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Intelligent Weld of Welding Robot

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Abstract. Based on the actual engineering requirements, this paper puts forward a robot weld position tracking based on laser sensor ranging technology, and the laser sensor is installed at the end of the robot welding gun. DTPS off-line programming software pre-programmed path, robot welding gun drives sensor to monitor weld location information in real time. Using the least square method to process the collected data, fitting out the intersection point of the line. The weld line formed by these feature points is projected onto the XOZ plane and YOZ plane, and the projection line is calculated to find the direction vector of the weld. The plane equation of the weld feature point and vertical weld line is written and and the seam edge points are found on the plane. Finding these points on DTPS offline programming software and finishing the welding procedure. The program is exported to the instructor and control robot to achieve intelligently weld.

Introduction

Nowadays welding can been seen everywhere and becomes one of the important technology in modern industry. Robot welding has been widely used in aircraft industry, chemical metallurgy, mechanical manufacture and so on . The quality of welding directly affects product's service life and the beauty of appearance. The items are easily changed by condition such as arc light and high temperature, but robot cannot make adjustment in time which cause the deviation on welding seam, poor quality of welding, and even failure. That brings up automatic welding technology, in which detect the character of welding seam is the key point. This paper presents a method that laser sensor has real-time detection on weld seam location with range finding technology, to ensure robot welding has real-time correction.

Strategy of Intelligently Welding

The experimental system is mainly composed of Panasonic TM1400 welding robot, KEYENCE company's LJ-G200 sensor with 2D function and acquisition card .

Longitudinal detection ranges of The laser sensor are between 45mm and 85mm, the laser sensor laser beam on the workpiece surface to measure the distance and get the data collected in time. The laser sensor is fixed on the welding torch of the welding robot. The height of the laser sensor is dimensioned and the horizontal direction is taken as in the coordinate system of the robot base. Controlling the welding robot to move as a constant speed with a constant height, walking 0.1mm every time in the direction of X axis and recording the data. There are three hundreds laser points. Every time a line is collected, the welding gun returns to the starting point of the line to move 10mm to the Y axis, then walks 0.1mm every time along the X axis to collect the data. Finally we will get the data of the five lines. At first this path planning which can be used to measure the distance can be done with the panasonic offline programming software DTPS, as shown in Fig. 1. The program is shown in Fig. 2.

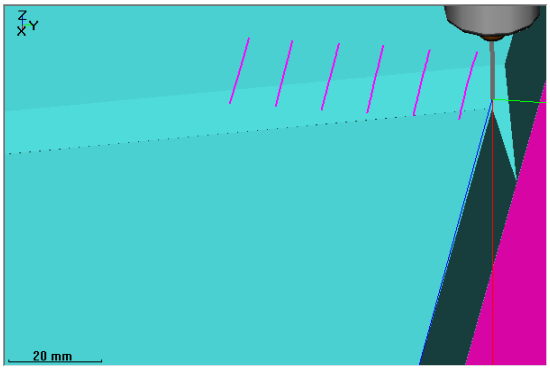

Fig. 1. Path planning simulation

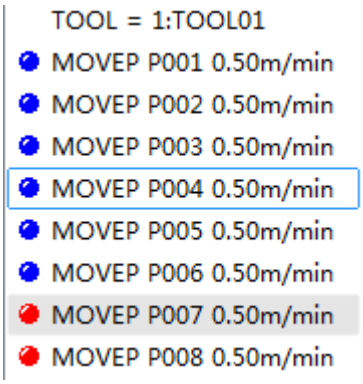

Fig. 2. Path planning procedure

The laser sensor is fixed on the welding gun, moving with the welding gun, scanning the work piece and the workpiece is tilted to a certain angle. The laser sensor communicates with computer by connect via Ethernet, and obtains data in real time. In this paper, LABVIEW is used as program development software to write the data acquisition program, as shown in Fig. 3.The upper machine software sends the data collection instructions in the form of triggered and receives the returned data.

```
#include <windows.h>
#include <utility.h>
#include <userint.h>
#include <stdlib.h>
#include <formatio.h>

#include "AI.h"
#include "Driver.h"



static char proj_dir[MAX_PATHNAME_LEN];
static char file_name[MAX_PATHNAME_LEN];

static int panelHandle;
static int handle;
long ErrCde;
long DriverHandle;
long DevNum=002;
long usChan=0;
float Voltage;
static int control_m=1;
int val=0;
static int num=0;
float data_w[2000]={0};
```

