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Simulation Design of Robot Localization and Navigation System

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Abstract: In order to effectively solve the problems of robot navigation, positioning and accumulative error correction, this study presents a kind of improved robot localization and navigation algorithm. Robot navigation is an important research field of robotics, it is the key of mobile robot to completely realize the independence of technology and accurate localization is the important problem which must be solved at first to complete navigation tasks. The experimental results show that the error of the improved method is smaller; therefore the formulation of robotic strategy route is more convenient and reliable.

Key words: Robot, obstacle avoidance, navigation system, localization algorithm

INTRODUCTION

In the robot technology, a key goal is to make the automatic robots can complete a series of work in the indoor environment. To achieve this goal, the robot must be able to perceive the surrounding environment and obtain its own location information. In order to make the robot reach the target accurately with a certain navigation effect, the general methods are line-tracking, visual sense, inertial navigation, encoder, etc. (Neda, 2000). It is a kind of high and new technology developed rapidly in the new technology revolution which has been applied in many scientific fields and industry departments and shows strong vitality.

Robot technology is a comprehensive discipline, it combines a variety of basic subjects, technology subject and many aspects of knowledge in new scientific and technological undertakings, distinctly reflects the characteristic of high polarization and high synthesizing in current science and technology development (Saberand Murray, 2004). Mobile robot groups usually need to complete a certain control tasks in the complex three-dimensional environment.

Path planning can be modeled as the path optimization process under certain constraints, in which the robot can avoid obstacles in the work process from the initial position to walk to the target position (Olfati-Saber *et al*., 2007).

This study adopts an improved robot localization and navigation algorithm, this improved method can effectively solve the localization, the cumulative error correction, the path planning and the obstacle avoidance problem in robot navigation process, this study introduces a wireless debugging system in the machine system which makes the variety of information of robots in the running process becomes controllable and observable and greatly accelerates the debugging schedule of system which makes the formulation of robot strategy route become more convenient and reliable.

DESIGN AND RESEARCH OF ROBOT CONTROL TECHNOLOGY

The robot line-tracking localization: Robot localization is mainly through the sensors to do line-tracking positioning (Ren *et al*., 2005). The main problem needed to be solved of line-tracking method is the stability of sensors, the anti-interference ability and more perfect line-tracking algorithm. Relative to the other positioning method, the line-tracking is easy to implement and has low cost. Under the condition of the stable sensors, if the line-tracking algorithm is relatively complete, the robot will be very stable; therefore, most teams use this point-position method (Lei, 2006). But the positioning method of line-tracking still has its drawbacks. First of all, it is difficult to get a stable line-tracking sensor; second, the walking style determines the robot can only move in "horizontal or vertical" which limits the flexibility of robot (Lei and Li, 2007).

Robot positioning system: Mobile robot path planning is mainly to solve three problems: (1) To make robot move from the initial point to the target point, (2) Via., a certain algorithm to make robot avoid obstacles and pass some points which must pass and (3) In the premise of above task, try to optimize the robot movement path. According to working environment the path planning can be divided into two kinds: Static path planning with known environmental information which is also called the global planning; the dynamic planning with unknown or partially unknown environmental information, also known as the local planning. The latter has more

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practical significance, because the obstacles in real environment are very likely the movement object with unknown law of motion. Path planning in dynamic environment is much more complex than that in static environment (Yi and Zhang, 2010).

Traditional robot positioning technology is mainly to do preprocessing to current values and do not integral process in real time to the history values, so the robot in each moment doesn't know its current angle and location information, only knows the current status (Sun, 2007). For example, when the robot is in a straight line, it only knows itself in a straight line and doesn't know its position and angle information in the walking process which is also like this in rotation (Khabit, 1986). If all the values after the initial states are done integral, robot can know its current position and angle information (Yung and Cang, 1999).

Robot localization algorithm model: Assuming the location information of robot uses [X, Y, θ] to describe, in which X and Y, respectively represents the coordinates under global coordinate system of robot, θ represents the azimuth angle of robot. Figure 1 is the model diagram of localization algorithm, C_G represents the global coordinate system, C_R represents the local coordinate system of the robot.

When the robot reaches the n+1-th state (red) from the n-th state (blue) after a very small movement, the left and the right driven wheels, respectively walk a small circular arc. Suppose the variation of left encoder of robot is L_1, the right variation is L_2. In the process the robot's rotation angle is d_θ which can be expressed as:

