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DESIGN AND IMPLEMENTATION OF AN FPGA BASED MOVABLE ROBOTIC ARM CONTROLLED WITH A MOBILEAPPLICATION

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ABSTRACT

The design and development of an FPGA-based movable robotic arm system with object identification capabilities and mobile application integration are presented in this paper. The main goal is to develop a versatile and effective proto type movable robotic arm that can be operated via user-friendly mobile interface and has real-time application in agriculture field.The robotic arm's control logic is implemented through the use of a Field Programmable Gate Array (FPGA),which is advantageous due to its high processing speed and reconfigurability. Accuracy and reactivity are guaranteed by the FPGA, which controls the arm's exact movements. The control interface is with a smart phone application that gives users easy-to-use in the field. The robotic arm is outfitted with an obstacle detection module that uses an infrared sensor in order to facilitate autonomous operation. The robotic arm can carry out operations like weed, fruit cutting in the agriculture field.

Keywords: FPGA-Based Robotic Arm, Mobile Application Integration, Object Identification, Agriculture Automation, Obstacle Detection

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I.INTRODUCTION

The necessity for automation in a variety of industries has accelerated the development of robotic systems in recent years. Particularly, robotic arms have found extensive use in residential, industrial, healthcare, and logistical settings. While successful, microcontroller- based systems are frequently limited in terms of processing speed, adaptability,and scalability when it comes to traditional robotic arms. This work investigates the design and development of a robotic arm system based on FPGA that is coupled with a mobile application and has a capability of cutting weed, fruits etc., and also obstacle identification in the path.

Real-time item identification further improves the system's capabilities by allowing autonomous task execution, such as object selecting, sorting, and placement without the need for human intervention.The system gains from high-speed processing and reconfigurability by using a Field Programmable Gate Array (FPGA) for the control logic. This is necessary for accurate and responsive arm movements. The smart phone application is a crucial part of the system and acts as the control interface. This program makes it simpler for users to handle the robotic arm by offering real-time feedback and straightforward controls.

Moreover, the robotic arm can recognize and communicate with items in its working environment on its own thanks to the object detection module,which uses in frared sensors.The flexibility, speed, and autonomy of the proposed FPGA-based robotic arm system are significantly higher than those of its conventional microcontroller-based counterparts. According to experimental results, the FPGA-based control system improves user interaction through the mobile application in addition to achieving improved performance and reliability. This novel fusion of object identification, mobile applications, and FPGA technology creates new opportunities for sophisticated robotic systems with potential applications in both home and industrial contexts

II.PROPOSEDS YSTEM

Using an FPGA, the mobile robotic arm is intended to automate agricultural jobs including picking fruits, leaves, and grass. An Android handset is used to control the robotic arm wirelessly through Bluetooth connectivity. The motors that drive the arm's movement receive precise control instructions from the FPGA after it has processed inputs from the smart phone app. The arm can rotate and move in many directions (up, down, left, and right), platform can move forward and backward directions to perform delicate tasks needed in farming, such as plucking fruits and pulling weeds. Improving efficiency and precision. With real-time control viaFPGA and wireless operation,farmer scan remotely operate the arm in hard-to-reachareas. Its innovation lies in wireless communication, programmable functionality and cost- effectiveness with scalable capabilities for diverse farming needs.

The use of numerous DC motors is arm and platform moments, Verilog programming on the FPGA is used in the construction of the control system, providing great accuracy and real- time responsiveness for intricate agricultural tasks

III.LITERATURE SURVEY

1. Creating a robot arm motion control integrated circuit (FPGA). A new generation of field programmable gate array (FPGA) technology makes it possible to combine an application and an embedded processor(IP) in to a system-on-a-programmable-chip(SoPC)environment.This work presents a motion control integrated circuit for a robot arm that is based on the SoPC environment. Two IPs are available for the FPGA-based motion control IC: an application IP and a Nios embedded processor IP. Point-to-point

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motion control, inverse kinematic calculation, and command generation are all

2. control functions are carried out by the application IP.

