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INTELLIGENT FOLLOWING CAR BASED ON ULTRASONIC POSITIONING

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Abstract: Aiming at the problem of blind area of safety monitoring in electric power operation site, an intelligent following car based on ultrasonic positioning is designed in this paper. The target coordinates are calculated by dual-chip ranging to achieve ± 10 cm accuracy tracking, supporting a maximum identification distance of 10 meters and a dynamic response of 1.5 m/s. The system adopts STM32F103RBT6 main control board, integrates ultrasonic sensor and wireless communication module, and combines with base-station and tag positioning mechanism to solve the problem of monitoring failure caused by manual intervention lag of traditional monitoring equipment. The test shows that the car can last for 4 hours under the condition of slope ≤ 15 ° and load 30 kg, which effectively improves the efficiency of operation safety management and control.
Keywords: Intelligent following; Ultrasonic positioning; Safety monitoring; Electric power operation; Mobile robot

1 INTRODUCTION

In order to further improve the efficiency and accuracy of safety management at the work site, the project team developed an intelligent following visual recognition robot as part of the intelligent safety supervision system, aiming to solve the problem that the existing video surveillance equipment fails to effectively follow the operators and improve the safety supervision level at the work site[1].

In terms of the current research status both at home and abroad, in the field of intelligent small vehicles, many countries have conducted multi-angle research. For instance, foreign researchers have explored extensively in aspects such as automatic control, environmental perception, and path planning of intelligent small vehicles. Some research institutions and universities have conducted in-depth studies on positioning, navigation, and obstacle avoidance of intelligent small vehicles, proposing various algorithms and system design schemes. Additionally, significant progress has been made in hardware design, control algorithms, and sensor technology of intelligent small vehicles abroad. For example, designs such as intelligent clothes drying racks and intelligent curtain control systems based on STM32 microcontrollers have demonstrated the application prospects of intelligent small vehicles in smart homes and industrial automation.

Domestically, significant progress has also been made in the research of intelligent small vehicles. For instance, the design of intelligent following small vehicles based on ultrasonic positioning, which uses ultrasonic sensors to measure the distance to the target object and achieve positioning, thereby realizing the following function. This system mainly includes sensor modules, control modules, and execution modules, featuring a simple structure, low cost, and fast response, suitable for automatic following tasks in indoor environments. Moreover, designs such as intelligent clothes drying racks and intelligent curtain control systems based on STM32 microcontrollers have demonstrated the application prospects of intelligent small vehicles in smart homes and industrial automation. Additionally, the design and implementation of intelligent following small vehicles based on STM32 microcontrollers, through the design of ultrasonic positioning modules, motor drive modules, and LCD, etc., have achieved the automatic following function of the vehicle[2].

In terms of the hardware design of intelligent following small vehicles, researchers at home and abroad have proposed various design schemes. For example, the design of intelligent following small vehicles based on ultrasonic positioning adopts a four-wheel movement mode, controlled by stepper motors, and uses infrared distance sensors to achieve anti-collision functions. A mathematical model for tracking the target position was established, and the hardware design of the control system was completed, followed by experiments. The experimental results show that the vehicle can effectively follow the target within 5 meters and well achieve the anti-collision function. Additionally, the design and implementation of intelligent following small vehicles based on STM32 microcontrollers, through the design of ultrasonic positioning modules, motor drive modules, and LCD, etc., have achieved the automatic following function of the vehicle[3-4].

In terms of the control algorithms of intelligent following small vehicles, researchers at home and abroad have proposed various algorithms and system design schemes. For instance, the automatic following algorithm of intelligent small vehicles based on ultrasonic positioning measures the distance to the target object in real time through three ultrasonic modules, and determines the target position by combining the distance difference comparison method and the plane coordinate method, thereby achieving automatic following. At the same time, the vehicle is equipped with an infrared obstacle avoidance module, which can automatically bypass obstacles. A servo is used to scan the ultrasonic module to expand the coverage range. The system uses Arduino uno for servo control and realizes speed regulation and alarm functions through software programming. Additionally, the design and implementation of intelligent following small

vehicles based on STM32 microcontrollers, through the design of ultrasonic positioning modules, motor drive modules, and LCD, etc., have achieved the automatic following function of the vehicle.

In terms of the application fields of intelligent following small vehicles, researchers at home and abroad have proposed various application scenarios. For example, the design of intelligent following small vehicles based on ultrasonic positioning is suitable for the needs of automated material handling in industrial, commercial, and elderly assistance scenarios, improving work efficiency and safety. Additionally, the design and implementation of intelligent following small vehicles based on STM32 microcontrollers are applicable to education, industrial automation, and smart home fields, which can be used as teaching cases to enhance practical abilities and also for material transportation or monitoring[5].

