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Automatic Driving System by Small Electric Vehicle for elderly person

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Abstract: This paper describes the automatic driving control system for elderly person using low cost sensors.
Firstly, the small automatic electric vehicle and the control devices are explained. Next, the path tracking method is explained. And in order to realize path tracking, GPS and IMU are used to calculate the current position and orientation separately in real time for steering angle control. By the fusion method of Ultrasonic sensors, CCD stereo camera, GPS and IMU, the automatic driving system and the obstacle avoiding system is realized.
Some test runs of automatic driving system of a small vehicle was done to verify the fusion and control methods in the outdoor experiments.

Keywords: Small electric vehicle, Elderly person, Stereo Camera, **U**ltrasonic Sensor, automatic driving control

1. INTRODUCTION

In recent years, with the improvement of ITS, the automatic driving system has much attention due to improve the safety and reduce CO2 emissions. The automatic driving system will enable autonomous driving and the avoidance of obstacles on busy streets as well as environmentally friendly driving through eco-drive automation and the use of navigation systems to select optimal routes.

Aiming to reduce carbon dioxide emissions and realizing safe driving for the elderly people, intelligent vehicle technologies become an important research topic.

We are developing the automatic driving control system in small electric vehicle for elderly person

This paper describes the automatic driving control system for elderly person using low cost sensors.

Firstly, we will explain the small automatic electric vehicle and the control devices. Next, we explain the path tracking method. And in order to realize path tracking, we use GPS and IMU to calculate the current position and orientation separately in real time for steering angle control. By the fusion method of Ultrasonic sensors, CCD stereo camera, GPS and IMU, the automatic driving system and the obstacle avoiding system is realized.

Finally, we made some test runs of the small electric vehicle to verify the fusion and control methods in the outdoor experiments.

2. AUTOMATIC ELECTRIC VEHICLE

The small electric vehicle which we use is a four-wheel electric car in shown fig.1. Table.1 shows the specification of it. The maximum speed is 20 kilometers per hour, traveling distance is 40 kilometers in full charge. For this vehicle, we installed the steering and brake control devices in shown fig.2 and Fig.3.

The small electric vehicle control system(fig.4) is constituted by a controller (Linux), control PC (Windows/XP),router, and the remote monitoring PC.

As the controller, we used AD7011-EVA controller by A&D corporation. The control system is designed by MATLAB /Simulink. The algorithm is transferred to the controller.

For the speed control, we developed the automatic speed control by IMC control method. And we can set as the operation mode, manual or automatic mode.

For the steering control, the steering angle is controlled by the voltage control (1 ~ 4V, -30 degrees to 30 degrees). We can also set the automatic or manual modes for steering .

The automatic brake control is also done by the voltage control (0-5V). Then, we have established an emergency stop system.

Fig.1 Small electric vehicle

Table 1 Specifications of. Small electric vehicle

Size	Length	Width	Height
	1950mm	790mm	1755mm
Weight	235kg		
Battery	12V32Ah×4		
Motor rated output	250W		
Maximum speed	23km/h		
Minimum turning radius	2200mm		

Fig 2 Steering control device

Fig 3 brake control device

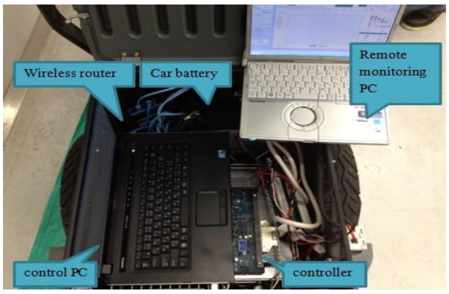

Fig 4 Control system

3. Sensor fusion system for automatic driving

We designed the automatic driving system by realizing high position recognition using GPS and IMU. And we select the optimal route by using the map information and set the sub-goal.

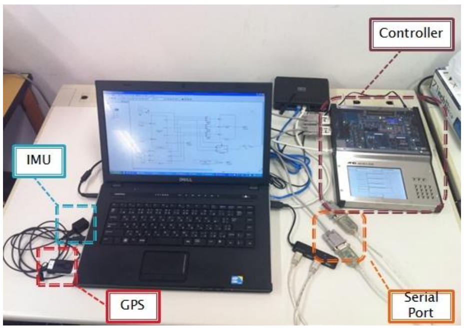

Fig 5 GPS and IMU

We also construct the driving model to control the vehicle to drive the destination.

