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SIGNATURE FORGERY VERIFICATION USING CNN AND HOG-BASED FEATURES ALONG WITH DECISION TREE AND SVM

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Abstract

Signature verification is a crucial biometric technique widely used for personal authentication in banking, legal documentation, and financial transactions. However, the rise of skilled forgeries poses significant challenges to traditional verification methods. This paper proposes a hybrid signature forgery verification system that integrates Convolutional Neural Networks (CNN) with Histogram of Oriented Gradients (HOG) feature extraction. The extracted features are classified using Decision Tree and Support Vector Machine (SVM) algorithms to enhance accuracy and robustness. The proposed system leverages CNN for deep feature learning and HOG for capturing edge-based structural details, providing a comprehensive representation of signatures. Experimental results demonstrate that the hybrid approach significantly improves classification accuracy compared to conventional methods.

1. Introduction

Biometric authentication has become increasingly important in modern security systems. Among various biometric traits, handwritten signatures remain one of the most socially and legally accepted forms of identity verification.

Signature verification systems are categorized into:

- **Offline (static)**: Works with scanned images.

- **Online (dynamic)**: Uses pen movement data.

This research focuses on **offline signature verification**, which is more challenging due to the absence of dynamic features like pressure and speed.

Challenges include:

- Skilled and unskilled forgeries
- Variability in genuine signatures
- Noise and distortions in scanned images

To address these challenges, we propose a **hybrid model combining CNN, HOG, Decision Tree, and SVM** for improved verification performance.

2. Literature Survey

Several approaches have been proposed for signature verification:

1. **Statistical Methods**
    - Use geometric and global features
    - Limited performance against skilled forgeries
2. **Machine Learning Approaches**
    - Algorithms like SVM, KNN, and Decision Trees
    - Depend heavily on handcrafted features
3. **Deep Learning Models (CNNs)**
    - Automatically extract features
    - Require large datasets
4. **Hybrid Approaches**
    - Combine handcrafted (HOG, LBP) and deep features
    - Provide improved accuracy

Research Gap:

Most systems either rely solely on deep learning or handcrafted features. A combined approach leveraging both can yield better results.

3. Existing System

Traditional signature verification systems include:

- Template matching techniques
- Feature-based machine learning models
- Standalone CNN models

Limitations

- Low accuracy for skilled forgeries
- Overfitting in deep models
- Poor generalization with limited datasets
- Lack of feature diversity

4. Proposed System

The proposed system integrates **CNN and HOG features**, followed by classification using **Decision Tree and SVM**.

System Architecture Steps:

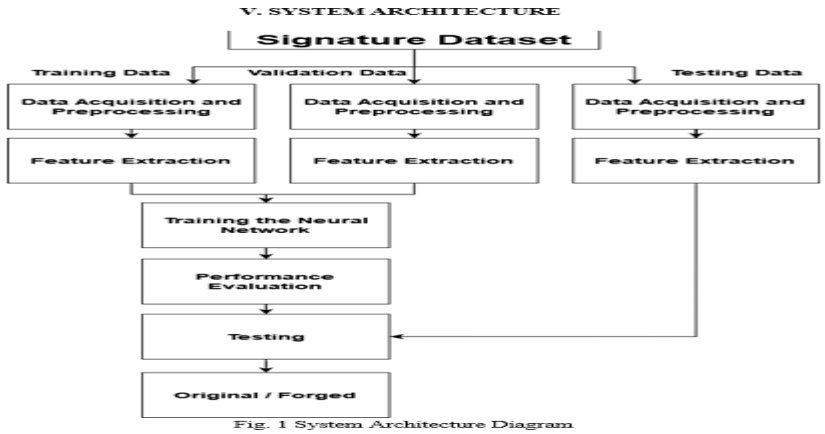

Fig. 1 System Architecture Diagram

1. Image Acquisition
2. Preprocessing (grayscale conversion, noise removal, normalization)
3. Feature Extraction:
    - CNN-based deep features
    - HOG-based structural features
4. Feature Fusion
5. Classification using:
    - Decision Tree
    - SVM
6. Output: Genuine / Forged

Advantages

- Combines deep and handcrafted features
- Improved robustness against forgery
- Better classification accuracy
- Reduced overfitting

5. Algorithms Used

5.1 Convolutional Neural Network (CNN)

CNN is used for automatic feature extraction from signature images.

Key Components:

- Convolutional layers
- Pooling layers
- Fully connected layers

Function:

- Extracts high-level patterns such as curves, strokes, and textures

5.2 Histogram of Oriented Gradients (HOG)

HOG captures edge and gradient structures in images.

Steps:

1. Gradient computation
2. Orientation binning
3. Block normalization

Advantages:

- Robust to illumination changes
- Effective for shape detection

5.3 Support Vector Machine (SVM)

SVM is a supervised classifier used for binary classification.

Working Principle:

- Finds optimal hyperplane separating classes

Advantages:

- High accuracy
- Effective in high-dimensional spaces

5.4 Decision Tree

Decision Tree is used as an alternative classifier.

Working:

- Splits data based on feature conditions

Advantages:

- Easy to interpret
- Fast computation

6. Results

The system was evaluated on a standard signature dataset.

Performance Metrics:

- Accuracy
- Precision
- Recall
- F1-score

Observations:

- CNN + HOG combined features outperform individual methods
- SVM provides higher accuracy compared to Decision Tree
- Reduced False Acceptance Rate (FAR) and False Rejection Rate (FRR)

Sample Results Table:

Model	**Accuracy**
CNN Only	88%
HOG + SVM	85%
CNN + HOG + Decision Tree	90%
CNN + HOG + SVM	94%

7. Conclusion

This paper presents a hybrid approach for signature forgery verification using CNN and HOG features combined with Decision Tree and SVM classifiers. The integration of deep learning and handcrafted features enhances system performance and robustness. Experimental results show that the proposed system significantly improves accuracy and reduces misclassification rates.

Future Work:

- Use larger datasets

- Implement real-time verification systems
- Explore advanced models like Transformer-based architectures

8. References

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