LABVIEW Based Simulation on Welding Seam Tracking Using Edge Detection Technique

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Abstract: High performance and precision characteristics in automatic welding technology continues to find a wider application in diverse industries. A welding simulation for seam tracking based on a purpose-built vision sensor is designed to improve the welding efficiency of robotic Gas Metal Arc Welding (GMAW). A shape-matching algorithm is suggested and simulated using graphical device design software LabVIEW to achieve a reliable and precise seam tracking process that is sensitive to groove styles. Relevant modules such as smart parameter setting, image capture and processing, welding expert database, robot communication and route planning modules are included in the software. The main feature of using vision technology is to acquire direct images of the real-time weld path and accurately process them. This is directly linked to seam tracking accuracy. The coordinates for the ABB industrial robot are fed through the profi-bus cable through the use of the Virtual Instrumentation with data acquisition system (DAQ) in NI LabVIEW.

1. Introduction

In modern industrial automation and development, the application of robots in welding is increasing. Teach-and-Playback variety of robots comprises the major type of welding robots. In the phase, welding process needs many variables, such as pre-machining oriented defects, work-piece fitting, and thermal based distortions, that result in changes in both gap size and seam location. In welding process, such subtle changes would seriously affect the quality of the welding joint. But these teach and playback robots cannot meet our requirement of both quality and diversification. This makes clear that real time seam tracking system creates a major issue. Compared to the off-line teaching model, seam monitoring saves time and achieves improved welding efficiency. Inductive sensors, ultrasonic sensors, electromagnetic sensors and vision sensors are the sensors used to achieve an on-line seam tracker. Among them, due to its high accuracy, fast speed, and non-contact nature, the vision sensor is the primary choice. The vision sensor continuously collects images of the weld seam during the welding process and extracts the geometric characteristics of the weld seam using optical image processing algorithms [1].

For practical use, most early vision-based robotic welding systems have been demonstrated to have minimal functionality and versatility. Effective implementation of the method includes the use of a high performance laser spot scanner that is very resistant to arc glares, metal radiation, reflection of metal surface laser light, and the welding fumes [2]. Owing to the unavoidable presence of the moving parts in scanning the laser spot beam, laser spot scanners are typically bulky [3]. The visual sensor used in robot welding seam
tracking is primarily divided into two groups, according to the light source used in image gathering: passive vision and active vision. In robotic seam monitoring, the passive vision system is cheaper and can get sufficient seam details [4][5]. The main component is a dimmer-filter system based on vision sensor robotic welding. The robotic seam tracking welding system is composed of an industrial robot, a vision sensing system, a power supply for welding and an industrial personal computer [6]. Robot based welding arms have been recently developed which can be used for multipurpose like welding, physiotherapy, material handling etc., [7]. Few welding applications have been done with the help of multi axis servo mechanisms [8].

2. Problem definition

Programming for the different welding path is difficult for the different size. To reduce the complexity in the robot programming, the coordinate values for the robot is send through the LabVIEW software. The profibus cable is used to transfer the co-ordinates. The major drawbacks of this system are programming for variable size, time consuming for the robot programming, and need for skilled labor.

3. Proposed system

In the proposed system, the co-ordinates value will be generated throughout the machine vision system and send to the ABB industrial robot through serial communication. So, the process and programming can be easily compared to the convectional method. The accuracy also is improved by the edge detection through LabVIEW software. The objective of the paper is to eliminate the practical difficulties involved in the process of robot programming and also to make the process much easier than existing conventional manual process. The robot arm is fitted with welding torch in the end effector. The machine vision camera has been placed in the respective place for the seam tracking. The vision camera takes an image 20 frame per second and stores in the system. According to that the coordinates has been generated and send it to the ABB industrial robot. VI package help us to interface the LabView and ABB industrial robot. So the 6- axis robot moves according to the coordinates.

4. Methodology

The methodology starts with literature survey suitable cost-effective working method selected. The new material to be welded is SS304L, Algorithm for the edge detection have been developed using LabVIEW. The developed algorithm generates the coordinates and sent to industrial robot through profibus cable and VI package helps to interface the LabVIEW and industrial robot.

Figure 1 shows the flow chart representation of the image processing technique used in this process. The vision camera capture the work piece image and found the edge by scanning the left to right and top to bottom. Hence the top edge corner is found and if we do vice versa the bottom edge corner will be found. So the offset value is set in the program. The generated coordinates will be sent to the industrial robot through VI package [9][10].

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4.1 Seam tracking system

LabVIEW programming platform is used to develop the seam tracking system consists of image processing mechanism under machine vision. ABB robot control mechanism is used for motion control of ABB robot. These four parts is divided into further smaller modules. Thus, the entire software flow architecture is shown in Figure 2. State-machine architecture used in this system is a different programming language with three concepts involved like state of operation/program, an event occurrence, and the action as response/reaction.

