F-016

A Safe Non-Contact Robotic Arm Control System for Anyone

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1. Introduction

We propose a method that uses Kinect V2 sensors to acquire human arm poses and then map and control the robotic arm. The feature of this study is to use spatial 3D shear mapping and transformation to correct the data of people with different heights, arm lengths and arm swing amplitudes, and then control the robotic arm after unification, which can be used more freely and widely in different scenes. This allows different people to safely control the robotic arm in different situations according to their own habits. In addition, we also added a combination of left- and right-hand gestures, which can make the control method more diverse.

2. System Overview

Our system structure is shown in Figure 1, which is to use a 3D camera to obtain the movement data of the human arm and palm, and after performing certain calculations, send the coordinate data to the robotic arm to make it move. The special feature of this system mainly has three parts.

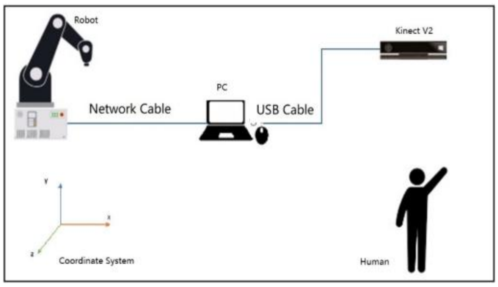

Figure 1

The first is to correspond the angles of each joint of the arm with the joints of the robotic arm. The second is how to correctly correct the coordinate data of the arm and transmit it to the robotic arm. The third is that the hands can cooperate to change a variety of control modes.

3. Principles and Methods

① The system is currently designed based on the human right arm, and the robotic arm uses a six-degree-of-freedom arm-type robotic arm. The biggest difference between robot joints and human joints is the single direction of rotation. Each joint of the robotic arm rotates in one direction. But human arms, such as shoulder or wrist joints, are like ball joints and can rotate in multiple directions. Therefore, the decomposition of human joints according to the direction of rotation is the key to this part [1][2].

As shown in Figure 2, the vertex of the U of the red arrow is used as the position of the palm. The O point serves as the origin of the shoulder. Since the shoulder joint is a spherical joint, we need to decompose the shoulder joint to correspond to the robotic arm's basic joint and shoulder joint. We make two dashed lines perpendicular to the auxiliary, can take the y-axis as the basis, and the rotation angle of the joint from the y-axis to the U can be equivalently decomposed into angles α and β. According to this principle, we can correspond to the joint angles of the human and the robotic arm, not completely correspondingly, but in an approximate case, some singular points of inverse kinematics of machinery can be solved to a certain extent.

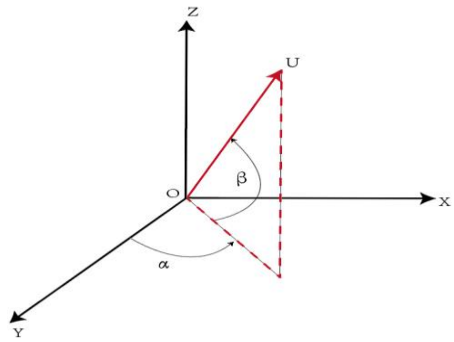

Figure 2

② The data correction aspect is mainly two parts. One is to unify the arm data obtained by the camera, because each person's arm swing amplitude and arm length are different, through 3D shear mapping correction [3], it is also possible to standardize the arm data of different people to a certain extent. The second is to calibrate the arm data and the robotic arm after the unified standard in the first step. In particular, the concept of using the shear mapping transformation of spatial 3D is explained. Because before we control the robotic arm, this data should be uniform for any operator. However, due to differences in personal habits and height, the collection of these data may not be very standard Cartesian coordinates.