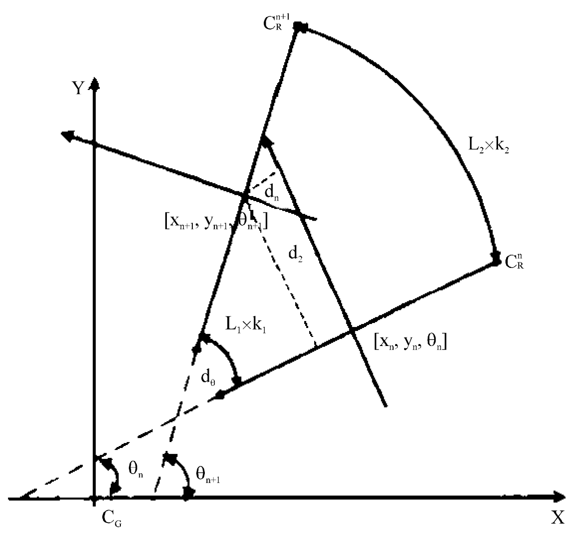

Fig. 1: Localization algorithm model

$$d_\theta = \frac{L_2 \times k_2 - L_1 \times k_1}{Len}$$

Thereinto:

$$k_1 = \frac{2\pi\tau_1}{N}$$

and:

$$k_2 = \frac{2\pi\tau_2}{N}$$

are the compensation coefficients of both sides of encoder which is related with the resolution N of encoders and driven wheel radius r; Len is the center wheel distance for the both sides of encoders. According to the d_θ value the variation values in x, y direction can be obtained in the robot coordinate system C_R:

$$d_x = -\frac{L_2 \times K_2 + L_1 \times K_1}{2(L_2 \times k_2 - L_1 \times k_1)} \times Len \times [1 - \cos(d_\theta)]$$

$$d_y = \frac{L_2 \times k_2 + L_1 \times k_1}{2(L_2 \times k_2 - L_1 \times k_1)} \times Len \times \sin(d_\theta)$$

The d_x, d_y, d_θ in robot coordinate system transfer into the position and angle information in the global coordinate system which need to undertake the following changes:

$$\theta_{n+1} = \theta_n + d_\theta$$
$$x_{n+1} = x_n + [d_x \times \cos(\theta) - d_y \times \sin(\theta)]$$
$$y_{n+1} = y_n + [\sin(\theta) + d_y \times \cos(\theta)]$$

Thereinto, $[x_n, y_n, \theta_n]$ represents the location information of the former moment. $[x_{n+1}, y_{n+1}, \theta_{n+1}]$ represents the location information of current moment. This accumulation of results can obtain the location information of the robot. From the point of the whole algorithm, if the robot is in lateral offset, the location information will appear relatively large error and because the angle value uses the difference value, there will be no greater error. Therefore in the whole movement process, the affected degree of angle values is small.

Because all the location information of the system is determined by the values of the encoder, although a correction is done to the parameters of encoder, the errors are still there, after long time work, accumulated error will cause the robot unable to positioning normally (Li, 1999). In order to ensure that the robot can work for a long period of time, this study uses the accumulated error correction algorithm to eliminate the mistakes.

A robot path is supposed as a circle, the distance between the center of circle and the center of the wheel is l, the coordinates of the circle are $[X^n_{Island}, Y^n_{Island}]$ and by the following equation the robot's current position can be obtained:

$$x = X^n_{Island} + l \times \sin(\theta)$$
$$y = Y^n_{Island} + l \times \cos(\theta)$$

Experimental results show that after the correction of accumulative error, the robot can run continuously along the path in the case there is no serious impact movement.

Robot navigation technology: Due to the system at each moment knows its position and angle, thus these information can be used to do feedback for robots (Rui *et al*., 2007). Specifically, this system uses the intersection angle as feedback parameters which is between the connection line between the target point and the center of encoder and the current robot walking direction, uses the distance between robot and target point as a condition of judging whether to arrive. It can be described by the model shown in Fig. 2.

As shown in Fig. 2, the intersection angle between the direction of car head of robot and target point is α, the coordinates of the target point are $[dis_x, dis_y]$, the coordinates of target points can be transferred to the local coordinates of the robot by the following expressions:

$$X_{local} = (dis_x - x) \times \cos(\theta) + (dis_y - y) \times \sin(\theta)$$
$$Y_{local} = (dis_x - x) \times \sin(\theta) + (dis_y - y) \times \cos(\theta)$$

Then:

$$\alpha = \pm \frac{\pi}{2} - \text{arctg}\left(\frac{Y_{local}}{X_{local}}\right)$$

is used to calculate α, (when $x_{local} < 0$, it is negative), the adjust method of PID feedback is used to do adjust according to α value to vehicle orientation. The adjust formula is like the followings:

$$PIDresult = \alpha_n p + (\alpha_n - \alpha_{n-1}) D + \alpha_n I$$

Thereinto, PIDresult represents the adjust degree, P, I and D, respectively represents the α values of three parameters α_n at current moment. α_{n-1} is the value of α_n at prior moment. When the distance between robot and target point is less than a certain threshold value, the robot can regard itself reach to the target point which should exit the navigation mode and execute the succeeding action.

