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Design and Implementation of Unmanned Agricultural Machinery

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Abstract. The unmanned agricultural machinery can greatly improve operating efficiency and can cover a large area of farmland operations with very little manpower, which saves agricultural investment costs. In this paper, the hardware and software design of unmanned agricultural machinery are introduced, the unmanned agricultural machine is developed, the autonomous driving experiments in different paths are carried out, and the accuracy of the operation is tested. The results of the experiments show that the unmanned agricultural machinery has high tracking accuracy and can meet the needs of field operations.

1. Introduction

Despite the rapid development of China's agricultural machinery industry in recent years, no large-scale agricultural machinery manufacturing enterprise with large scale and strong international influence has been formed, and the overall level of agricultural machinery technology in China has lagged behind, especially in the application of unmanned control technology. The demand for the unmanned of agricultural machinery technology is becoming more and more urgent [1-2].

The Thirteenth Five-Year Plan National Science and Technology Innovation Plan proposed that agricultural transformation and upgrading should be the main target, specifically focus on the development of key technologies of unmanned agricultural equipment [3].Promoting the application of information technology on agricultural machinery is not only in line with the world's development trends, but also in accordance with China's major needs to improve the level of agricultural intelligence, and has great significance for accelerating the development of smart agriculture[4].

In this article, we developed the unmanned agricultural machinery which can realize field information collection and processing, generate electronic maps, plan the optimal driving path, and drive autonomously according to the planned path.

2. System hardware design

The overall design of unmanned agricultural machinery is shown as Figure 1. The system is mainly composed of industrial computer, GPS navigation system, steer and control system [5]. GPS navigation system is mainly composed of GPS receiving device and supporting antenna. By processing the position and attitude data received from the GPS receiver, the boundary of the plot is displayed on the touch screen. The path generation software plans a reasonable operation path based on the situation of the plot and the operation requirements. When the agricultural machinery is operating, it displays the position of the agricultural machinery in real time by dynamic tracking data and realizes automatic navigation.

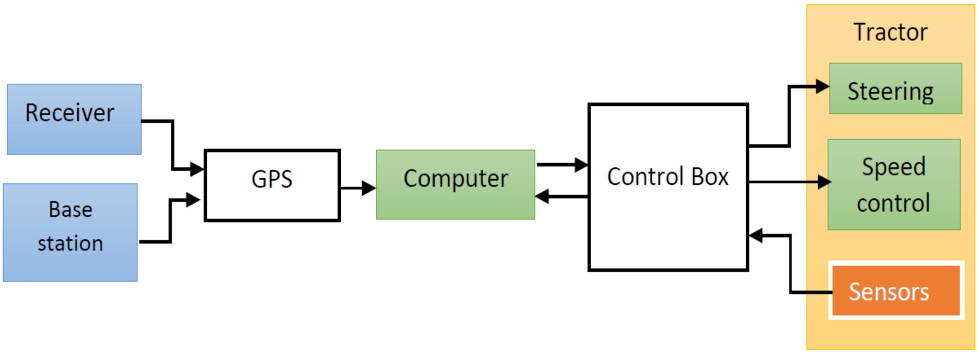

Figure 1. Overall design of unmanned agricultural machinery.

We chose Advantech ARK-3500 industrial computer as the system control centre. This type of industrial computer has rich I / O interfaces, including 4 USB 3.0 and 8 COM ports. The differential positioning accuracy of the selected GPS device can be within 3 cm, the data update rate can reach 50 Hz, and the power consumption of the GPS device is low, which is suitable for field navigation. The ATmega328p chip is selected as the main chip of the steering control system. It has six PWM channels, eight 10-bit ADCs, and a programmable serial USART, the operating speed can reach 20MHz [6]. The circuit design of the steering controller is shown as Figure 2.

