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Simulation Design of Industrial Robot Welding Workstation Based on Robot Studio

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Abstract

By utilizing the simulation function of Robot Studio software, combined with the graphical programming methods of 3D software UG and ABB Robotics' Robot Studio software, the entire workstation design is completed through steps such as workstation construction, simulation system configuration, I/O configuration, parameter setting, and program writing. This simulation can provide a theoretical basis for the design and path planning of real industrial robot welding workstations, and effectively improve design efficiency.

Key words: *industrial robot; robot studio; simulation*

1 Introduction

Industrial automation requires high efficiency in enterprise production to reduce production costs. It is impractical to spend much time on the inspection or commissioning of industrial robot programming on the production line, as it requires shutdown for teach pendant programming. Offline programming refers to modeling and programming on a computer using software tools without occupying the robot, meaning robot programming operations are performed outside the production line. Offline programming avoids the production "downtime" waste caused by online teach programming. Through robot offline programming, the robot workspace can be better debugged and planned, and design errors can be avoided. During robot programming, offline programming can simultaneously create robot application systems, allowing programming of the robot application system while manufacturing products, thereby enabling early production of products[1].

The industrial robot welding workstation designed in this paper adopts a graphical programming method, which automatically generates the robot's motion trajectory according to the curve characteristics of the 3D model. This method can save time, reduce labor costs, and easily ensure trajectory accuracy. Based on the curve characteristics of the 3D model, the "Auto Path" function of RobotStudio software can be used to automatically generate the running trajectory of robot welding.

2 Construction of Industrial Robot Welding Workstation

The industrial robot welding workstation mainly consists of a robot module, an automobile model, and a welding platform module. The robot module includes an ABB IRB2600 robot and a Binzel water 22 tool. The welding platform mainly imports four completed models into the empty workstation and places them in appropriate positions. The automobile model mainly includes a car body and a car cover model[2].

2.1 Establishment of 3D models

This simulation involves welding the car cover to the car body. Therefore, the car cover and car body

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models shown in Figures 1 and 2 are drawn in UG software. The appearance of the model imitates that of an off-road vehicle, with a vehicle length of 575mm, a vehicle wheelbase of 430mm, a maximum vehicle width of 245mm, a maximum vehicle height of 230mm, a distance from the roof to the upper edge of the rear wheel of 120mm, a distance from the hood to the upper edge of the front wheel of 60mm, and a maximum distance of 165mm and a minimum distance of 135mm between the side panels of the vehicle. Since the car cover is to be installed on the car body by welding, welding grooves should be reserved between the car cover and the side panels, with 4mm welding grooves on each side. Therefore, the maximum width of the car cover is 157mm and the minimum width is 127mm. Then, the welding workbench on which the car body and car cover models are placed is imported into the workstation. The welding workbench has a length of 700mm, a width of 600mm, and a height of 400mm. The overall size of the car can be just placed in a suitable position on the workbench.

2.2 Model import and layout

Save the 3D model in SAT format for import into RobotStudio software. Enter RobotStudio software, select "Import Geometry" in the Basic tab, click "Browse Geometry", find the car model just saved on the computer, and import it into RobotStudio software[3]. Due to the inconsistency between the modeling coordinates in UG and the coordinates in the workstation, the position is incorrect during installation and placement. It is necessary to adjust the coordinate axes and set the workpiece coordinates, which usually run in a user-defined Cartesian reference system. Align the X, Y, Z axis directions of the model with those of the workstation to adjust to a direction convenient for installation and placement, as shown in Figure 3 below.

