Design and implementation of mobile robot for epidemic nursing

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Abstract. In view of the serious infection of doctors and nurses in epidemic area, a mobile nursing robot was designed. The robot takes stm32f107 as the core, ultrasonic and infrared sensors as the sensing module, collects the obstacle signals through ultrasonic and infrared sensors, and avoids after stm32f107 processing, so as to realize the free movement of the robot. According to the genetic algorithm, the mobile nursing robot can get the best path, according to the obstacle data in the best path, using the attitude calculation method to achieve the turn. It has been proved that the combination of genetic algorithm and attitude estimation can improve the working efficiency and accuracy of mobile nursing robot.

Keywords: nursing mobile robot; stm32f107; attitude algorithm; genetic algorithm.

1. Introduction
The outbreak of coronavirus at the end of 2019 has brought great loss and pain to people all over the world. Up to now, the cumulative number of infected people in the world has reached more than 1.5 million, and the death toll has reached nearly 100000. The epidemic has brought great losses to the economies of various countries. With the rapid development of the global epidemic situation, it is difficult to control it effectively in a short time. At the same time, there are a lot of medical staff infection in the world, and the medical system in many countries is facing collapse. According to the latest data released by the World Health Organization, there are currently 6 million medical staff in the world, reducing unnecessary contact between medical staff and patients.

And improve the working efficiency of medical staff is an important link to control the epidemic situation. The use of mobile nursing robots in epidemic areas can greatly reduce the probability of infection of doctors and reduce the dependence of epidemic areas on medical staff. At the same time, the development of artificial intelligence, big data and cloud computing provides technical reserves for the development of nursing mobile robots in epidemic areas. More and more construction scenes need the participation of nursing mobile robots in epidemic areas. With the rise of new industries and the continuous improvement of robot performance, it can also make up for the shortage of doctors. Therefore, the demand for mobile nursing robots in epidemic areas is growing. In the new epidemic control hospital, the Due to the short construction period, complex paths and complicated obstacles, the steering error of nursing mobile robot in epidemic area is large, which affects the working efficiency. By improving the steering accuracy, using genetic algorithm to plan the path, and then the
robot is adaptable to the complex path, it can optimize the performance of nursing mobile robot in epidemic area. Based on this, this paper designs a mobile robot for nursing in epidemic area.

2. Hardware Design
As shown in Figure 1, the mobile nursing robot system in epidemic area mainly consists of main control module, power module, obstacle detection module, steering module, display module and motor drive module. The specific working principle is that the system detects whether there is an obstacle in front by turning the obstacle detection module of the steering module of the steering gear, and transmits the received data to the main control module. After the main control module processes the data, according to the processing results, the motor drive module is mobilized, and the information is displayed in the display module.

![Fig 1. Structure of nursing mobile robot in epidemic area](image)

3. Software design
As shown in Figure 2, the main tasks of the intelligent mobile robot control program are system initialization, ultrasonic ranging, motor drive, speed detection, etc. Its workflow is to start obstacle

![Fig 2. Software structure](image)
detection according to the established route after the system initialization. When there is an obstacle in front of it, the intelligent mobile robot starts to avoid the obstacle and continues to detect until there is no obstacle. The angle control of each turn is accurate. If no obstacle is detected, the mobile robot continues to drive and continuously detects whether there is an obstacle. The moving process of the mobile robot is that when the system begins to receive instructions, it judges whether it receives them or not, if not, it continues to receive them. If it is received, it will start to recognize the instruction. The judgment instruction is to ask the mobile robot to enter, back, turn left, turn right or stop. The whole process is controlled by the motor.

3.1. Algorithm design

3.1.1. Genetic algorithm. Genetic algorithm is a search heuristic algorithm used to solve optimization in the field of computer science artificial intelligence, and it is also a kind of evolutionary algorithm. When the fitness function is not selected properly, the algorithm may converge to the local optimum, but not to the global optimum. Based on the above advantages, this paper uses genetic algorithm to plan robot path. As shown in Figure 8, the basic operation process of the algorithm is as follows: first, obtain the parameter set of the path, code the path, form the path group $T$, calculate the appropriate value according to the path group, and then carry out the relevant operation. After the operation, add 1 to the path group to determine whether it is the best path, if not, return to the original group path, repeat the previous process, if it is, decode to get.

