The Research of Welding Robot off-line Programming System

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Abstract. In the applied process of robot off-line programming technology, it is necessary for the model to solve the correction problem which is between the practical working and off-line simulational environment. Robot coordinate system calibration method is proposed by measuring workpiece coordinate system and base coordinate system, homogeneous transformation matrix of coordinate measuring system. The kinematics analysis for FS30L robot is done and off-line programming system for welding robot is developed in VC ++. The modularization design is applied in the system. It includes the modules of coordinate system calibration, off-line programming, off-line simulation, serial communication, function extension. By the example verification for the system, the experiment results show that the off-line programming system is rational and feasible.

1 Introduction

In the process of the application of the robot off-line programming technology, we must solve the problem of the model object's calibration in the actual operating object and the off-line simulation environment, which is the robot coordinate system calibration problem [1-2]. Calibration method can be divided into forward calibration and inverse calibration[3]. Forward calibration is generally required to coordinate system calibration by means of measurement equipment, which can get a high accuracy[4-5]. The coordinate system calibration of the robot's joint encoder data is carried out by the reverse calibration[1].These methods are based on the measurement of the work piece coordinate system in order to check the transformation matrix of the work piece coordinate system and the robot base coordinate. The research of the robot off-line programming system has been a lot of progress, which meets the requirements of industrial production. But the practical level of off-line programming is not deep，it needs to be studied further[6-8].

2 Coordinate system calibration and Kinematics analysis

According to the relationship between the structure and the position of the robot welding system, the robot coordinate system is set up as shown in Figure1.

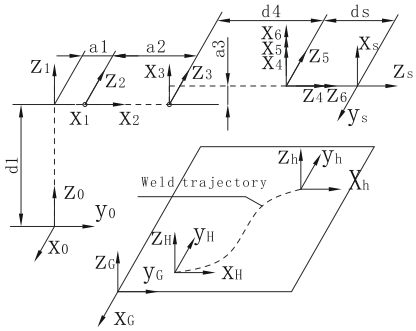

Fig. 1 coordinate system for welding system

Referring to formular1, the generalized transformation equation of the robot welding system is given.

$$ {}^{0}T_{6} \cdot {}^{6}T_{S} = {}^{0}T_{H} \cdot {}^{H}T_{h} \tag{1} $$

The relationship between the robot coordinate system is represented by the formula 2:

$$ {}^{0}T_{6} = \begin{bmatrix} n_x & o_x & a_x & p_x \\ n_y & o_y & a_y & p_y \\ n_y & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^{0}T_{1} \cdot {}^{1}T_{2} \cdot {}^{2}T_{3} \cdot {}^{3}T_{4} \cdot {}^{4}T_{5} \cdot {}^{5}T_{6} \tag{2} $$

Coordinate system calibration and positioning principle of workpiece are the same substance, so it can measure the coordinate system based on the principle of the workpiece positioning.The specific measurement method of the coordinate system is related to the shape of the workpiece. Measuring the workpiece coordinate system is to select a different calibration method according to the positioning of the workpiece principles method.

$$ {}^{H}T_{0} = {}^{0}T_{G}^{-1} \cdot {}^{H}T_{G} \tag{3} $$

Positive and inverse kinematics analysis is the basis of robot control. According to the definition of Craig, reference Figure.1 can create a robot body parameter table as shown in table.1.

Table 1. Robot Body Parameter List

Link	θi/°	α_{i-1} /°	a_{i-1}	d_i	Rang/°
1	90	0	0	d_1	(-160,160)
2	0	-90	a_1	0	(-180,0)
3	-90	0	a_2	0	(-155,180)
4	0	-90	a_3	d_4	(-270,270)
5	0	90	0	0	(-130,130)
6	0	-90	0	0	(-360,360)

On the right side of the calculation formula, the coordinate system of the weld can be obtained from the right side of the weld line h in the 0 homogeneous transformation matrix of the. The general method of inverse kinematics of the robot's kinematics is taken by the inverse kinematics of the robot kinematics, which is the angle of each joint of the manipulator.