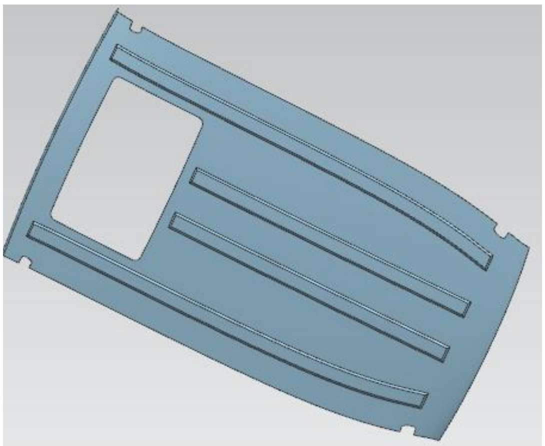


Figure 1 Car cover

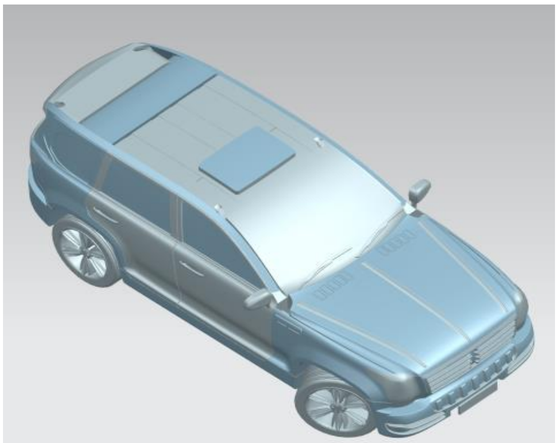


Figure 2 Car body

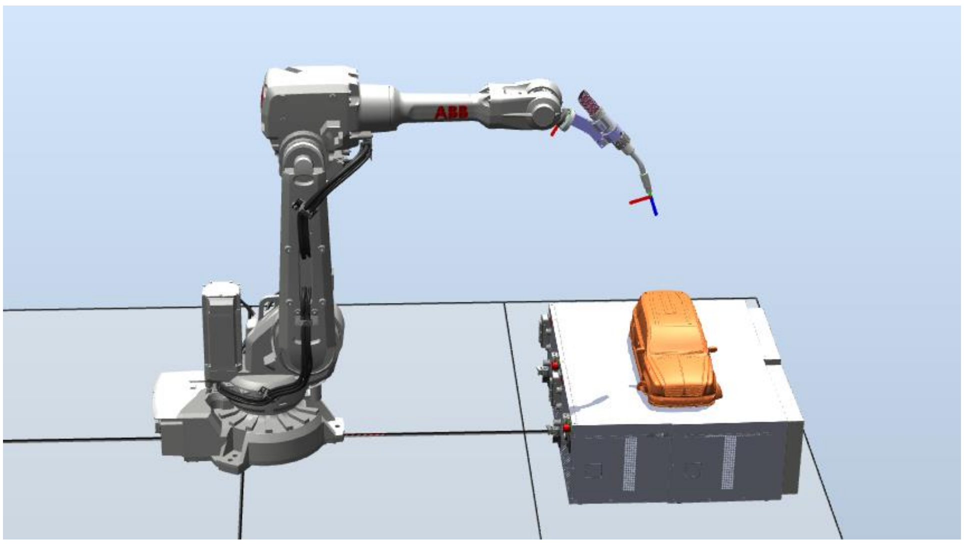


Figure 3 Geometry layout diagram

3 Design of Industrial Robot Welding Simulation System

The design of the industrial robot welding simulation system includes the creation of the robot system, addition of I/O signals, creation and design of Smart components, creation of workstation logic, and writing of welding programs. The design parameters are shown in Table 1 below.

Table 1 Design Parameters

No	Name	Main dimension parameters
1	Welding platform	700×600×400
2	Robot body	IRB 2600_12_165_02
3	Industrial network	709-1 Device net master
4	Bus adapter	840-2 PROFIBUS anybus device
5	I/O configuration	DSQC652 board

3.1 Creation and design of smart components

To realize the welding simulation of industrial robots, it is necessary to truly simulate the welding environment, mainly including the simulation of the light emitted during welding and the weld seam generated by welding. Smart components are efficient tools for realizing animations in RobotStudio. They can realize the animation effect where the light appears during welding, the light disappears when welding is completed, but the weld seam remains on the car model, achieving the restoration of the real environment[4-6].

The creation of Smart components includes the creation of welding laser components and welding seam components. For the creation of welding laser Smart components, two point light sources need to be selected in "Create Light". Change the color to blue to simulate the color of the light, set the diffuse intensity to the highest, set the highlight intensity to the lowest, place the two point light sources at the tip and tail of the welding torch, and then use the Smart components to control the light to appear and disappear during welding.

The creation of welding seam Smart components involves establishing a sphere named "Weld Pool" as the geometry for realizing the weld seam. The length, width, and height of this weld pool should be the same as those of the welding groove. Place the "Weld Pool" in the welding Smart component.

Arrange all Smart components in a suitable position, and finally connect the output signal of the timer with the input signal of the copy. The signal configuration of the welding Smart component is basically completed. The connection of the welding Smart component is shown in Figure 4 below.

