Traffic Sign Recognition for Speed Regulation in Urban Areas

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Motivation

It is fascinating to realize that, ten years ago, machine learning algorithms such as ChatGPT or OpenArt would have seemed like pure science fiction. However, seeing the latest autonomous cars driving on our roads led me to question how their algorithms actually work.

Context

Machine learning has become highly useful in many domains. I decided to focus on an urban application of this technology: autonomous vehicles. Their contribution is essential for assisting drivers, both in terms of comfort and safety.

Annotated Bibliography

Traffic sign detection and recognition represent a major challenge in road scene analysis. The main difficulties are linked to uncontrolled viewing angles and the variability in the appearance of signs. Another major challenge in the deployment of autonomous vehicles is obstacle detection, which requires more advanced image recognition since obstacles are not standardized objects. The use of AI-based algorithms can therefore be very effective in these tasks.

Far from exhibiting a human-like intelligence, as Alan Turing questioned in 1950 [1], artificial intelligence—and more specifically machine learning—relies on mathematical and statistical approaches to determine models and solve problems, based on a given dataset. If this dataset is labeled, meaning that each input x has a known output y, the learning process is called supervised learning. Conversely, unsupervised learning extracts classes by identifying similarities among objects [2].

Even though the quality of embedded car cameras has improved significantly, variations in lighting (shadows, reflections, backlighting) still affect color. Furthermore, geometric distortions or rotations may appear depending on the viewpoint. However, traffic

signs, being standardized objects, present geometric and colorimetric features that make them distinguishable from their environment [3].

The first step in traffic sign recognition is to isolate the sign within a video frame. Several methods can be used, such as the Hough transform, which detects both lines and circles in an image [4]. A second approach focuses on color analysis: comparing the RGB components of each pixel with a labeled database. For this task, the k-Nearest Neighbors (KNN) algorithm, a supervised learning method, is effective. It calculates Euclidean distances between the unknown sign and the reference dataset, then assigns the class based on the majority of the k closest matches. Choosing the right value for k can be optimized using a confusion matrix and by maximizing precision and accuracy [5].

Other methods can be applied, notably neural networks, which also allow obstacle detection and more complex image recognition than simple geometric signs. Convolutional Neural Networks (CNNs) are especially suited to automatically identify features and equivalence classes, such as distinguishing between a pedestrian and another vehicle [6]. Once a sign or obstacle is detected, a signal can be sent to the car to adjust speed or apply emergency braking [7].

Research Question

How can we implement an embedded image recognition system in autonomous vehicles in order to improve passenger comfort and safety?

Objectives

- Extract traffic signs from dashcam video frames.
- Identify the extracted sign using the KNN algorithm.
- Perform recognition with Scikit-learn and compare results with the KNN method.
- Implement a neural network to detect obstacles around the vehicle.

References

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