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Development of Road Detection Algorithm on Mobile Cart Platform

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***Abstract*— Recently, research related to mobile deep learning research and autonomous driving has been actively conducted in various fields. In particular, the lane detection algorithm secured high performance and real-time performance by using deep learning research. However, it is very difficult to apply the lane detection algorithm to an environment with various characteristics that do not have a uniform shape, such as a golf cart road. In addition, since it is difficult to utilize a high-performance chip in the small golf cart platform, it is important to develop a fast and lightweight mobile deep learning research. In this paper, we propose a cart road detection algorithm for a small mobile platform. As a result, based on the Resnet-50 network, we achieved IoU 88.4%, top1 accuracy 82.1%, top3 accuracy 97.6%, and 5.3fps.**

Keywords*— *deep learning, mobile application, robot software, embedded software, detection

I. Introduction

Recently, research related to deep learning research is being actively conducted with the development of hardware [1]. In addition, the mobile deep learning field is also growing due to the popularization of smartphones. In the field of autonomous driving, there have been many advances through deep learning research. In particular, research on lane detection with standardized features achieved a high detection rate because features can be defined in the image processing field [2,3,4]. Research on autonomous driving research is also actively underway in the golf research field. However it is difficult to use lane detection algorithm for cart road detection because the width, color information, and characteristic information of a cart road are very diverse compared to vehicle roads. Therefore, in this paper, the cart road in the golf course environment is recognized by the mobile terminal and a technique for following the cart road is proposed using the detection result.

II. Mobile Cart Road Detection Method

A. Robot-based mobile platform

Fig. 1 shows the robot-based mobile platform for cart road detection. An Android device was mounted on the robot platform to drive image acquisition. The robot platform was driven at a constant speed of 1 m/s during data acquisition and driving tests. Also, Table 1 shows the technical specifications of the test environment mobile hardware.

Fig. 1 Robot-based mobile cart platform

TABLE I. H/W SPECIFICATIONS

	Hardware Technical Specifications
CPU	Qualcomm Snapdragon 865+
RAM	11 GB
GPU	Qualcomm Adreno 650 670 MHz

B. Network

The proposed network uses residual block as shown in Fig. 2 for feature extraction, and then rearranges the position of the feature vector through the inner product. This network is designed as a classification type that detects the position of the cart road, and the final output tensor has 40 anchors, 100 grids, and 2 dimensions, and each class means the left and right cart road. Grids and anchors are designed to compress pixels to reduce detection speed.

C. Datasets

The cart road environment image DB was acquired from Korean golf courses in Sunsan County, Gochang Country, and Dongwon Royal Country. A labeling operation was performed on the entire obtained dataset as shown in Table 2.

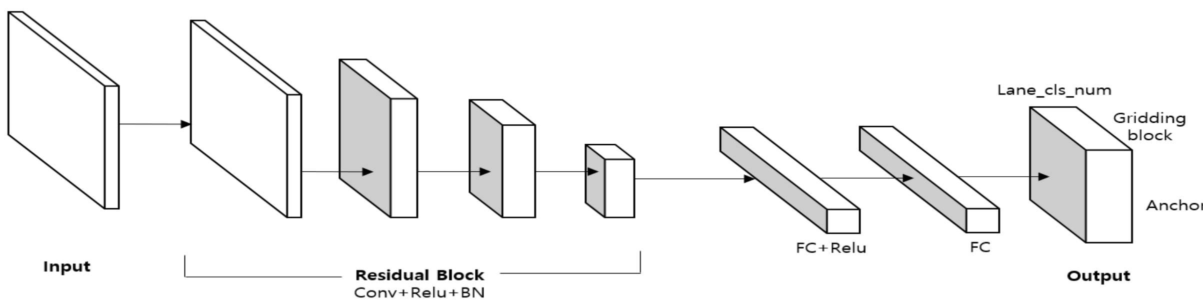

Fig. 2 Cart road detection network

TABLE II. DATASET

	Number of image
Training	23,790
Validation	5,947
Test	3,000

D. Training

During training, a total of three loss functions were defined. L_{cls} calculates the loss value as the cross entropy of the difference between the final output tensor and ground-truth as shown in Equation (1).

$$L_{cls} = \sum_{i=1}^{C} \sum_{j=1}^{h} L_{CE} \, (P_{i,j,:}, T_{i,j,:}) \tag{1}$$

All anchors have probability values according to Equation (3), L_{sim} designed the loss function so that each anchor has the same probability distribution as shown in Equation (3).

$$Prob_{i,j,:} = softmax(P_{i,j,1:w}) \tag{2}$$

$$L_{sim} = \sum_{i=1}^{C} \sum_{j=1}^{h-1} \left\| P_{i,j,:} - P_{i,j+1,:} \right\|_1 \tag{3}$$

For all anchors, the estimated coordinates for the cart road area can be obtained by Equation (4), L_{shp} is designed to minimize the difference between adjacent anchors as shown in Equation (5).

$$Loc_{i,j} = \sum_{k=1}^{w} k \cdot Prob_{i,j,k} \tag{4}$$

$$L_{shp} = \sum_{i=1}^{C} \sum_{j=1}^{h-2} \left\| \begin{matrix} (Loc_{i,j} - Loc_{i,j+1}) \\ -(Loc_{i,j+1} - Loc_{i,j+2}) \end{matrix} \right\|_1 \tag{5}$$

Therefore, the total loss is the sum of L_{cls}, L_{sim}, and L_{shp}. By assigning α, the weights between the three losses were adjusted.

$$L_{total} = L_{cls} + \alpha L_{sim} + \alpha L_{shp} \tag{6}$$

III. EXPERIMENTAL RESULTS

In the existing autonomous driving of cart road, the self-driving method using magnets [5] or GPS [6] is mainly studied, so it is difficult to compare the performance. Therefore, the data set was acquired and evaluated on its own. As a performance detection method, IoU (Intersection Over Union) compared to segmentation ground-truth was measured, and the top 1 to 3 were measured by constructing a network using classification. When designing a mobile-based network, it was difficult to utilize other backbone networks due to memory problems. In this paper, the backbone network was designed based on Resnet. In addition, the performance of each basic network and VPGnet [7] was compared and analyzed as shown in Table 3. VPGNet is composed of a segmentation task, and this study is composed of a classification method, so the performance indicators are not the same. Therefore, it was difficult to compare. Also, Fig. 3 shows the result of cart road detection on mobile.

Base network	IoU(%)	Top 1 (%)	Top 2 (%)	Top 3 (%)	Average Frame per Second
Resnet-18	80.9	77.3	89.7	95.9	**5.3**
Resnet-34	86.7	80.8	92.3	96.4	2.9
Resnet-50	**88.4**	**82.1**	**93.4**	**97.6**	1.4
VPGNet	73.4	-	-	-	-

Fig. 3 Detection results

IV. CONCLUSION

In this paper, we proposed a method for detecting a cart road using an Android-based mobile device. It was learned using the geometrical features of the camera, and the existing autonomous driving method incurs a large cost in initial environment construction, however the method proposed in this paper has the advantage of saving unit cost. In addition, in a golf course environment, the performance of the learning data can be used as a test performance because the cart runs on the same driving course differently from the vehicle. It is expected that this study can be used not only in cart roads but also in other harsh environments.

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