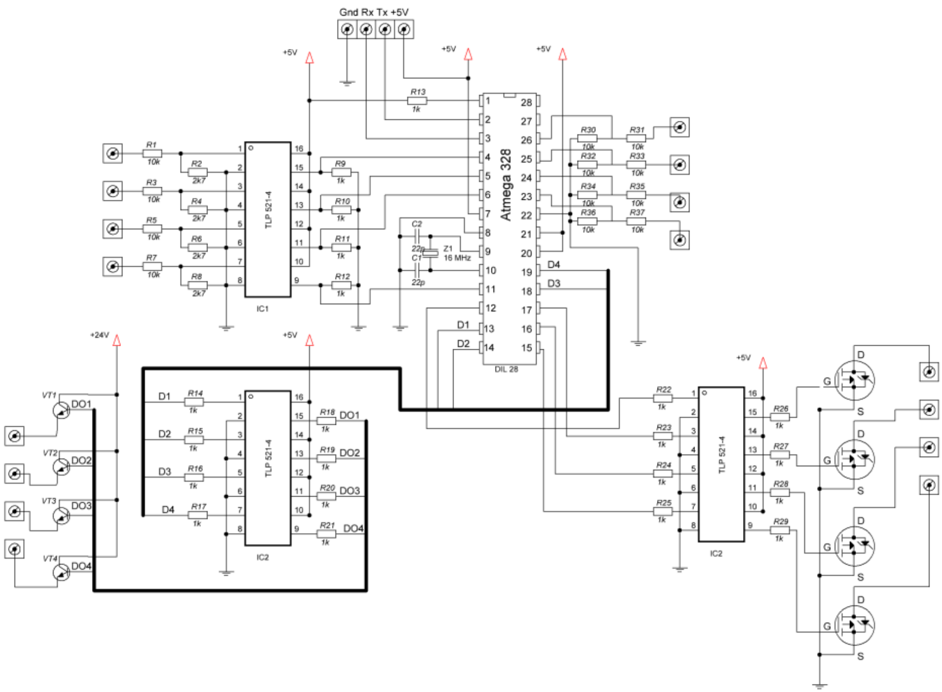

Figure 2. Circuit design of the steering controller.

3. System software design

In the unmanned agricultural machinery system, the industrial computer communicates with the navigation system and the steering control system. The touch screen displays and processes status information of each system, farmland outline maps, and man-machine dialogue information. As for the heading tracking algorithm, we choose to use the incremental PID calculation method. The sum of the heading at the current moment and the estimated heading is used as the system feedback. The input deviation of the controller is the difference between the expected heading and the feedback. The logic block diagram of the heading tracking algorithm is shown as Figure 3.

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The unmanned agricultural machinery software is written in C++ language, and the software interface is shown as Figure 4. The software can visually show the deviation between the planned path and the real-time position of the agricultural machinery, and monitor the status of the GPS system, steering system, communication system and other parts.

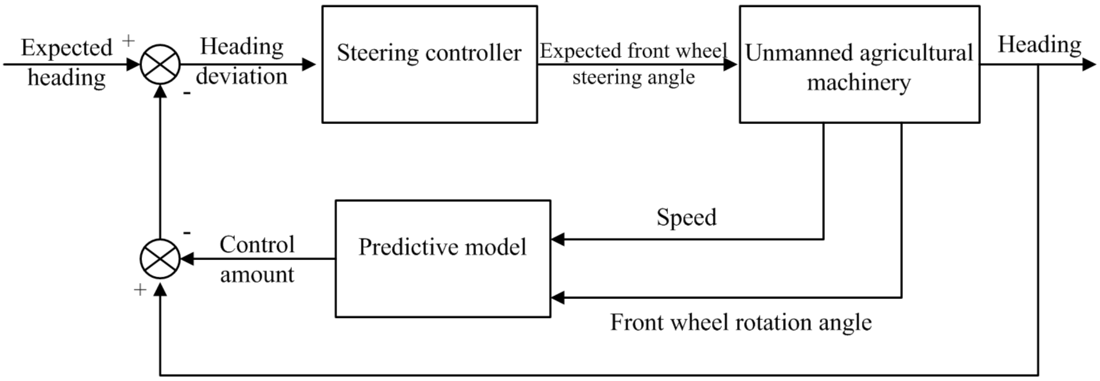

Figure 3. Logic block diagram of the heading tracking algorithm.