Fig. 3. Procedure of welding data collection

After data collection, using the least squares method to calculate out the weld feature points, the weld line were projected onto XOZ, YOZ plane and we get the linear equation. Finally, the direction vector of the weld expression is obtained. Through this vector and weld feature point, the equation of a plane that passes the weld point and is perpendicular to the weld line is written. Then on the plane finding out some point on the surface of the weld slope, the points become the starting point for the various welding line, the solder joint coordinates input DTPS off-line programming software and finishing the welding procedure. At last the procedure will be export to the teaching apparatus to control the robot moving to welding according to the specified welding trajectory.

Experiment Data and Intelligently Weld

The Original Data of Initial Measurement

During measurement process, measurement mode of the laser sensor was set to trigger mode, then the computer gives trigger instructions to the laser sensor , and sensor measures surface data and returns the distance data. It is important to extract Weld feature points during weld tracking. This paper uses the least square method to deal with the experimental data to fit the lines and obtaining intersection point of the fitting line. Data acquisition of laser weld surface is shown in Fig. 4.

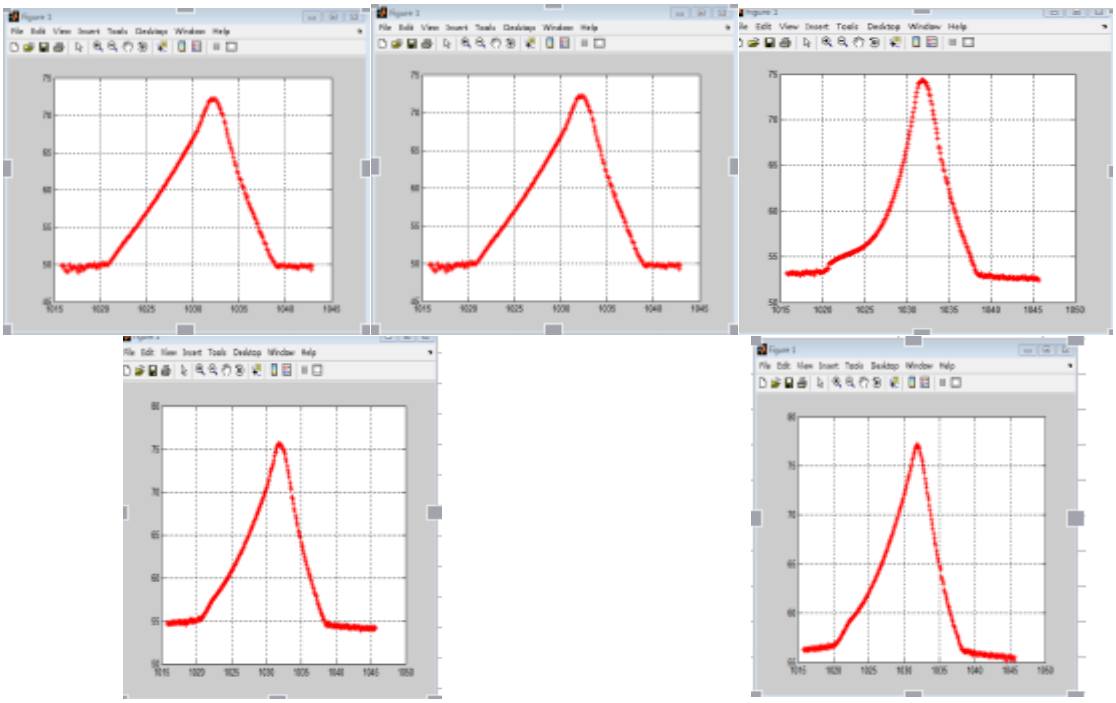

Fig. 4. Surface data of the workpiece

The Extraction of Welding Seam Feature Point and Automatic Weld

The fundamental principle of the least square fitting is to minimize the residual sum of square between all data and estimated points. Certainly, you can use MATLAB to write programs, quickly fitting a straight line, find the straight line equation, and calculate the straight line intersection point. The calculation result of linear parameters as illustrated in Table 1.