In terms of the challenges and development trends of intelligent following small vehicles, researchers at home and abroad have proposed various challenges and solutions. For instance, the current automatic following carts mostly adopt active positioning technology, which requires the target to be followed to carry a signal transmitter. This brings about problems such as inconvenience in application and high cost, making it difficult to be widely adopted. This paper proposes a positioning and obstacle recognition method based on ultrasonic array, analyzes the possible situations in front of the cart and formulates control strategies to solve the problem of ultrasonic ranging error. In addition, the design and implementation of an intelligent following cart based on STM32 is presented. Through the design of functional modules such as ultrasonic positioning module, motor drive module and LCD, the automatic following function of the cart is realized.

2 TECHNICAL RESEARCH PROGRAMME

2.1 Positioning Process

The base station performs two times of ranging with the tag through two chips, establishes an equation according to the time phase difference and distance of the two times of ranging, calculates the X and y coordinates and distance values of the tag relative to the base station, and calculates the X and y coordinate values, which is equivalent to knowing the angle deviation from the tag to the base station. Taking the rectangular coordinate axis as an example, from the front direction of the base station, the negative half axis of the X axis is the right side of the base station, and the positive half axis is the left side of the base station. The positive half axis of the Y axis is the front of the base station, and the back of the base station cannot get the correct coordinates, see Figure 1.

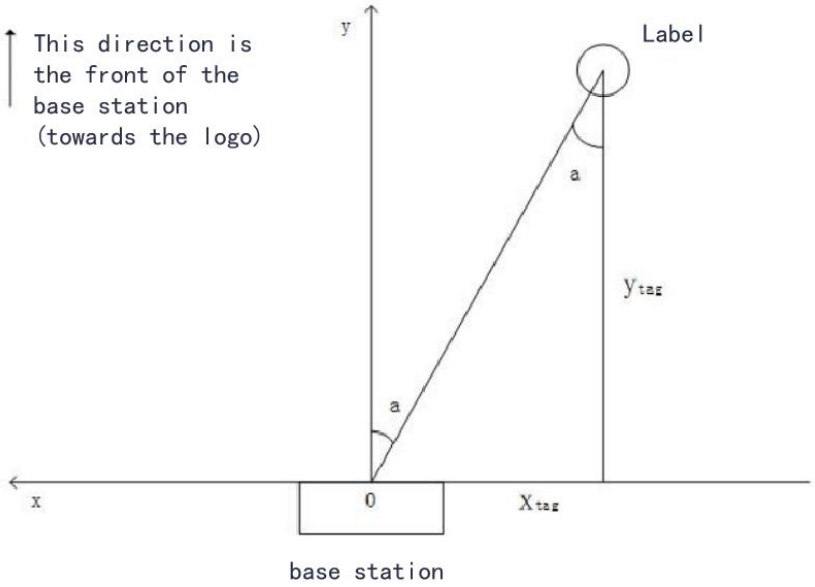

Figure 1 Analytic Diagram of Base Station Coordinate

2.2 Label List

A label list (Knownlist, referred to as K list) is stored inside the base station. The K list stores information such as IDs of tags with which the base station is to perform ranging and positioning. That is to say, the base station will only perform ranging and positioning with the tags stored in the K list. When the base station detects a tag, the base station firstly compares the ID of the tag with the ID existing in the K list of the base station, if the ID does not exist in the K list, the base station actively reports the information (NewTag) that a new tag is monitored once, and then the base station is required to send a command (AddTag) to the base station through a serial port from the outside. This ID information is stored in the K list of the base station. After successful addition, the base station will start ranging and positioning with the tag. The user can issue a Save command to save the current configuration of the base station to Flash, and the information in the K list can still exist after the power is turned off and the power is turned on again. If

the user powers off the base station without issuing a Save command, the tag needs to be powered on again when the base station locates the tag next time, see Figure 2.

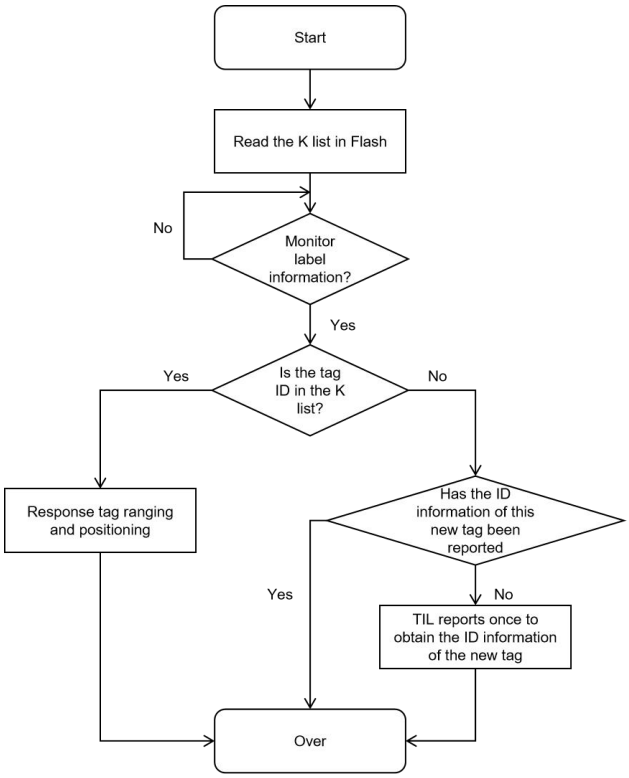

Figure 2 Flow chart of base station positioning

2.3 Description of Control Mode

The control board will always monitor the new tag information reported by the base station. If the base station is monitored to report new tag information, the base station will be ordered to add the tag for positioning. It will not send a message to the base station to save the tag, and after responding to a following tag, it will not respond to the newly powered tag.

