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Control of a Robotic Vehicle for Entertainment Using Vision for Touring University Campus

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Abstract: This paper presents the navigation of an entertainment robotic vehicle that follows the line on the pavement. The robotic vehicle is built with the purpose of carrying two passengers to look around the campus. Instead of using fully autonomous techniques, a semi-autonomous line following task is implemented. A line is detected by a camera from the pavement with two colors and used as the reference trajectory for the vehicle to follow. The robotic vehicle should be localized where colors are not available. Experimental studies of following the line trajectory detected by a camera are conducted to demonstrate the feasibility as an electric vehicle for traveling a short distance.

Keywords: Line detection, line tracking, entertainment robot, vision, semi-autonomous navigation

1. INTRODUCTION

Mobility of robots is an excellent technique for robots to have infinite degrees-of-freedom to explore their terrains. Mobility has been actively used in surveillance and navigation. In addition, mobility is used for service robots to help humans in their home environment.

Recently, the task of mobile robots is getting more demanded in the purpose of transportation than surveillance. Major three technologies for mobile robots to perform tasks are localization, path planning, and control. For the surveillance task, localization is the most important technology for autonomous navigation. Therefore, the majority of mobile robot research is about localization which deals with simultaneous localization and mapping (SLAM). SLAM is still the most popular topic in the mobile robot research.

However, control is the most important technology for mobile robots used in transportation where drivers operate directly mobile robots. The paradigm of merging electric vehicles and mobile robots comes true.

The typical mobile robot as a transportation vehicle is Segway which has two wheels to balance and drive [1]. The successful appearance of Segway has leaded to active research on developing many mobile robots utilized for the transportation purpose [2-7]. In Korea, a personal transportation vehicle with a seat where a driver can sit, has been developed [8]. Furthermore, a two-wheel transportation vehicle with two seats has been developed as an extension of Segway [9].

A two-wheel transportation vehicle for entertainment, AmuseTransBot (ATB) has also been developed in our previous research [10-14]. The purpose of developing ATB is to provide a tour service to visitors when they visit our university. The ultimate goal of the ATB is to navigate autonomously from the main gate to the administrative building of the university. The path from the main gate to the administrative building is complicated and colored with two tones. A problem occurs where the path with two tone colors is disconnected. At this current stage, however, only a line tracking task is performed instead of fully autonomous navigation.

In this paper, therefore, the semi-autonomous driving task of the ATB is implemented. Firstly, a line is detected from two colors of the pavement by image processing so that it can be used as the desired trajectory for the ATB to follow. Secondly, the ATB is controlled to follow the trajectory. Lastly, the line tracking task is performed in the places where colors are missing. Experimental studies of driver control and unmanned control are conducted to confirm the feasibility of the proposal.

2. ENTERTAINMENT VEHICLE

The robotic vehicle is designed for entertaining visitors touring the University Campus. The vehicle has two wheels to maintain balance like Segway. The vehicle has two seats to carry two passengers and is required to carry visitors from the entrance gate to the administrative building. In addition, the vehicle has bounce control to entertain visitors while they are touring the campus [11-13]. Extra support wheels are attached to the front and back of the vehicle for bouncing control [14]. Fig. 1 shows the real vehicle.

(a) Front view (b) Side view

Fig. 1. AmuseTransBOT

3. CONTROL SCHEMES

3.1 Line detection

To navigate autonomously from the main gate to the administrative building, there are many problems to be solved. Above all, localization is the most important technique. Accurate position tracking control is required to navigate inside the fixed pavement. The width of the pavement is limited as shown in Fig. 2. Another problem is how to deal with the pavement without colors along the trajectory. The other problem is how to perform collision avoidance for pedestrians.

Here, we assume that the ATB operates in daytime only. The most important technique of semi-autonomous navigation for the ATB is to detect the line accurately between two colors as shown in Fig. 2. Colors are close to red and yellow.

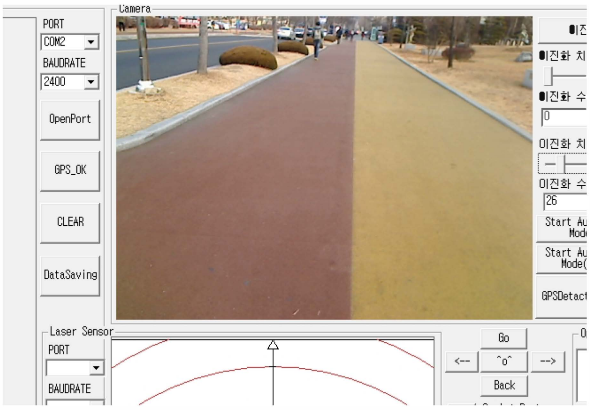


Fig 2. Colors of pavement in the campus

The colors of the pavement are distinguishable. However, a problem occurs when the shadow of trees appears on the pavement as shown in Fig. 3. A more advanced image processing technique is required to deal with noises by those shadows.