![Software Architecture of seam tracking system](image)

**Figure 2.** Software Architecture of seam tracking system

4.2 Vision Camera (C310)

The specs are HD image capture with recommended system capturing images till 5 megapixels as software enhanced mode with hi-speed USB 2.0. With these, universal clip-fits laptop, LCD/ CRT monitors are connected.

4.3 Experimental Setup

Figure 3 shows the seam tracking for MIG welding using industrial robot. The time is reduced for programming and production is also increased in industries due to the structure of programming analysis.

![Experimental setup for weld seam tracking with ABB robot](image)

**Figure 3.** Experimental setup for weld seam tracking with ABB robot
The welding experimental set up is interfaced with the ABB robotic arm as shown in Figure 3. Robot is configured initially with teach pendant mechanism. A machine vision camera which is interfaced with LabVIEW programming platform is used for weld seam tracking. Usually, the camera system has intrinsic and its extrinsic observation parameters. They include focal length, principal focal point, distortion parameters, and camera position. There must be a traditional way to calibrate the camera done by matching every the corner point with the corner points of the acquired image. The front panel pellets in the GUI programming window consists of coordinates for on/off controls of the program. The LabVIEW program will generate the coordinates according to the program offset value and is set in the Virtual Instrument (VI) program for the welding path.

5. Results and Discussion

The program for the seam tracking is done in the LabVIEW environment. LabVIEW platform is the area which is a Graphical User Interface (GUI) is seen as a programming platform in Figure 4. The analysis of image acquisition follows a series of programming sequence in state machines architecture. They are,

1. Initialization
2. Start of program
3. Image acquisition
4. Threshold
5. Particle filter
6. Left Edge detection
7. Top edge detection
8. Offset calculation Centre Line calculation
9. Stop of program

In the initialisation process, the process requests raw input data from the use., This is the command to initialise or trigger the welding process. The moment it is triggered, the process acquires a profile data (2D) and transfers it to the acquisition system. Figure 5 represents the initialisation of the constant and assigning of controls to the constants for processing. Figure 6 represents the case which starts the program after it gets the control in the front panel. Figure 7 shows the case which acquire the image from the camera and upcoming cases help us to find the edge.

The acquired data is processed to identify some important features like edges of the weld joint. The extracted features sends a command to the robot arm on movement to its next position. Then the robot sends back the 3D coordinate details to the state machine architecture, used as a command trigger to the Extract features. This cycle of operation is repeated until the full scan is acquired/completed.

Figure 4. Graphical User Interface(GUI) for Seam Tracking
Figure 5. Initialize and Assign Control Data Case GUI

Figure 6. Start of the process GUI

Figure 7. Image Acquisition GUI
Figure 8 shows the threshold case which helps to get the clear image by replace nearby value of 255. And Figure 9 shows the particle filter utilized to improve or change the image of the object. Figure 10 shows the range to detect the left side of the object in order to find the corner. Edge and Line option in the program helps to find out the left side.

The unexpected data can directly affect the welding position/coordinates between each sample data acquired and this consequently affects mechanical properties in the weld process. Thus a suitable filtering method must be applied to eliminate this process in the extracted points.
Figure 10. Left Edge Detection GUI

Figure 11. Top Edge Detection GUI

Figure 11 shows to detect the top side of the object to find accurate corner. This edge and line option helps to find out the top side of the weld image in order to find the corners.

Figure 12. Offset Calculation GUI
Figure 12 shows the case after found the corner the offset value is setted to weld the weld path absolutely.

![Figure 13. Centre Line Calculation GUI](image)

Figure 13 shows to gives the value of coordinates. Those values are fed to the industries robot for weld path.

![Figure 14. Stop of the Program GUI](image)

Figure 14 shows to stop the program manually by using the front panel option.

![Figure 15. Deleted image](image)

The detected image shown in Figure 15 give coordinates values in array type and those values are sent to the industrial robot acquisition system. The robot end effector moves along the weld path. Figure 15 shows the
values of the coordinates and detected image. Thus it can be stated that the state machine algorithm overcomes
the effect of missing data areas/regions and extracts the feature points to a highly satisfactory level

6. Conclusion
This paper shows the simulation for seam tracking. It reduces the time for programming in the ABB robot which
will be use in industries for mass production. For any type of groove the edge detection technique will find the
co-ordinates hence the seam tracking system is much easier than compared to conventional method. The noises
in the image are also reduced because of the VI programming. Vision assistant helps to increase the contrast,
resolution and threshold so that accuracy is also high. Artificial Intelligence will be the future scope which
should help us to calibrate the displacement automatically. IoT will also be implemented using the mobile phone
the industrial robot will be operated.

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