Stop Sign Detection in Street Images Using Traditional Machine Learning Algorithms

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INTRODUCTION

The growing interest in intelligent transportation systems has highlighted the need for reliable methods to enhance road safety and traffic management. A crucial aspect of this is the ability to identify stop signs, which play an essential role in regulating traffic flow and preventing accidents. This project focuses on developing a stop sign detection system using traditional machine learning algorithms applied to street data, leveraging established techniques to tackle a practical challenge.

Our approach relies on traditional machine learning methods, such as feature-based techniques and standard classifiers (e.g., Support Vector Machines or Random Forests), to build an effective detection system. We aim to create a solution that performs consistently across various real-world conditions, balancing accuracy with computational efficiency. This emphasis on traditional algorithms underscores their value in delivering practical and interpretable results, particularly in scenarios where resource constraints are a key factor.

In this project update, we share our progress in designing and implementing the stop sign detection system, covering aspects like data preparation, model development, training, and initial testing. Through this effort, we aim to showcase the potential of traditional machine learning techniques in addressing real-world problems, offering insights into their practical applications.

SIGNIFICANCE

The development of a stop sign detection system utilizing traditional machine learning algorithms is of substantial importance in the domains of road safety, autonomous navigation, and traffic management. As stop signs play a pivotal role in regulating vehicular movement and preventing collisions at intersections, their accurate and timely detection is critical to reducing traffic accidents and enhancing public safety. The significance of this project lies in its ability to leverage traditional machine learning algorithms to address a vital need in traffic safety and autonomous navigation, by providing a cost-effective, efficient, and reliable approach to stop sign detection.

METHODOLOGY

A. DATASET

In this project, we evaluated the detection mechanism using a publicly available stop sign dataset, which focuses on detecting and classifying stop signs through natural images. This stop sign dataset includes 50 stop sign images and 50 non-stop images. Each image is carefully annotated by experts, ensuring precise and reliable labels for classification tasks. All images in the dataset are resized to uniform resolution of 64×64 pixels during preprocessing.

B. Feature Extraction

To capture the distinctive characteristics of stop sign the Histogram of Oriented Gradients (HOG) method was employed. HOG features were extracted from each preprocessed greyscale image.

HOG features are stored as `X_features`, transforming the raw pixel data into a compact representation suitable for traditional machine learning algorithms.

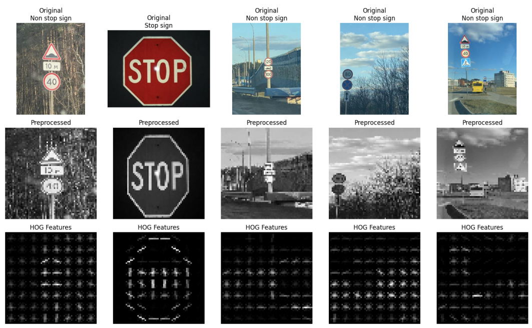

Fig. 1. Feature Extraction

C. Dataset Splitting

The dataset was divided into training and testing sets with a test size 20% and train size 80%.

D. Model Training

A Support Vector Machine(SVM) classifier with a linear kernel, implemented via `sklearn.svm.SVC`, was selected as the primary model.The SVM was trained on the HOG feature set `X_train` with corresponding labels `Y_train`.

E. Model Evaluation

The trained SVM model was evaluated on the test set. The performance was assessed using multiple metrics from the `sklearn.metrics` module. Accuracy was calculated by finding a value of 0.9, indicating that the model correctly classified 90% of the test sample. Additionally, performance was measured, such as precision, recall, and F1-score. A confusion matrix was visualized using Seaborn's heatmap to analyze true positives, true negatives, false positives, and false negatives.

Fig. 2. Mode Evaluation

F. Evaluation on Unseen Data

A `predict_stop_sign` function was developed to classify unseen images by resizing them to 64x64 pixels, converting to grayscale, normalizing, and extracting HOG features with training parameters. The SVM model predicts "Stop sign" or "Non stop sign" labels.

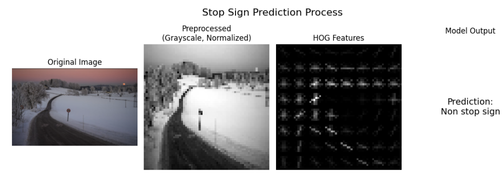

Fig. 3. Evaluation on Unseen Data

Future Work

Moving forward, we plan to expand the scope of this project by exploring a broader range of traditional machine learning models to enhance the stop sign detection system. Our next steps will involve experimenting with additional algorithms beyond the ones currently implemented, such as Decision Trees, k-Nearest Neighbors, or Gradient Boosting, to determine their effectiveness in this context. Additionally, we intend to conduct a comprehensive comparison among the applied models, evaluating their performance based on metrics like accuracy, speed, and robustness across diverse conditions. By analyzing the strengths and limitations of each model, we aim to identify the most suitable approach for practical deployment, further refining our system and contributing to a deeper understanding of how traditional machine learning techniques can be optimized for real-world applications.

Conclusion

In this project, we developed a stop sign detection system using traditional machine learning algorithms, demonstrating their potential for practical applications. Our initial results highlight the effectiveness of these methods, and with plans to test more models and compare their performance, we aim to further improve the system's accuracy and reliability.