TRƯỜNG ĐẠI HỌC FPT

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Project Title: CPV301
Traffic Sign Recognition

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TRAFFIC SIGN RECOGNITION

by Do Tuan Kiet

1 Introduction

Traffic sign detection is crucial to advanced drivers assistance system (ADAS) and autonomous driving technologies. Accurate detection and classification of traffic signs enhance road safety by providing timely information to drivers or autonomous systems. This project focuses on detecting traffic signs from images using Histogram of Oriented Gradients (HOG) for feature extraction and evaluating the performance of two popular classification algorithms: Support Vector Machines (SVM) and K-nearest Neighbors (KNN).

Histogram of Oriented Gradients (HOG) is a powerful feature descriptor that captures the edge or gradient structure in an image. It is widely used due to its effectiveness in representing local shapes and appearances, making it suitable for detecting the distinct shapes of various traffic signs.

Support Vector Machine (SVM) is a supervised learning algorithm known for its effectiveness in high-dimensional spaces. It works by finding the hyperplane that best separates different classes in the feature space, making it suitable for distinguishing between different types of traffic signs.

K-Nearest Neighbors (KNN) is a simple yet robust classification algorithm that classifies a sample based on the majority class of its nearest neighbors in the feature space. It is widely appreciated for its ease of implementation and intuitive nature, making it a practical choice for traffic sign classification. Introduction

2 Scope

The scope of this project is to develop and evaluate a system for traffic sign recognition using image processing techniques. The project focuses on the following key aspects:

2.1 Problem Definition:

Traffic Sign Detection: The primary goal is to accurately detect and classify traffic signs from a set of images. Traffic signs are crucial for road safety and provide essential information to drivers and autonomous vehicles.

Feature Extraction: Using the Histogram of Oriented Gradients (HOG) transform to extract features that represent the shape and appearance of traffic signs.

2.2 Objectives:

Feature Extraction with HOG: Implement and optimize the HOG transform to capture the distinctive features of various traffic signs effectively.

Classification with SVM: Train and evaluate a Support Vector Machine (SVM) classifier to distinguish between differnt types of traffic signs based on HOG features.

Classification with KNN: Train and evaluate a K-Nearest Neighbors (KNN) classifier as an alternative approach to traffic sign classification.

Performance Comparison: Compare the performance of SVM and KNN classifiers in terms of accuracy, computational efficiency, and robustness.

2.3 Limitations and Assumptions:

Image Quality and Variability: The project assumes that the images used for training and testing are of sufficient quality and represent a wide range of traffic sign types and conditions (e.g., lighting, occlusion, and rotation).

Predefined Dataset: The project relies on a predefined dataset of traffic sign images for training and evaluation purposes.

Real-time Processing: While the project aims to develop an efficient detection system, real-time processing is not a primary focus and may be considered for future improvements.

3 Methods

The method section outlines the approach taken to achieve the project's objectives, detailing the processes of data collection, feature extraction, classification, and evaluation.

3.1 Data Collection and Preprocessing

Data Source: Collect a dataset of traffic sign images from publicly available repositories such as the German Traffic Sign Recognition Benchmark (GTSRB).

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labels
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[3]

	ClassId	Name
0	0	Speed limit (20km/h)
1	1	Speed limit (30km/h)
2	2	Speed limit (50km/h)
3	3	Speed limit (60km/h)
4	4	Speed limit (70km/h)
5	5	Speed limit (80km/h)
6	6	End of speed limit (80km/h)
7	7	Speed limit (100km/h)
8	8	Speed limit (120km/h)
9	9	No passing
10	10	No passing for vechiles over 3.5 metric tons
11	11	Right-of-way at the next intersection
12	12	Priority road
13	13	Yield
14	14	Stop
15	15	No vechiles
16	16	Vechiles over 3.5 metric tons prohibited

Figure 1: Labels

Image Preprocessing: Perform preprocessing steps including resizing, normalization, and augmentation (e.g., rotation, scaling, and translation) to enhance the robustness of the model and increase the dataset size.

3.2 HOG Transform for Feature Extraction

Feature Extraction: Implement the Histogram of Oriented Gradients (HOG) transform to extract features from traffic sign images. The HOG descriptor captures edge and gradient information, representing the local shape and appearance of traffic signs.

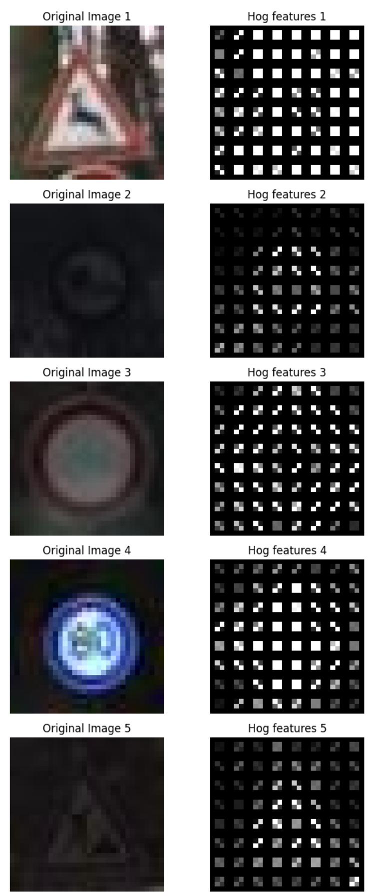

Figure 2: HOG feature extraction

Steps in HOG:

- Compute gradients in x and y directions.
- Calculate the magnitude and orientation of gradients.

