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Embedded Real-Time System for Traffic Sign Recognition on ARM Processor

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ABSTRACT

This article proposes the design of a novel hardware embedded system used for automatic real-time road sign recognition. The algorithm used was implemented in two main steps. The first step, which detects the road signs, is performed by the maximally stable extremal region method on HSV color space. The second step enables the recognition of the detected signs by using the oriented fast and rotated brief features method. The novelty of the embedded hardware system, on an ARM processor, leads to a real-time implementation of the ADAS applications. The proposed system was tested on the Belgium Traffic Sign Detection and Recognition Benchmark and on the German Traffic Signs Datasets. The proposed approach attained a high detection and recognition rate with real-world situations. The achieved results are acceptable when compared to state-of-the-art systems.

KEYWORDS

Advanced Driver Assistance Systems (ADAS), ARM processor, Detection, Raspberry Pi, Real-Time, Recognition, Road Traffic Sign

1. INTRODUCTION

Automatic Traffic Sign Recognition (TSR) is becoming an essential component of the new cars (Greenhalgh & Mirmehdi, 2012a; Greenhalgh & Mirmehdi, 2012b; Ruta et al., 2010; Xu, 2009; Kassani et al., 2016), it is an important application for Advanced Driver Assistance Systems (ADAS) (Wahyono, 2014; Hsieh et al., 2014; Rublee et al., 2011; Grana et al., 2013). The inability to observe road signs due to various conditions might result in road accidents. Many car accidents are caused by drivers' lack of awareness or fatigue. Thus, early warning of the driver will keep him more attentive. Consequently, the integration of an automated embedded system of traffic signs recognition increases safety conditions.

A road traffic sign recognition approach can be composed of two stages: detection and recognition (Hsieh et al., 2014; Jung et al., 2016; Seo et al., 2015; Timofte et al., 2014). The purpose of the first step is to extract the signs from the whole scene. The second stage tries to recognize the symbols accordingly to a predefined database. Traffic sign detection and recognition in unstructured scenes have been drawing the attention of many researches, both theoretically and technically (Gudigar et al., 2016; Salti et al., 2015). One of the foremost difficulties of TSR applications is the understanding of

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the environment and orientation of the signs in real scenes. The first challenge is to consider urban scenes understanding under complex conditions (time of the day, weather, noise, occlusions, lighting changes, shadows, distortion, etc.) as presented in Figure 1.

The proposed system is divided into two main stages: the detection and the recognition stages. In the detection step, the image is transformed to the HSV color space, and the Maximally Stable Extremal Regions (MSERs) algorithm (Greenhalgh & Mirmehdi, 2012a), (Greenhalgh & Mirmehdi, 2012b), (Salti et al., 2015) is used to detect all possible candidates. For the recognition step, the Oriented fast and Rotated Brief (ORB) descriptor (Rublee et al., 2011), (Grana et al., 2013) is used to extract features serving the recognizing process and enables the identification of signs. Thus, we try to integrate the methods while ensuring a compromise between processing time and accuracy. In the following, we justify the choice of HSV color space, MSER algorithm and ORB feature.

Many researchers (Jung et al., 2016), (Gudigar et al., 2016), (Lillo-castellano et al., 2015) prefer the HSV color space for its ability to separate color and brightness and therefore its resistance to lighting changes. In (Farhat et al., 2015), (Lunge & Pawar, 2014), (Berkaya et al., 2016), a color space comparison shows that HSV color space presents the best robustness in traffic signs recognition. Moreover, similar works show that MSER is an efficient and rapid technique that provides better robustness to blurred images and improves matching performance over large-scale changes. For these reasons, we have to consider applying MSER in HSV color space (Ellahyani et al., 2016).

ORB feature is comparatively scale and rotation-invariant while still using the very efficient Hamming distance metric for matching. Thus, it is preferred for real-time applications as it ensures a compromise between accuracy and execution time.

The second challenge for such TSR system is to respect the real-time constraint regardless of the speed of the vehicle. To achieve this purpose with an embedded system, it is important to consider a suitable hardware platform.

In this paper, we present a novel embedded system able to detect and recognize traffic signs efficiently in real-time based on ARM processor, and we compare its robustness with similar hardware implementations.

The remainder of this paper is organized as follows: Section 2 provides a review of targeted recognition techniques and gives an overview of past works. Section 3, outlines the proposed detection

Figure 1. Problems of traffic sign detection: Over-Illumination, under-illumination, occlusion, rotation and deterioration of the signs, deficiency, complexity scene and weather situations.