In this research, for short distance avoidance, we select the ultrasonic sensor with high sensitivity at a low price advantage. In terms of sensitivity, the ultrasonic sensor is less affected by the color and brightness, easy to transmission. To identify the obstacles, we use sensor-fusion technology.

In long distance obstacle detection, we developed an algorithm for obstacle recognition by utilizing the features, azimuth difference of a stereo camera.

Fig 6 Ultrasonic sensor and stereo camera.

Also, if there is a white line on the route, we use a single camera and recognize the white line, to prevent lane departure.

Fig 7 White line recognition camera

We developed the sensor fusion method for ultrasonic sensors and camera for obstacle detection by kalman filter and particle filter.

3.1 GPS and IMU

In order to realize autonomous driving , it is necessary to recognize the current position of vehicle in real time. The Global Positioning System (GPS) is a space-based global navigation satellite system that provides reliable location information at all time. By equipping the vehicle with GPS device, the current position of vehicle is recognized for calculating of steering control angle. What's more, another essential factor for vehicle control is the orientation angle, which means the current direction of vehicle in real time. In this research, it uses inertia measurement unit (IMU) to solve this problem because IMU is a device which measures the high accuracy information such as acceleration, gyro and compass in a short period of time.

By dispersed integral of gyro data, we can calculate the angle changing of IMU device, so we applies this feature to vehicle for calculating the orientation in any time. The figure 8 shows the path tracking model by using GPS and IMU.

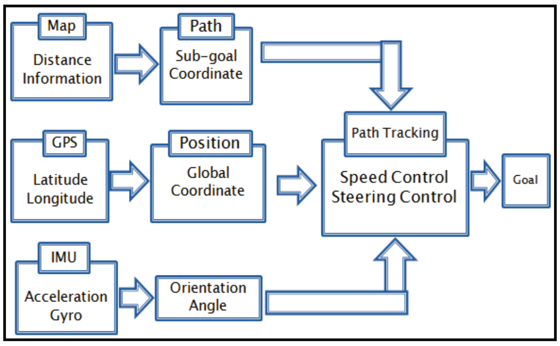

Fig 8 Path tracking model

3.2 Ultrasonic sensor

In this research, we use ultrasonic sensors which have advantage of high sensitivity and low-price. In the factor of sensitivity, the ultrasonic sensor is not susceptible to the effects of color and brightness. It is easily to recognize things such as transparent glass and people.

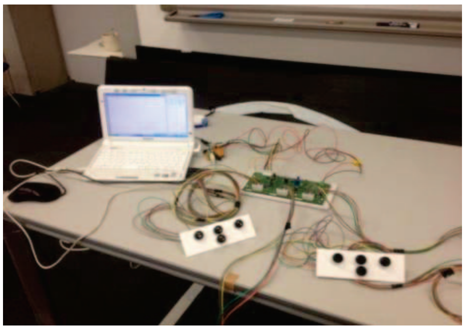

Fig9 Experimental apparatus for ultrasonic sensors

In this research, we used multiple Ultrasound sensors to detect the distance between the obstacles. We can calculate the distance by the following formula.

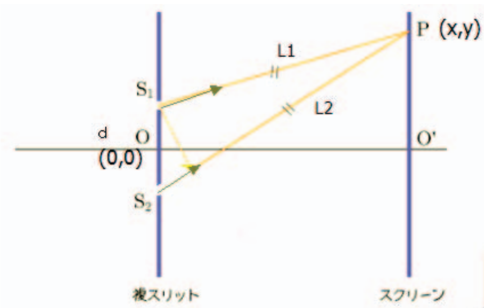

Fig 10 Position calculation

$$x^2 + (y - d/2)^2 = L1 \quad (1)$$
$$x^2 + (y + d/2)^2 = L2 \quad (2)$$

3.3 Camera

We measure the distance between the vehicle to obstacles by stereo camera.

