AUTOMATIC ROAD TRAFFIC SIGN DETECTION AND RECOGNITION (TSDR) USING IMAGE PROCESSING

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Abstract: *This article presents an overview of road traffic sign detection and recognition (TSDR) using image processing. Moreover, this paper expounds on aspects of image processing of the road signs, which represents our data, and the challenges of detecting and recognizing them. The end goal is to incorporate such a system into a self driving car and, in accordance with the Highway Code of the Republic of Moldova, redress the issues of precision when positioning and visualizing them on the road.*

Keywords*: road sign, image detection, raspberry pi, color, shape.*

Introduction

Due to the different types of sensing and positioning technologies, driving assistance becomes a popular research topic. For unmanned vehicles and driving assistance systems, the safety problem is always the highest priority compared with the convenience or practicality for a project or system designer.

When driving a vehicle, a driver can get different messages according to local road signs. Traffic signs are often designed with eye-catching colors and easy-to-understand symbols. However, if a driver drives in a complex environment or a driver's mental state is not well, this might cause the driver to overlook messages from traffic signs. If there is an automatic detection and recognition system for traffic signs, it can report correct traffic signs quickly to the driver and also reduce the burden of the driver. When the driver ignores a traffic sign, the system can give a timely warning. If this system is used in an unmanned vehicle, it can help the automatic driving system to judge the road condition. Hence, the safety of vehicle driving is greatly improved and the risk of accidents can be reduced.

Domain Analysis

Traffic sign detection and recognition has gained importance with advances in image processing due to the benefits that such a system may provide. The recent developments and interest in self-driving cars has also increased the interest in this field. An automated traffic sign detection and recognition system will provide the ability for smart cars and smart driving. Even with a driver behind the wheel, the system may provide vital information to the driver reducing human errors that cause accidents. Certainly with such a system integrated into vehicles, it is expected that the number of car accidents will be reduced greatly saving human lives and the monetary value associated with car accidents. Automated systems will be able to control traffic on both open roads and intersections as well. For handling traffic signs, a recognition system should also classify traffic signs into different classes in a real-time environment and avoid recognition errors. Machine learning is divided into supervised learning, unsupervised learning, semi-supervised learning, and reinforced learning. In this paper, the choice of deep learning for an unsupervised learning approach is done by design because even though basic traffic signs are limited yet combined with road signs and street name signs. The dataset becomes larger with endless possibilities.

The ultimate goal is to have a system fitted into cars and that can detect and recognize any traffic sign to assist the driver or assist in the self-driving process. With deep learning algorithms, [1] unlabeled data can be used and the system can extract features automatically without human intervention.

System Architecture

The core process, after defining a solution to an IoT project, lies into the construction of a concise conceptual model. A successful execution, when referring to an automatic traffic sign detection and recognition, is an efficient image processing. The general system architecture of our image processing (Figure 1) is divided into three layers of execution and includes the interrelationship of the start point, represented via an imager, with the end point, expressed as a successful or unsuccessful result.

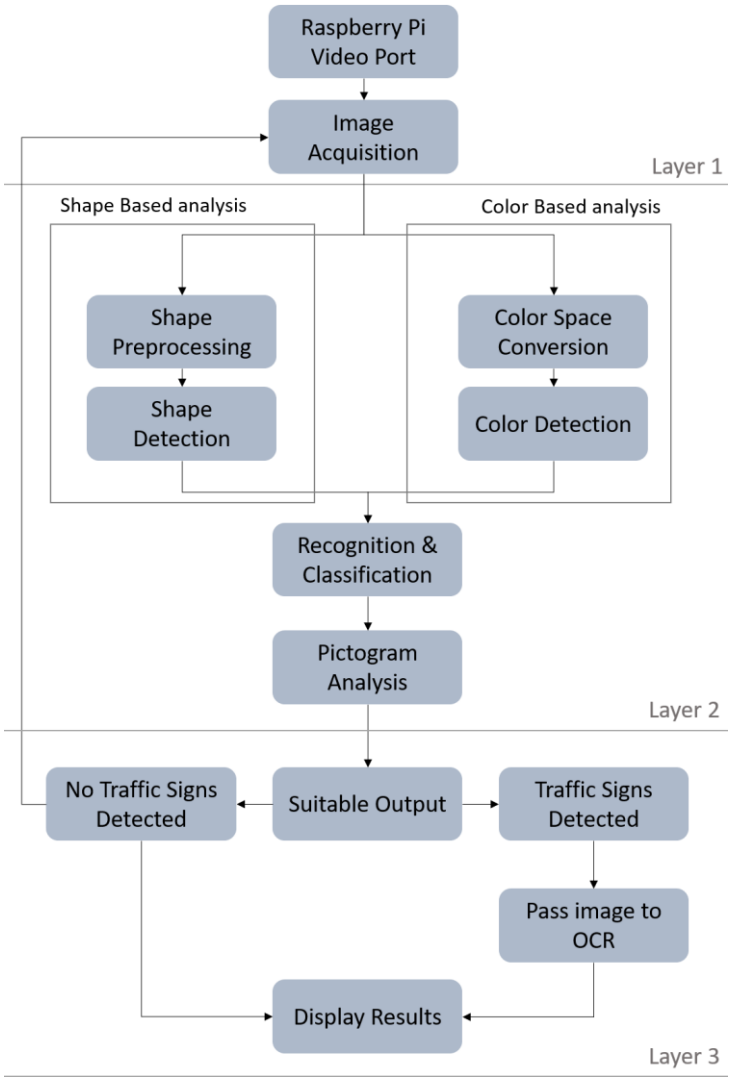

Figure 1. Image processing system architecture

First layer represents acquiring data from our visual sensor, represented by a Raspberry Pi, which is able to capture in a very short period of time a stream of images using its video-capture port with JPEG encoder. For our project we chose the capture_sequence method, because of its fastest algorithms. Using this method our Raspberry Pi camera can capture images at a rate of 20fps at a 640×480 resolution.

