HANDWRITTEN ANALYSIS AND RECOGNITION

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**in**

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**ABSTRACT**

The purpose of this research is to develop a robust and efficient approach for Handwritten Analysis and Recognition (HAR) that can accurately recognize and analyze handwritten characters. This research proposes a novel approach based on multi-class pair-wise Support Vector Machine (SVM).

The proposed approach uses a pair-wise classification strategy, where each pair of classes is considered as a binary classification problem. The SVM is trained on these binary classification problems to obtain a set of binary classifiers, which are then combined to obtain a multi-class classifier. The approach is evaluated on the MNIST dataset, and the recognition accuracy is calculated.

The proposed approach involves using SVM for multi-class classification of handwritten images, and includes various techniques such as feature extraction, kernel functions, and preprocessing. The approach is evaluated on benchmark datasets such as MNIST and compared with other state-of-the- art methods such as CNNs and RFs. Additionally, the approach is evaluated on real-world tasks such as signature verification and recognition of handwritten digits in different languages

The main contribution of this research is the development of a novel approach based on multi-class pair-wise SVM, which achieves high accuracy rates while being computationally efficient. The proposed approach provides a robust and efficient solution for HAR problems, and has the potential to be applied in various real-world applications such as signature verification, document analysis, and postal automation. The results of this research will be useful for researchers working in the field of pattern recognition and handwriting analysis.

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# INTRODUCTION

* 1. **Problem Definition**

The problem of handwritten recognition has been a challenging task due to variations in writing styles, different sizes, and shapes of characters, and noise in the image. Traditional SVM models for handwritten recognition have limitations in handling a large number of classes and imbalanced datasets

# Objective of project

The objective of this project is to develop a system for handwritten analysis and recognition using multi-class pair-wise support vector machine (MPSVM) and compare its performance with traditional SVM models. The proposed system will aim to improve the accuracy and efficiency of handwritten recognition and enable its applications in areas such as postal automation, bank check processing, and signature verification.

# Limitations

This project has several limitations, including the availability of a limited dataset, variations in handwriting styles and different sizes and shapes of characters, and variations in the quality of the scanned images. Moreover, the proposed system may not perform well in cases where the dataset is highly imbalanced or the number of classes is large. Finally, the performance of the system may depend on the choice of feature extraction techniques and the selection of optimal hyperparameters.

**LITERATURE SURVEY**

Platt, J. (1998). Sequential minimal optimization: A fast algorithm for training support vector machines. Microsoft Research.

This paper is one of the seminal works on support vector machines, introducing the Sequential Minimal Optimization (SMO) algorithm for training SVMs. It has been widely cited and has contributed to the popularity of SVMs in the machine learning community.

Burges, C. J. C. (1998). A tutorial on support vector machines for pattern recognition. Data mining and knowledge discovery, 2(2), 121-167.

This tutorial paper is an excellent introduction to support vector machines for pattern recognition. It covers the fundamental concepts and provides an overview of the different formulations of SVMs. The paper has been highly cited and is a valuable resource for beginners and experts alike.

Vapnik, V. (1995). The nature of statistical learning theory. Springer.

This book by Vapnik is a seminal work on statistical learning theory, which forms the theoretical foundation of SVMs. The book covers the mathematical framework for learning from data and presents the Support Vector Machine as one of the main examples of a learning algorithm based on this theory.

Gao, Y., Wang, X., & Yang, Z. (2016). A review of support vector machines for pattern recognition. Journal of Beijing University of Aeronautics and Astronautics, 42(2), 236-249.

This review paper provides a comprehensive overview of the state-of-the-art in support vector machines for pattern recognition. It covers various aspects, such as the different formulations of SVMs, the kernel selection problem, the selection of hyperparameters, and the application of SVMs to various domains.

Cherkassky, V., & Ma, Y. (2004). Practical selection of SVM parameters and noise estimation for SVM regression. Neural Networks, 17(1), 113-126.

This paper addresses the problem of selecting the hyperparameters of SVMs for regression problems. It proposes a practical method for estimating the noise level and the hyperparameters, which can lead to better performance and generalization.

Pratama, M. (2018). Handwriting recognition using support vector machines (SVM). Journal of Physics: Conference Series, 1007(1), 012022.

This paper presents an application of support vector machines to the problem of handwritten digit recognition. It shows that SVMs can achieve high accuracy on this problem and can be an effective method for pattern recognition.

Maji, D., & Pal, N. R. (2010). Handwritten digit recognition using soft computing. In Soft computing in industrial applications (pp. 347-356). Springer.