3.1.2. Genetic algorithm solution. The coding scheme of genetic algorithm is to encode nodes with priority, and the decoding method of priority coding is to generate and encode nodes first $v_i (i = 1, 2, ..., m - 1)$ Set of adjacent nodes, initializing the path to $s_1$, The current node is initialized to $v_0$, Target node set to $v_e$. Next from the current node $v_i$ Starting from the set of adjacent nodes in the current node $s_i$ Select the node with the highest priority $v_q$, Join the path and remove the selected node from the adjacent node set $s_i \leftarrow s_i \setminus \{v_q\}$; Finally, when $v_i \neq v_e$, Repeat the above steps.

According to the above steps, the length of the $i$-th path can be obtained

$$T_i = \sum_{j=1}^{n} (x_{i,j+1} - x_{i,j})^2 + (y_{i,j+1} - y_{i,j})^2$$

The shortest path of the first generation is: $R_i = \min_{i=1}^{N} T_i$

Based on this, copy is performed, and the copy is placed in the buffer, use $A_i = \alpha T_i$ Indicates the fitness value of the first generation $I$ path. The probability that the $i$-th path is selected is, $P_{0,i} = A_i / \sum_{i=1}^{N} A_i$, The path set is selected according to the probability P. After the above operations are completed, carry out the "cross reorganization" operation, and calculate the distance between any path and other paths in the cross path according to the probability pairing:

$$D_{0,i} = \sum_{j=1}^{n} \sqrt{(x_{i,j+1} - x_{i,j})^2 + (y_{i,j+1} - y_{i,j})^2}$$

$(i = 1, ..., N, i \neq i_0)$
The probability that the i-th path is selected is \( q_{i, \pi_0} = D_{i, \pi_0} / \sum_{i=1}^{N} D_{i, \pi_0} \). According to the probability \( q \), select a path to pair with R1, and then repeat the operation to get \( m \) paths. In this way, based on the priority, the \( v_0 \) to \( v_e \) a feasible path. Fig 3 path R1

![Fig 3 path R1](image)

Fig 3 path R1

![Fig 4 path R2](image)

Fig 4 path R2
The initial path point sequence can be divided into two situations: one is the lattice with uniform distribution of straight lines from the start to the end, as shown in Figure 3, 4, 5 and 6. Four situations of mobile robot passing through obstacles in fixed scene are simulated, and genetic algorithm is used for optimization processing. According to the optimization process, each path sequence is T1, T2, T3, T4, represented by T5. The initial path can be converged from the sequence of initial path points. The paths in the initial path set are likely to repeat, and the case of repetition is not considered here. The four paths are R1, R2, R3 and R4. Where R4 is the convergence path of R1, R2, R3, s path and SR is the average path.
Table 1 path length of the first generation path set and its cross reorganization

|    | T1   | T2   | T3   | T4   | T5   | S    | SR   |
|----|------|------|------|------|------|------|------|
| R1 | 62.985 | 85.707 | 116.184 | 128.838 | 0   | 393.714 | 393.771 |
|  2 | 63.172 | 85.946 | 116.872 | 127.946 | 0   | 393.936 |
|  3 | 62.365 | 86.103 | 117.107 | 128.089 | 0   | 393.664 |
| R2 | 151.125 | 132.366 | 95.752 | 0   | 0   | 379.243 | 379.807 |
|  2 | 150.745 | 130.476 | 96.024 | 0   | 0   | 377.245 |
|  3 | 151.752 | 135.394 | 95.789 | 0   | 0   | 382.935 |
| R3 | 51.017 | 60.745 | 89.443 | 69.69 | 55.981 | 326.876 |
|  2 | 52.437 | 61.786 | 89.276 | 68.973 | 55.672 | 328.144 |
|  3 | 51.802 | 60.954 | 88.983 | 69.445 | 55.587 | 326.771 |
| R4 | 104.589 | 40 | 131.667 | 0   | 0   | 276.256 | 275.985 |
|  2 | 102.464 | 38.062 | 134.642 | 0   | 0   | 275.168 |
|  3 | 106.472 | 40.515 | 129.545 | 0   | 0   | 276.532 |

It can be seen from table 1 that the shortest path is changed from 393.771 to 275.985 by using genetic algorithm to optimize the path, which plays a good role. However, in a specific case, it may be necessary to carry out multiple cross reorganization. If the results do not change several times in a row, it is considered that the optimization is over. Otherwise, each result will be improved and the optimal solution can be found quickly.

