A Positioning System on Robot for Agricultural Environment

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Abstract. Focus on the complex environment in the wild, we designed a positioning system for agricultural environment. This system has multiple parts such as SLAM robot, remote console, mobile monitoring terminal, cloud monitoring platform, which fully fulfills the requirements of the dynamic positioning system. The system takes into account the characteristics of wide positioning range and large coverage area of the SLAM robot, which can greatly reduce the positioning complexity of the system and reduce the required positioning equipment, while reducing operating costs and increasing the coverage area.

1. Introduction
In the traditional agricultural environment positioning system, automatic line finding, wireless positioning and other navigation systems are usually used [1]. By deploying the fixed monitoring nodes of the system, a large number of positioning nodes are deployed within a certain agricultural range to real-time monitor the positioning data of key positions of agricultural environment or randomly selected sample points, and finally converge to the server to realize the positioning function. Each node communicates with each other through radio frequency technology, uses wireless communication protocol such as Wi-Fi to network, and sends the measured data to the background server for subsequent data processing. However, in the agricultural environment, the automatic line finding and wireless positioning and navigation system will be limited by the coverage area and crop signal interference, and cannot adapt to the changing agricultural environment. And when the system is running, in order to achieve the complete coverage of agricultural environment, it usually needs to lay a large number of nodes to meet the positioning requirements, so the cost will rise rapidly.

Currently, the research and development of positioning robot is mainly used in scientific research field, carrying high-precision sensors, high-precision radar and other equipment. The equipment is complex and expensive, and it is mostly used in scientific research, military and other fields [2]. Because it runs in the field and other complex environment, it needs to run under harsh conditions. Therefore, the designed positioning robot has large volume, strong horsepower and fast speed, which increases a lot of additional energy consumption. It needs to carry high-power battery module to ensure the long-term stable operation of the robot, which increases the manufacturing cost of the robot and reduces the flexibility in the positioning process.

In the agricultural environment, in order to maintain the stable operation of the positioning system [3], the slam robot is small in size, only equipped with radar module, IMU driving module [4] and
depth camera monitoring module, with raspberry pie [5] and STM32 as the main control module, the
functions of obstacle avoidance and path planning are comprehensively realized, the overall cost is
reduced, and the location and obstacle detection are ensured. The detection has enough accuracy to
meet the positioning requirements in common agricultural environment such as greenhouse. In this
positioning system, there are slam robot, remote console, mobile monitoring terminal, cloud
monitoring platform and other parts, which fully meet the requirements of dynamic positioning system.
Based on the characteristics of slam robot positioning range and large coverage area, the positioning
complexity of the system is greatly reduced, the positioning equipment required is reduced, the
operation cost is reduced, and the coverage is increased Product.

2. Overall framework of positioning system
In this positioning system, there are slam robot, remote console, mobile monitoring terminal, cloud
monitoring platform and other parts, which fully meet the requirements of dynamic positioning system.
Based on the characteristics of slam robot positioning range and large coverage area, the positioning
complexity of the system is greatly reduced, the positioning equipment required is reduced, the
operation cost is reduced, and the coverage is increased the overall structure of the system is shown in
Figure 1.

Figure 1. A robot positioning system for agricultural environment

2.1. Slam robot
In the automatic positioning system of agricultural environment, slam robot is responsible for the main
work of system positioning. In order to ensure that the robot can effectively complete the positioning
task, the main body needs to carry the relevant sensors for data acquisition; in order to realize the
robot's automatic operation requirements, the robot needs to have the function of automatic path
planning; in order to ensure the safety of the robot's automatic operation, the robot needs to run under
the condition of manual control and have the ability of automatic obstacle avoidance. The robot can
move autonomously or receive the control command sent by the remote console or mobile monitoring
terminal. After collecting the positioning data, the robot will send the data to the remote console, cloud
monitoring platform and mobile monitoring terminal. The slam robot is designed as follows.

(1) Robot body and power equipment
Slam robot body model adopts three-layer aluminum alloy plate upper and lower joint structure,
which can stably operate in the agricultural greenhouse environment; the power system uses 12V high
torque with encoder motor connected with 4-drive 100 mm mcnamb wheel, and adopts 12V 8400ma
lithium battery as a power supply unit can effectively avoid the influence of insects, weeds and crops
on the tire entanglement in the agricultural greenhouse environment. The power equipment is
controlled by the central control unit. The command of the central control unit is sent to send the
control command to the motor and the electronic governor. After the electronic governor receives the
control command, the motor speed is adjusted, and the operation of the SLAM robot is driven to
change the running state of the main body of the robot.

