CHAPTER

7

THERMAL IMAGING AND MACHINE LEARNING FOR ADVANCED DRIVER ASSISTANCE SYSTEM

Cheah Shengli and Usman Ullah Sheikh

7.1 INTRODUCTION

The autonomous vehicle promises a safer journey where most accidents caused by human errors can be fully eradicated (Shinar, 2007). Driver fatigue, disobeying traffic rules, distraction, failure to check for blind spots and even driving under the influence of drugs or alcohol will no longer be an issue. Since the vehicle is fully autonomous, the driver can eventually sit back and relax.

The Society of Automotive Engineers (SAE) defines six levels of driving automation in the J3016 standard. SAE Level 0 indicates no automation and requires manual control while the highest SAE Level 5 indicates a fully autonomous vehicle. There is no commercially available SAE Level 4 car as of 2020. To reach a higher automation level, the vehicle must be able to understand its surrounding environment and make critical decisions to prevent accidents. That is where the Advanced Driver Assistance System (ADAS) comes into play in an autonomous vehicle. Multiple sensors such as cameras are deployed in the vehicle granting visual capability to ADAS.

When driving on the road, there will be pedestrians, cars, trucks, and many more other objects. By integrating deep learning models such as Convolutional Neural Networks (CNN) into ADAS, objects on the road can be recognized and detected to avoid a collision. Since there is size and power constraint on a vehicle, a compact embedded system is much preferred over a full-sized computer. Hence, a single shot detector-based CNN is suitable for this scenario due to the lower computation requirements.

Thermal cameras are mostly used in military or search and rescue operations, and they are rarely utilized in a standard vehicle due to the higher price. The self-driving Uber car accident in 2018 highlighted that the current sensor topologies of using radar, LIDAR and a visible camera are insufficient, and a thermal camera is required to improve the robustness of the system. Hence, Forward Looking InfraRed (FLIR) introduces thermal sensing in the next generation of vehicles.

Usage of CNN detection network can be seen everywhere. However, most of the CNN networks are trained on Red Green Blue (RGB) images. CNN networks trained on RGB images will not work well on thermal images as the network learns the colour of an object during the training process and will use it during inference. In addition, the region proposal-based CNN network is computation heavy and requires a long processing time for object detection and classification. ADAS systems typically require fast processing time to handle various driving situations.

This chapter is organized by firstly presenting related works in Section 7.2. Section 7.3 describes the proposed system design while Section 7.4 explains the results. Section 7.5 of this chapter provides the conclusions drawn from the study.

7.2 ADVANCED DRIVER ASSISTANCE SYSTEM

Sensors play an important role in helping the ADAS system to achieve context awareness. Data from multiple sensors and sources will be gathered, combined, and processed through Sensor Fusion to allow ADAS to sense the physical environment (Shakshuki et al., 2013). Even though each sensor may have its weakness and is unreliable, the usage of multiple sensors can compensate for their weakness and create a more comprehensive detection and robust classification system.

A visible light camera is the most common sensor technology implemented in ADAS due to its attractively low price. This technology is used as it is matured and is used in multiple fields; hence it can be easily integrated into an ADAS system. A visible camera has the same working principle as human eyes where lights hit an object and are reflected into light receptors in the eye. In a visible camera, the light will be captured by Charge-Coupled Device (CCD) or Complementary Metal-Oxide-Semiconductor (CMOS) image sensors. ADC is then used to convert the value of each pixel into a digital value. During daytime with sufficient sunlight, a visible camera can provide clear images that resemble What You See Is What You Get (WYSIWYG). Objects in the image can be identified quickly and easily. However, a visible camera is unable to produce images at night or in low light conditions. Some may argue that there is still a night vision camera that requires light or else the clarity of the image will be affected.

In contrast with a visible camera, a thermal camera does not require any light sources for producing images. Instead, a thermal camera captures heat or infrared energy which is also part of the electromagnetic spectrum. All objects in the universe emit infrared energy and a thermal camera can capture and translate these heat signatures into images regardless of lighting conditions. Depending on the heat, the images will be displayed as shades of grey or with different colours. Due to the operating principle of a thermal camera, it can work well in inclement weather conditions. For fog, smoke, overcast or even haze that strikes Malaysia annually, a thermal camera can penetrate through them easily compared to a visible camera and will always show clear and reliable pictures. Nonetheless, thermal cameras do have their disadvantages. First, a thermal camera costs more than a visible camera due to different manufacturing processes and the usage of more complicated components. Car manufacturers will not bear the extra cost and it will be transferred to the end consumer. Besides that, thermal imaging is unable