Table 1. The linear parameters of welding seam

	A/mm	B/mm
1.1	-1.9407	3031
1.2	3.5204	-2607.2
2.1	-1.8662	2953.4
2.2	3.4941	-2581.5
3.1	-1.8672	2938
3.2	3.5365	2597.7
4.1	-1.7757	2857.7
4.2	3.3448	-2428.1
5.1	-1.7714	2851.8
5.2	3.3734	-2458.8

The intersection point of the line as illustrated in Table 2

Table 2. The intersection coordinates of lines

Points	X/mm	Y/mm	Z/mm
1	1032.429	241.1	1027.36
2	1032.5728	231.1	1026.41
3	1032.33	221.1	1025.29
4	1032.32	211.1	1024.6
5	1032.22	201.1	1023.3135

According to these weld feature points, the linear equation of the weld projection to the XOZ plane and YOZ plane is calculated, and the direction vector of the weld is calculated. Using least square method to solve the projection equation:

XOZ plane $x=0.068709z+961.92$ (1)

YOZ plane $y=10.097z-10133.29$ (2)

So

the weld direction vector= $\vec{n}_1 \times \vec{n}_2$ =0.06871i+10.097j+k (3)

So the equation of a plane that passes the weld point and is perpendicular to the weld： 0.06871*(x-1032.429)+10.097*(y-241.1)+(z-1027.36)=0 (4)

The plane equation is used to find the point of the edge of the seam, and the edge point of the weld is shown in Table 3.

Table 3 Edge point coordinates of seam

points	X/mm	Y/mm	Z/mm
1	1028.429	240.732	1031.34
2	1036.429	240.68	1031.34
3	1026.429	240.548	1023.33
4	1038.429	240.47	1033.33
5	1024.429	240.364	1035.32
6	1040.429	240.26	1035.32
7	1022.429	240.18	1037.31
8	1042.429	240.05	1037.31
9	1020.429	239.996	1039.3
10	1044.429	239.84	1039.3

Then, the DTPS offline programming software can be used to find these points, write programs, and the program is exported to the instructor and control the robot to automatically follow the designed trajectory welding. The program and simulation diagram are shown in Fig.5.

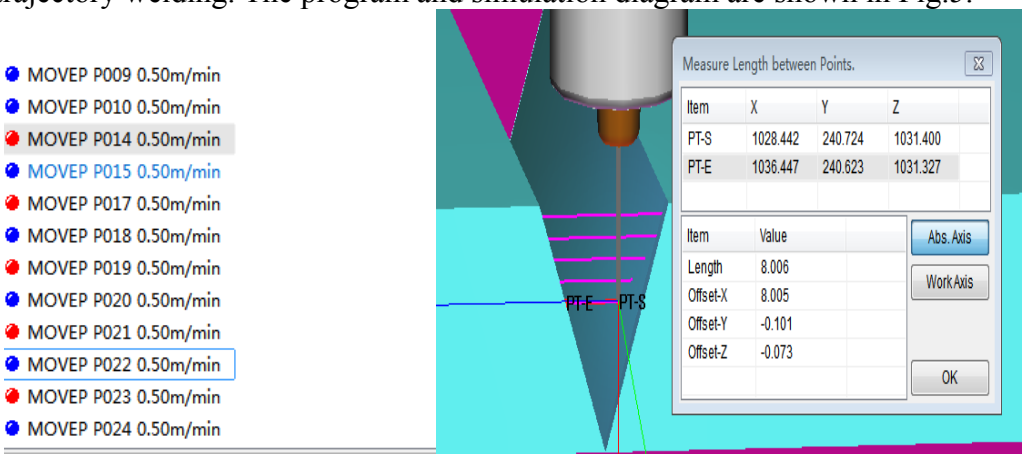

Fig. 5. Welding procedure and simulation diagram

Conclusion

The article establish a system tracking position based on laser sensor ranging and giving a study on the welding information of V groove welds. The welding seam information is obtained quickly and accurately by laser scanning, At the same time the distance data processing is very convenient. Using the least square method to extract the weld feature points, finally find the starting point and terminal point of the welding trajectory. Then using DTPS off-line programming software to directly write welding procedures, without on-site operation. It can not only realize intelligently welding, but also bring great convenience and reduce manual load.

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