(2) Central control unit
Slam robot combines raspberry pie 3b and STM32 as the central control unit. In raspberry pie and
STM32, the ROS system and driver are written respectively, and the central control program of slam
robot is run. Raspberry pie has strong computing ability. It is mainly responsible for running ekf multi-
sensor attitude fusion algorithm, lidar map building algorithm, real-time obstacle avoidance algorithm
and image processing based on depth camera. STM32 is used as the external board of large load driving motor, mainly responsible for ROS mileage feedback, dynamic PID parameter adjustment, motor PID adjustment, IMU automatic correction, etc. The central control terminal is responsible for collecting positioning information acquisition unit, depth information acquisition unit, obstacle detection unit, driving auxiliary unit and signal receiving and transmitting unit to return data, send output results to the sending end, calculate robot status in real time, and send follow-up travel command to power equipment.

(3) Positioning information acquisition unit
Slam robot collects real-time environment information during its operation, and returns the corresponding laser monitoring data by relying on the lidar module connected to the central control terminal. In addition, the robot is equipped with multi-sensor modules such as current sensor, voltage sensor, soil temperature and humidity. The current sensor and voltage sensor monitor their own running state, and collect the soil environment data, and then return to the central control unit for further data processing. In the patrol process of slam robot, the central control unit calculates the sensor return value and analyzes the corresponding sensor data. With the help of the robot GPS module, it records the environmental parameters of the agricultural greenhouse environment at different times and locations, which can be sent back to the remote monitoring terminal and cloud monitoring platform for real-time display, and recorded into the local database for subsequent greenhouse environment inspection Inquiry and analysis.

(4) Depth information acquisition unit
Slam robot is equipped with depth camera module to collect the real-time depth image in front of it and store it locally. At the same time, the depth image is pushed to the remote monitoring unit in real-time to monitor the depth state in front of the robot. At the same time, the real-time image processing algorithm is run in the central control module of slam robot. Combined with the improved depth vision analysis algorithm, real-time image analysis is carried out on the collected depth image. When obstacles are found in front, it is returned to the central control unit to re-plan the path. Due to the use of depth camera module, compared with the traditional high-definition camera module, it can ensure strong outdoor light the result of distance calculation.

(5) Obstacle detection unit
The depth camera module mounted on slam robot body can calculate the approximate distance of obstacles in front through the depth data. In order to strengthen the robustness of obstacle avoidance system, the obstacle detection can be more accurate by combining with lidar data, and the distance is expanded to 15 meters. The central control unit integrates the lidar ranging results and combines the distance of obstacles in front returned by the depth camera. Therefore, the combination of depth camera and lidar becomes the obstacle avoidance detection unit of slam robot.

(6) Driving aid unit
The automatic navigation function of slam robot is one of the key capabilities to ensure its patrol. The unmanned vehicle is equipped with GPS module and 9-axis IMU module to assist in completing the navigation task. After a certain period of initialization, the positioning error can be controlled within 0.5m, and the real-time longitude, latitude and altitude values can be obtained by processing the data. However, the GPS module cannot complete the navigation function. Due to the possible occlusion and signal uncertainty in the agricultural greenhouse environment, the unmanned vehicle is equipped with IMU module to monitor the three-dimensional motion status of the vehicle body in real time. The nine axis angular acceleration value output by gyroscope and accelerometer is used to calculate the real-time pitching angle and roll angle of the vehicle body, and the data is transmitted back to monitor the vehicle body in view. In addition, the nine axis acceleration data and the output of the electronic compass are combined to accurately calculate the driving direction of the car body, which greatly increases the time of the vehicle body driving direction angle drift, and basically realizes the stable driving direction monitoring in the driving period. The real-time driving data of slam robot is transmitted back by GPS and IMU. After calculation by automatic navigation algorithm, the
vehicle's travel planning route can be accurately given, and the position, status and route of the vehicle body can be observed in real time at the monitoring end.

(7) Signal transceiver unit
Slam robot is equipped with Wi-Fi communication module and 4G transmission module as the signal receiving unit. In order to ensure the safe operation of the vehicle body and smooth operation in the initial stage, manual remote control can be realized within the range of 100m from the remote console, which is only used to transmit control signals and terminal coordinates. After receiving the control signal, the Wi-Fi receiving terminal transmits the control signal to the central control unit for subsequent sub-division at the same time, it can also be used as the feedback of the command made by the sender. And through 4G.