The method comprises the following steps of: using a label which is not added to a base station K list; electrifying the trolley, and then electrifying the label; After hearing the buzzer, the representative has been added to the tag. Each successful communication will cause LED3 to flash. At this point, the car has begun to follow the label.

3 Conclusion and Prospect

3.1 Conclusion

1. The robot can automatically follow the person in charge of the work or the special guardian wearing the controller according to the needs of the work site, which solves the problem that the traditional video surveillance equipment can not move in time due to the transfer of the staff. The realization of this function relies on acoustic wave technology, which can accurately track the movement of workers wearing acoustic wave remote control machine and maintain the whole monitoring of the whole operation site.

2. Robots can implement real-time safety supervision covering 360 degrees of the operation site and the whole process to ensure that every work link is monitored and avoid potential safety hazards due to human negligence or inadequate monitoring equipment. Combined with intelligent safety supervision system, robots can become an important part of real-time supervision, thus improving the standardization and scientificity of safety production.

3.2 Prospect

As an important part of the on-site intelligent safety supervision and management system, the intelligent following visual recognition robot will greatly improve the safety management and control efficiency of the operation site. With the continuous development of technology, the application of this intelligent equipment will have a far-reaching impact on the safety supervision of all walks of life, and help to create a safer and more standardized working environment.

The development of intelligent small vehicles also faces some challenges. For instance, high technical costs, incomplete regulations, and low consumer acceptance have to some extent restricted the popularization and application of intelligent small vehicles. Additionally, the market development of intelligent small vehicles also encounters some challenges, such as high technical costs, incomplete regulations, and low consumer acceptance. These issues have to

some extent restricted the popularization and application of intelligent small vehicles. In the future, with the further maturation of technology and the in-depth expansion of the market, these problems are expected to be gradually solved.

In the future, the development of intelligent small vehicles will present multiple trends and directions, which are not only reflected in the technical aspect but also in the market, application, and policy. With the continuous progress of artificial intelligence, the Internet of Things, 5G communication, and other technologies, intelligent small vehicles will demonstrate their unique value and potential in more fields.

In the technical aspect, the development of intelligent small vehicles will rely more on the deep integration of artificial intelligence, big data, and cloud computing. The application of artificial intelligence technology will enable intelligent small vehicles to have stronger autonomous learning and decision-making capabilities, and better adapt to complex and changeable environments. For example, through deep learning and machine learning algorithms, intelligent small vehicles can continuously optimize their path planning, obstacle avoidance, and navigation capabilities, improving their adaptability and safety in complex scenarios. At the same time, with the popularization of 5G communication technology, intelligent small vehicles will achieve more efficient communication and data transmission, enhancing their capabilities in real-time data processing and remote control.

In the application field, the application scope of intelligent small vehicles will further expand. Currently, intelligent small vehicles are widely used in logistics transportation, autonomous driving, security patrol, medical diagnosis, industrial automation, and other fields. In the future, with the continuous progress of technology and the reduction of costs, intelligent small vehicles will find application scenarios in more emerging fields, such as smart cities, smart homes, and agricultural monitoring. Moreover, the combination of intelligent small vehicles and the Internet of Things will promote their application in smart homes and intelligent transportation systems, achieving a more efficient and convenient lifestyle.

In the market and industry aspect, the intelligent small vehicle market will face more intense competition. With the continuous progress of technology and the expansion of the market, more and more enterprises will enter this field, promoting the innovation of intelligent small vehicle technology and the diversification of products. At the same time, the government and enterprises will increase their investment in the research and development of intelligent small vehicles, promoting their application in more fields. Additionally, with the continuous improvement of policies and the gradual establishment of laws and regulations, the market environment for intelligent small vehicles will become more standardized and orderly.

In terms of challenges, the development of intelligent small vehicles also faces some challenges. For instance, high technical costs, incomplete regulations, and low consumer acceptance have to some extent restricted the popularization and application of intelligent small vehicles. Moreover, the safety and privacy protection issues of intelligent small vehicles also need to be urgently addressed. Therefore, the future development requires joint efforts in technological innovation, policy support, and market regulation to promote the healthy development of intelligent small vehicle technology.

In the future, the development of intelligent small vehicles will move towards a more intelligent, networked, collaborative, and secure direction. With the continuous progress of technology and the expansion of the market, intelligent small vehicles will demonstrate their huge potential and value in more fields, bringing more convenience and innovation to society[6-8].

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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