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The Design and Research of the Following Robot Based on Human Skeleton

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Abstract

How to replace the cumbersome and complicated program operation in the past through more natural human-computer interaction for the Following Robot. In this paper, Xtion Pro Live Somatosensory devices is introduced into the robot control system, and designed a kind of Following Robot based on bone identification. The full paper analyzes the overall design composition of the Following Robot and conducts experimental analysis. The results show that: On the basis of realizing target following, this robot can also recognize and execute target action, which greatly improves the maneuverability of the robot.
Keywords: Human-computer interaction; gesture recognition; Following; ROS.
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INTRODUCTION

With the development of technology and society, robots are used more and more widely. In the robot neighborhood, The development of robots that can be followed with the user's permission has been a steadily growing research trend. Wired, an American technology magazine, reported that Following Robots is the next big trend in robotics [1].

The Following Robot is the combination of the intelligent control system and the mobile robot platform, while the intelligent control system usually needs to rely on the computer to complete. In recent years, scientists have been working to develop a more natural human-computer interaction to replace the cumbersome procedures in the past, while human motion is undoubtedly the most direct and natural human-computer interaction. This paper designs a kind of Following Robot based on bone identification, which is used to study how to carry out man-machine interaction through bone identification, and realize the function of human target following and human motion recognition.

System Framework Design

In this paper, the robot design according to the hierarchical, modular thinking to build the overall system framework. The control of the Following Robot is completed by the bottom Arduino Due control board and the upper airborne Mini PC, while the transmission between them relies on USB serial communication. The bottom Arduino Due control board mainly receives the motion control information issued by the upper decision layer, and then controls the motor rotation in real time through the motor drive board to realize the basic movement behavior of the chassis. The bottom Arduino Due also needs to return the motor encoder value to the upper PC. Other external equipment sensors, such as inertial navigation IMU, Xtion Pro Live, etc., are directly connected to the airborne Mini PC via USB. Data collected by various sensors are directly returned to PC for data processing and information transformation. The overall framework of the system is shown in Figure-1.

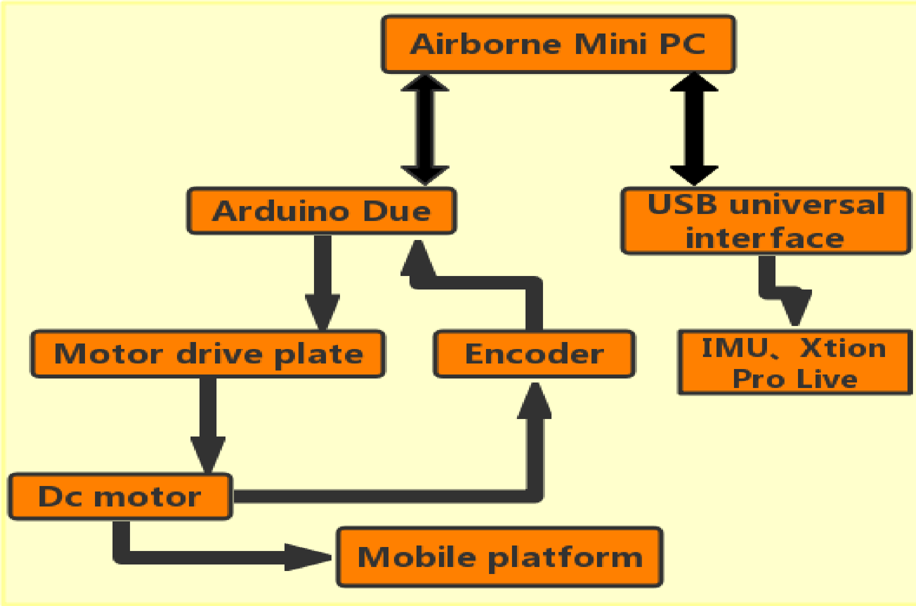

Fig-1 System frame diagram

Following Robot Motion Control Analysis

Mobile chassis design

The mobile chassis adopted in this paper is a four-wheel omnidirectional mobile chassis (shown in Figure-2). The omnidirectional mobile chassis is able to travel in any direction because it is powered by a Mecanum wheel. The main difference between it and the general theory is that it is surrounded by a ring of small rollers, each of which rotates around its own axis when the wheel is driven by a motor. When the component forces are synthesized, it can be found that different steering and rotating speed can constitute the moving speed in any direction.

