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IMAGE SEGMENTATION ROLE IN SELF DRIVING CAR

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Abstract-- With the development of image processing techniques and the growing GPU computing power, these techniques are very common in real-time systems such as self-driving cars. Photo-separation methods, which allow us to locate objects in the image and mark pixels of these objects, are image processing techniques commonly used in self-driving cars. In addition to the study of classical photographs, detailed reading-based techniques are widely available in textbooks. This paper discusses why photo classification methods are important for self-driving cars. We explore ways to classify images into two main groups: semantic classification and example. We see that these methods are used in many different situations in self-driving cars and how important they are in safe travel.

KEYWORDS- self-driving, image processing, image segmentation, semantic segmentation, instance segmentation, deep learning

I. INTRODUCTION

Image processing is the operations performed on the pixels of an image to extract a pattern or meaningful information from an image. Since these operations are performed on a pixel basis, the processing time can be longer depending on the image's size, quality, and operation. These processing times limit the use of imageprocessing techniques in real-time applications. However, using image processing techniques on real- life applications has become more available with the increasing GPU computing power [1]. Now, we see thatthese techniques are used in many areas of our lives, such as healthcare, military operations, agriculture, automotive, retail [2] [3] [4] [5]. According to The AI Image Recognition Market report, the market value of image processing, whose usage areas are increasing day by day, was USD 1695.93 million in 2020. Accordingto the same report, this value is expected to reach USD 5161 million by 2026 [6]. This increase in market value means that we will meet many new sectors, products, developments, andnew services in our lives, and one of the biggest of these new developments is occurring in self-driving cars. Currently, many investment and research groups are investing in this field to contribute to the future of this field. Google, Uber, Baidu, Lyft, Aptiv, Tesla, Nvidia, Aurora, Zenuity, Daimler and Bosch, Argo AI, Renesas Autonomy, Almotive, AutoX, Mobileye, Ambarella, Pony.ai, Idriverplus, Toyota, Ford, Volvo, and Mercedes Benz are companies that contribute to the development and improvement of self- driving vehicles[7] [8][9][10]. These companies use image processing techniques while developing their self- driving cars. One of the purposes of using image processing techniques in self-driving cars is to extract meaningful information from the image taken with the techniques are image processing techniques used to achieve these goals in self-driving cars [11] [12] [13]. Image segmentation methods, which allow grouping objects on the image, are one of the basic domains of computer vision. This research will examine different image segmentation techniques for self-driving cars and discuss their importance in reaching a successful ride.

II. WHAT IS IMAGE SEGMENTATION?

One of the main purposes of computer vision projects is to detect objects on the image. Detecting and separating these objects in the picture makes it easy to extract meaningful information. The image segmentation method, which works with the "divide-and-conquer" approach, helps detect different objects and areas by different based grouping them on the picture. Andreas Koschan and Wladyslaw Skarbek explain the different approaches for grouping objects such as pixel-based, area-based, and edge-based in image segmentation [14]. After specifying the objects and areas on the image according to their attributes, it becomes easier to analyze the image. Considering these, we can see that image segmentation methods are indispensable for many image processing technologies. We use image segmentation methods in many areas of technology where we use image processing techniques such as the detection of cancer cells, characterizing products in the retail sector, analyzing space images, and doing traffic planning in smart cities.

In addition to these areas, image segmentation methods have become a crucial key for self-driving cars to achieve safe trips. The interaction that self-driving cars establish with the outside world is thanks to the images they obtain. Making sense of these images, that is, detecting the objects on the image and determining their boundaries, is important for self-driving cars to drive onthe roads without causing any casualties because the algorithms responsible for guiding the movement of self-driving cars consider all the objects around the car, their properties and movements before giving an output aboutmovement.

When a self-driving car is in motion, the image it takes from around includes objects such as other cars, people, road lines, traffic lights. It is extremely important to determine the boundaries of these objects correctly for self-driving cars, which will run different algorithms for each object type. When these objects are not well

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determined on the image, theself-driving car may make a wrong decision, and this situation may cause an accident. For this reason, it is necessary to choose the right image segmentation methods in self-driving applications.

In their research, Nida M. Zaitouna and Musbah J. Aqelb did an in-depth review of image segmentationmethods using either classical image processing or deep learning- based image processing approaches [15]. Porikli et al examine deep learning-based image segmentation methods in their survey [16]. With this paper, we are going to examine the image segmentations used in self-driving cars in two main groups:

1. Semantic Image Segmentation
2. Instance Image Segmentation

Semantic segmentation treats all objects belonging to the has same class label such as pedestrians, vehicles, roads,traffic lights as a single instance, and every pixel is assignedto one class label. Each vehicle detected in semantic segmentation is not considered separate; contrary to this, the instance segmentation treats each detected object as a separate object. In other words, more than one car of a class can be obtained separately for a separate model. During the application, these two different groups of image segments give different results. In the next section, we will examine the use of these two different groups for separating images from self-driving cars.

