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Coordination of dual Arm Robot using 3-D Vision Sensor

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Abstarct: A robot system is proposed to realize coordinated motion of two arm robot. Due to a 3-D vision sensor, precise coordinated motions could be realized. Using a sophisticated IC chip, real time image processing could be executed using a simple circuit.

Key Words:Coordination, Duar arm, Arc welding,Vision sensor

1. Introduction

In the case of welding a complicated workpiece, coordinated motions of the welding torch and the target work are desired in order to assure the welding quality. This coordinated motion resembles a work done by a skilled welder who moves his left hand holding a workpiece so that a gradient of the welding line with respect to the ground will become constant and at the same time moves his right hand holding the welding torch so that the torch position and the tip speed of welding torch relative to work piece will become constant.

In order to realize the coordinated motion of a dual arm robot,improvement of precision and rigidity of the robot is necessary. However, coordinated motion can be realized without any improvement of precision and rigidity of the robot if some sensors are employed. Force sensors and vision sensors are effective ones.

In this paper we present one method to realize a coordinated motion of a dual arm robot using a 3-D vision sensor. The principle of this 3-D vision sensor is based on the slit-ray projection method. This sensor is mounted on the tip of one arm robot. This sensor detects the geometrical relation between one arm and the other arm. The dual arm robot considered here is composed of two industrial robots, one robot moves the welding torch and the other robot moves the workpiece. Image processing is executed by a sophisticated FPGA(Field Programmable Gate Array). Due to this sophisticated IC chips and a computer board, 3-D information of the robots can be obtained. The 3-D information is transferred to the robot controller and desired coordinated motions are executed.

Experimental results reveal the applicability of our system.

2. System Configuration

Configuration of our robot system is shown in Fig.1. One manipulator holds the welding torch and the other grasps the workpiece through the gripper. On the manipulator holding the torch, a 3-D vision sensor is mounted to detect the position and the posture of the

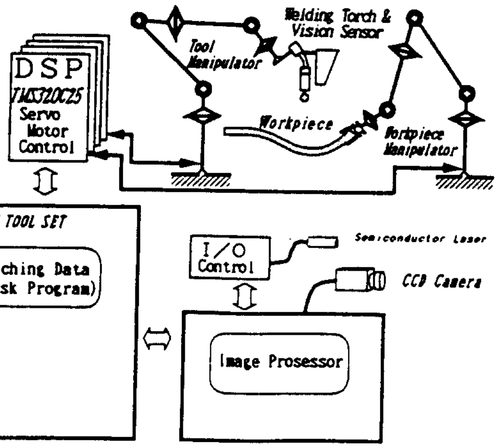

Fig.1 System Configuration

welding groove.Data obtained by the 3-D vision sensor is used to modify the teaching data so that the intended coordinated motion can be realized. In order to enhance the computing performance of the controller of two robots, parallel data processors(Inmos Transputer) are employed. Control data calculated by parallel data processors are sent to the servo motor controller equipped with DSP(Digital Signal Processor:TMS320C25).

For the coordinated motions, relative geometry between two robots is essential. And the absolute position and posture is not essential. The following relation is important.

(worldXtool)=(worldXwork)(workXtool) (1)

where (worldXtool) is the transformation matrix from world coordinate system to tool coordinate system settled on the welding torch, (worldXwork) is the transformation matrix from world coordinate system to work coordinate system settled on the workpiece,(workXtool) is the transformation matrix from work coordinate system to tool coordinate system.

In the coordinated motion of the arc welding, the relative position and the orientation between the torch and the workpiece (workXtool) is specified. Therefore, if movement of the workpiece (worldXwork) is specified by the operator, movement of the torch (worldXwork) is determined consequently from Eq.(1).

3. 3-D Vision Sensor

A 3-D vision sensor is mounted on the tip of the torch manipulator as shown in Fig.2. One semiconductor laser projects slit-ray on the welding groove on the workpiece.Images are fetched by a CCD camera and processed by a real time image processor. The real time image processor is composed of a FPGA(Field Programmable Gate Array:Xilinx XC4003) and a CPU(80386) as shown in Fig.3. Due to the feature of the FPGA, a logic circuit to deal with 8-bit image data can be realized. The function of the programmed FPGA is to detect the most bright pixel at every

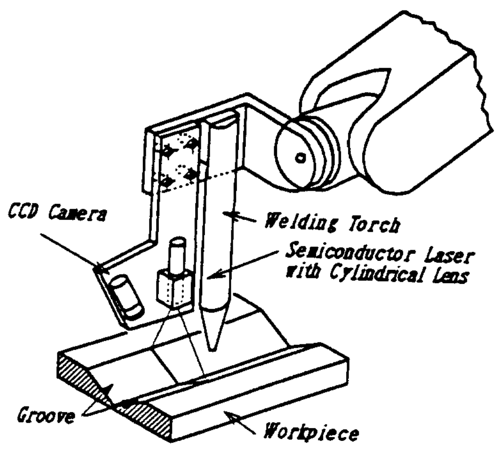

Fig.2 3-D Vision Sensor

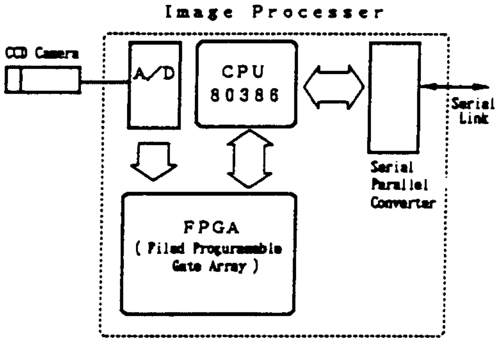

Fig.3 FPGA in the Image Pressor

horizontal scanning. Therefore, FPGA send the coordinate u and the intensity at the most bright pixel to the CPU(80286).

