Intelligent Guide Cane design Based on Ant Colony Algorithm

Li Cai*, XiaoLing Zhu1

1School of Electrical and Mechanical Engineering, Wuhan Polytechnic, 430074
*1401763814@qq.com

Abstract. The traditional guide cane for blind people is designed for visually impaired people, which can alert the blind to obstacles on the road. But it can not warn other walking hazards and obstacles in space above the waist. Therefore, due to the narrow search scope, it is not suitable for the current actual needs of the blind. And with the application of computer technology, the blind man navigation system can be designed by single-chip computer based on ant colony algorithm. This article mainly uses traditional walking stick as carrier, 51 single-chip computer as core, using infrared technology, the speech module to realize the goal of the blind person to avoid obstacles. Then the ant colony algorithm for blind guide is introduced and the simulation results in the software show that the method of introducing ant colony algorithm into blind guide is feasible.

1. Introduction

With the development of more and more advanced computer technology, people have tried various ways to help the blind. But if these devices are designed to achieve their purpose regardless of the cost, they are not suitable for ordinary families in most developing countries. Therefore the search for a functional, low-cost solution is needed for current social development. At present, the navigation of blind people mainly depends on traditional walking stick, it is not convenient to provide road information for blind people due to narrow search area. There are already a number of navigational devices for the blind, using voice-guided GPS and sophisticated processors. The equipment could detect the distance from the obstacle and shift this into voice prompt and vibration alarm. Son Lam Phung presented a vision-based algorithm for pedestrian lane detection in unstructured scenes, and introduced a fast and robust vanishing point estimation method based on the color tensor and dominant orientations of color edge pixels[1]. M.F. Razali studied the control steering angle system for an intelligent path guidance robot by using Fuzzy Logic Controller with MATLAB applications[2]. Utkal designed a smart path guidance system for the blind and visually impaired, particularly the mobile aid to carry by hand, contains a smart sensor logic system. Through several experiments, the sensors are calibrated to increase the accuracy of decision[3]. Yankai Liu proposed a special map-matching algorithm by probabilistic and verified the matching precision and time complexity through experimental analysis, which can be applied to the map navigation system[4]. However, the cost of these devices is too high and the purchase capacity of ordinary visually impaired persons is limited. Therefore, it is necessary to develop low cost guide system. Xu Li studied a intelligent walking stick based on AT89C51 chip microcomputer as controlling centre, with ISD4004 speech chip and the shaking electric engine[5]. Zhou Dongsheng proposed an improved ant colony algorithm to solve this problem, which is effective and simple. the improved ant colony algorithm was compared with the classic ant colony algorithm through the experiments. The simulation results verify the correctness and effectiveness of the proposed algorithm[6]. Fatima Zahra Baghli used ant colony algorithm to find the
optimal path from an initial to a final position in the presence of five obstacles with rectangular shapes and sizes in the robot environment. The algorithm has been tested in simulation and the obtained results show the efficiency and reliability of the proposed method[7]. At present, intelligent algorithms are developed in navigation technology, which could also be a good attempt in guide design. There are various problems in the production of guide blind equipment, but the price of mature cane products abroad is more expensive, it is difficult to become popular, so the use of cheap single chip computer for blind navigation design has practical significance.

Aiming at the application of blind navigation, this paper proposes a guide cane based on ant colony algorithm through obstacle detecting and avoidance method, which using the photoelectric sensors and tracking navigation. Section 2 explains the hardware system design of a guide cane based on single chip microcomputer. Section 3 introduces the hardware system design of a guide cane. Section 4 introduces the principle and simulation steps of the ant colony algorithm, and then give the simulation results in the software.

2. Hardware system design

In this work, a handy mobile device is developed for a visually impaired person. The portable electronic walking stick is suitable to navigate, which is simple to handle and a low cost solution to replace a traditional navigation device. Another objective is to provide a smart cane to warn the user not only the detection of an object, but also the distance of object relative to the user and the distinguishing of the obstruction.

It is composed of infrared emission module, infrared receiving module and speech cue output module. Through the principle of infrared reflection, the distance between blind people and obstacles can be calculated. Then the speech module is used to remind blind people to avoid obstacles. This system mainly analyzes the warning of obstacles at different distances: When the distance of the obstacle is greater than 50 cm, the speech module will prompt permission to proceed at a normal speed. When the distance of the obstacle is less than 50 cm, the speech module will prompt a stop or turn to avoid obstacles.