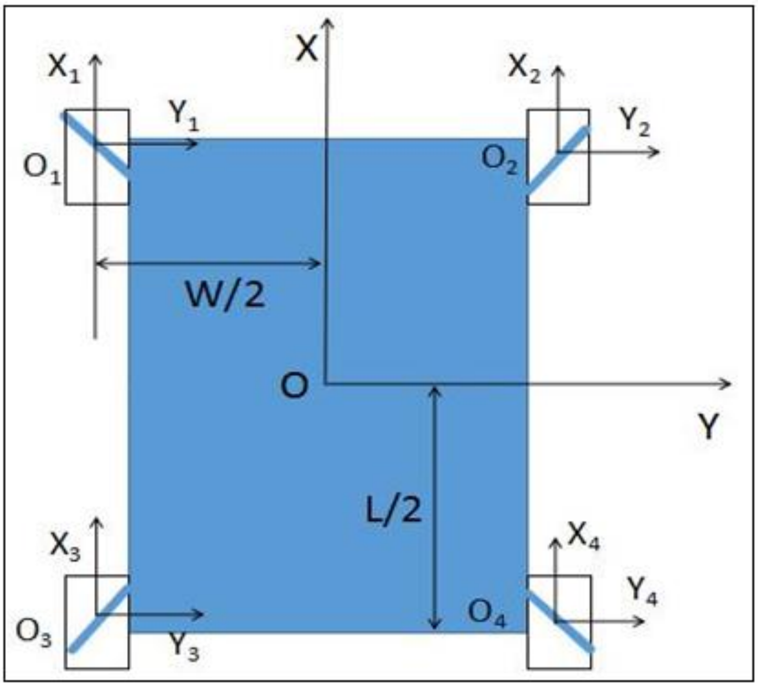

Fig-2: Chassis coordinate system

Kinematic Analysis

The axis movement speed of the four Mecanum wheels is defined as $\mathbf{V_{oi}}$,The roller speed Of each wheel is $\mathbf{V_i}$, the angular velocity as the $\mathbf{w_i}$, **W** is the wheelbase of left and right sides

L is the wheelbase before and after, **R** is the radius of the wheel. While **i** is 1、2、3、4. According to the analysis, the moving speed of the wheel axle is:

$$V_i = \begin{bmatrix} V_{ix} \\ V_{iy} \end{bmatrix} = \begin{bmatrix} R & \cos\alpha \\ 0 & -\sin\alpha \end{bmatrix} \quad (1)$$

Where, when i =1、4, $\alpha = 45^\circ$; when i =2、3, $\alpha = -45^\circ$.

Make i =1、2、3、4 substituting into the formula, and obtained the simultaneous equations:

$$\begin{bmatrix} V_x \\ V_y \\ w \end{bmatrix} = k \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix} = \frac{R}{4} \left[\begin{matrix} 1 & 1 & 1 & 1 \\ 1 & -1 & -1 & 1 \\ \frac{-1}{W+L} & \frac{-1}{W+L} & \frac{1}{W+L} & \frac{1}{W+L} \end{matrix} \right] \quad (2)$$

The inverse kinematics equation is:

$$\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix} = k \begin{bmatrix} v_x \\ v_y \\ w \end{bmatrix} = \frac{1}{R} \begin{bmatrix} 1 & 1 & \frac{-(W+L)}{2} \\ 1 & -1 & \frac{W+L}{2} \\ 1 & -1 & \frac{-(W+L)}{2} \\ 1 & 1 & \frac{W+L}{2} \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ w \end{bmatrix} \quad (3)$$

According on the basic knowledge of kinematics: The motion characteristics of the moving mechanism are reflected by the principle characteristics of the Jacobian matrix. When the Jacobian matrix is not ranked, the moving platform will lose the ability of omni-directional movement. According to formula (3), the mobile platform in this paper can satisfy the omni-directional mobile platform model. The control system can calculate the rotation speed of each wheel according to the formula, and then make the moving platform move correspondingly through the corresponding control.