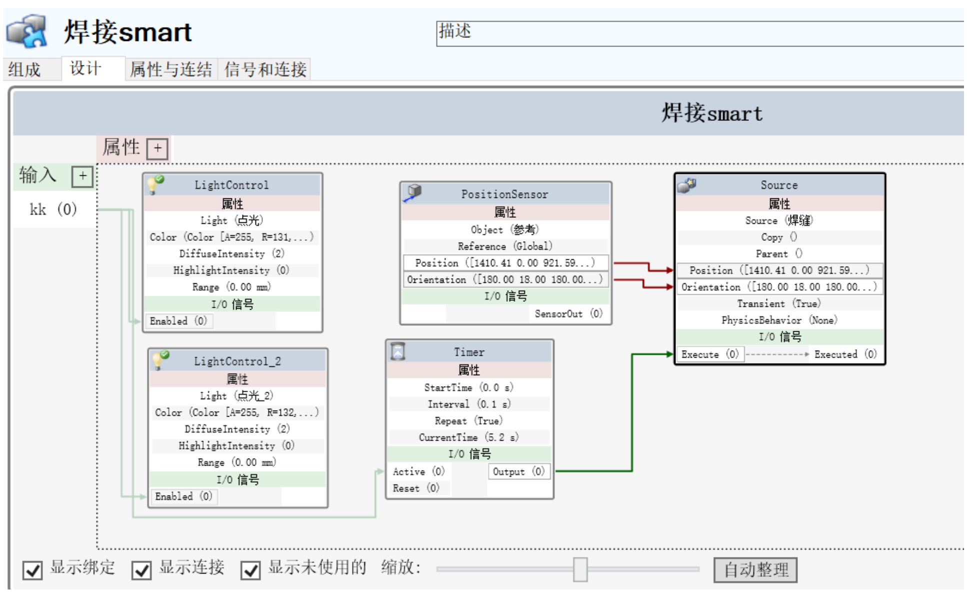


Figure 4 Welding smart component design

3.2 Writing welding programs

Welding programs generally start with ArcLStart or ArcCStart. ArcLStart is usually used as the starting statement, and the welding process generally ends with ArcLEnd or ArcCEnd. The path function is a major feature of offline programming, which visualizes the motion process of the robot tool for user editing. This paper adopts the offline programming method.

When creating a welding path, a red trajectory (i.e., Edge 1) will appear. Change the reference surface to the car cover model. Since the contour of the car cover is not a straight line, arc motion should be performed to make the trajectory more fitting. Therefore, change the approximation parameter to arc motion, and set both the minimum distance and tolerance to 1 to make the trajectory arc more accurate. The created welding path is shown in Figure 5.

4 Industrial Robot Welding Simulation

The industrial robot welding simulation process is shown in Figure 6 below. With the cooperation of the robot's 4 axes, it moves from program point 1 to program point 2, which is the process of the welding torch approaching. Moving from program point 2 to program point 3 is the arc starting preparation stage. During this process, the welding joint will gradually melt under the action of high temperature. The movement from program point 3 to program point 4 is linear, and the movement from program point 4 to program point 5 is arc motion. These two stages are the welding process and arc ending, during which welding trajectories will be formed to realize the connection between the car cover and the car body. From program point 5 to program point 6, no welding is required in this simulation, and no welding trajectory will appear during the simulation. From program point 6 to program point 8, the process from program point 3 to program point 5 is repeated, and finally returns to program point 1, and the program simulation ends.