Fig.4 shows one typical example of the image data obtained by the TV camera. By the data processed by FPGA, the CPU(80286) estimates two lines and crossing point as shown in Fig.5. From these two lines or three points A,B,and C, the position of the welding groove can be determined. Also the posture of the welding groove can be determined analyzing the time variation of the slit-ray image. Of course,movement of robots need to be considered since the movements of robots effect the image.

Due to the employment of the real time image processor, the robot controller receives 3-D information 30 times per one second.

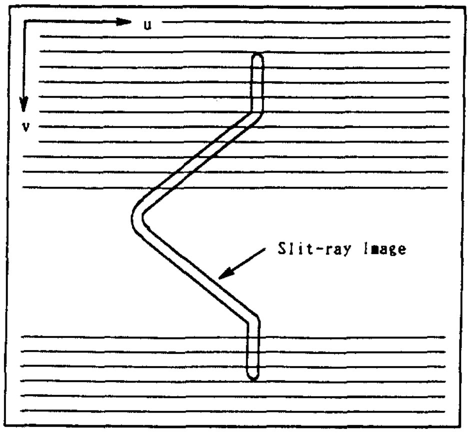

Fig.4 Example of Slit-Ray Image

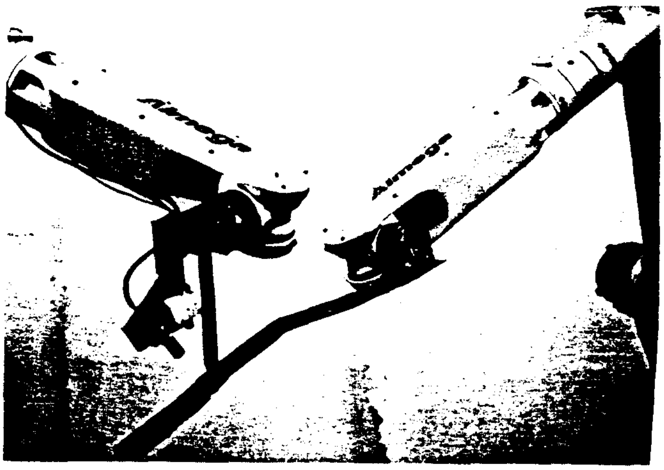

Fig.6 Dual Arm Robot

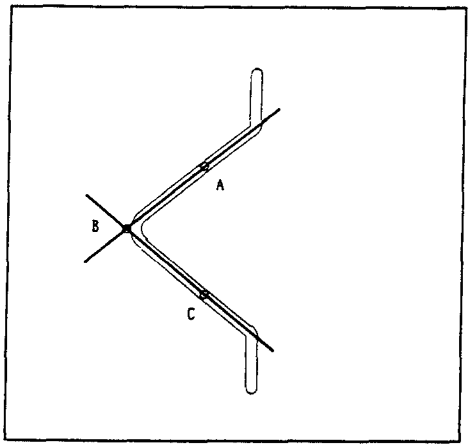

Fig.5 Extracted Data from Slit-Ray Image

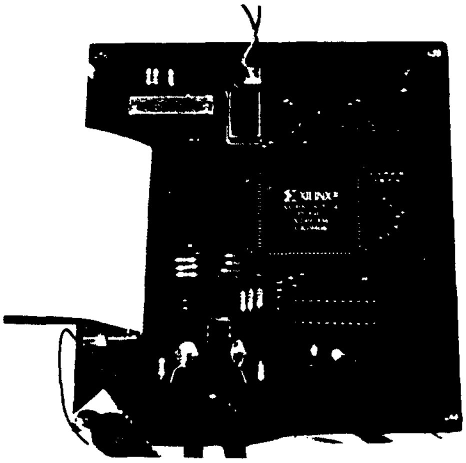

Fig.7 Image Processing Board

4. Experiment

we had a experiment, where the workpiece was a twisted material. Two points on the workpiece were specified as a starting and ending point of the arc welding. Two robots moved so that the relative movement generated the desired coordinated motion.Fig.6 shows the overview of the robot system. Fig.7 shows the image processing board. Due to the FPGA, only a few IC chips are enough to extract essential information from the slit-ray image.

Fig.8 shows the logic circuit programmed inside the FPGA. The logic circuit is composed of some basic blocks, like counter,comparator, latch and so on.

5. Conclusion

Employing a 3-D vision sensor, coordinated motion of two arm robot can be realized. Features of the 3-D vision sensor is that real time image processing is possible by employing the FPGA. In the experiment, we confirmed that the 3-D vision sensor is effective to realize precise coordinated motion.

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