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Image Classification with k-Nearest Neighbors: Reflective Journal

Introduction

This reflective journal captures the essence of my lab experience in executing a fundamental machine learning algorithm, the k-Nearest Neighbors (k-NN), for image classification tasks. The lab explores from the initial data exploration and preparation, through the intricacies of model training, to the critical evaluation of the model's performance. The goal is to gain a comprehensive understanding of the process and challenges involved in applying computer vision techniques to real-world problems.

Activities Performed

My journey through the lab began with downloading the requisite Jupyter file and setting up my environment on Google Colab with the famous MNIST dataset of handwritten digits and powerful tools like scikit-learn, matplotlib, and numpy. The activities I embarked upon were methodically structured to ensure a comprehensive understanding and application of the k-Nearest Neighbors algorithm, such as data exploration and preparation, model training, and model evaluation.

Results

Based on my lab experience, the k-NN algorithm exhibited simplicity and intuitiveness, making it easy to understand and implement. Moreover, the k-NN classifier demonstrated a high level of accuracy on the MNIST testing set, underscoring the algorithm's capability in handling image classification tasks, as seen in the following images.

```
# Calculate accuracy
accuracy = accuracy_score(y_test, y_pred)
print(f"Model accuracy: {accuracy * 100:.2f}%")
```

```
Model accuracy: 97.13%
```

Predicted: 8 True: 8	Predicted: 4 True: 4	Predicted: 8 True: 8	Predicted: 7 True: 7	Predicted: 7 True: 7

However, “it can be computationally expensive, especially for large datasets, because it requires calculating distances between the new data point and all existing data points.

Additionally, choosing the right value for K and the appropriate distance metric can impact the quality of the predictions” (Verma). It is also crucial to consider The balance between overfitting and underfitting in the k-NN model. Overfitting might occur with a low K value, making the model too sensitive to the training data's noise, while underfitting could arise with a high K value, causing the model to miss important patterns. To mitigate overfitting, increasing K and applying dimensionality reduction techniques like PCA can help the model generalize better by simplifying its complexity. Conversely, to address underfitting, decreasing K and enhancing the feature set can improve the model's sensitivity to the data's underlying structure.

Key Learnings

- “Lazy learning is a type of machine learning that doesn't process training data until it needs to make a prediction” (Awan, par. 2). “Lazy learning algorithms like k-nearest neighbors are effective for clustering unlabeled data, detecting anomalies, and classifying data points into existing labels. They are simple, easily updatable models that can handle new data with minimal effort. However, lazy learning algorithms are slow to make predictions and do not perform well in applications that require real-time predictions, like facial recognition, stock trading algorithms, speech recognition, and text generation” (Awan, par. 23).
- To reduce computation time using k-NN with larger datasets, “dimension reduction techniques like PCA to lower feature space complexity or numerosity reduction to decrease the dataset size should be considered. An approximate k-NN, like Locality Sensitive Hashing, can offer faster, although approximate, solutions” (Tokuç).

Works Cited

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Tokuç, Aylin. "k-Nearest Neighbors and High Dimensional Data." *Baeldung*, 9 November 2022, https://www.baeldung.com/cs/k-nearest-neighbors. Accessed 11 February 2024.

Verma, Nandini. "Understanding K-Nearest Neighbors (KNN) Regression in Machine Learning." *Medium*, 5 November 2023, https://medium.com/@nandiniverma78988/understanding-k-nearest-neighbors-knn-regression-in-machine-learning-c751a7cf516c. Accessed 11 February 2024.