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Self-position estimation of Mini 4WD AI using digital camera images

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***Abstract*— Mini 4WD machine has to run in high speed but remains quite stable while a racing game. In order to achieve the previous, Mini 4WD should adjust its speed depending on its running course such as a straight course, a curve and a jump ramp. In this paper, we propose a self-position estimation method for our Mini 4WD AI utilizing digital camera images.**

Keywords—Self-position estimation, Mini 4WD AI, Image processing

I. Introduction

For the purpose of making fast lap time Mini 4WD, research is conducted to control its speed by AI chip. If you want to make only high speed Mini 4WD, you should use high speed motors. However, there are several obstacles, for example in the courses of "Mini 4WD AI competition" [1], and therefore, in order to make fast lap time Mini 4WD, it is important to accelerate and decelerate at an appropriate position so as to break through obstacles, not to go out of a course. In order to control the speed at appropriate positions, self-position estimation is an important factor to make the fast lap time Mini 4WD. For this reason, we propose a self-position estimation method for Mini 4WD AI by using digital camera images.

Mini 4WD AI carries various sensors, and there is therefore a possibility that the sensors may be damaged by impact while running. Also, because sensors are carried on Mini 4WD AI, sensor noise increases. For these reasons, the sensor information from Mini 4WD AI has to be downsized as much as possible. In this paper, we propose to use a digital camera outside Mini 4WD AI to estimate the self-position of Mini 4WD AI.

II. EQUIPMENT USED

A. Mini 4WD AI

Mini 4WD is a four-wheel drive model with a small motor sold by Tamiya. Mini 4WD is powered by AA batteries and moves the motor at maximum power to run the course. Mini 4WD does not have the ability to bend a curve by itself. If the speed of Mini 4WD is too fast, the Mini 4WD may run out of the course due to curves or slopes, etc. It is important to have the ability of running not fast but stable. In this paper, we use a Mini 4WD AI developed by RT Ltd., which is equipped with Mini 4WD control board "AI chip" [2]. The Mini 4WD AI uses the Bluetooth to wirelessly send the sensor data to the host machine.

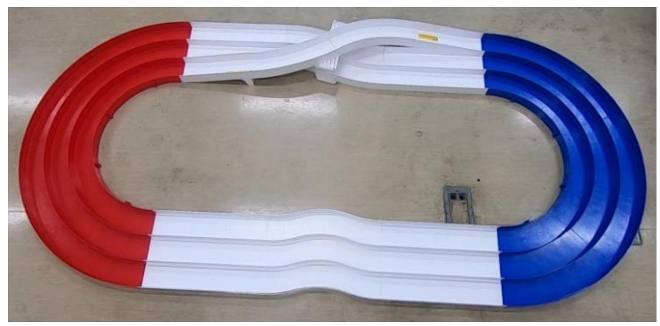

Fig. 1. Mini 4WD course.

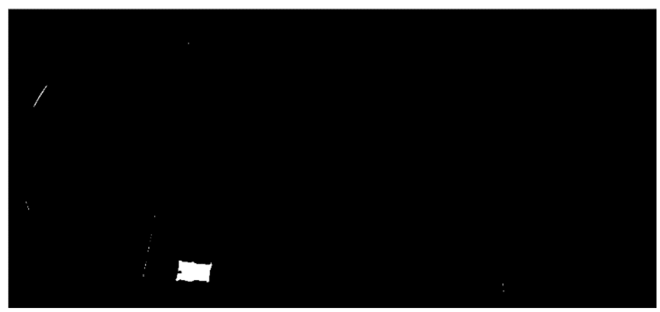

Fig. 2. A result using background subtraction method.

B. Digital camera

In our system, we set up digital camera above the course and take a video of the Mini 4WD AI and overall view of the course. Since the Mini 4WD AI runs fast, we use a digital camera that can shoot at more than 30 fps.

