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Research on Three Dimensional Measurements of Object and Guidance Controls of Mobile Robots for Obstacle Avoidances

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Abstract: Nowadays, needs for robots that coexist with people are rising. A lot of obstacles exist in our living environments, so when mobile robots run autonomously, the robot requires information of the environment. Therefore we attach sensors on the robot for getting the information .This paper, we show our developed guidance control system with LRF for mobile robots at first. Then we show experimental results of three dimensional measurements and results of a guidance control of the robot for the obstacle avoidance in order to develop the autonomous mobile robot.

1. Introduction

In recent years, demands for security robots and care robots that coexist with people are rising. A lot of obstacles, such as buildings and trees, exist in our living environments. When mobile robots run autonomously in the environment, we need to give a map and precise position information to the robot. However, it is difficult that we give a map of the first visit to the robot in advance. If the robot can get a map beforehand, information about obstacles are not included in many cases. Therefore we need to attach external sensors on the robot for getting information of the environments.

In this paper, we show our constructed mobile robot and the guidance control system. Then we shows experimental results of three dimensional measurements and results of the guidance control of the robot for the obstacle avoidance in order to develop the autonomous mobile robot.

2. Mobile robot

Fig. 1 Our constructed mobile robot

Fig. 1 shows our constructed the robot. The robot has 65 [cm] in length, 55 [cm] in width, 110 [cm] in height and 34 [kg] in weight. This mobile robot is the PWS (Power Wheeled Steering) type using the DC motor. Therefore its right and left driving wheels of the robot have encoders for measurement of angular velocities, respectively. The robot has the GPS for getting absolute positions and the LRF (Laser Range Finder) for measurement of the distance from the robot to the obstacle in running environment.

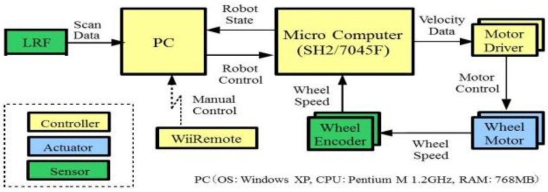

Fig. 2 Control system

Fig. 2 shows the construction of control system including computers and sensors. The robot can be run by the remote control with a Wii hand controller for the manual control.

3. Control system

3-1. Dead reckoning

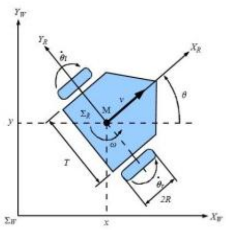

Fig. 3 Kinematics of the mobile robot

Positions and orientations of the robot are estimated by the dead reckoning method. The velocity and the angular velocity shown in Fig. 3 are calculated by the following equations.

$$v = \frac{1}{2}\left(R\dot{\theta}_r + R\dot{\theta}_l\right) \tag{1}$$

$$\omega = \frac{1}{T}\left(R\dot{\theta}_r + R\dot{\theta}_l\right) \tag{2}$$

Where (1)and (2), R is the radius of right and left wheels, θ_r and θ_l are angular velocities of right and left wheels, T is tread, respectively. The position $x(t)$, the position $y(t)$ and the angular posture $\theta(t)$ at time t are calculated by the following equations with the v and the ω.

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$$x(t) = x(t_0) + \int_{t_0}^{t} v(\tau)\cos\theta(\tau)d\tau \quad (3)$$

$$y(t) = y(t_0) + \int_{t_0}^{t} v(\tau)\sin\theta(\tau)d\tau \quad (4)$$

$$\theta(t) = \theta(t_0) + \int_{t_0}^{t} \omega(\tau)\,d\tau \quad (5)$$

Where $x(t_0)$, $y(t_0)$ and $\theta(t_0)$ are the initial values.

3-3. Recognition and avoidance of obstacles

The measurement area is obtained by summation of distances from the LRF to the obstacle in a certain pan angle. When the measurement area becomes less than 90 [%] of pre-determined, the robot judges that an obstacle exist. The robot recognizes the obstacle by comparing the measured area and the pre-determined area.

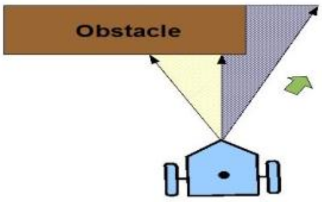


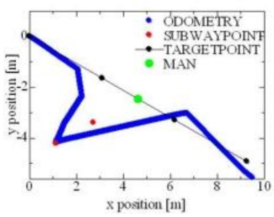
Fig. 5 Recognition of an obstacle

As shown in Fig. 5, when the obstacle is recognized by the above mentioned method, the robot compares the right area and the left area of the obstacle. The robot changes the trajectory towered not being the obstacle.

4. Experiments

4-1. Experiments of the obstacle avoidance

Experiments were done at traffic track in the Funabashi campus. In the experimental environment, the road is flat and there is no obstacle to the sky from the road surface.

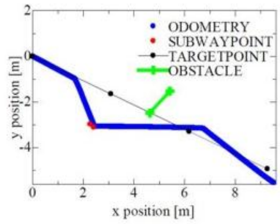


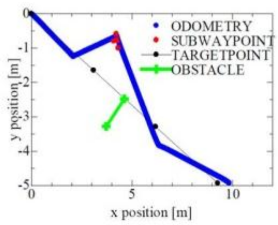
(a) Overview of experiment　(b) Result of trajectory

Fig.6 experimental environment

Figs. 6 (a) and (b) show the experimental environment and the running trajectory of the mobile robot, respectively. In order to verify the validity of the proposed method, experiments of the obstacle avoidance were performed in the situation in which a man was treated as an obstacle. From the figures, it was confirmed that subway points were made by proposed method and the robot could avoid the obstacle. The details of subway points are omitted here.

4-2. Experiment results of the obstacle recognition



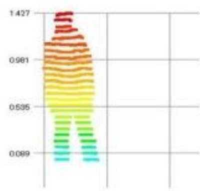


(a) In case of right side　(b) In case of left side

Fig. 8 Guidance control result

When the long obstacle was placed at the right and the left sides from the center of the desired trajectory, experiments were performed. Fig. 8 (a) shows the running results of the robot in the case that the obstacle was placed on the right side. Fig. 8 (b) shows the case of the left side. From Fig.8, it was confirmed that the robot could recognize the obstacle during traveling and avoid traveling and avoid the obstacle by creating subway points.

4-3. Three dimensional object measurements



(a) Man　(b) Measured result

Fig. 9 Three dimensional object measurement result

Fig. 9 (a) shows the experimental environment. Fig. 9 (b) shows result of three dimensional object measurements. Comparing Figs. 9 (a) and (b), the three dimensional shape of the obstacle was obtained.

5. Conclusions

This paper showed experiment results of the guidance control of the mobile robot for the obstacle avoidance and results of the three dimensional object measurements. From the results, it was confirmed that subway points could be made and the guidance control of the mobile robot for the obstacle avoidance could be performed. In addition the tree dimensional shape of the obstacle could be obtained by moving LRF in the tilt direction.