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A NOVEL CONTROL SYSTEM FOR ROBOTIC DEVICES

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ABSTRACT

It is difficult to find an autonomous robot capable of performing certain services in a real environment. One advantage of a robot is its ability to accomplish many of the tasks entrusted to him with high efficiency compared to that of humans. This paper aims to design and implement a robot system which has the ability to route traffic through a specific route and move with discretion through a place in so many forms, classified and put in place every time. A field programmable analog array (FPAA) technology has been used in building the proportional-integral (PI) controller system on the route of the robot in addition to the use of this technology in the programming the movement of robotic arm used to pick up the required objects. The proposed robot system underwent many tests, which showed the possibility of movement and it completed the required tasks with high accuracy according to the path planned..

Keywords: *Robot , FPAA, PI Controller, Driver Circuit, Path Tracking, Arm Controller.*

1. INTRODUCTION

The recent rapid progress in robot technologies has led to great expectations for mobile robots to be applied in various fields such as industrial robots, guard robots and home robots. Rescue activities at disaster sites, inspection works at hazardous environments and planetary explorations are dangerous tasks for human workers and a tele-operated mobile robot has been tried to execute such kind of dangerous tasks instead of human workers [1]. Because it is still difficult to develop autonomous mobile robots that function well in real environments with current robot technologies, a system structure where a human operator remotely controls a robot is one of realistic solutions that works well in real environments [1]. The dynamic equation of a robotic arm is considered in paper [2]. Based on sensor signal feedback, a PID control is designed for the arm to achieve the desired position. The papers [3] and [4] established a simulation system of the robotic arm so that the coordinates of each joint can be computed by the simulation system. Thus, the arm can be controlled to track an assigned trajectory. The reference papers [5] and [6] calculated the magnitude of the torque for each joint of the robotic arm when the arm grabs an object Using PA-10 robotic arm made by Mitsubishi company as a platform, the paper [7] proposed a concept of a harmonic drive model to investigate the gravity and material influence on the robotic arm. Moreover, the robotic arm is controlled to track a desired trajectory and the motion error is analyzed. A two-link robotic arm is controlled by a fuzzy sliding mode controller in which the parameters are adjusted by fuzzy-neural techniques [8]. Line tracking is a basic method in the field of mobile sensors attached to the bottom of a robot detect a signal from a path on the ground using various types of sensing technologies such as electric inductance, magnetic field, radio frequency identification, vision system, and others. It offers an advantage as it provides proven technology of line tracking- based locomotion, but it also has a weakness that results from the limitation of the fixed track robots itself [9]. Many of the solutions were provided for the application of a digital, control system for robotics used by the DSP chip FPGA or Microcontroller while requiring systems of modern high precision in performance, ease of design and construction, and the consumption of a small capacity; and these specifications are available together in the system of proposed robot system that use FPAA technology.

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The paper is organized as follows: in section 2, the system structure is presented and section 3 concludes the paper.

2. SYSTEM STRUCTURE

There are two parts in the proposed system structure, one is the computer system and the other is the robot system. The computer system deals with the picture capture, image processing and decision making. The robot system includes the Path tracking system, a robotic arm, the FPAA-controller, servo system design, driver circuit and sensors as shown in Fig.1.

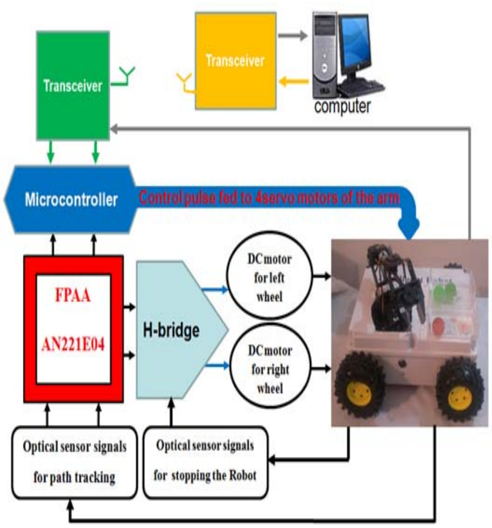

Figure 1 System Model

2.1. COMPUTER SYSTEM

In the computer system, there is a micro-camera set on the body of the robot, in which the image is captured. Those images are the environment around specific objects which may contain color pattern . An image recognition system regulates the location of the robot to trace the object and identifies the location of the object from the real-time image, respectively. The micro-camera is with the size 1.5cm x 2.5cm x 3.5cm and the weight 50g. The control center is a laptop computer which takes charge the images processing and pattern recognition, decision making and then sends a command to the robotic arm through FPAA Controller.

