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CNN Design for Real-Time Traffic Sign Recognition

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Abstract

Nowadays, more and more object recognition tasks are being solved with Convolutional Neural Networks (CNN). Due to its high recognition rate and fast execution, the convolutional neural networks have enhanced most of computer vision tasks, both existing and new ones. In this article, we propose an implementation of traffic signs recognition algorithm using a convolution neural network. The paper also shows several CNN architectures, which are compared to each other. Training of the neural network is implemented using the TensorFlow library and massively parallel architecture for multithreaded programming CUDA. The entire procedure for traffic sign detection and recognition is executed in real time on a mobile GPU. The experimental results confirmed high efficiency of the developed computer vision system.

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Keywords: TensorFlow; Convolutional Neural Networks; Traffic Sign Recognition; Image Processing; Computer Vision; Mobile GPU

1. Introduction

Development of the technical level of modern mobile processors enabled many vehicle producers to install computer vision systems into customer cars. These systems help to significantly improve the safety and implement an important step on the way to autonomous driving. Among other tasks solved with computer vision, the traffic sign recognition (TSR) problem is one of the most well-known and widely discussed by lots of researchers. However, the main problems of such systems are low detection accuracy and high demand for hardware computational performance, as well as the inability of some systems classify the traffic signs from different countries.

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Recognition of traffic signs is usually solved in two steps: localization and subsequent classification. There are many different localization methods [1], [2], [3]. In papers [4] and [5], the authors proposed effective implementations of the image preprocessing and traffic signs localization algorithms, which performed in real time. Using a modified Generalized Hough Transform (GHT) algorithm, the solution allowed to determine the exact coordinates of a traffic sign in the acquired image. Thus, in the classification stage, the simple template matching algorithm was used. Combined with precise localization stage, this algorithm showed the final results of 97.3% accuracy of traffic sign recognition. The datasets from GTSRB [6] and GTSDB [7] was used for training and testing the developed algorithms. Fig. 1 shows the images for training the traffic signs recognition algorithm and testing the localization algorithm.

Fig. 1. Images from GTSDB and GTSRB.

While testing the developed technology for detecting and classifying traffic signs in real conditions, i.e. using videos from cameras installed on a windshield, the end-to-end technology showed significant decrease in the efficiency. Studies have shown that such a decrease arose because of too strong variations in the illumination, contrast, and angle of rotation in images of localized traffic signs. Thus, a simple classification algorithm like template matching was not able to achieve high-quality recognition because of a limited set of predefined templates. To improve the system performance, the localization algorithm that has shown good results can be combined with recognition using the convolutional neural networks that have received such a wide application in recent years [8], [9].

In this paper, we describe a revised end-to-end technology for detecting and recognizing traffic signs in real time. The developed system uses the speed received from the vehicle. This allows you to predict not only the presence of the object, but also the scale and its exact coordinates in the neighboring frame. Thus, the accuracy of detection increases, while the computational complexity remains the same. The classification of localized objects is implemented using convolutional neural networks (CNNs). One of the main contributions of this paper is describing the process of designing a convolutional neural network. The use of the GPU allows real-time processing of the frames in the video sequence.

2. Traffic Sign Localization and Tracking

The developed technology for traffic signs recognition consists of three steps: image preprocessing, localization and classification.