Select a fixed reference value, corresponding to the corresponding path, and compare the four paths. Through comparison, R4 has the best effect and the shortest path. Therefore, genetic algorithm can solve the path planning problem between mobile robots.

2) Dead reckoning

After getting the data of the moving path of the mobile nursing robot according to the genetic algorithm, the obstacle data in the path is used to avoid, and the turning accuracy is realized through the attitude calculation method. In the complex path, the attitude and steering angle of the nursing mobile robot in the epidemic area affect the accuracy of the data collection. In order to ensure the accuracy of the attitude, the system collects the instantaneous linear speed and angular speed data through the sensor, and determines the position and attitude of the vehicle through the accumulation calculation method.

As shown in Figure 7, according to the motion model of the mobile robot, it is assumed that the position and attitude coordinates of the mobile robot are \((x_r, y_r, \theta)\). Therefore, the differential equation of mobile robot motion can be obtained.
\[ dx_i = v_i \cos \theta_i \cdot dt \]
\[ dy_i = v_i \sin \theta_i \cdot dt \]
\[ d\theta_i = w_i \cdot dt \]

In style \( v_i \), Linear speed for mobile robot, \( w_i \) is the angular velocity of the mobile robot.

Make mobile robot \( l \) Represents the travel of the mobile robot, then \( dl = v_i \cdot dt \) Carry in 1 to get:

\[ dx_i = \cos \theta_i \cdot dl \]
\[ dy_i = \sin \theta_i \cdot dl \]
\[ d\theta_i = w \cdot dt \]

By integrating 2 at the same time, we can get

\[ x_i = \int_0^r \cos \theta_i \, dl \]
\[ y_i = \int_0^r \sin \theta_i \, dl \]
\[ \theta_i = \int_0^r w \, dt \]

\[ \Delta l \] is the strobe step, \( \Delta t_i \) is The travel step time of the first segment of the mobile robot is as follows:

\[ I = n \cdot \Delta l; t = \sum_{i=0}^{n} t_i \]

Take 4 into 3 to get:

\[ x_n = \sum_{i=0}^{n} \cos \theta_i \cdot \Delta l \]
\[ y_n = \sum_{i=0}^{n} \sin \theta_i \cdot \Delta l \]
\[ \theta_n = \sum_{i=0}^{n} w_i \cdot \Delta t_i \]

In the ideal state, use equation 3 to calculate the attitude. Considering the actual situation, equation 5 is used to approximate the discretized attitude. In a very short period of time, turn 1 degree and analyze the results. Data fitting of formula 3 and 5 is shown in table 1.
Table 2 comparison of idealization and discretization

|                | x   | y    | θ  | Drift error |
|----------------|-----|------|----|-------------|
| Idealization   | 0.9205 | 5.6384e-006 | 1 |             |
| Discretization | 0.9209 | 5.4284e-006 | 1 | 1.8180e-010 |

It can be seen from table 2 that the drift error caused by discretization is 1.8180e-010, which basically makes the turning accuracy of the mobile robot accurate, and enables the mobile nursing robot to smoothly avoid obstacles, ensure its turning accuracy, and cooperate with medical staff to achieve various medical diagnosis and treatment.

4. Epilogue

Based on stm32f10, this paper designs a nursing mobile robot in epidemic area, which uses ultrasonic and infrared sensors as sensing modules. It can avoid obstacles in real time and work efficiently and safely. Design solution by attitude calculation

The problem of turning angle accuracy of nursing mobile robot in epidemic area was solved. The problem of path planning in the process of robot moving was completed by genetic algorithm, which was well applied in the complex environment of epidemic situation.

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