- Divide the image into small spatial regions (cells).
- Compute histogram of gradient orientations for each cell.
- Normalize histograms across larger spatial regions (blocks).
- Concatenate normalized histograms to form the feature vector.

3.3 SVM for Classification

SVM Training: Train a Support Vector Machine (SVM) classifier using the extracted HOG features.

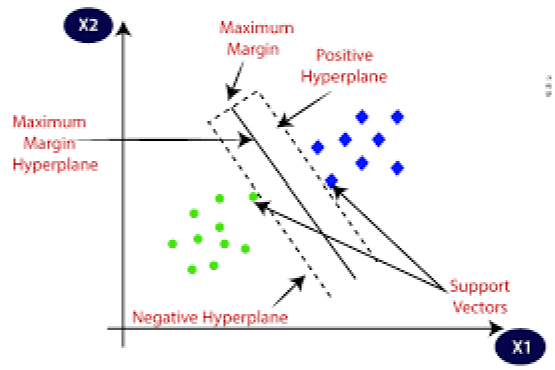

Figure 3: Support Vector Machine modeling

SVM Evaluation: Evaluate the trained SVM model on a separate test set to measure its accuracy, precision, recall, and F1-score and the number of actual occurrences of each class in the true labels.

3.4 KNN for Classification

KNN Training: Train a K-Nearest Neighbors (KNN) classifier using the extracted HOG features.

KNN Evaluation: Evaluate the trained KNN model on the test set and compare its performance with the SVM model in terms of precision, recall, f1-score

3.5 Evaluation Metrics

Accuracy: 0.93% for SVM and 0.9% for KNN of correctly classified traffic signs out of the total number of signs.

Precision: The proportion of true positive classifications among all positive classifications.

Recall: The proportion of true positive classifications among all actual positive instances.

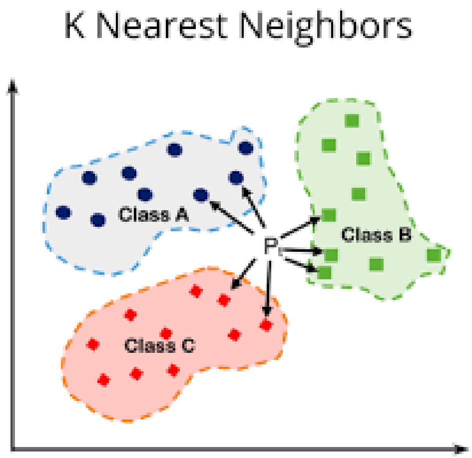

Figure 4: K-Nearest Neighbor modeling

F1-Score: The harmonic mean of precision and recall, providing a balanced measure of the classifier's performance.

4 Demo:

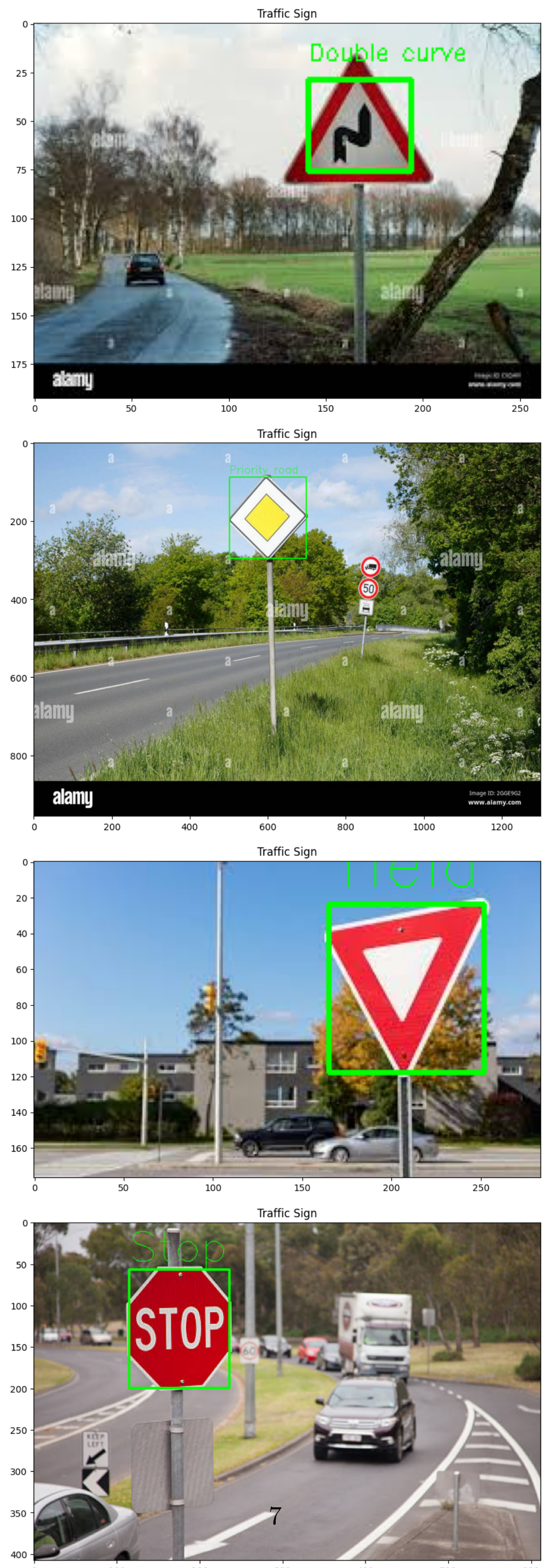

Figure 5: Project results