Because of the complex control method and low sampling frequency control(lessthan100 Hz),the former is implemented by software. Because the latter requires simple calculation

3. AnFPGA-BasedTwo-Phase Stepper Motor Driver Analysis.To accomplish motion control at a high speed and precision, programmable logic and a flexible algorithm will be required from the controller.This paper describe show to divide a step in to micro steps with the necessary resolution for a stepper motor to improve positioning accuracy. It also explains how to design and implement a micro stepper motor driver that has a field programmable gate array (FPGA) at its core. With a built-in sine/cosine look-up tablein the FPGA, the sine/cosine micro stepper approach is used in this work to precisely and uniformly change the current in

New FPGA-based stepper motor controller with hardware implementation A new stepper motor controller with impressive performance is proposed in this study, based on field programmable gate arrays. To accomplish both fast speed and great precision on a small hardware foot print, the system combines programmable logic with an innovative algorithm.[6]

Creating a robotic arm controlled via Bluetooth using an FPGA, Arduino, HC-05Bluetooth module,L293 D motor driver,and DC motors involves several components and steps. Here's an overview of how the system works.

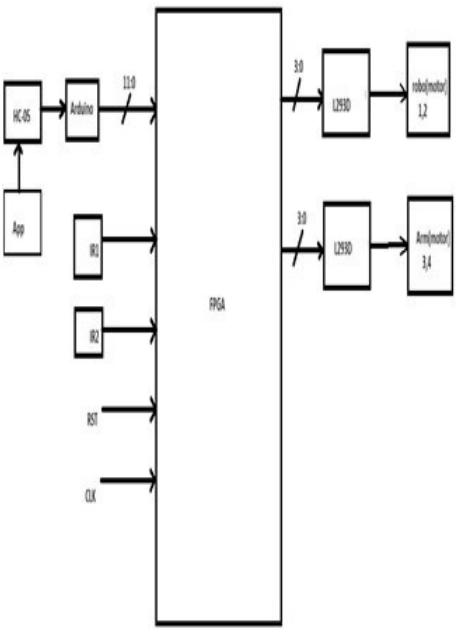
The field programmable gate array serves as the brain of the robotic arm. It processes the signalsreceivedfromtheArduinomoduleandsen dscontrolsignalstotheL293Dmotordriver to move the DC motors accordingly. The logic for controlling the arm, including the direction of each motor, is written in the Verilog and uploaded to the FPGA.

handled by the Nios processor. The robot arm's five-axis position but high sampling frequency control (control loop: 1 kHz, PWM peripheral circuit: 4/spl sim/8 MHz), hardware is used to implement it. Finally, an experimental setup has been assembled, and a few experimental findings are presented.[2]

each winding of the stepper motor, resulting in exact micro steps.

Additionally, detailed designs for the hardware and software are suggested in order to precisely control the motor's currents. To confirm the efficacy of the suggested approach, an FPGA logic simulation for the realization of micro stepper functions has been finished. [5]

IV.BLOCKDIAGRAM EXPLANATION AND WORKING



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The HC-05 module is used to establish wireless communication between the Arduino and a smart phone or another Bluetooth-enabled device.Commands like forward,left,right,back,half second left & right, drop, pick, up_arm, down_arm are sent from a smart phone app or a computer to the FPGA via thearduino,HC-05.These commands typically to FPGA about the desired movements of the robotic arm.

The L293D is a dual H-bridge motor driver IC that can control the direction of two DC motors. For more motors, additional L293D ICs can be used. Based on the signals from the fpga, the L293D drives the DC motors, enabling them to rotate in the desired direction.

The DC motors are connected to the joints of the robotic arm. When powered, they rotate to move the arm's joints, allowing for various movements like lifting, lowering etc.

The Fpga can be powered via USB or an external power source (e.g., a 9V adapter). The DC motors require more power, usually supplied by a adapter connected to the L293D. How it works

Bluetooth Connection:The HC-05 Bluetooth module is paired with a Bluetooth-enabled device (like a smart phone). Once paired, commands can be sent wirelessly to the FPGA.

Command Reception: The FPGA receives these commands through its serial pins connected to the arduino & HC-05 module.

Processing Commands: The FPGA processes the in coming commands,determines which motors need to be activated, and sends corresponding signals to the L293D motor driver.

Motor Activation: The L293D, upon receiving signals from the Arduino, controls the flow of current to the connected DC motors.This causes the motors to rotate in the required direction, moving the arm's joints.

Arm Movement: The robotic arm performs the desired movements based on the rotation of the DCmotors. The precise movement depends on the timing and direction of the motor rotations.