2.2. Remote console
In the positioning system of agricultural environment robot, the remote console is responsible for real-time monitoring, command sending and data processing for slam robot. Remote console is a console program developed on the basis of ROS operating system. It provides the remote operator with a visual interface to observe the state of the unmanned vehicle and the collected data, so as to construct slam map and realize the robot positioning function. It has the functions of network service, image service, map service, terrain restoration, location distribution and so on.

(1) Remote server
In the remote transmission process of slam robot and test system, the slam robot and the remote monitoring console use Wi-Fi for positioning data transmission, connect the wireless hot spots provided by the console, and establish a remote transmission server at the control console. After detecting the server signal, slam robot connects to Wi-Fi as a client, and returns a series of slam map positioning data collected.

(2) Image receiver
In slam robot, the depth image is transmitted by TCP protocol. Slam robot, as the depth image acquisition terminal, collects the depth information in real-time and stores it in the local system. At the same time, it continuously transmits the real-time depth image to the remote-control terminal. After receiving the image, the control end provides it to the central control module to run the real-time image processing algorithm.

(3) Positioning indication
The remote-control terminal receives the lidar information and real-time longitude and latitude information returned by slam robot and records them as the driving points received each time, generates the route map of each patrol and stores it locally. At the same time, in the process of real-time monitoring, the longitude and latitude coordinates are displayed, and the visual icon is called to mark the coordinate points. After continuous marking, a continuous driving path map can be observed, which is convenient for implementation the security measures and the terminal switching.

(4) Terrain reappearance
The longitude, latitude and depth information collected by slam robot can form a group of three-dimensional data, and each time it returns a three-dimensional coordinate point, the remote-control terminal processes a series of three-dimensional data received, which can record the maximum distance between obstacles and objects collected in the agricultural greenhouse environment and give warning. After a period of patrol, a series of three-dimensional coordinate sets can be collected. Finally, the console can conduct comprehensive processing on the collected data, restore the rough terrain of agricultural greenhouse after screening, and warn the surrounding obstacles and terrain that may threaten the robot's driving, and calibrate the warning points.

2.3. Cloud monitoring platform
In order to increase the detection effect and application scope of the agricultural environment positioning system, the cloud monitoring platform is also running. Slam robot runs in the coverage of 4G base station, and sends the collected information through 4G technology, which ensures that real-
time information such as location and surrounding environment map can be viewed without the monitoring range of remote console. It can support multiple users to view the driving track and collected positioning information in different regions at the same time, and store the historical driving route and historical positioning information for comparison.

2.4. Mobile monitoring terminal
In order to increase the applicability of agricultural environment positioning system, mobile monitoring terminal is added to realize the monitoring effect similar to cloud monitoring platform. Mobile app is provided to support query of real-time driving route, positioning map information and historical driving route record. At the same time, the mobile phone client can exist as a portable mobile platform. When the client can be within the communication range of slam robot, it can establish communication with automatic slam machine after the confirmation of the terminal, and exist as a mobile terminal. Therefore, it has the additional function of Wi-Fi issuing instructions, which can send the location information while realizing the monitoring function.

3. Conclusion
The positioning system of agricultural environment robot designed in this paper gets rid of the position limitation of fixed monitoring network, transplants the traditional agricultural environment positioning system into the dynamic slam robot positioning situation, replaces the fixed radio frequency node with slam robot, and no longer needs a large number of nodes to complete the complex networking and wiring process. In the process of patrol, slam robot can complete the basic coverage of the target area according to the expected planned map and driving route. After making a perfect driving plan, it can control the agricultural environmental data as a whole, and obtain the agricultural surrounding map and basic positioning status once a complete patrol. Such a dynamic monitoring system does not need to be bound to a greenhouse, slam robot can be conveniently placed in all target greenhouses to patrol, so the automatic positioning system can be flexibly deployed in different greenhouses for positioning, and the terminal node collecting the positioning information is only composed of one slam robot, which effectively controls the cost, does not need to invest a lot of energy, and adapts to complex It can save computing equipment resources and reduce monitoring cost.

4. Acknowledgments
This work was supported in part by the Major Science and Technology Projects of Wenzhou under Grant 2018ZS001, in part by the Public Welfare Technology Research Project of Zhejiang Province under Grant LGN20F020002, in part by the Basic Scientific Research Project of Wenzhou (G2020021), and in part by the Wencheng County 2018 Second Phase Innovation and Entrepreneurship Seed Fund Project (2018NKY04)

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