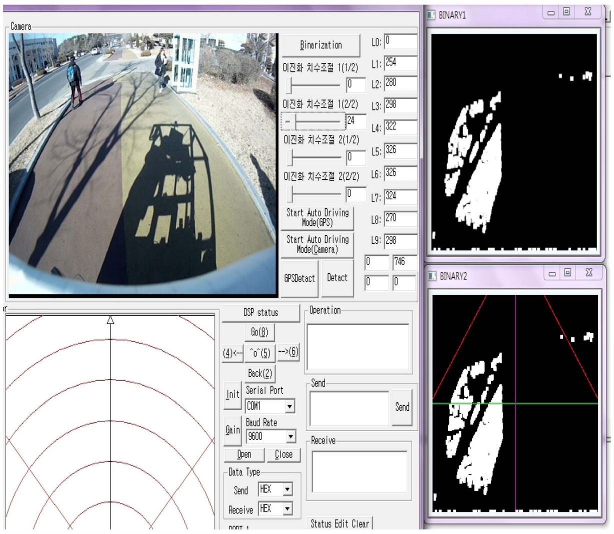


Fig 3. Image processing in GUI

3.2 Control

For the driving control, simple linear control method is used. Position and heading angles are controlled separately as shown in the control block diagram of Fig. 4.

$$u_P = k_{pp}(p_d - p) + k_{pd}(v_d - v) \tag{1}$$

$$u_\phi = k_{p\phi}(\phi_d - \phi) + k_{d\phi}(\omega_d - \omega)$$

where p is the position, ϕ is the heading angle, and $k_{pp}, k_{pd}, k_{p\phi}, k_{d\phi}$ are controller gains.

Then torque to each wheel is defined as

$$\tau_R = u_P + u_\phi$$
$$\tau_L = u_P - u_\phi \tag{2}$$

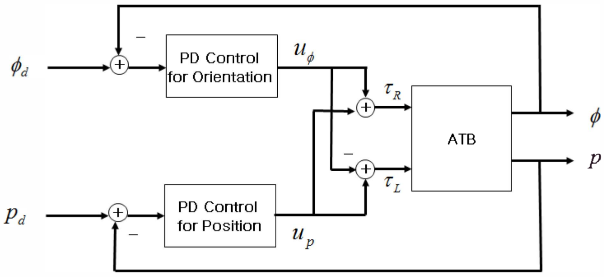
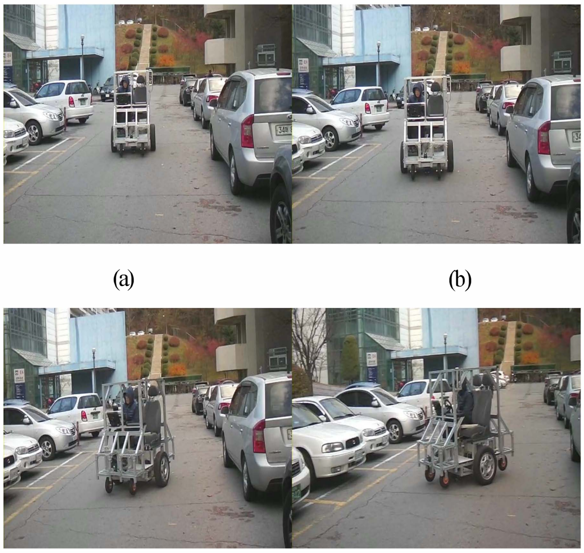


Fig 4. Control block diagram

4. EXPERIMENTAL STUDIES

4.1 Driving control performance

Firstly, a driver controls the vehicle in an outdoor parking lot. Fig. 5 shows the images of driving control of the vehicle. The vehicle is well controlled as the driver operates. Direction is changed by turning a handle and driving acceleration is done by pressing a pedal.



(a) (b)

(c) (d)

Fig 5. Performance of driver control

4.2 Unmanned driving control performance

Next experiment is semi-autonomous navigation based on vision. The camera mounted on the body captures the image of the pavement and detects colors. The vehicle moves slowly, but follows the line between colors as shown in Fig. 6.

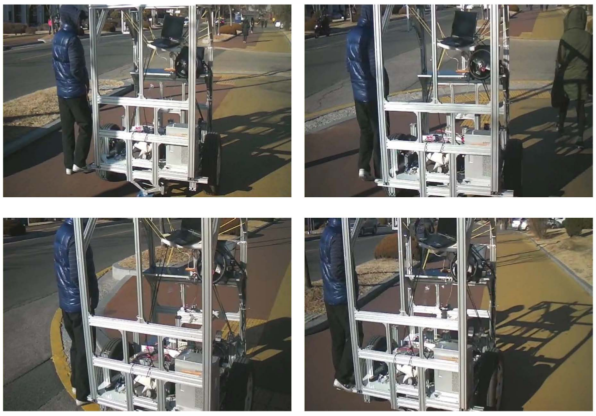


Fig 6. Unmanned driving performance

During the experiment in the outdoor environment, several problems have been observed. The vehicle moves slowly, but oscillates a little about the line. Another problem observed is the noise by shadows of the vehicle itself. The vehicle was successful to cross over the place where colors are not available, but the movements are quite slow. Further advanced algorithms are required to be developed.

5. CONCLUSION

This paper presented the feasibility of using mobile robots as a tour-guide vehicle for visitors in the university campus. Line was detected by a camera from two colors on the pavement. Experimental study showed that feasible result that the vehicle follows the line. However, the vehicle has to deal with the place where the road is disconnected without colors. Another problem occurs when the shadow appears in the image frame. Therefore, further research on semi-autonomous navigation based on vision is required.

ACKNOWLEDGEMENTS

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