2.2. THE ROBOT SYSTEM

2.2.1. CONTROLLER

AN221E04's were used to implement the controller model. FPAA consists of four configurable analog blocks, each of which contains op-amps, a comparator, and switched-capacitor arrays, integrated with an analog switch fabric. Configurable analog modules, such as inverters adders, multipliers and integrators, are implemented easily due to system/block level design instead of transistor level design. The analog circuits are fully differential within the chip, but differential-to-single/single-to-differential ended chip converters are provided on the evaluation board that hosts the chips to access the outputs/inputs of the chips respectively as shown in Fig. 2 [10].

Controllers are the most important components in a robot system. If a robot has n joints, n controllers are needed to control all joint actuators. The design of robot controllers is to solve the problem how robot actuators are driven to achieve a desired performance. In the proposed robot system, there are a FPAA-Controller (AN221E04 module), Sensors, a Power Supply, and a Transformation Interface. The main tasks of the AN221E04 are to control the rotation degrees of the robotic arm, give the motion command to the wheeled robot's wheels, and communicate with Laptop computer.

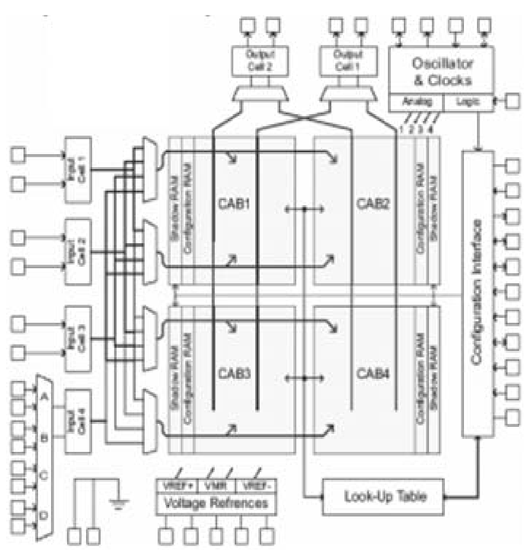

Figure 2 Block diagram of AN221E04 FPAA

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2.2.2. DRIVE CIRCUIT SCHEMES

Physical motion of some form helps differentiate a robot from a computer. It would be nice if a motor could be attached directly to a chip that controlled the movement. But, most chips can't pass enough current or voltage to spin a motor. Also, motors tend to be electrically noisy (spikes) and can slam power back into the control lines when the motor direction or speed is changed. Specialized circuits (motor drivers) have been developed to supply motors with power and to isolate the other ICs from electrical problems. A very popular circuit for driving DC motors is called an H-bridge. It's called that because it looks like the capital letter 'H' when viewed on a discrete schematic. The great ability of an H-bridge circuit is that the motor can be driven forward or backward at any speed, optionally using a completely independent power source. One driver circuit for each motor on the robotic is used. These drive circuits are needed because the control system does not supply enough power to drive the motors directly as shown in Fig. 3.

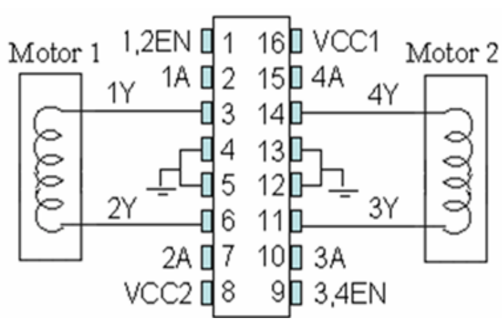

Figure 3 H-Bridge circuit L239D for DC motors

2.2.3. PATH TRACKING

Path tracking circuit of the proposed system consists of a pair of sensors as shown in Fig. 4. One is used to sense the right side while the other is used for the purpose of sensing the left side of the robot system. The output signal of these sensors is fed to the PI controller, which was designed and implemented using FPAA techniques for the purpose of the rerouting of the system on an ongoing basis, as illustrated in Fig. 5. The track is created on a white reflective surface. White shiny tape can be used. A black line is created with electrical tape (optically absorbing.) The contrast between the white background and the black line should be large enough so that the line sensor can easily determine if the robot is over white or black.

2.2.4. SENSORS

In order to provide feedback of the robot's positioning in the maze, three Opto-Reflector sensors will be mounted on the robot. Two will be mounted slightly off-center in the front of the robot, and one will be mounted 1.5 inches from the center along the front curve of the robot. The middle two sensors will be used to detect the path the robot is following, and the outside sensor will be used to detect intersections.