The hardware shape of the system is shown in Figure 1, 1 is a straight stick, 2 is a roller, 3 is a ring disk with three sets of sensors, 4 is a control module, including core chip, speech module, key module and alarm module, 5 is an extensible hollow handle. The control hardware of the system is mainly composed of AT89S51 single chip, infrared emission module, reception module and voice module, as shown in Figure 2.

Figure 1 Cane structure

Figure 2 shows the overall system block diagram that highlights the integration of various parts to satisfy the objectives. The electronic circuit compromises of the sensors, AT89S51 microcontroller, power, infrared emission module, receiving module, speech module and output circuitry such as a voice module and an alarm module.
The infrared emission tube is modulated to transmit 38kHz signal by the interrupt of single chip microcomputer. The emitted infrared light is reflected back when it encounters a barrier, and the infrared receiver demodulates the reflected signal to output TTL level, controls the motor and turns the basic robot. External interference with infrared signal is small and easy to realize. The sensor receiver adopts the integrated probe HS0038A2, whose output foot, OUT, is connected to the INT0 pin. When the infrared receiver does not receive the infrared signal, the INT0 pin will output high level, the single chip will not interrupt. Instead, When the signal is received, the INT0 pin will output low level and the MCU will be interrupted.

At present, there are many MCU series, such as Intel MCS-48 series, MCS-51 series, MCS-96 series products. The AT89S51 in Series 51 was selected. There are various sensors currently, including ultrasonic, infrared, visual, radar and other ways. Among them, the ultrasonic is not affected at night, but vulnerable to environmental effects, such as weather; Visual sensor has good resolution, but it can not measure the distance directly and the process is relatively complicated; Radar is not affected by night, but it is susceptible to dust and other factors. And infrared sensor price is reasonable, detection distance meets the requirement. Therefore, the infrared sensor HS0038A2 is selected. When HS0038 receives the pulse modulated signal with a carrier frequency of 38kHz, the infrared sensor in HS0038B converts the modulated infrared signal into electrical signal, which is amplified and processed by the preamplifier and the automatic gain control circuit. Then it is filtered by a bandpass filter and demodulated by the demodulation circuit. At last, the output circuit is reversed to amplify and the output level is low. When the carrier signal is not received, the output level is high.

The voice module uses ISD 4004 series single chip voice recording chip, with the working voltage 3V. And it is suitable for portable electronic products with CMOS technology, containing oscillator, anti-confusion filter, smooth filter, audio amplifier, automatic quiet. Operation command of voice modules can be sent through serial communication SPI interface, and the lower the sampling frequency, the longer the recording time.

3. Software system design
The MCU mainly monitors the signal transmitted by ultrasonic module in real time. The signal is collected and processed. Figure 3 is a flow chart of specific barriers.
In Figure 3, when the walking stick detects an obstacle on the left, the voice module will prompt you to turn right. Instead, when the walking stick detects an obstacle on the right, the voice module will prompt you to turn left. And when the obstacles are detected on the left and right, the voice module will prompt to stop for avoiding obstacles.

The main control program flow chart is shown in Figure 4. Figure 4 shows the main process, starting initialization. By means of external interruption, two sets of infrared probes are installed at the bottom and middle of the stick to detect obstacles in the ground and mid-air. Under normal circumstances, when an obstacle is encountered, the pin INT0 will receive a signal change, and the cane will automatically alert the alarm and indicate that there is an obstacle ahead. If there is no interrupt signal in the system waiting for the timer to occur, the stick will not make an output indicator.

![Main flow diagram](image_url)

**Figure 4 Main flow diagram**

4. **Software system design**

4.1. **The principle of ant colony algorithm**

The ant colony algorithm is based on a computational paradigm inspired by ants foraging. Ants use media to convey information about the shortest food route. In the process, the ants leave pheromones on the ground. In this way, other ants can also use pheromones to find this path and find food. The rules for foraging are as follows: ants can look for food within a perceptive range, compare these pheromones and choose a path with more pheromones. If there is no pheromone to guide them, the ants will move in their own original direction. If there is an obstacle in the direction of movement, it will chooses the other direction. If $t = 0$, amount of information of each road are equal. Ants selects next road according to probability. Probability is a function about the distance between the nodes and
the amount of residual information. At a time, transition probability $P^k_{ij}(t)$ of ants from one node $i$ to another node $j$ is expressed as follow:

$$P^k_{ij}(t) = \frac{\tau^a(i,j)\eta^\beta(i,j)}{\sum \tau^a(i,s)\eta^\beta(i,s)}$$ (1)

In the formula, $\eta_{ij}$ is on behalf of visibility from one node $i$ to another node $j$. There are two important parameters about information intensity and visibility: $\alpha$ represents the impact factor of the information amount for choosing the sections and $\beta$ represents the impact factor of visibility $\eta_{ij}$.