V.HARDWAREREQUIREMENTS

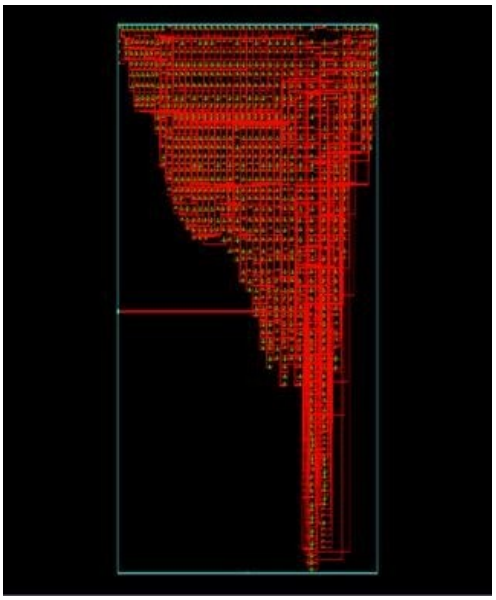
1.FPGA (Spartan3A)
2.DC Motors4 No's (Typically used to control the joints of the robotic arm)
3.L293 Driver IC 2No's
4.IR Sensors 2No's
5.HC-05is a Bluetooth module
6.Arduino Uno
7.Arduino Uno Bluetooth control Mobile App
8.Power Supply (For both Arduino and motors)
9.Wires and Bread board
10.Arm body with blades

VI.SOFTWAR EREQUIREMENTS

1.ILINXISE
2.Programming Language.
3.Design Simulation
4.Generating Bit stream for ElbertV2

VII.OUTPUT

RTL SCHEMATIC



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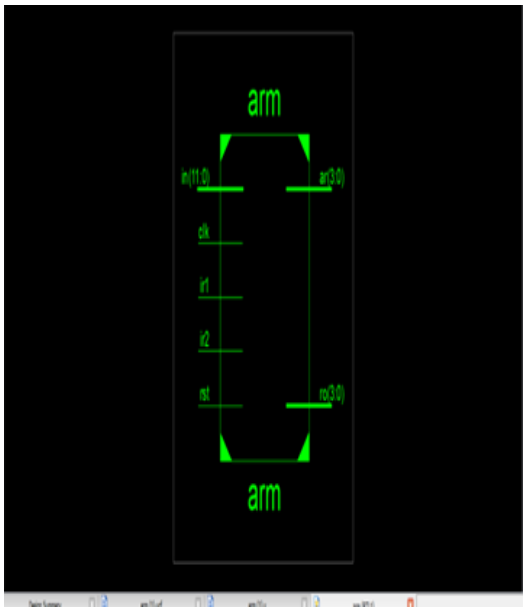
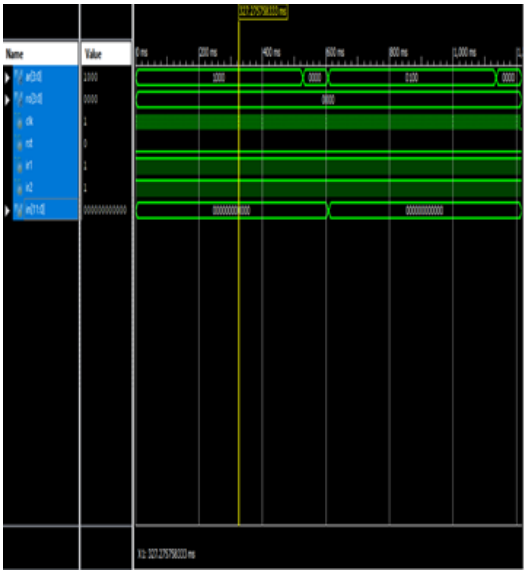
TECHNOLOGY SCHEMATIC



SIMULATION OUTPUT



VIII.CONCLUSION

This study showcases the development of an FPGA-based robotic arm system with object identification and mobile app integration for agricultural tasks. The system aims to create a versatile and efficient robotic arm operated through amobileinter face,offering real-time object identification. The FPGA ensures precise control, high processing speed, and flexibility compared to traditional microcontroller-based systems.The integration of object identification, mobile apps, and FPGA technology paves the way for advanced robotic solutions with in creased autonomy and performance in various sectors. Future research could focus on enhancing the system with additional sensors and improving the mobile app interface.

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