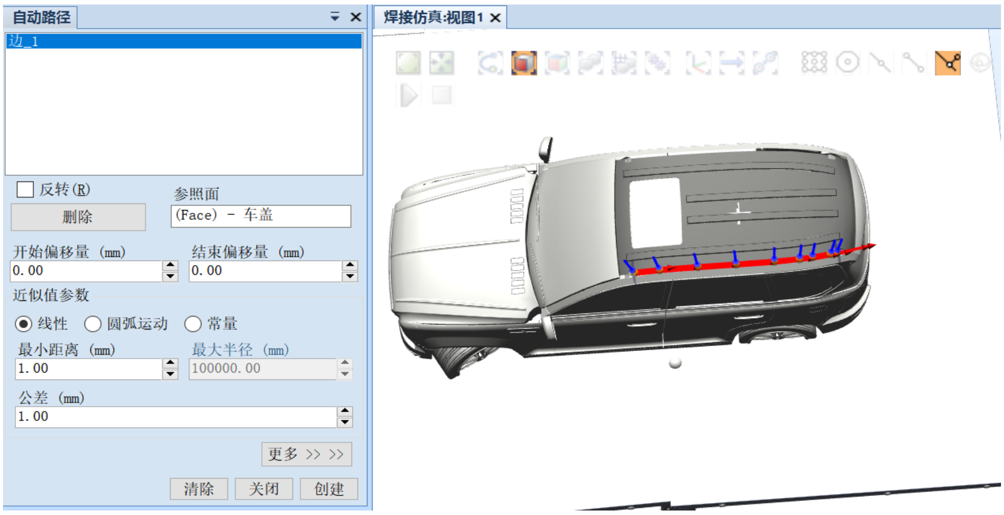


Figure 5 Creation of welding path

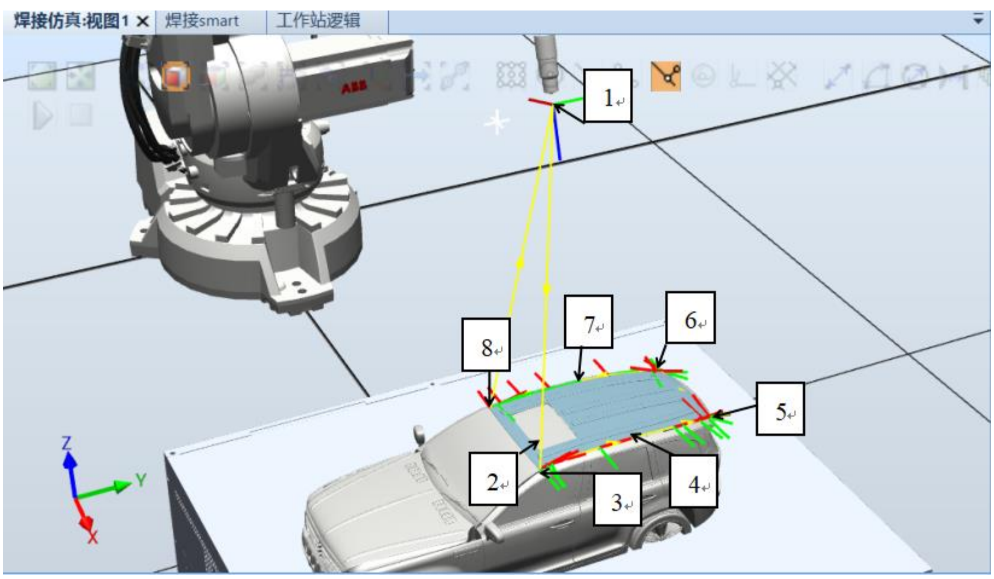
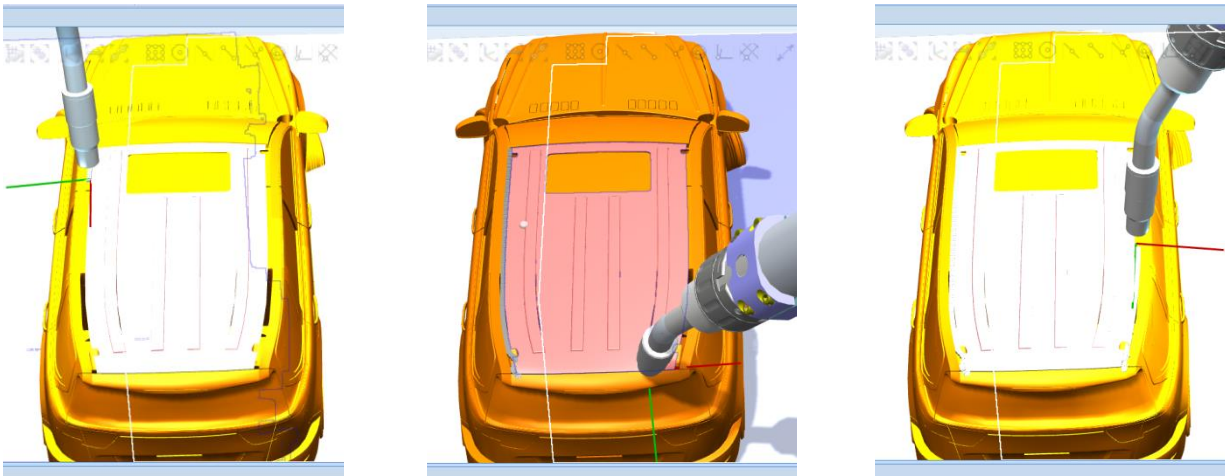