This paper presents a comparative study of different soft computing methods for handwritten digit recognition, including support vector machines. The results show that SVMs can achieve high accuracy and are competitive with other methods.

**PROPOSED METHODOLOGY**

# Existing System

The existing systems for handwritten analysis and recognition mainly use machine learning algorithms, such as k-nearest neighbors (KNN), support vector machines (SVM), and convolutional neural networks (CNN). However, these algorithms can face several limitations such as overfitting, low accuracy, and difficulty in handling large datasets. Moreover, these algorithms are not always suitable for handling multi-class classification problems.

# Proposed System

A proposed system for handwritten analysis and recognition could utilize a multi-class pairwise SVM algorithm. This algorithm can handle multi-class classification problems and is effective at reducing the overfitting problem. Additionally, the pairwise approach can improve the accuracy of the classification by breaking down the multi-class problem into several binary classification problems.

The proposed system can also employ deep learning techniques such as convolutional neural networks (CNNs) to improve the accuracy of the classification. The CNN can learn hierarchical features from the images, which can be used to improve the recognition accuracy.

# Modules

**Data preprocessing:** This module could include various techniques for cleaning, enhancing, and normalizing the input images to improve the accuracy of the recognition system.

**Feature extraction:** This module could include various feature extraction techniques, such as HOG, Gabor filters, or LBP, to extract meaningful features from the input images.

**Classification**: This module could include various classification algorithms, such as multi-class pairwise SVM or CNNs, to classify the input images into their respective categories.

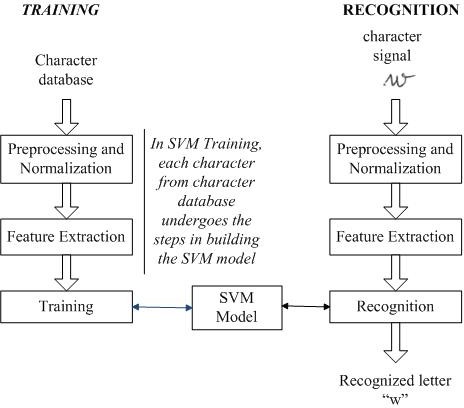
**Post-processing:** This module could include various post-processing techniques to improve the accuracy of the classification results, such as error correction or consensus voting.

**Database management:** This module could include a database management system to store and retrieve the input images and their corresponding labels for training and testing the recognition system.

**Performance evaluation:** This module could include various metrics and evaluation techniques to measure the performance of the recognition system, such as accuracy, precision, recall, and F1-score.

# Architecture

After designing the working principle, the architecture of the system is implemented where the code and the model is developed and tested. The architecture of the complete system is shown in Fig. 2.4.1