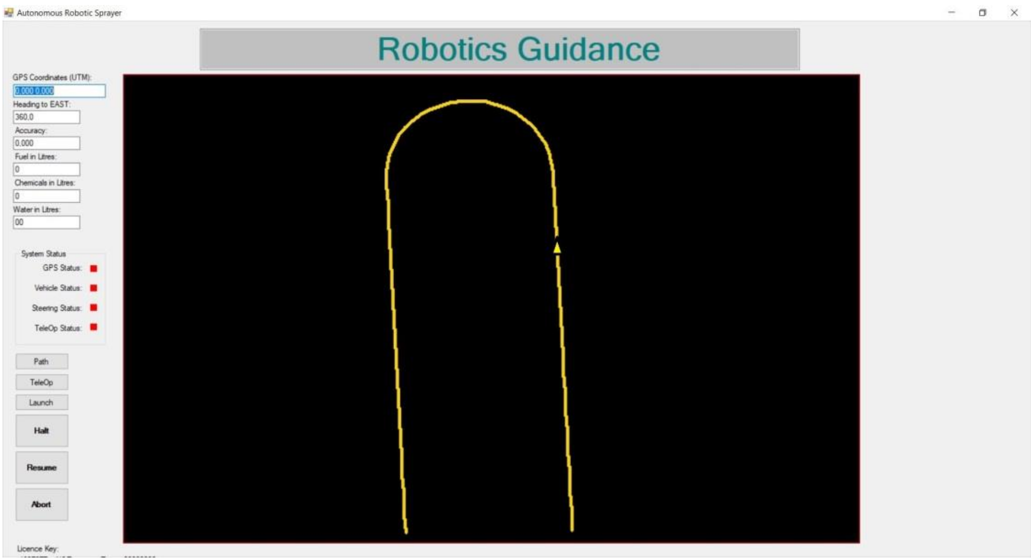

Figure 4. Unmanned agricultural machinery software interface.

4. Experiments

We have modified the 3WP-3000 pesticide spraying agricultural machine, and the completed experimental prototype is shown as Figure 5. After starting, the agricultural machine tracks the target path at a speed of about 2m/s, and the host computer records the position, speed, and heading information of the agricultural machine to evaluate the unmanned performance of the agricultural machine.

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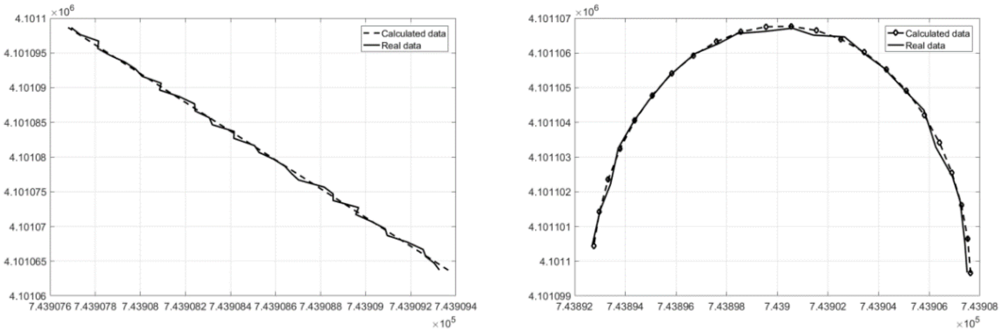
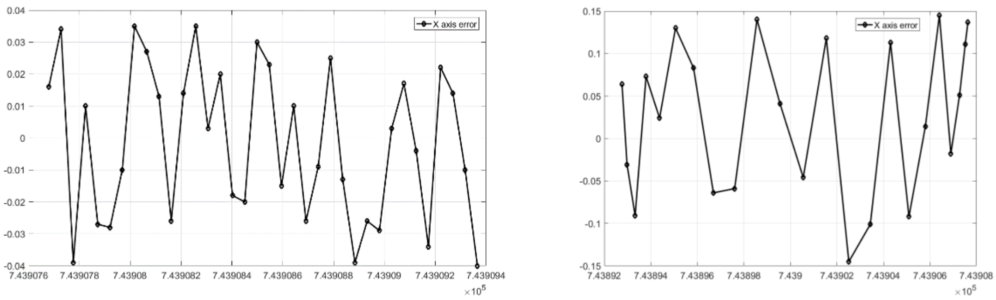
Figure 5. The unmanned agricultural machine prototype.

We tested the tracking of straight path and curved path of the unmanned agricultural machinery, compared the real driving path and the target path. The comparison diagrams of straight path tracking are shown in Figure 6(a), the comparison diagrams of curved path tracking are shown in Figure 6(b). The lateral tracking error of the straight path is shown in Figure 7(a), and the lateral tracking error of the curved path is shown in Figure 7(b).



(a) (b)

Figure 6. Comparison of real path and target path.



(a) (b)

Figure 7. The lateral tracking error.

The experimental results show that the unmanned agricultural machinery can complete the task of tracking planned path well. The maximum lateral deviation of the straight path tracking is about 4cm, and the maximum lateral deviation of the curved path tracking is about 15cm.

5. Conclusion

The hardware and software design of the unmanned agricultural machinery is introduced in details in the paper. The experiments show that the accuracy of the agricultural machinery tracking is high, the overall tracking error can be kept within a very small range and the unmanned agricultural machinery can effectively complete unmanned tasks.

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