Motion Control

In this paper, the chassis controller used is Arduino Due. Cooperate with two DC Motor driver dual Motor driver plates to jointly control the four 24V DC deceleration motors of the chassis. The connection diagram is shown in Figure-3. The Arduino Due of chassis is mainly to receive the speed control information released by the upper computer, and then accurately regulate the speed and steering of each motor, and carry out PID adjustment on the motor.

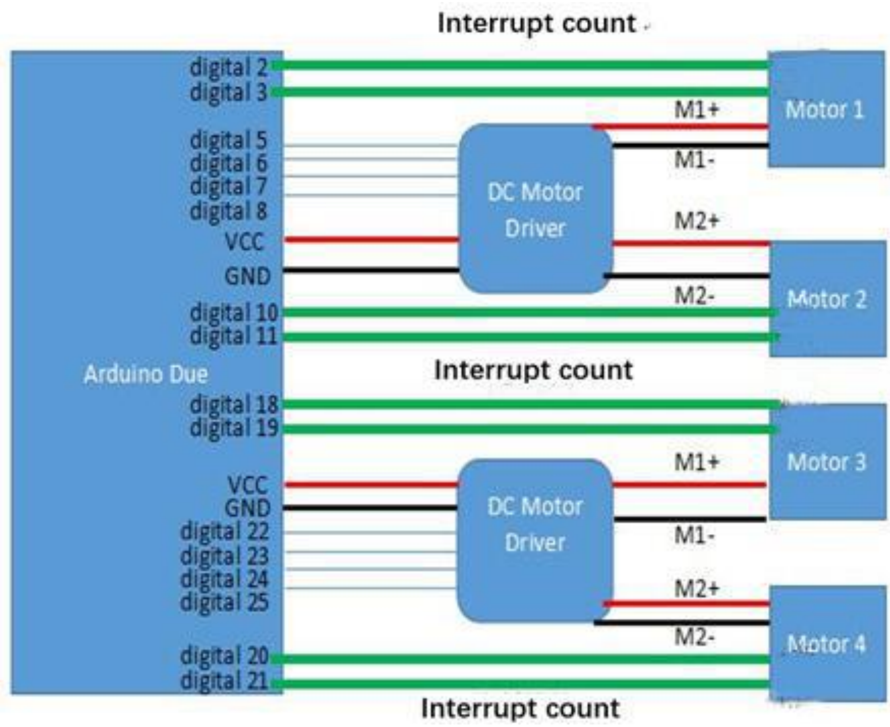

Fig-3: Arduino control circuit diagram

Human-Computer Interaction

Target Detection and Following

Due to the strong open source nature of ROS system, this paper adopts ROS system as the software control system of robot. Under the framework based on OpenNI, Xtion Pro Live, an external somatosensory device, can extract human bones and realize human body detection and tracking. As shown in Fig-4, it can be seen that each node of the human body is reflected in the way of coordinate system. Xtion Pro Live transmits the detected skeleton coordinates to the computer for processing. The computer judges the position and posture of the detected person by comparing the relationship between different coordinate systems, and then sends instructions to the chassis to control the robot's movement.

