Development of End Beam Obstacle Avoidance Program based on ABB Automatic Painting Programming

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Abstract. In order to improve the company’s production efficiency, in response to the call of the country to accelerate the industrial automation, the company’s developers have independently developed a painting line parametric automatic programming system based on ABB robot using C++ language, the automatic spraying of the main beams of the crane is realized. The automatic programming system can only spray the main beam of the end beam without end. The end beams obstacle avoidance program is optimized based on the automatic programming system, which aims to control the robot to avoid the end beam of the main beam, so that the system can spray the main beam of the crane with the end beam normally.

1. Introduction
Crane and the country’s bridges, buildings and military industry are closely linked, and in order to prevent the corrosion of the crane, increase the service life, the crane spray has become a crucial link [1]. The intelligent parametric automatic programming system for painting line is an application software developed for the painting of crane girders [2]. Its main function is to read the parameters of various girders in the configuration file by using the graphical interface written by Qt, according to the parameters and C++ program, the Control Command File of ABB robot is generated, and the intelligent parameterized spraying of ABB robot is realized [3]. As shown in figure 1.

Figure 1. Robotic spray painting.
2. Function Optimization Analysis of Painting System

2.1. System Functions
The automatic programming system of coating line is an application software that generates the corresponding spraying control command files according to the data parameters of the main beam in the INI configuration files in QT [4]. The files can be run on the ABB robot, and the robot sprays the main beam according to the commands in the files. The function of the system is to read and write INI file data, select INI file and generate control command MOD file.

(1) Read and write INI file data. The INI file format is an informal standard for configuration files on some platforms or software, consisting of keys and values. Through the UI interface generated by QT, the user can directly read the corresponding parameter values, modify the parameters, and generate a new INI configuration file. The user can more intuitively adjust the parameters of the main beams according to the data displayed in the interface, so that the ABB robot can spray various types of main beam.

(2) Select INI file. As the automatic programming system of the painting line needs to complete the spraying of many kinds of crane main beams, it is necessary to generate the corresponding INI configuration file according to different main beams type and data. When the user needs to spray a certain type of main beams, you can select the corresponding file from the folder of the configuration file and display the data in the file to the UI interface.

(3) Generate control command MOD file. The control command MOD file is the file that controls the operation and spraying of the ABB robot. In the file, it is the ABB robot timing, waiting for the delivery chain, switching spray brushes, moving the spray gun to the target position, changing posture and other commands. Through the C++ code written in VS and the parameters in the INI file, the control command is generated, and the command is written into the MOD file. In the original system, the automatic painting program of crane main beams without taking away platform and taking away platform can be generated.

2.2. Functions Optimization
After many times of development, the intelligent painting system can spray many types of main beam, but it still can not completely meet the needs of all the main beam painting in the workshop, and still need to be improved. At present, there are some main girders with spray width and height in the workshop, but because of the end beam welded, the robot can not avoid the end beam to spray, the main beam which meets the requirements can not enter the spraying line for automatic spraying. In view of the above problems, the original program is optimized, and the automatic painting code for controlling the obstacle avoidance of END BEAM OF ABB spraying robot is written on the basis of original code. Figure 2 shows the spraying effect of the main beam with unwelded end beam and figure 3 shows the effect of the main beam with welded end beam, in addition, the end beam of the main beam connected by bolts need not be disassembled, which saves time and cost and makes more main beams meet the spraying condition.

Figure 2. Effect of end beam spraying.
3. System Optimization

3.1. System Optimization Logic

3.1.1. System Program Logic Analysis. This paper is based on the secondary development and optimization of the automatic programming system of the coating line. The logic of the code is as follows.

(1) Initialize the main window and use the Qsettings class to read the key value in the sprayline.ini file where key is name. Find the corresponding configuration files under the data folder in the readWorkParams function, get the corresponding key value according to the array value defined in the code and the prefix name in the configuration files, and initialize the robot parameters.

(2) Four buttons are defined in the interface. When the corresponding button is clicked, the corresponding slot function is executed through the click signal connection, the configuration files is read and written, the parameters displayed in the interface are changed, and the robot spray trajectory is compiled in genCode.

(3) The spraying order of the robot is below-> side-> top-> walk-> walk-> above-> side-> below. Bypass the supporting structure of the main beams when spraying the middle section. Determine the direction of the three axes of the robot coordinate system XYZ, calculate the start and end positions of the robot in each direction, and make the spray gun run according to the predetermined trajectory spacing. The position of the support point of the main beams is calculated, and whether a certain section of spraying process passes through the support point is judged by the IF condition, and the obstacle is avoided.

3.1.2. System Program Structure. There is an ABB robot on the left and right sides of the painting workshop, which sprays the left and right sides of the main beams respectively, so six painting control command MOD files that can be recognized by the robot can be generated in the system, which are generated by four functions that do not take away the left and right sides of the main girder (genLeft/ genRight) and the left and right sides of the main girder (ztgenLeft/ztgenRight). The user's UI interface is divided into five tables, which are the general parameters of the left and right sides, the general
parameters of the left robot, the general parameters of the left robot, the general parameters of the right robot, and the attitude parameters of the right robot. According to the data in the parameters, the position and attitude of each point in the spraying process of the ABB robot can be calculated. The generated control commands are written into the corresponding MOD file through the program, and the file is imported into the robot. The ABB robot will follow the command line in the files to perform the appropriate trajectory operation.

3.1.3. Program Optimization. Add a data in the UI parameter table and INI configuration file to indicate whether the end of the main beam is connected to the end beam, the width of the end beam, and when the end beam is connected, the user can change the value of the ‘End beam width welded on the end of the main beam’ in the form, in mm, according to the end beam width, the new spraying starting point is calculated, and the spraying continues after the main beam is transported by the conveying chain to the starting point. If not connected end beam, then do not input data to the UI, directly choose the type of workpiece to generate MOD file, robot normal spray.

3.2. System Optimization Effect
(1) Running `.exe` program, enter the system graphical interface. After loading the application, click ‘Select workpiece’, select the appropriate crane girder type, the girder length, width, height and robot spray the main girder surface of the attitude parameters read into the program. Depending on the artifact name selected, the name display at the top of the UI changes accordingly, as shown in figure 4.

![Figure 4. System interface.](image)

(2) Click ‘Generate program’ to generate the corresponding MOD file in the folder. The list of files is shown in figure 5.

![Figure 5. List of robot trajectory control files.](image)

(3) The above four MOD files are the left and right side spraying trajectory command files without the platform, the left and right side spraying trajectory command files with the platform, and
ztbcxx10225m-left. Mod with ztbcxx10225m-right. The MOD file is opened in the ABB Shopfloor Editor to transform the ABB Robot’s spray path. figure 6, figure 7.

**Figure 6.** The robot spray path on the left side of the main beam.

**Figure 7.** Spray path of robot on the right side of main beam.

ZTBCXX10225 m-left by comparing the trajectories. The length of the path generated by the mod file in the negative direction of x is equal to the width of the end beam, while ztbcxx10225m-right is shown above. The trajectory generated by the MOD file is withdrawn from the sprayed end face, and the rest of the main girder is sprayed after the conveyor chain reaches the new starting point. From the diagram, it can be seen that the left and right robots have successfully avoided the end beam to achieve the desired effect.

4. Summary
With the progress of science and technology, the country vigorously promotes the development of industrial automation, the development prospects of enterprises often depend on their own level of automation. Through the functional analysis of the painting system, the shortcomings of the system are found, and the end beam obstacle avoidance function optimized by the user’s digital parameterization is further realized, which increases the production efficiency of the company’s painting line, raised the level of automation in the company.

References
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