Chapter 22
Lightweight Neural Networks for Pedestrian Detection in Intelligent Vehicles

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ABSTRACT

Most actual intelligent vehicles (IV) are powered by a variety of sensors and cameras. Vision-based applications for IV mainly require visual information. In this paper, the authors introduce a pedestrian detection application used for pedestrian safety. The authors proposed a deep fully convolutional neural network (DFCNN) for pedestrian detection. The proposed model is suitable for mobile implementation. To do this, the authors propose to build lightweight blocks using convolution layers, and replace pooling layers and fully connected layers with convolution layers. Training and testing of the proposed DFCNN model for pedestrian detection were performed using the Caltech dataset. The proposed DFCNN has achieved 85% of average precision and an inference speed of 30 FPS. The reported results have demonstrated the robustness of the proposed DFCNN for pedestrian detection. The achieved performance was low computation complexity and high performance.

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INTRODUCTION

The explosion in the number of both vehicles and pedestrians makes it hard to share the same environment safely. According to the Association for Safe International Road Travel (2019), 1.25 million persons die in a crash accident each year with an average of 3,287 deaths per day. Besides, 20-50 million persons are injured or disabled.

One of the proposed solutions is IV which is used to help the driver in a complicated situation or to perform a simple task like driving on a highway. Most IVs are equipped with the latest technologies. An IV is equipped with a big number of active sensors like ultrasonic and passive sensors like cameras. Most IV applications are based on passive sensors thanks to their low power consumption. In addition, an IV can control the vehicle through the engine, gearbox, and brakes. It can apply a set of authorized actions in case of potential danger such as a crush on another vehicle or pedestrian. A vision-based application for an IV is the most important. Many vision applications like traffic sign detection and recognition (Ayachi, 2019a), (Ayachi, 2019b), and traffic light detection (Dimian, 2019) have been stacked in IV to provide the driver with important information about the traffic environment. IV has been developed to enhance traffic security and to ensure a safer environment. Human beings, either the driver or the pedestrian, represent the most important element to focus on their safety.

Motivated by pedestrian safety, the pedestrian detection system was designed through an intelligent vision that processes camera data and localizes pedestrians automatically. A high-performance pedestrian detection system can locate pedestrians under challenging conditions such as occlusion and warn the driver to avoid potential accidents. This can help to improve driving safety in urban spaces. However, implementing an accurate pedestrian detection system on a limited computation resources device is considered a hard challenge that must be addressed. The mentioned challenge was considered a motivation for the proposed approach in addition to pedestrian safety.

With a focus on pedestrian safety, a pedestrian detection application for an IV was proposed. The main idea of the proposed application is to process the visual data and detect pedestrians while crossing the street to warn the driver. The main challenge of building a robust pedestrian detection application comes first from the limited computation resources of the platform used for IV and from the complexity of the environment because of the lighting conditions, the point of view, the complex background, and occlusion. A reliable and robust pedestrian detection application must overcome those challenges as a priority. Besides reliability, real-time operation is another challenge for pedestrian detection applications. The application must detect pedestrians even at high speed and moving pedestrians. Advances in artificial intelligence (AI) techniques have achieved great success in different fields including computer vision and its applications. Those AI techniques are considered a suitable solution for pedestrian detection in IV.

The proposed pedestrian detection application is based on a convolutional neural network (CNN) (Krizhevsky, 2012). It is a deep learning (Schmidhuber, 2015) model generally deployed to solve vision-based applications. Convolutional neural networks are inspired by the biological system (Fukushima, 1980) where the connectivity between the artificial neurons is similar to the organization of the visual cortex of an animal. This connectivity allows the building of a deep convolutional neural network (DCNN) with tens of hidden layers and enables feeding the network with a huge amount of training data without overfitting it (Zeiler, 2014). DCNN was deployed successfully to solve vision-based applications. Many DCNN models were proposed to solve vision-based applications such as object detection (Ayachi, 2020), indoor object recognition (Afif, 2018), face identification (Ranjan, 2019), and human pose estimation