III. SEMANTIC SEGMENTATION

Semantic segmentation refers to mapping each pixel in an image to a class label. These class labels usually belong to road lines, pedestrians, and traffic lights in self-driving cars. This segmentation method marks multiple pedestrians on theimage as a single pedestrian object while a vehicle is traveling on the road.

Many methods have been used while performing semantic segmentation in the past few decades. For reference one method in the model is the deep neural network-based fully connected layer structure designed by Shelhamer et al [17].

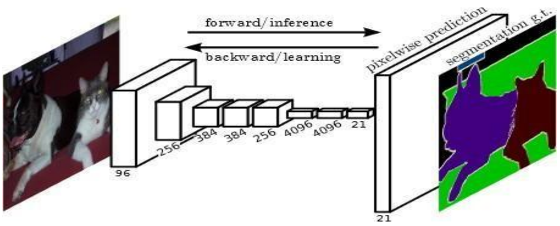
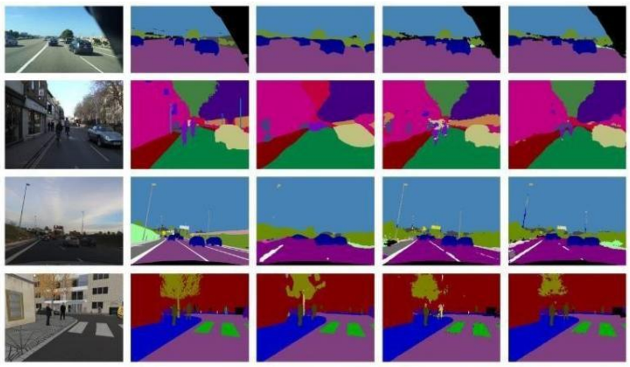


Fig. 1. Fully Convolutional Networks for Semantic Segmentation [17].

The image passes through convolutional neural networks in fully connected layer structures, reducing the image size by down-sampling. At the last stage,instead of making a single output about the image, the image is enlarged again with the up-sampling method, and thanks to the features collected until this stage,pixels are grouped.

Segmentation methods are used in self-driving cars because they can classify the image based on pixels. It is important to determine the boundaries of all objects around self-driving cars during their journey. While the semantic segmentation method classifies these objects on a pixel basis, it determines all objects with the same feature as a class. The importance of the semantic segmentation method emerges atthis point in self-driving cars. For example, a self-driving vehicle must segment the lane lines and the road to stay in its lane while on the road. While performing these operations, semantic segmentation considers the lanes a single object and the road between the lanes as a separate object. It provides a better perspective



so that self-driving cars do not deviate from the road.

Fig . 2 SegNet Structure for Semantic Segmentation1[18].

The SegNet model designed by Vijay Badri Narayanan etal. [18] performs semantic image segmentation using convolutional neural networks. This model gives good results in self-driving car applications, segmenting objects in the images. According to SegNet's road class segmentation comparisons in its paper, SegNet has an accuracy rate of over 80% detecting roads, cars, and buildings.

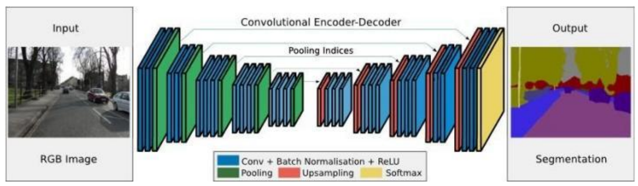


Fig 3 Output segmentation from various samples [19].

When a self-driving car is moving on the road, considering the car's speed, the objects around it can change in seconds. For this reason, image segmentation models need to make the detection process fast. Anisha Pal et al. designed the SegFast model [19], which requires fewer parameters and works faster than theSegNet model, which performs semantic segmentation.

Another important reason why semantic segmentation is used in self-driving cars occurs during parking. For the self-driving car to park properly, it must calculate the length and height of the areas to be parked on the road. Classification of the parking areas on the road as aseparate class from the road is possible with image segmentation methods. Since this classification is made on a pixel basis, the size of that area can be easily calculated, and the self-driving car can decide whether this area is suitable for the

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park. Here, it is more appropriate to use semantic segmentation methods since parking areas do not need to be defined as separateobjects.