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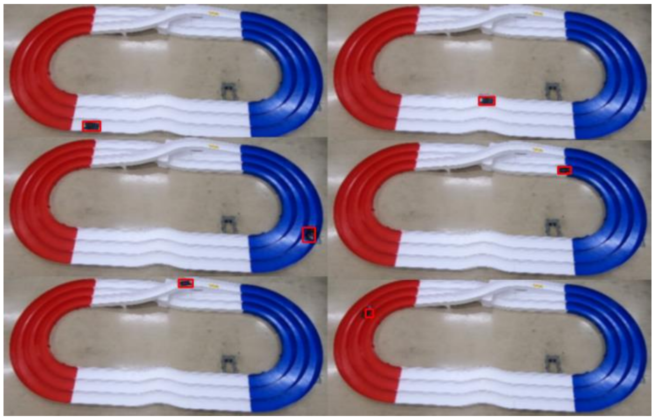

Fig. 3. Detection result of Mini 4WD AI.

III. SELF-POSITION ESTIMATION USING DIGITAL CAMERA IMAGES

A. Motion detection

We use background subtraction method [3] based on Gaussian mixture modelling to detect the Mini 4WD AI in digital camera images. Background subtraction method is general method of motion detection which uses the difference of the current image and the background image to detect moving objects.

The mini 4WD course used in the experiments of Section III is illustrated in Fig. 1, and a result using background subtraction method is illustrated Fig.2

B. Self-Position estimation

Using the background subtraction method, we can detect moving objects from the background. However, the movie includes Mini 4WD AI and not Mini 4WD AI objects. In order to remove not Mini 4WD AI objects, we calculate the contour area of each moving objects, and select only moving objects having an area range. In the experiments of Section III, we set the area range is set to 11-1000 pixels. And then, we calculate the circumscribed rectangles of the selected moving objects, and use their centers of gravity as the estimation of the position of the Mini 4WD AI in digital camera image.

C. Position estimation of Mini 4WD AI

The digital camera movie something includes moving hand, foot, shadow, etc., and at that time, there are more than one moving objects and we need select one appropriate moving object. In our system, we select one moving object which is the nearest to the position of the Mini 4WD AI at the previous time step. From this algorithm, we can reduce the failure that occurs when including not Mini 4WD AI objects. The detection result of Mini 4WD AI example is illustrated in Fig. 3. The red rectangles in Fig. 3 show the selected moving objects.

IV. EXPERIMENT

A. Detecting Mini 4WD AI

The Mini 4WD AI course used in this experiment is illustrated in Fig. 1. In this experiment, the red circle in Fig. 1 is start point, and we define one lap as what the Mini 4WD AI goes three rounds from the start point. Course parts are set in order from the start point: straight, wave, straight, curve, change course, and curve. In this experiment, we use GoProHERO7 BLACK to take a video of the Mini 4WD AI and the course, which is operated at 1920 × 1440 pixel resolution, 60fps, and wide angle mode. Under this condition, we take a video until Mini 4WD AI runs one lap. The number of acquired images is 404 frames. The number of frames where our system can detect the Mini 4WD AI is 397 frames, and the detection rate is 98.27%. Examples of detecting Mini 4WD AI are illustrated in Fig. 3.

Fig. 4. An example where our system cannnot detect Mini 4WD AI.

An example where our system cannot detect Mini 4WD AI is illustrated in Fig. 4. This frame is taken at the timing that the Mini 4WD AI passes under the change course and just disappears. The Mini 4WD AI exists under the change course in red dotted rectangle in Fig. 4. How to tackle this problem is our future work.

B. Position estimation accuraxy verification

We verify how accurate self-position estimation of Mini 4WD AI is in digital camera image. In this experiment, we select 40 frames in equal intervals from the 404 frames used in section III.A. We manually calculate correct positions of Mini 4WD AI in the 40 frames by human eye, and calculate the root mean square error between the correct and estimated positions. As a result, the root mean square error is 2.27 pixels and the maximum root square error is 6.18 pixels. Since the width of each lane is 11.5cm which is less than 13 pixels, this result is acceptable.

V. CONCLUSIONS

In this paper, we propose a self-position estimation method of Mini 4WD AI using digital camera images. Experimental result shows that our system can detect Mini 4WD AI object from the images including Mini 4WD AI and not Mini 4WD AI objects.

Our future work is to detect the Mini 4WD AI when there are more than one Mini 4WD AI in the camera images, and the Mini 4WD AI disappears, for example, the Mini 4WD AI runs under the bridge.

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