A Study on Autonomous Driving Mobile Robot by using Intelligent Algorithm

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Abstract: In this paper, we designed a intelligent autonomous driving robot by using Fuzzy algorithm. The object of designed robot is recognition of obstacle, avoidance of obstacle and safe arrival. We append a suspension system to auxiliary wheel for improvement in stability and movement. The designed robot can arrive at destination where is wanted to go by the old and the weak and the handicapped at indoor hospital and building.

Keywords: ARV, ultra sonic sensor, nonholonomic, kinematic model, suspension system

1. INTRODUCTION

Due to increment of the demand of the nursing facilities and hospital in the advanced age society, it is expected the necessary of the assistants. In accordance with that, in this paper, we designed a guide mobile robot for an old man. The robot is made of two parts. The one is electro signal process part for the operating control. The other is the signal process part for the lever and laser scan sensor.

The Fig1 is the block diagram that shows the signal flow of the system. The user who wants to receive the service of the robot inputs the his location to the main controller at first. Then the main controller sends the digital signal to the MMC. The signal passes interface card and drives the motor, which send the user to the place where the user wants to go. And giving a pressure to the lever including the sensor (Load cell), MMC gets analog signal then main controller calculates it to react the power of the signal. If the calculated value is included in the range which is related with the speed control, the main controller controls the robot’s speed.

\[
\dot{x}_M = \frac{r}{2}(\dot{\theta}_1 + \dot{\theta}_2)\cos\psi
\]
\[
\dot{y}_M = \frac{r}{2}(\dot{\theta}_1 + \dot{\theta}_2)\sin\psi
\]
\[
\dot{\psi}_M = \frac{r}{2}(\dot{\theta}_1 - \dot{\theta}_2)
\]

2. SYSTEM MODELING

2.1 The design of the mobile robot’s operating part.

To design a controller, we explain the physical mechanism of the mobile robot. Fig2 shows schematic diagram of the mobile robot to design controller. In the Fig2,

To get the simple the physical mechanism of the mobile robot, we assume that there is no slide of the side. Under the assumption, we can get the followed equations.
So the state equation is
\[ \dot{X} = B(X)U \]  
Equation 7 is expressed that
\[ \dot{\chi} = -\frac{1}{2} \begin{bmatrix} y \\ 0 \end{bmatrix} + \begin{bmatrix} \cos \psi & \sin \psi \\ -\sin \psi & \cos \psi \end{bmatrix} \begin{bmatrix} \ddot{\chi}_p \\ \ddot{\gamma}_p \end{bmatrix} \]  
(9)
If the point, \( P \), is relocated \( O \), the Equation 8 is expressed that
\[ \dot{\chi} = 0 \]  
(10)
The input of the controller, \( B(x) \), is that
\[ B(x) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \]  
(11)
At this time, we confirm stability of \( B(x) \). At first, if \( d \) is zero, that is set that the location of controller is located the center of the vehicle, we can do the feedback control by using Lyapunov’s stability theory. The input of the control is that
\[ U = \begin{bmatrix} v \\ \gamma \end{bmatrix} = \begin{bmatrix} k_1 \chi \\ k_2 \gamma \end{bmatrix} , \quad k_1 > 0 , \quad k_2 > 0 \]  
(12)
We can see the result at Fig. 3.

In the simulation, it cannot reach to the zero when \( d \) is zero. The reason is that the \( B(x) \) is to be singular matrix when zero point. So, we locate the \( d \) near to zero to avoid the singular point.

2.2 The modeling of the assistant wheel.

To apply to the path algorithm, we need the mechanism of the operating system which satisfy the slide of the side. So we apply the mechanism of the suspension to the system. To settle the capacity of the suspension we are modeling the suspension.

\[ m \begin{bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{bmatrix} = -F_b - F_k \]  
(13)
where, \( x_1 \): movement of mobile robot
\( F_b \): damping power
\( F_k \): elasticity-transformation power
\( x_1 \): displacement

3. THE DESIGN OF THE CONTROLLER.

Fig. 5 is the block diagram of controller which is designed to this system. As you see, thus controller is composed with two feedback loops. The one is inner loop which is made of the PID controller following in the desired velocity which is made by Fuzzy controller. The other is outer loop(main controller) which decides velocity of the vehicle and steering angle depending on the location of the object and the input of the sensor. The value of the outer loop’ output is changed to the velocities of the two wheels.