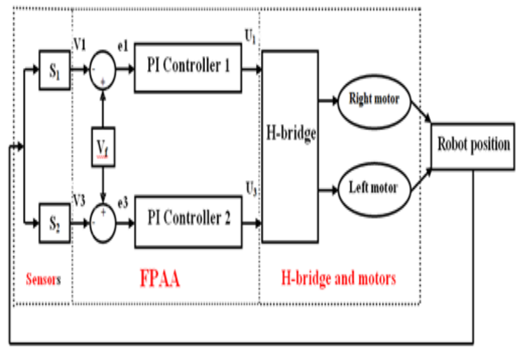

Figure 4 Path Tracking Robot Control System Block Diagram

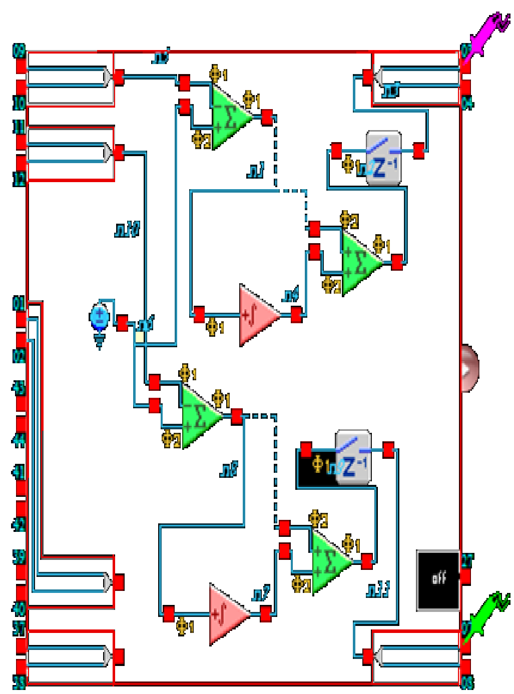

Figure 5 PI Controller FPAA Circuit

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Finally, the hardware structure of the robotic arm is produced. The arm has three links with four motors. There is a servo motor at the base, which allows for structure; another at the shoulder which allows circular movement of the whole upward and downward movement of the arm; while the last servo motor at the wrist allows for the picking of objects. All motors are HS-422 servo motors with an operation voltage of 5 V. The maximum length of the arm extension is 34 cm and each link's length is shown in Fig. 6. The first and second links have one degree of freedom each while the third line and the end e ector have two degrees of freedom. The controller were trained to control three of these, i.e. the angle of rotation of the first link, and the angles between links 1 and 2 and links 2 and 3. These three degrees of freedom were su cient to allow the controller to reach target positions in the space directly in the front. Fig. 7 shows the FPAA controller circuit used to control the arm motion. The target is placed in the reachable space of the robotic arm, and the obstacle is centered around the midpoint of the line joining the end e ector and the target so that the robot has to avoid obstacles for every training example. The target set was chosen so that all targets were within the robot's reach space. The obstacles were placed directly on the path between the end effector and the target so that the controller move the arm around them.

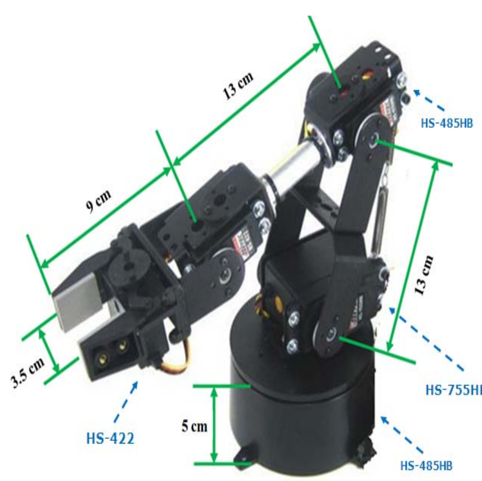

Figure 6 Arm Specifications

3. CONCLUSION

This paper has presented an alternative solution for controlling robotic arm using FPAA technology. More than one novel feature has been discussed which would make this robotic arm robust. First, the controller is designed by using FPAA to operate all the joints, second the PI controller which was designed and implemented using FPAA techniques. The experimental results show the effectiveness of the proposed system in addition to the ease of programming control systems that are designed and implemented using the FPAA techniques to control the movement of the robot in addition to control the movement of the robotic arm. It has become easy to program the system to be used in completing many different tasks quickly and easily.

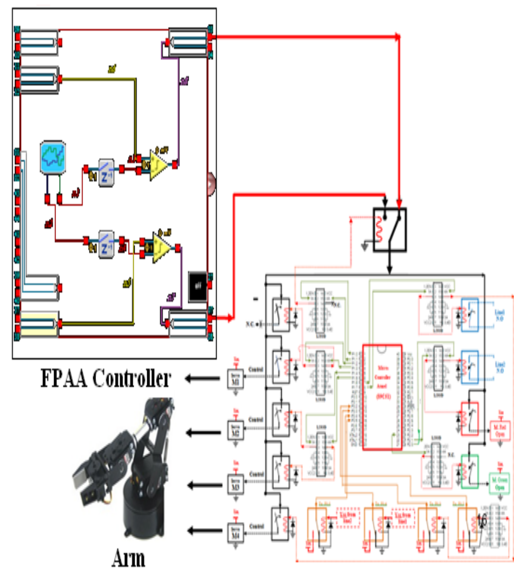

Figure 7 FPAA controller circuit used to control the arm motion

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