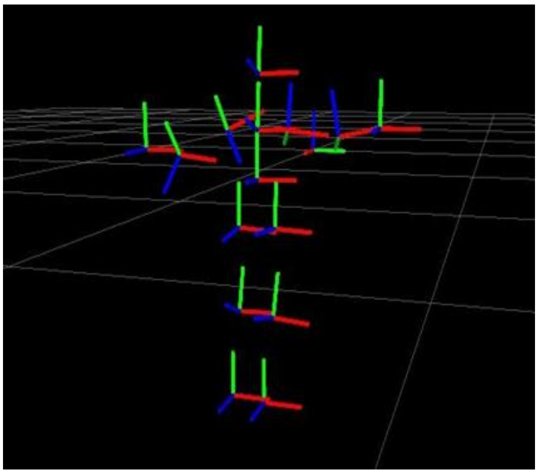

Fig-4 Skeleton coordinate detection diagram

Target Action Recognition

In this paper, bone-based human motion recognition is hand motion recognition, which mainly adopts four skeleton node information: Hand_Right, Shoulder_Right, Hand_Left and Shoulder_Left. Other skeleton node information is used as an auxiliary threshold condition to improve the recognition performance. The skeleton diagram of action instruction is shown in Fig-5.

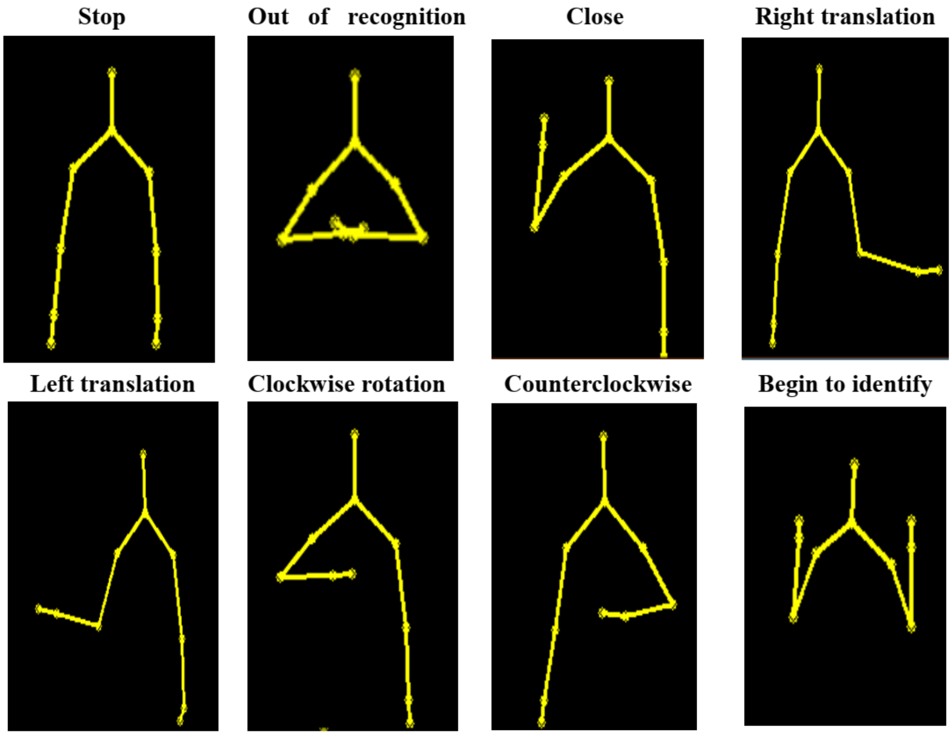

Fig-5: Skeleton instruction diagram

By detecting the coordinate data of the four key bone nodes in the human skeleton coordinate diagram, the computer compares them with the set bone instructions, so as to execute different action instructions. For example, when the value of the Hand_Right and Hand_Left skeleton nodes in the detected skeleton graph on the z-axis is greater than Shoulder_Right and Shoulder_Left, then the following robot executes Begin to identify command and starts human detection and real-time follow.

Experiment

CONCLUSION

We propose a bone-based motion recognition method to determine the arm motion state with a small number of bone joints, so as to overcome the difficulties in the traditional action recognition of the Following Robot. Although the following robot designed by us still has some imperfections, the experiment shows that the Following Robot based on human skeleton can not only follow the target, but also perform action recognition, with strong human-machine interaction.

REFERENCE

1. Wu, X. F. (2016). Design of tracking robot control system based on Kinect [D]. South China University of Technology.