An agricultural autonomous working platform based on crawler robot

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Abstract：

Agriculture is the foundation of human life, but with the continuous development of society, the aging of the population and the continuous reduction of the farmers have brought severe challenges to agriculture. Therefore, people need more intelligent equipment to improve agricultural production needs, this paper proposes an agricultural autonomous working platform based on crawler robots, which can be combined with a variety of agricultural production tools to meet various needs. With the help of artificial intelligence technology, the platform can implement the following features:(i) path tracking in normal mode. (ii)Collision avoidance and human following.

1. Introduction

1.1Research Background

With the rapid development of the Urbanization, quantities of the young and middle-aged are continuously moving to urban and non-agricultural sectors, which promote the agricultural aging in traditional agricultural country. Chinese researcher concludes that age changes play a vital role in agricultural output [1]. But now, things can be a lot different, artificial intelligence has shared a lot of change to the modern agriculture. This is the aim of the agricultural autonomous working platform.

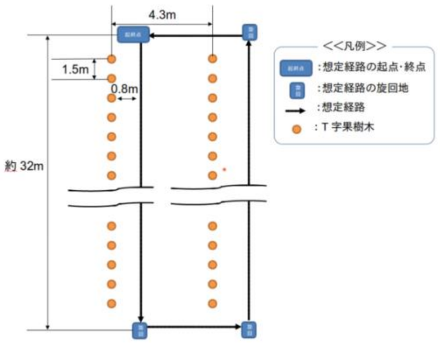
1.2Current Research State

Nowadays, most of the research is aimed at a specific crop and a specific pavement; the designed robots can complete the certain tasks. Prof.Noguchi established a robot farming system using multiple robots which are responsible for rice, wheat and soybean [2].Andrew designed a special small vehicle which use camera to guide the vehicle to complete the agricultural work [3].

In addition.Garcia-Alegrem designed an agricultural robot based on agricultural tractors to complete agricultural work with the help of sensors [4].However, there is no research on this aspect of agricultural robots. The platform can speed up the promotion of agricultural robots. Farmers only need to buy the tools they need and build up the system with the platform.

1.3Purpose of the autonomous working platform

In order to be able to design the platform which can be actually used into actual production, a lot of investigations are conducted .The main investigation targets were placed on the orchard type. The original target is shown in Fig 2(1) and Fig 2(2).



The target is as follows:
1.Make the path-tracking across the tree
2.When detect people it can stopped autonomously
3.Have a module to follow the people
4.Can change to different map

Fig. 1 (1) 2D map of the target farm (2) Concrete target

2. System building

2.1 Hardware Modification

2.1.1Communication Modification

The remote communicate with the robot by two wireless modules called IM920.Then the PLC (programmable logic controller) will perform corresponding operations on the received signals according to the programmed Program .The PLC controls the speed of the two motors by generating PWM waves with the assistance of the motor drive board. If an acceleration command is received. The PLC will generate a higher duty circle PWM wave. If the steering command is received, the PLC will send a reverse drive command to the relevant motor drive board while generating the PWM wave.

Combine with other ways of communication like CAN-BUS or Serial Communication , The IM920 has such advantages(i). Long transmission distance up to 7km (ii).Low cost, the modification is easier.Using C++ to write the driver of the IM920 and set the working frequency. For the details refer to [6].

2.1.2Sensor selection

We choose the RTK-GPS Fig 2(1).IMU Fig 2(2) IM920 Fig 2(3). ZED camera Fig 3. The RTK-GPS is using the swift GPS Toolkit. It can use 16 satellite to make the accurate locating of the robot with a refresh time 0.2s.In Tsukuba test. It shows the deviation is less than 1m.

Fig. 2(1) RTK-GPS (2) IMU(3)IM920

The IMU is very versatile, performing accurate, high speed orientation and relative displacement measurements. By the use of three different MEMS sensors 3-axis gyroscope, 3-axis accelerometer and 3-axis magnetometer low-drift, high-speed orientation data around all three axes is achieved.

Matlab Simulink module

Fig. 3 ZED camera

The zed camera is used to get the information of the object. With the image processing technology, the vision module can detect five objects once and send the type and distance of each object to the decision module.

2.2 Software Structure

The software architecture is hidden in the deepest part of the system. The basic software structure is built as Fig 4(1). The system is mainly built on the framework of ROS platform and Matlab/Simulink. The ROS system is responsible for processing the communication between the sensor, the robot and the mobile APP, and simply processes the relevant data and sends to MATLAB. Then compute the control strategy in MATLAB. The relevant commands will be sent to the robot via the wireless module. The control structure is established as Fig 4(2) the control module in Matlab is divided into six parts.

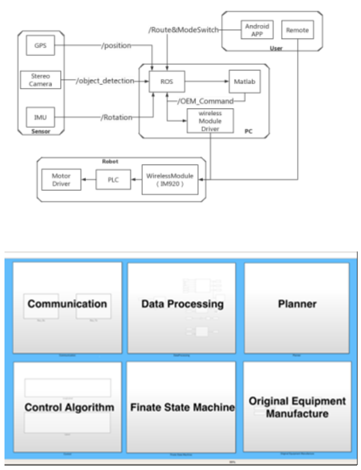


Fig. 4(1) Framework of ROS (2)

3. Algorithm Design

3.1 Human following

After detect the human from the image processing. We design the algorithm as Fig 5 In fact we can calculate the orientation of the human. Then make the judgment if human can be followed if human is near the robot it will follow in a low speed .then if human want to move from the camera them. Distance will show if human want to move out .Then the robot will spin turn to chase human.

