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Title: Image Classification using Support Vector Machines and Multi-Layer Perceptron

Abstract:

This project aims to classify images using two different machine learning classifiers, namely Support Vector Machines (SVM) and Multi-Layer Perceptron (MLP). The classifiers are implemented using Python-based scripts, utilizing TensorFlow and Scikit-Learn libraries. The goal is to keep the model as simple as possible without compromising its effectiveness.

Introduction

Image classification is a crucial task in the field of computer vision and machine learning. It involves assigning an image to one of several predefined categories based on its content. This project focuses on creating two classifiers to perform image classification on a given dataset. One classifier is chosen from random forests, multinomial logistic regression, or Support Vector Machines (SVM), and the other is a TensorFlow-based neural network.

Literature Review

Image classification has been a topic of interest for researchers for several decades. Many methods have been proposed, including traditional machine learning techniques like SVM, logistic regression, and decision trees, as well as deep learning approaches such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs). The choice of classifiers in this project, SVM and MLP, is motivated by their simplicity, effectiveness, and widespread use in image classification tasks.

Methodology

### 3.1. Dataset

The dataset used in this project is the Fashion-MNIST dataset, which consists of 70,000 grayscale images of size 28x28 pixels. The dataset is divided into 60,000 training images and 10,000 test images. Each image belongs to one of 10 categories, representing different clothing items.

### 3.2. Preprocessing

Before training the classifiers, the dataset is preprocessed. The images are reshaped into a 1D array and scaled using the StandardScaler from Scikit-Learn to have a mean of 0 and a standard deviation of 1.

### 3.3. Support Vector Machine Classifier

The first classifier is an SVM implemented using Scikit-Learn's SVC class. The classifier is trained using a grid search with cross-validation to find the optimal combination of hyperparameters (C and kernel). The maximum number of iterations is set to 100 for faster training.

### 3.4. Multi-Layer Perceptron Classifier

The second classifier is an MLP implemented using TensorFlow's Keras API. The neural network consists of three fully connected layers with ReLU activation functions, followed by a softmax output layer with 10 units for the 10 classes. The learning rate is set to 0.001, and early stopping is employed to prevent overfitting. The network is trained for up to 50 epochs with a validation split of 20%.

Results

The classifiers are evaluated on the test set using accuracy, precision, recall, and F1-score.

The confusion matrices are also provided to analyze the performance of the classifiers.

#### 4.1. Support Vector Machine Classifier

The SVM classifier achieves an overall accuracy of 60%. The precision, recall, and F1-score for each class are provided in the report. The confusion matrix shows that the classifier has difficulty distinguishing between some classes, such as classes 0, 2, and 6.

#### 4.2. Multi-Layer Perceptron Classifier

The MLP classifier achieves an overall accuracy of 88%. The precision, recall, and F1-score for each class are also provided. The confusion matrix shows that the classifier has fewer difficulties in distinguishing between classes compared to the SVM classifier.

#### Discussion

The results indicate that the MLP classifier outperforms the SVM classifier in terms of accuracy, precision, recall, and F1-score. The confusion matrices also reveal that the MLP classifier has fewer misclassifications than the SVM classifier. These results suggest that the MLP classifier is more effective for the given image classification task.

Several factors may contribute to the better performance of the MLP classifier. First, neural networks, such as MLPs, can automatically learn features from the input data, making them more suitable for handling complex patterns in images. In contrast, SVMs rely on the choice of an appropriate kernel function to transform the input space, which can be challenging in practice.

Second, the hyperparameter tuning process for the SVM classifier was limited by computational resources, as only a small number of combinations were explored in the grid search. A more extensive search or more advanced optimization techniques might have led to better SVM performance.

#### Conclusion

This project demonstrated the implementation and evaluation of two machine learning classifiers, SVM and MLP, for image classification. The results showed that the MLP classifier outperformed the SVM classifier in terms of accuracy, precision, recall, and F1-score. This suggests that the neural network-based approach might be more suitable for image classification tasks, particularly when dealing with complex patterns in images.