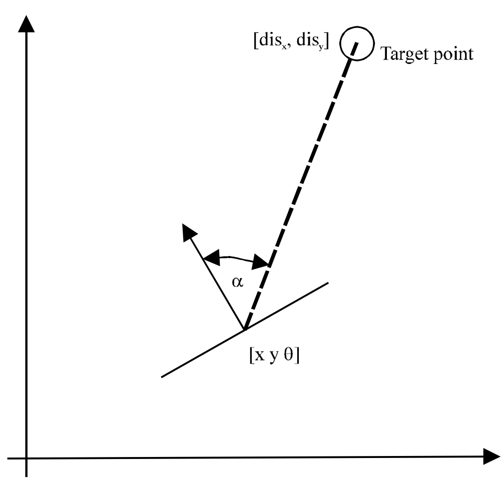

Fig. 2: Illustration of navigation algorithm

EXPERIMENT RESULT AND ANALYSIS

In the experiment system, the navigation data communicates with computers through the wireless module in robot. Some orders of movement control of robot are all through the end control software of computers and wireless modules to send signals. Aiming to the improved algorithm borough forward in the previous section, this study compiles, draws and analysis through MATLAB, to achieve the effectiveness and practical applicability of robot positioning navigation algorithm.

In this study, the robot is placed on the horizontal ground, after the demarcation of zero point coordinates, starting from the original point and is controlled continuous free movement on the ground, finally, location marker is used to make the robot return to the original initial point, this study adopts the algorithm to descript the robot tracks which are illustrated in Fig. 3.

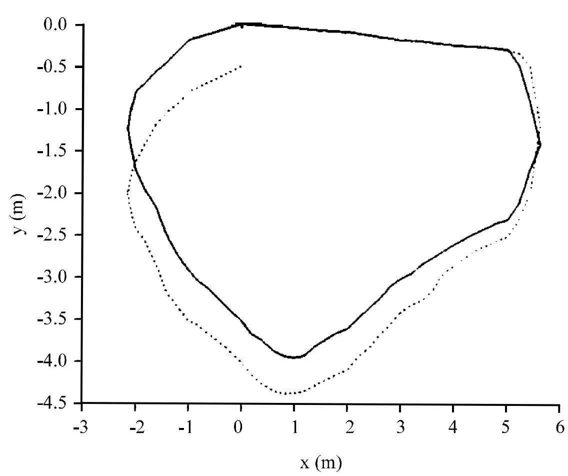

Fig. 3: Path trajectory output by robot trajectory navigation and positioning system

From Fig. 3, what the solid line expressed is the track of robot practical movement, what the dotted line expressed is the path trail of robot using this method in this study to output. From the experiment, it is shown that the maximum error is less than 10%.

CONCLUSION

Because the robot positioning and navigation method need huge of the computation, the stability of the navigation depends on the setting of PID parameters; at the same time, the robot executive actuator is very complex, in order to improve the score efficiency, the parallel process of executive actuator and navigation has to be done, the path planning is one important research area in robotics which is one integration point in artificial intelligence and robotics. Robotic path planning can be modeled as in the conditions with certain restraints; the robot in the working process can avoid barriers to realize the path optimization process from the initial position to target position.

The experiment result indicates the method error is less in this study which can trail and position the robots in real time to make the formulation of robot strategy line more convenient and reliable.

REFERENCES

Khabit, O., 1986. Real-time obstacle for manipulators and mobile robot. Int. J. Robotic Res., 5: 90-98.

Lei, B., 2006. The research of multi mobile robot path planning in dynamic environment. Wuhan University of Technology.

Lei, B. and W. Li, 2007. A fuzzy behaviours fusion algorithm for mobile robot real-time path planning in unknown environment. Proceedings of the IEEE International Conference on Integration Technology, March 20-24, 2007, Shenzhen, pp: 173-177.

Li, S., 1999. Fuzzy Control, Nerve Control and Intelligent Control Theory. Harbin Industrial University Press, Harbin.

Neda, Z., 2000. The sound of many bands clapping. Nature, 403: 849-850.

Olfati-Saber, R., J.A. Fax and R.M. Murray, 2007. Consensus and cooperation in networked multi-agent systems. IEEE Trans. Automatic Control, 95: 215-233.

Ren, W., R.W. Beard and E.M. Atkins, 2005. A survey of consensus problems in multi-agent coordination. Proceedings of the American Control Conference, June 8-10, 2005, Baltimore, MD., pp: 1859-1864.

Rui, Y., X. Jiang and X. Liu, 2007. Research on AS-R mobile robot path planning based on ant colony algorithm. Mech. Electrical Eng., 35: 73-75.

Saber, O.R. and R.M. Murray, 2004. Consensus problems in networks of agents with switching topology and time-delays. IEEE Trans. Automat. Control, 49: 1520-1533.

Sun, Z., 2007. Intelligent Control Theory and Technology. Tsinghua University Press, Beijing.

Yi, H. and B. Zhang, 2010. The graphical method of the path planning problem based on the topology. Robot, 12: 20-24.

Yung, N.H.C. and Y. Cang, 1999. An intelligent mobile vehicle navigator based on fuzzy logic and reinforcement learning. IEEE Trans Syst. Man Cybernetics Part B: Cybernetic, 29: 314-320.