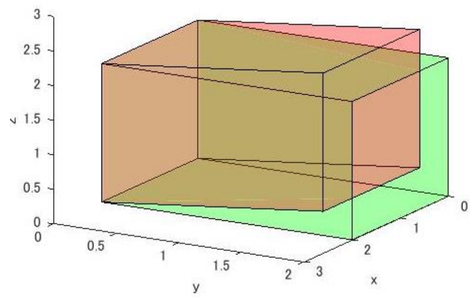

Figure 3

As shown in Figure 3, we see a collection of data such as red cubes in space. This is the acquired hand data, if the number is enough, we assume it is such a red parallelepiped. We then collect as much collection of data as possible into the green cube in the form of a 3D mapping transformation. In this way, it is possible to ensure that the robot arm and the data sent can use a fixed calibration relationship as much as possible. This is more convenient when different people control the robotic arm.

③ The use of a two-handed control mode is also intended to add more freedom to the system, the left hand is more inclined to switch the control modes, and the right hand is mainly for data collection. The combination of gestures of both hands can increase the number of commands, and it is also possible to increase the recognition accuracy of single gesture recognition.

The simple control description is as follows in Figure 4. We start from the identification of the left hand. When the left hand is the palm and the right hand is also the palm, the robotic arm is controlled to move normally. When the left hand is in the lasso state and the right hand is in the palm, control the robotic arm to move quickly. When the left hand is in the lasoo state and the right hand is also in the lasoo state, control the robotic arm to move slowly. When the left and right hands are clenched fists and change to lasoo state, the whole system stops [4].

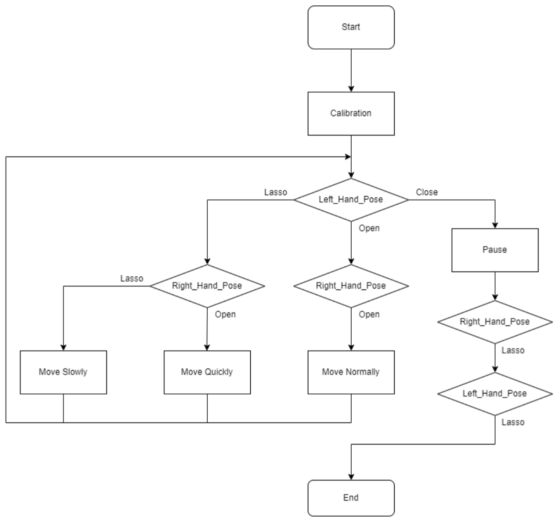

Figure 4

4. Results and Discussion

After these transformations above, from acquiring data to 3D shear mapping transformation, after calibration and multi-mode control, as shown in Figure 5. The green line segment is the data obtained by tracking the human arm through the camera, and this part of the data is also the original data. The current database is from me, so the database including the following staggered transformation is also transformed according to my arm. Then the blue line that almost overlaps with green is the data after the 3D staggering transformation. The red dotted line which is the target data sent to the robotic arm. Since the length of the robotic arm is longer than mine, the movement range of the entire data is also greater.

From the experimental results, the basic non-contact control purpose has been achieved. And according to my personal arm swinging habits and control requirements, it can work as a basic system to a certain extent. However, there are still some problems in the actual control, which is also the solution direction in the future.

The first problem is that when the arm moves too fast or the movement interval is too large, the movement of the robotic arm is prone to singularity problems, which can only be corrected to a certain extent through the correspondence of joint angles. This part may require breakthroughs in mechanical inverse kinematics

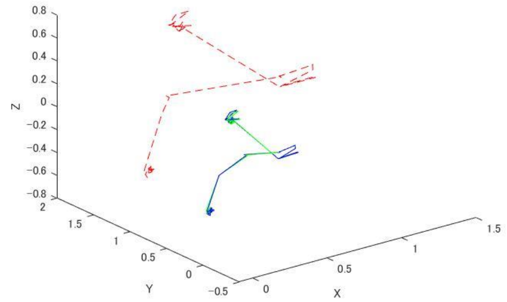

Figure 5

The second is that it is only my personal body data. I hope to obtain more experimental samples, including height, shortness, fatness, thinness, men, and women, young and old so on next. In addition to the currently used UR5e robotic arm simulator, I hope to add different arm lengths in the future or experimental data on different brands of robotic arms. This enhances and validates the applicability of the control system.

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References

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