The major issue we found during the work with Raspberry Pi and mainly in capturing images is the bandwidth, that is very limited. Also, sometimes the SD card size can be small and not able to hold all the pictures that are captured by the camera. Road and traffic signs are recognizable by many features, starting with their 2-D shapes such as circles, rectangles, or triangles, and finishing with their specific unnatural to the environment colors, which makes them distinguishable from the natural or man-made backgrounds. By being designed, manufactured, and installed according to the Highway Code of the Republic of Moldova, the importance of their precision, whether it is the location, shape, or color, is crucial.

However, in our days, the road environment becomes more complex, with a lot of intersections, traffic signs, road markings, that's why traffic signs can be found in difficult conditions and the detection and recognition of these signs can create difficulties as the following. Because of time passing, sunlight, and other pollutants in the air, the color of the sign may change the shade. Also, whether conditions (such as fog, rain, clouds and snow) can affect the visibility of the road. The color can become a very unstable information due to illumination, shadows, sun, clouds, also it depends on how the camera perceives the color (depending on the contrast, light, shadows). The environment can also be an obstacle in processing the image, buildings, trees, vehicles and pedestrians. Signs may be found disoriented, damaged or occluded. Therefore, the data must be analyzed through image processing, described in the next layer of this system.

The second layer expounds the process of recognition and classification of the road signs. This procedure is achieved by two main stages: detection, and recognition.

When data is being passed from the first layer to the second one, the image is in a phase of pre-processing and enhancement, [2] which is an important step in the data mining process and includes filtering steps such as cleaning, normalization, transformation, and selection. The final training set is a segmented image with regions likely to be acknowledged by the system as possible road signs. An issue that arrives when talking about preprocessing data is that the image contains an iteration of irrelevant information, therefore discovering, during the training phase, which parts are relevant to the scope is more difficult and time-consuming. Therefore, an efficient algorithm for the speed of the detection is needed, in order to reduce the search space in point directly to the potential regions of search. The image has two possibilities of segmentation, according to the sign properties, and can be scanned for its color or shape property [3].

Colors represent one of the main distinguishable features of a road sign. Thanks to their strict specification and the tint of the paint that should correspond to a specific wavelength in the visible spectrum, the color-based detection system is simplified. A favorable feature is color space conversion, which means converting the RGB image into another form that simplifies the detection process. This means separating the color information from the brightness information by converting the RGB color space into another color space, which gives good detection abilities depending on the color cue.

Each traffic sign has a special color depending on its type, but it also has a specific shape that determines the type of the sign and that can be searched for. That's why we can determine the type of the traffic sign using its shape. Shape methods are based only on the characteristics of shape and totally ignore the colors. Detection of a traffic sign using its shape means to find the margin of the sign and its contour and approximate it to find the final shape. We can use shape detection for traffic signs recognition the color of the sign is damaged, or can't be recognized because of whether or light condition. Also, shape detection and recognition minimizes the search for the road from the whole big image to a small number of pixels. On the other hand, this method requires a huge amount of memory for large images. Also, damaged, partially obscured, faded and blurred traffic signs may cause difficulties in detecting traffic signs accurately, leading to a low.

The recognition phase comes with a set of tests, data being checked again for a set of features. This will decide whether it is in the group of road signs or not, and then according to these features, they are classified into different groups, categorized by shape, to indicate the

differences amongst the classes. Thereby, it is easy to define the individual class of the sign by evaluating pictogram shapes in accordance with the text available in the interior of the sign.

The final layer describes the process of data detection and display. It consists of two outcomes, whether the traffic signs were detected or not. If the process is unsuccessful, the data will be resent to the first layer, at the phase of image acquisition, for a repeated analysis. If the second process will fail again, the system will pass an error message when displaying the final result. However, if a road sign is detected, the system passes data to an Optical Character Recognition (OCR), where the text within the image will be recognized, if needed, and finally all gained data will be displayed and compared, alongside with the traffic code rules, for any mismatch of their location on the road or partial or the quality of their display to the drivers.

Conclusions

The goal of this project is to develop an efficient Automatic Traffic Sign Detection and Recognition (TSDR) system based on used trained model pattern. Through the Raspberry Pi computer images will be received and optimized, after which we images will be sent to our mathematical model. The recognition process will be done in 2 stages. First of all the image is pre-processed, enhanced, and segmented according to the sign properties such as color or shape. After which images are filtered and grouped by shape and color according to our stored set of features. Our TSDR system will be used to determine and compare the current situation on a road section with the situation that should actually be described in the traffic code.

References

1. Lai, Y., Wang, N., Yang, Y., & Lin, L. (2018). Traffic signs recognition and classification based on deep feature learning. In 7th International Conference on Pattern Recognition Applications and Methods (ICPRAM).
2. C. Bahlmann, Y. Zhu, Visvanathan Ramesh, M. Pellkofer and T. Koehler, "A system for traffic sign detection, tracking, and recognition using color, shape, and motion information," IEEE Proceedings. Intelligent Vehicles Symposium, 2005 [online]. [accessed 22.02.2021]. Available at: https://ieeexplore.ieee.org/abstract/document/1505111.
3. S. Houben, J. Stallkamp, J. Salmen, M. Schlipsing and C. Igel, "Detection of traffic signs in real-world images: The German traffic sign detection benchmark," The 2013 International Joint Conference on Neural Networks (IJCNN), Dallas, TX, USA, 2013, pp. 1-8, [online]. [accessed 22.02.2021]. Available at: https://ieeexplore.ieee.org/abstract/document/6706807.