IV. INSTANCE SEGMENTATION

The instance segmentation method, which is one of the image segmentation methods, assesses each object detected on the image as a different instance, even if it belongs to thesame class, unlike semantic segmentation. In segmentations using the instance segmentation method, not every pixel on the image belongs to a class. The main purpose here is to mark all the object pixels onthe image that we want to detectand draw the borders of that object. The object detection methodology is also an image-processing technique used to detect objects on the image, but the detected object is only indicated by a bounding box. The instance segmentation method detects the object on the image and marks all pixels belonging to that object. For this reason, this method is used in self-driving cars and many areas where image processing is required. [20] [21] [22].As in the semantic segmentation method, there are also deep-learning-based approaches in addition to classical image processing techniques in the instance segmentation method. Dia Tian et al. reviewed deep learning-based instance segmentation methods in their research [23]. Kaiming He et al. from the Facebook AI Research (FAIR) team published the deep learning- based Mask RCNN [24], which has become one of the most popular instance segmentation frameworks.

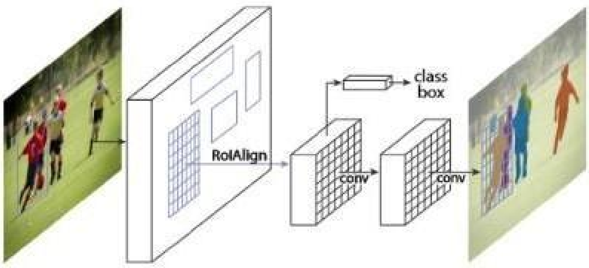

Fig 4 The Mask R-CNN framework for instance segmentation [24].

Self-driving cars need to constantly and instantaneously classify the objects around them not to cause any accidents during the journey. While making these classifications, unlike semantic segmentation methods, there may be cases where it is necessary to evaluate each detected object as a different instance, even if it belongs to the same class. In cases where these classifications need to be made on an object-specific basis, the importance of instance segmentation methods comes into play.

It is necessary to detect pedestrians and vehicles separately in self-driving car applications. Labeling pedestrians under a single class can complicate the self- driving car's action mechanism because the location and distance of each pedestrian are important for the self- driving car. The self-driving car must plan its next move, paying attention to every pedestrian around it. Thanks to this technique, self-driving cars can separately detect more than one pedestrian in the image on the road.

Using the Mask R- CNN framework, Chenchen Xu et al. apply the instance segmentation method, which enables the segmentation of pedestrians and vehicles on the road separately [25].

Fig. 5. Experimental result of Mask R-CNN for instance segmentation [25].

Tagging items found only with responsible boxes may not be enough for self-driving cars that require accurate statistics. In addition to the acquisition of an item, all acquired pixels are marked separately for example. In these cases, you may need to know all the pixels of the object. When all pixels of objects are detected and marked, the movement of self-driving vehicles is carried out with the utmost safety. For example, locating cars separately and marking their pixels allows self-driving vehicles to calculate their distance to other vehicles andto adjust their movement consistently. For this reason, the method of separating samples, which allows for the visualization of objects in the image and marking the pixels of these objects, is one of the most important modes of safe driving.

V. CONCULUSION

Image processing is a method that allows us to extract a pattern or meaningful information from an image by performing pixel calculations. With the growth of studies in this field, we are experiencing technologies that use imaging techniques in many areas of our lives, such as health care, local technology, smart cities, and stores. Image processing techniques are also widely used in self-driving cars, which is where most technology and automotive companies focus and operate. In self-driving cars, it is important to always take pictures from the outside and get the items in this photo on a safe trip. For this reason, the proper use of imaging techniques in self-driving cars is very important.

Knowing all the pixels of objects found allows self- driving cars to organize their movements continuously because sometimes it is not enough to find the objects in the picture; in such cases, image classification methods are introduced. Photo-sharing methods enable us to see objects in a picture and mark pixels of these objects. These pixel assignments are made using two different methods: semantic separation and example. Semantic classification shows objects acquired as a single class when they are in the same class, so all pixels in an image are assigned to a category. Different objects of the same category are shown as different conditions according to the classification pattern. During automatic parking for self-driving vehicles, you may need to know all pixels for parking in order to park successfully. Another situation such as self-driving cars

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traveling through traffic, finding pedestrians and cars and distributing pixels provides additional information about the exact locations of these objects. In this and similar situations, image separation methods are required in self-driving cars, and are used in many different areas in self-driving cars.

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