Calculate the sight difference and generate the distance image by stereo matching of images from left camera according to standard images which are defined from images of right camera,

The following formula shows parallax calculation. B means the distance between the cameras. F means the focal distance, and xl - xr means parallax.

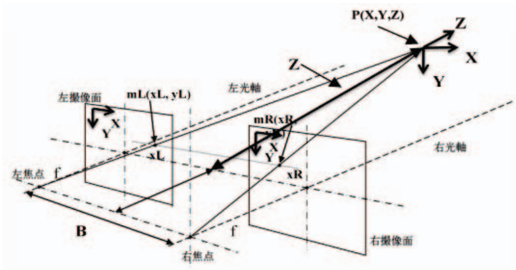

Fig 11 Distance calculation method

$$Z = \frac{Bf}{x_l - x_r} \quad (3)$$
$$X = \frac{Z}{f} x_r \quad (4)$$
$$Y = \frac{Z}{f} Y_r \quad (5)$$

By recognizing the surrounding environment based on the stereo camera ,the obstalce avoidance program will take actions if there has obstacles in the safety area.

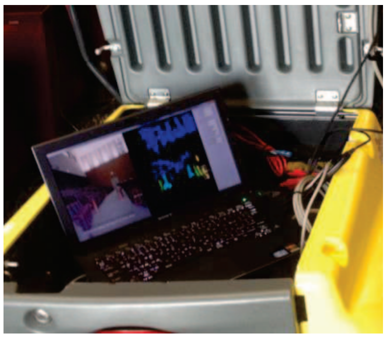

Fig 12 Distance calculation

We use image processing technology for recognizing the white lines on the road, and transfer the processed information from white lines of road to driving control model. It gets extension cords based on pixel values after monochrome of the images in order to make the system stable. After calculating the centre position of white line based on right and left line position in the same horizontal direction, the direction angle θ can be calculated by some centre points at different horizontal directions.

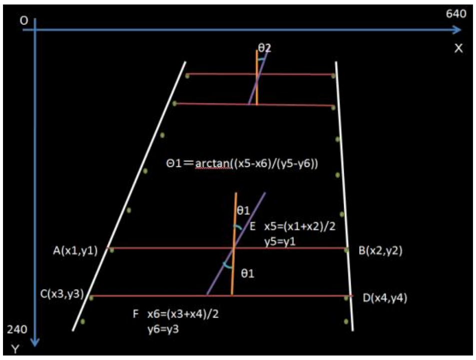

Fig 13 Angle calculation method

4. AUTOMATIC DRIVING SYSTEM EXPERIMENTS

For the autonomous running around campus building, the position of destination is checked by Google Map. We use IMU, white line recognition by the camera to realize the position correction.

We use the stereo camera and the ultrasonic sensor to recognize the obstacles, stop or avoid doing the traveling in shown fig.15.

We made the experiment of this research around the campus as shown in Fig 14. We can learn the global coordinate of these points with latitude and latitude from Google Map. In our experiment, we put the vehicle at the place of "Start", and set our destination at place of "Destination ".

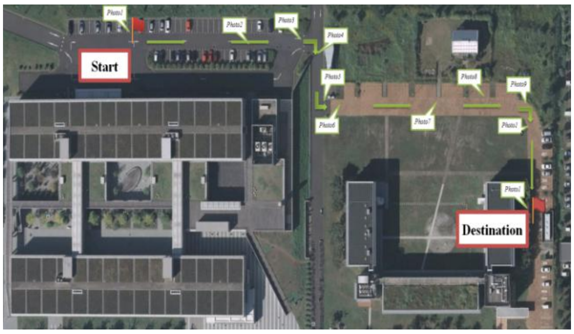

Fig 14 Automatic driving course

Fig 15 Obstacles avoidance test

Table 2 Automatic driving results

Photo1	***Photo 7***
Photo 2	***Photo 8***
Photo 3	***Photo 9***
Photo 4	***Photo 10***
Photo 5	***Photo 11***
Photo 6	

5. CONCLUSION AND FUTURE WORK

By using the small electric car, we developed the automatic driving system for elderly person. We did the experiments to test the performance and practical of this system. As a result, the feature of automatic driving has been confirmed.

In the future, we aim for realizing new function and also improving both performance and safety of system.

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