The ant colony algorithm makes full use of the optimization mechanism of selection, updating and coordination through information exchange and collaboration among individuals, which makes it have strong ability to find the better solution. The more pheromones the path, the more the path is selected. The pheromone on the path increases as the ant passes, and it also evaporates over time. Ants actually communicate and work together through secretions. To a large extent, the selection of the best path in the process of intelligent walking stick blindness is very similar to the selection of the ant foraging and individual pheromones. Therefore, the ant colony algorithm is applied to intelligent path planning. According to the environment information, many feasible paths are generated in the course of motion. The shortest path can be found by ant colony algorithm.

4.2. Simulation of ant colony algorithm
The ant colony algorithm is one of swarm intelligence methods, and it constitutes some metaheuristic optimizations. The steps of ant colony algorithm in path planning in blind guide system are as follows:

Firstly, according to the actual problems the initial parameters, such as the starting grid path planning, target grid, the maximum number of cycles, evaporation coefficient, need to be set.

Secondly, the paths are constructed through the application of repetitious state transition rules. After one search is completed, pheromone will be updated.

Thirdly, local update rules are modified. When multiple searches are completed in line with the termination conditions, the optimum path will be found, and then the global updating rules are applied again on the pheromone concentration updating.

According to the simulation steps, the simulation results is presented with distance in meters in figure 5, assuming a two-dimensional space range $[x, y]$ is as follows: $[0, 0]$-$[200, 200]$. The coordinates of starting point is $S= [10, 180]$, and the coordinates at the end is $T= [150, 90]$.

In figure 5, the green dotted lines are painted through the endpoints of obstacles to facilitate
subsequent analysis. The blue solid lines are all possible routes. And the red point line is the shortest path that we hope to find it rapidly by the ant colony algorithm. The figure 6 gives the total length of path under different conditions. The simulation results in figure 5 and figure 6, show that ant colony algorithm is similar to the probability algorithm in the case of one starting point. The individual action of a ant can not represent the whole system design, so we hoped to keep more than one individual actions for complex movement. In the meantime, there may be two or more starting points in the actual path planning. So, we need further research on multiple starting points in the future.

5 Summary
In view of the limitation of the traditional guide cane, this paper proposes a smart stick with obstacle avoidance module circuit, taking the single chip microcomputer AT89S51 as the core. The hardware system mainly consists of three parts, including infrared emission module, infrared reception module and speech cue output module. And the software flow diagrams are given out with the blind cane as carrier, combining single chip computer technology and infrared sensing technology. By means of the voice module, the intelligent walking cane can remind the front road condition, and alarm by the buzzer, thus it can realize the purpose of warning blind person obstacle avoidance. The circuit has simple structure and stable performance. Finally, the principle of the ant colony algorithm is introduced and the simulation results in the software show that the method of introducing ant colony algorithm into blind guide is feasible.

References
[1] Son Lam Phung, Manh Cuong Le, Abdesselam Bouzerdoum. Pedestrian lane detection in unstructured scenes for assistive navigation. Computer Vision and Image Understanding. 2016: 186-196.
[2] M.F. Razali, S.F. Toha, Z.Z. Abidin. Intelligent Path Guidance Robot for Visually Impaired Assistance. Procedia Computer Science. 2015, Vol.76: pp. 330-335.
[3] Utkal Mehta, Mohammed Alim, Shivneel Kumar. Smart Path Guidance Mobile Aid for Visually Disabled Persons. Procedia Computer Science. 2017, vol.105: 52 -56.
[4] Yankai Liu, Zhuo Li. A novel algorithm of low sampling rate GPS trajectories on map-matching. Journal on Wireless Communications and Networking .2017: 30
[5] Xu Li, Cao Shengnan, Tang Liwei. The Design and Realization of the Intelligent Walking Stick Based on AT89C51 Chip Microcomputer. Taiyuan Normal University(Natural Science Edition). 2009, Vol.8 No.4: 66-68. 1.1.
[6] Zhou Dongsheng, Wang Lan, Zhang Qiang. Obstacle avoidance planning of space manipulator end-effector based on improved ant colony algorithm. SpringerPlus.2016, 509.
[7] Fatima Zahra Baghi, Larbi El bakkali, Yassine Lakhal. Optimization of Arm Manipulator Trajectory Planning in the Presence of Obstacles by Ant Colony Algorithm. Procedia Engineering. 2017, 560-567.