNN | 98% | 90% |

*F. CNN*

Convolutional Neural Networks (CNNs) have transformed face recognition by autonomously learning hierarchical features straight from raw pixel data, in contrast to traditional methods like PCA and LDA, which call for handcrafted features. CNN architectures that are used for facial recognition usually include fully connected, pooling, and convolutional layers. The CNN is trained using a loss function, typically cross-entropy, to minimize classification error:

$$L = -\sum_{i=1}^{N} y_i \log(\hat{y}_i)$$

Where $y_i$ is the true label, and $\hat{y}_i$ is the predicted probability for the class.

## IV. Results

Convolutional neural networks, or CNNs, have become the gold standard for face verification due to their many advantages over more conventional techniques. In contrast to manual feature-based approaches like PCA and LDA, CNNs learn hierarchical representations on their own from unprocessed pixel data.

Convolutional, pooling and fully connected layers are common components of CNN architectures used in facial recognition applications. To extract significant information from inputimages, like edges and textures, the convolutional layers use learnable filters. These filters are optimized during training to reduce recognition errors.

CNN outperformed other machine learning approaches and traditional methods with 98% accuracy and 90% validity in a comparative analysis of face verification algorithms. This improved performance highlights CNNs' potential to further facial recognition research and their usefulness in practical situations.

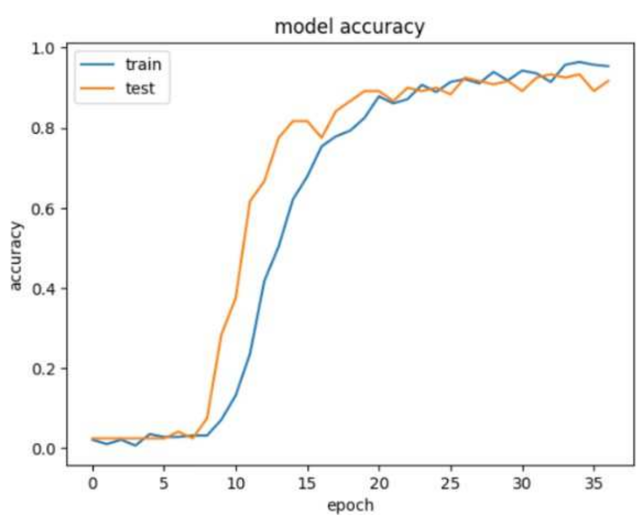


Fig. 3. Model Accuracy plot

While Fig. 4 displays the training and testing set's loss plot in CNN, Fig. 3 displays the accuracy plot of the trainingand testing set. With validation loss and accuracy of 0.304and 0.908, the model runs for 37 epochs. Figure 3 showsthat as the number of epochs rises, both test and trainingaccuracy increase. In model training, training accuracy is typically slightly higher than test accuracy. Accuracy peaks after a while, indicating ideal learning. As the model learns, both the test and training loss values in Fig. 4 initially drop dramatically. Both lines level off after about five epochs, indicating convergence. Better model performance is indicatedby a lower loss.

The model shows low overfitting and rapid convergence, which is consistent with the high accuracy rates that have been previously reported. These findings imply that CNNs are quite successful in face recognition in voting systems, but more testing on a variety of datasets is advised to guarantee robustness and fairness.

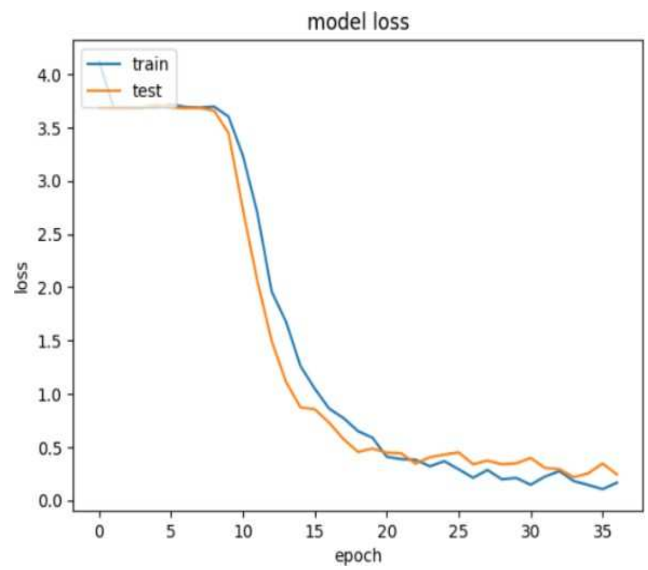


Fig. 4. Model Loss plot

## V. Conclusion and Future scope

The Proposed paper examines the use of face verification technology in voting systems and emphasizes how it can improve security and integrity. Face verification is highlighted as being essential to safeguarding voting procedures since it offers a dependable and practical way to confirm voter identities and may even curtail fraudulent activity. The research highlights the want for additional investigation to tackle issues concerning the precision, velocity, and resilience of facial recognition technology, urging further progress to guarantee successful practical application. To create a more safe and dependable voting environment, the paper addresses the advantages of introducing face verification, including increased transparency, efficiency, and trust in the electoral process. The study's drawbacks include the variety of datasets, scalability issues, privacy issues, generalization to different demographics, and technological difficulties in actual election systems. By addressing these, system implementation and reliability will improve. Overall, the findings suggest that face verification technology can significantly enhance the credibility and integrity of voting systems, paving the way for more secure and transparent electoral processes in the future.

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