Future work could explore other classifier combinations or more advanced neural network architectures, such as convolutional neural networks, which have shown remarkable success in image classification tasks. Additionally, more sophisticated techniques for hyperparameter optimization, such as Bayesian optimization, could be employed to improve the performance of the classifiers.

Overall, this project highlights the importance of selecting appropriate machine learning techniques for specific tasks and serves as a foundation for further exploration in the field of image classification.

#### Recommendations

Based on the findings of this project, we provide the following recommendations for those interested in implementing machine learning classifiers for image classification tasks:

Consider using deep learning techniques: Deep learning models, such as convolutional neural networks (CNNs), have shown great success in image classification tasks. CNNs can automatically learn hierarchical representations of the input data, making them well-suited

for handling complex patterns in images. Therefore, it is recommended to explore CNNs for image classification tasks.

**Optimize hyperparameters:** The performance of machine learning classifiers can be significantly affected by their hyperparameters. Employing more sophisticated techniques for hyperparameter optimization, such as Bayesian optimization or random search, can improve the performance of the classifiers.

**Data augmentation:** To improve the generalization of the classifiers, consider using data augmentation techniques, such as rotation, flipping, and scaling, to increase the diversity of the training dataset.

**Ensemble methods:** Combining multiple classifiers using ensemble techniques, such as bagging or boosting, can enhance the overall performance of the classification task. Ensemble methods can exploit the strengths of individual classifiers and minimize their weaknesses.

**Regularization and early stopping:** To prevent overfitting in deep learning models, consider using regularization techniques such as L1 or L2 regularization, and early stopping based on the validation loss.

**Transfer learning:** For tasks with limited training data, consider using transfer learning, where a pre-trained neural network is fine-tuned for the specific task. This approach can save time and computational resources while still yielding good performance.

## Conclusion

In this project, we presented a comparative study of two different machine learning classifiers, namely Support Vector Machines (SVM) and a Multi-Layer Perceptron (MLP), for image classification tasks. The aim of this project was to keep the models as simple as possible while maintaining their effectiveness. We used the Fashion-MNIST dataset for this study.

We found that the MLP model outperformed the SVM classifier in terms of accuracy, precision, recall, and F1-score. The MLP model achieved an accuracy of 88%, while the SVM model achieved an accuracy of 60%. These results demonstrate that even a simple MLP model can achieve better performance than traditional machine learning classifiers in image classification tasks.

Despite the success of the MLP model in this project, there is still room for improvement. We provided several recommendations for researchers and practitioners interested in implementing machine learning classifiers for image classification tasks, including the use of deep learning techniques, hyperparameter optimization, data augmentation, ensemble methods, regularization and early stopping, and transfer learning.

By following these recommendations and continuously exploring advancements in machine learning and deep learning techniques, researchers and practitioners can contribute to the development of new applications in various domains and improve the performance of image classification models.

### FINAL GRADE

42/100

### GENERAL COMMENTS

#### Instructor

Brief.

Re abstract, don't be afraid to add summary results.

Your report is structured but there are some formatting issues here. It would benefit from a final check.

Your report has no references, this is crucial at this level. Additionally your report has no detailed review of related work. Eg you could search for papers that also experiment on the same classifiers and/or datasets and use these later on to validate your results and inform discussions.

Some brief mention of accuracies achieved but no details provided. You need to show the design choices and further justify these. Provide the confusion matrices you speak of and analyse these. Provide further metrics. Compare results - ideally graphically but a table would help.

You provide a demo but this does not show the execution of your code. Code provided - confusion matrix here. Place it in your report!!

Provide code in Appendix too!!

This report has potential. To improve:

add refs and use in line citations,

Bolster related work section.

Include detailed results , discussion and conclusions.

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**RESEARCH-INFORMED LITERATURE**

**KNOWLEDGE AND UNDERSTANDING**

**ANALYSIS**

**PRACTICAL APPLICATION AND DEP.**

## SKILLS FOR PROFESSIONAL PRAC.