3.1 Algorithm of the Route recognition

The mobile robot is applied by the algorithm which determine the location and attitude of mobile robot using the laser sense scan for inner the surface of the wall. Fig. 6 shows the surface of the wall related to the mobile robot.

Above the model, the mobile robot recognize the
coordinates of the attitude and the distance from the surface of the wall. The polynomials about recognizing the coordinates of the attitude and the distance from surface of the wall is then given as:

\[
\theta_w = \frac{\pi}{2} - \cos^{-1}\left(\frac{d_x^2 - d_y^2 - d_z^2}{2d_xd_y}\right) - \theta(k) \tag{14}
\]

\[
h = h' - \cos\theta_w \cdot l \tag{15}
\]

where,

\[
d_i = \sqrt{d(k)^2 + d(k+1)^2 - 2d(k) \cdot d(k+1)\cos\theta} \tag{16}
\]

\[
\tilde{\theta} = \theta(k+1) - \theta(k) \tag{17}
\]

\[
\theta_i = \cos^{-1}\left(\frac{d_x^2 - \tilde{d}^2 - d_z^2}{2\tilde{d}d_x}\right) \tag{18}
\]

\[
\tilde{d} = d(k+1) - d(k) \tag{19}
\]

\[
d_a = d(k+1) \cdot \tilde{\theta} \tag{20}
\]

where, \(\theta_w\) is the attitude of the mobile robot, \(h\) is to be the distance toward x axis from the surface of the wall. The mobile robot travels by the algorithm of the route recognition to minimize the distance from the surface of the wall to the mobile robot.

3.2 The fuzzy Algorithm.

Fuzzy theory is proposed by professor Zadeh, 1969 in Unite State America initially. The fuzzy theory recovers from the imitation of math of existing dividing tow parts and expresses well the real natural situations.

Fig. 7 shows that the Fuzzy controller is based on the knowledge base designed IF – Then types as the obscure natural language, the interface system resulted from prepresented input of the fuzzy and the regulations of fuzzy, the defuzzification system consisting of the crisp value resulted from the conclusion of the fuzzy theory.

3.2.1 Fuzzy variable

In this paper, we propose that the mobile robot achieve the Function of the route creation and avoidance of the obstacle. Desired results. The fuzzy controller is designed by the purpose which the direction of the target and the location of the obstacle and the load shell accepted the variable input. The mobile robot is designed to determine the speed and the steering angle using the input variable of the fuzzy set. The fuzzy value of the fuzzy input and output variable are proposed that they hold the value of Table. 1 and Table.2, respectively.

3.2.2 The regulation base.

The regulation of the mobile robot determined the speed is then given as:

- When the mobile robot is close and in front of the obstacle, it is slowly moves.
- When the mobile robot is far, it is fast moves.
- When the mobile robot is in middle of the obstacle and
the size of the obstacle is small, it is move the obstacle.

4. A SIMULATION RESULT

4.1 The avoidance of the obstacle

Fig. 8 shows that the simulation that the mobile robot recognizes the signal of the obstacle from the laser scan sensor.

Fig. 8 Simulation of navigating the recognized path

4.2 SUSPENSION

From Fig. 9 to Fig. 10 show that the simulation results of the suspension system in case of the the obstacle on the road. The dotted line shows the obstacle of the road, the solid line shows the assimilation of the suspension. Likewise, From Fig. 11 to Fig. 14 show that the result from the simulation in case of the disturbance applied the road.

Fig. 9 5HZ(Magnitude : 0.001)

Fig. 10

Fig. 11 5HZ(Magnitude : 0.001)

Fig. 12 10 HZ(Magnitude : 0.001)
5. CONCLUSION

In this paper, on the assumption the kinetics of the mobile robot we conclude the simulation that the propriety of the control algorithm applied the mobile robot.

The result of the research contents in this paper is then given as:
1. Using the fuzzy control algorithm the mobile robot for the service of the guidance tracks the route well.
2. The algorithm of recognizing the route and the obstacle are synthesized each other, we propose the algorithm for the tracking the route by the fuzzy logic controller.
3. We make out the superior suction for the obstacle on the road due to equip the suspension system in the assistance wheel.

REFERENCES