3 Off-line programming system

The off-line programming system is a special system for arc welding robot, which is designed in VC++ environment. The system uses modular design, which is convenient for the development and improvement of the system[6]. The work flow is shown in figure 2.

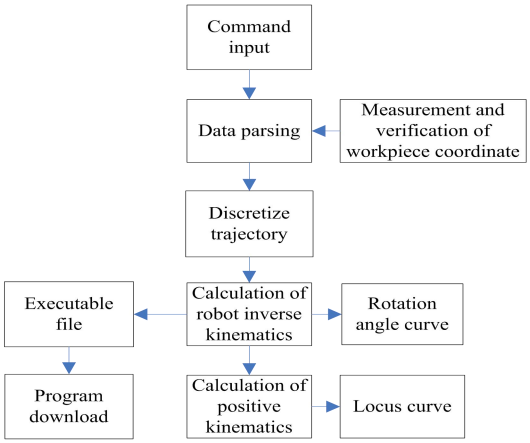

Fig.2 working flow chart of the off line programming system

Off-line programming system is built in the MFC, the system main interface as shown in fig.3. The system has the function of coordinate system calibration, off-line programming, off-line simulation, serial communication and extended function module.

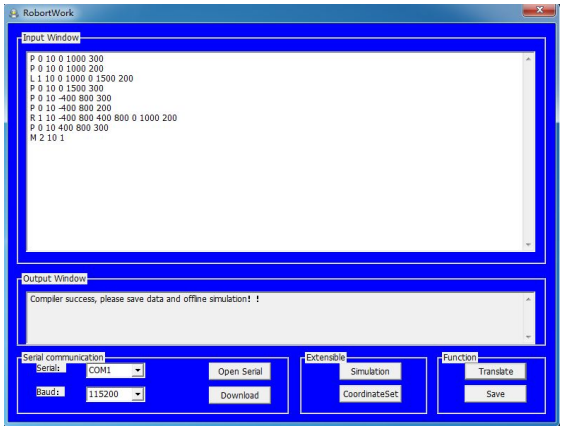

Fig.3 system main interface

4 Experimental verification

The off-line programming system is developed for the FS30L robot, and the robot body parameters are shown in Table1. In the Table1. a_1=150mm, a_2=950mm, d_1= 680mm, d_4=1000mm , d_s=750mm.

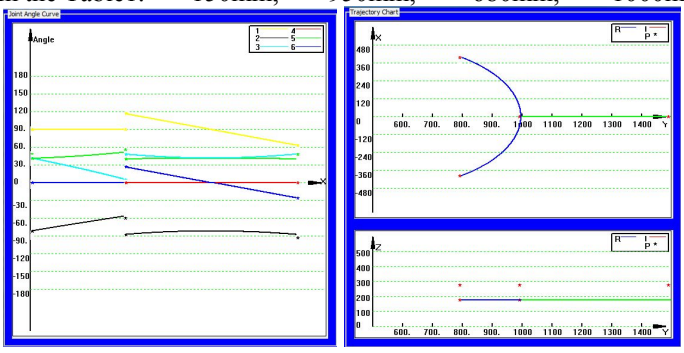

Fig.4 Effect of off-line simulation

It is an off-line simulation diagram in Figure 4, which is shown in the end of the end effector trajectory curve and joint angle curve. It can be seen from the graph that the robot does not have a strong flexible and rigid impact, and the end motion estimation is the same as that of the robot's trajectory. It is indicated that the off-line programming system can realize the simulation of robot off-line programming.

5 Conclusion

In this paper, we put forward an indirect method for measuring the coordinate system of the robot based on the indirect measurement of the workpiece coordinate. The robot base coordinate system is presented in view of the problem of robot coordinate system calibration. Then we develop an off-line programming system of welding robot based on FS30L robot. The system is designed in modular with the character of good openness reasonable and feasible.

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