Fig. 5 Logical algorithm

3.2 Obstacle avoidance

Using R-CNN Algorithm do the obstacle detection and the decision making program do the avoidance. The R-CNN network can be described as follows: First, get the picture from the camera. Second, split image based on the data characteristics. Third, compute the CNN features .Then classify regions. The decision making program can be described as the Fig.6.

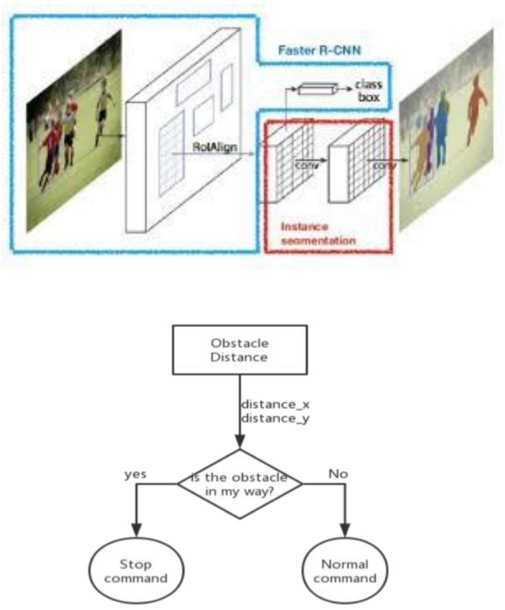


Fig. 6 (1) R-CNN network (2) Logical algorithm of Obstacle avoidance

3.3path-tracking

First of all we can traverse all the map points according to the GPS date. Then suppose that we have got the heading angle from the IMU. The step of selecting the following points can be divided in to two steps:

1. Using the GPS information, the angle θ formed by the current location of the five map points around the rain is calculated, and compared with the heading angle ψ obtained by the positioning system, |ψ−θ| < 45◦ we use this as the judgment condition of whether the map point is directly in front of the vehicle.

$$\theta_n = tan^{-1}\frac{y_n-y}{x_n-x+\varepsilon} \quad (1)$$

$$d_n = \sqrt{(y_n-y)^2-(x_n-x)^2} \quad (2)$$

2. Next, calculate the distance from all the map points in front of the current position, and select the closest point as the next following coordinate point.(x_n, y_n) is the map point position.(x,y) is the platform position.

After selecting the points Fig. 7, we design the travel toward algorithm. Consider the delay front the GPS to the robot ,we prefer to use the ignorance zone that is ,the angle is consider to be completed within a certain error range and the experiment proves that this method effectively reduced the influence of hardware delay in the control effect.

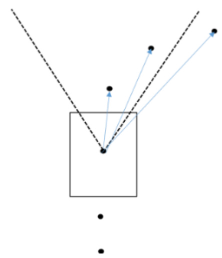


Fig. 7 Select the point for path-tracking

4. Experiment

4.1path-tracking

The Fig.8 is combined with two map (Blue line and Yellow line).The red line is the real-path of the robot.(X: longitude Y: latitude)

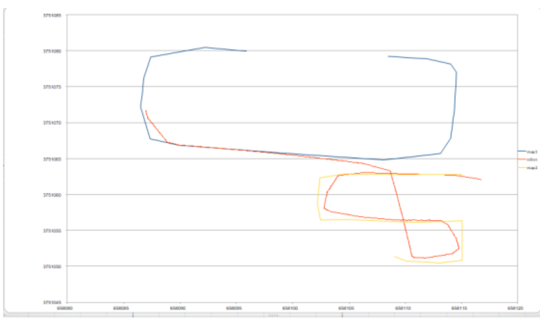


Fig. 8 Actual route (Red) and design route (Yellow and Blue)

4.3obstracle avoidance

It will stop when it detect the red corn and human as Fig 9

Fig. 9(1) Corn detection (2) Human detection

4.4human follower

It can successfully follow people with medium speed as Fig 10.

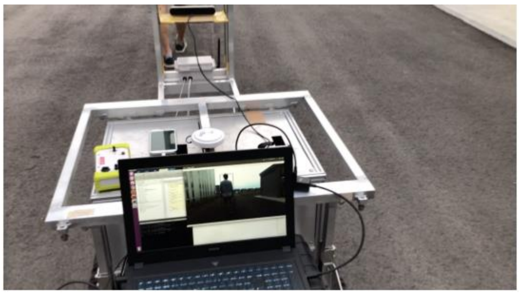


Fig. 10 Human Following Module

5. Conclusion and Future Plan

So far this paper has completed the design of an unmanned agricultural platform based on crawler robots. The application of this agricultural platform has certain positive significance for adapting to the aging of agriculture. The main contribution contain three parts:(i)innovatively put forward the concept of agricultural work platform.(ii)A GPS-based localization algorithm is designed. (iii)A simple pedestrian tracking system is designed.

We have already done the test in Tsukuba. The results of the experiment shown that the agricultural autonomous working platform can finish all the function we scheduled. But the environment of the weather can generate uncertainties for the GPS system and the sensors. We plan to improve it with other relative positioning methods. And increase the credibility of image recognition to improve system adaptability.

Reference

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