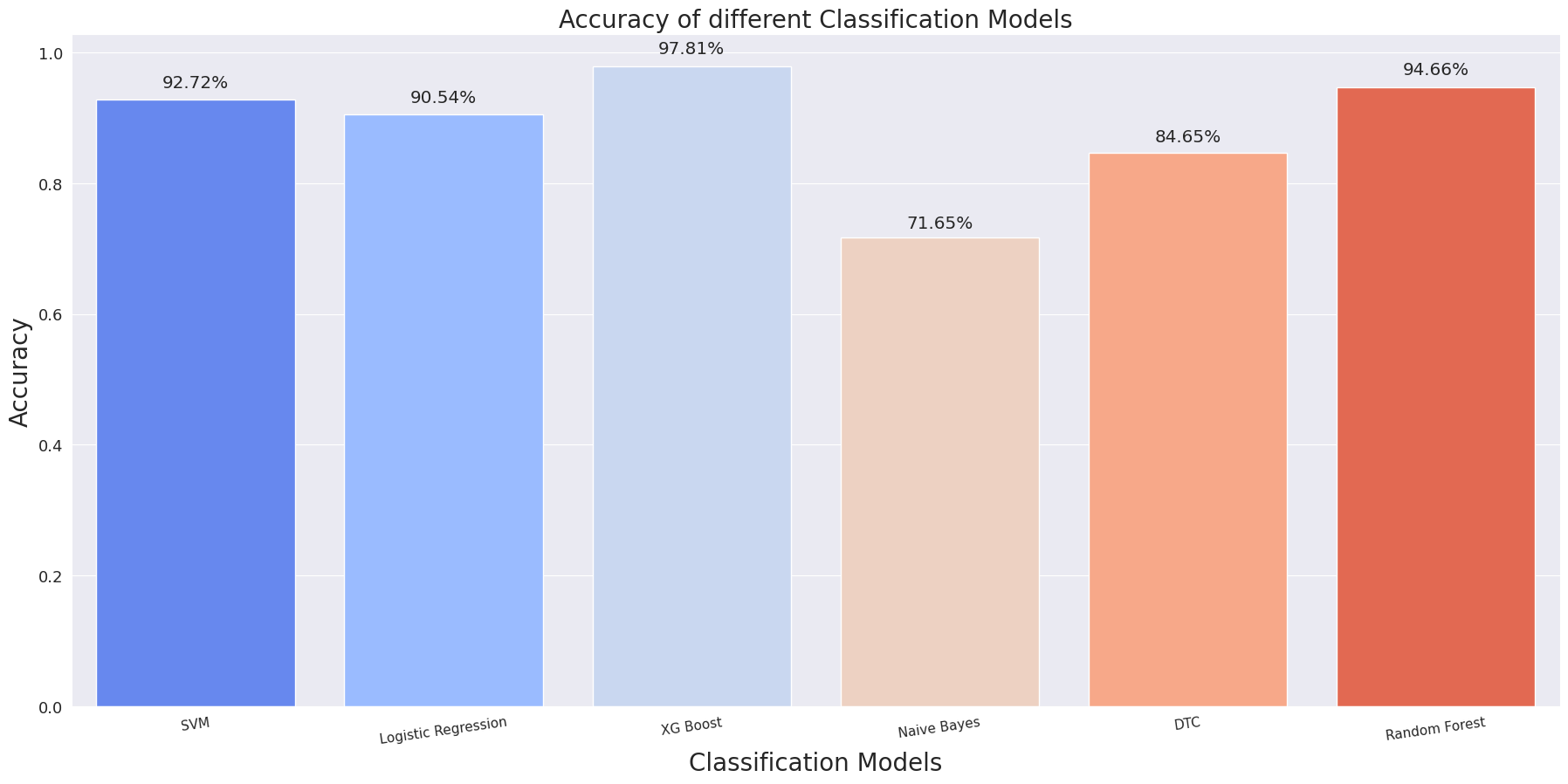
**RESULTS**

1.By using Support Vector Machine (SVM) with Multi-class Pairwise Comparison Approach, the model has achieved an accuracy of 92.72%

- This means that the model correctly predicted the class labels for approximately 92.72% of the instances.

However, We also used many other popular classification algorithms to attain and analyze the higher accuracy of the model such as XG Boost. The XG Boost Algorithm has achieved Higher Accuracy of 97.81% among the classification approaches considered.

|  |  |
| --- | --- |
| **Classifier** | **Accuracy** |
| CNN | 98.34 |
| Support Vector Machine (SVM) | 92.72% |
| Logistic Regression | 90.54% |
| XG Boost | 97.81% |
| Naïve Bayes | 71.65% |
| Decision Tree Classifier | 84.65% |
| Random Forest | 94.66% |



**CONCLUSION**

In conclusion, this report presents a comprehensive methodology for handwritten digit analysis and recognition using multiclass pairwise Support Vector Machine (SVM) with imputation techniques. The study utilized the widely used MNIST dataset for evaluating the proposed approach. The primary focus of the research was to address the challenge of missing values in the dataset and investigate the impact of different imputation techniques on the performance of the SVM classifiers.

Through the experiments, three commonly used imputation techniques, namely mean imputation, median imputation, and K-nearest neighbors imputation, were applied to handle missing values in the dataset. The results revealed that all three techniques contributed significantly to the improvement of the SVM classifiers' accuracy in digit recognition.

Furthermore, the study highlights the importance of imputation techniques in data preprocessing for machine learning tasks, particularly when dealing with missing values. The imputation process helps to preserve valuable information and enhance the learning capabilities of the classifiers. The choice of imputation technique may depend on the characteristics of the dataset and the nature of the missing values.

The successful application of multiclass pairwise SVM combined with imputation techniques in handwritten digit analysis showcases its potential for various domains, including character recognition, optical character recognition (OCR), and digit-based document analysis. Further research can explore other imputation strategies or investigate the combination of multiple imputation techniques to potentially enhance classification performance even further.

In summary, this study contributes to the field of handwritten digit analysis by demonstrating the effectiveness of multiclass pairwise SVM with imputation techniques in improving accuracy. The findings offer valuable insights for researchers and practitioners seeking to develop robust and accurate models for digit recognition tasks.

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