Figure 6 Simulation path design

To be similar to the real welding scene, there should be splashes, sparks, and weld seams during the simulation. The weld seam is formed by geometry movement and copying, and the sparks are replaced by point light sources. The simulation process is shown in Figure 7 below. Figure**7** (a) fills the groove between the car cover and the car body by continuously copying the "Weld Pool" and following the local coordinates of the "Reference" geometry, forming a continuous welding trajectory, i.e., the weld seam. During welding, in addition to the appearance of the weld seam, point light sources emit light to simulate splashing sparks. Figure**7** (b) shows no welding, the point light sources are turned off, and the "Weld Pool" no longer copies with the "Reference" geometry. Figure**7** (c) shows the light and weld seam appearing again, repeating the process of Figure**7** (a).The final welding result is shown in Figure 8.



(a) (b) (c)

Figure 7 Welding process diagramt

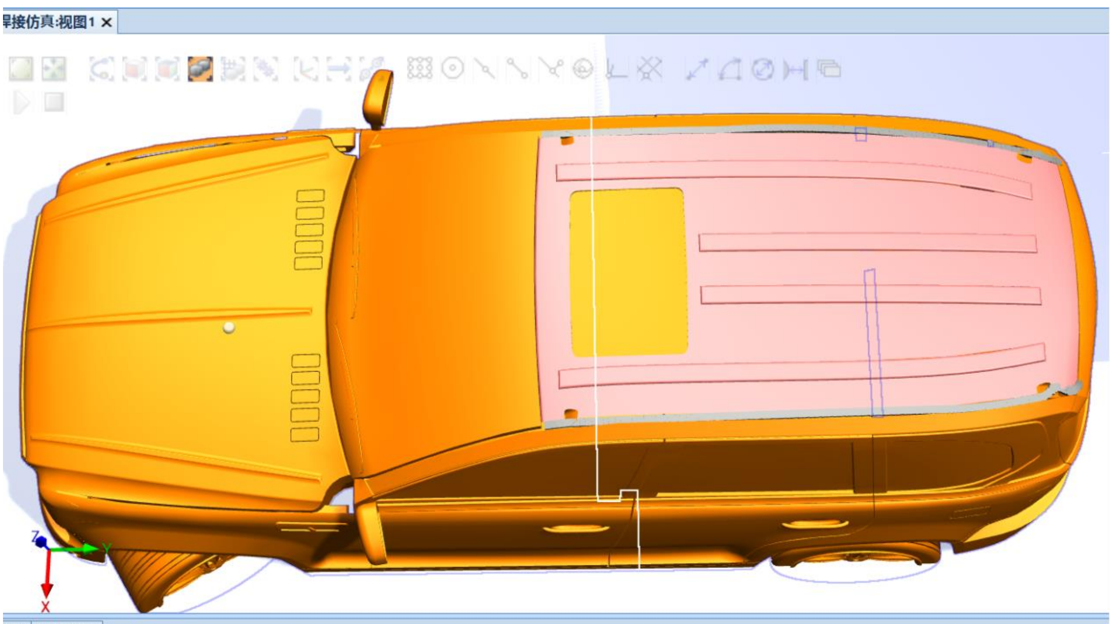


Figure 8 Welding simulation result

From the simulation results, it can be seen that the handling robot and welding robot in the workstation move completely in accordance with the preset sequence and trajectory, completing the handling of the car cover and the welding of the weld seam. All clamping and placing actions of the handling robot, as well as all starting, welding paths, and termination of the welding robot, can meet the preset requirements. The dynamic simulation of the entire process shows the real motion rhythm of the robot, which can illustrate the correctness and applicability of the offline programming simulation program of the industrial robot welding workstation.

5 Conclusion

Starting from the simulated robot welding workstation, this paper presents the structural composition and basic layout of the workstation, and details the process of arc welding workstation system configuration, I/O configuration, parameter setting, program writing, and debugging. The virtual simulation of the workstation runs well and can truly simulate arc welding operations.

Taking the industrial robot welding workstation on the real production line as the research object, this paper uses the graphical programming functions of UG and RobotStudio to design and simulate the path of the robot welding workstation. The design of this welding workstation saves time and labor, easily ensures trajectory accuracy, and reduces the design and commissioning costs of the production line.

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