Performance Evaluation for Biometric Security Project

Project Overview

The primary goal of this biometric security project is to evaluate the performance of fingerprint recognition using two distinct feature extraction methods, namely Minutiae-based and Texture-based approaches, combined with two classifiers: Support Vector Machine (SVM) and k-Nearest Neighbors (k-NN). The evaluation involves analyzing True Positive Rates (TPR) and False Positive Rates (FPR) and comparing the performance using Receiver Operating Characteristic (ROC) curves and Area Under the Curve (AUC) metrics.
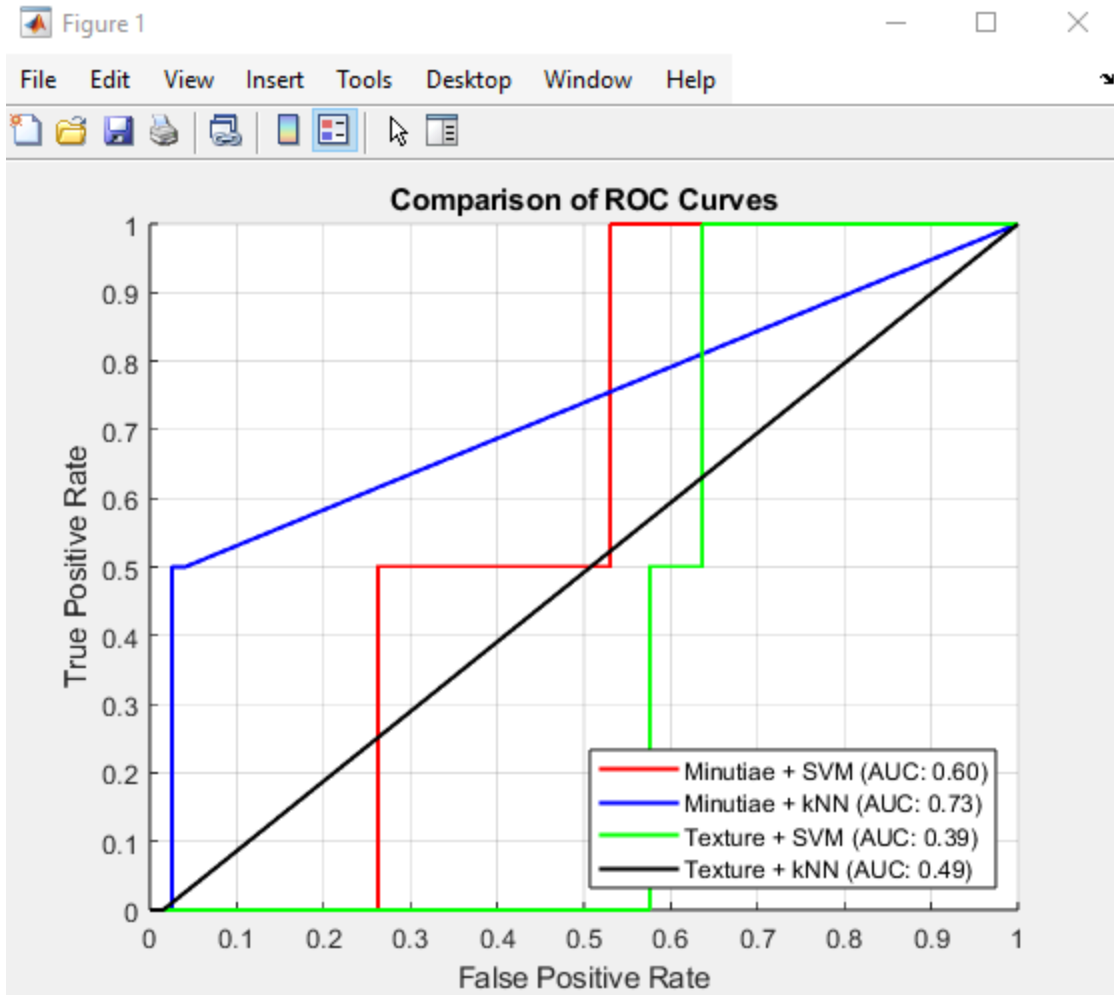
Methodology

1. Feature Extraction Methods:
   - Minutiae-based: Focuses on identifying specific points of interest, such as bifurcations and ridge endings, to describe the fingerprint's unique characteristics.
   - Texture-based: Employs spatial and frequency domain analysis to extract texture patterns from the fingerprint image.

2. Classifiers:
   - SVM: A supervised learning algorithm that constructs a hyperplane to separate data points into classes with maximum margin.
   - k-NN: A non-parametric algorithm that classifies data points based on the closest labeled examples.

3. Performance Metrics:
   - ROC Curve: Illustrates the trade-off between TPR and FPR for various decision thresholds.
   - AUC: Measures the overall capability of the classifier to distinguish between classes.

Results

The ROC curves and AUC values for the different combinations of feature extraction methods and classifiers are summarized below:

Combination	AUC Value
Minutiae + SVM	0.60 (60%)
Minutiae + k-NN	0.73 (73%)
Texture + SVM	0.39 (39%)
Texture + k-NN	0.49 (49%)

Comparison of ROC Curves

Legend:
- Minutiae + SVM (AUC: 0.60)
- Minutiae + kNN (AUC: 0.73)
- Texture + SVM (AUC: 0.39)
- Texture + kNN (AUC: 0.49)

Observations

1. Minutiae-based Methods:
   - The combination of Minutiae + k-NN yielded the highest AUC (0.73), indicating robust performance in distinguishing between classes.
   - Minutiae + SVM performed moderately with an AUC of 0.60. SVM performed worse due to: Overlapping decision boundaries, which may perform poorly in scenarios with many class overlaps. (100 classes).

2. Texture-based Methods:
   - Both Texture + SVM and Texture + k-NN demonstrated relatively low AUC values of 0.39 and 0.49, respectively, suggesting limited effectiveness for this dataset.

3. Overall Classifier Comparison:

- k-NN outperformed SVM in both feature extraction methods, particularly when used with Minutiae-based features.

Conclusion

The results highlight the superiority of Minutiae-based feature extraction over Texture-based methods for fingerprint recognition in this study. Texture based extraction performed poorly for this dataset, this is probably because with 100 classes, there is a high likelihood of overlap between the texture patterns of different fingerprints. Among the classifiers, k-NN demonstrated better performance, especially when paired with Minutiae-based features. These findings suggest that the Minutiae + k-NN combination is the most effective approach for this biometric security application.

Future work may include testing with larger datasets, exploring additional feature extraction techniques, and employing ensemble classifiers for potentially improved performance.