

Real Time Control Communication for Robotic Arm Application by using Arduino Uno

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ABSTRACT: This article offers a project to format The “**Real Time Control Communication For Robotic Arm Application By Using Arduino Uno**” aims to demonstrate how real time communication can enhance the responsiveness, precision, and coordination of robotic arms. It also highlights the potential of Raspberry Pi as affordable alternative to industrial controllers for automation, research, and educational application. Robots are increasingly being used in manufacturing , packaging material handling and inspection tasks performs industrial automation. This system is designed for it combines important concepts in robotics, control systems and networking in a practical, hands on way. It is also flexible and relevant in industrial application.

KEYWORDS: 6 DOF; robotic arm; computer control system; give instruction to robotic arm; pick and place

I. INTRODUCTION

The rapid advancement of automation and robotics technology has transformed the way industries and organizations perform complex, repetitive, and high-precision tasks. Robotic arms are among the most widely used robotic systems because of their ability to imitate human arm movements and perform operations such as lifting, gripping, assembling, welding, painting, and material handling. Traditionally, robotic arm systems were mainly used in large-scale industries due to their high cost and complex control mechanisms. However, with the development of low-cost microcontrollers like Arduino Uno, robotic arm technology has become more affordable, accessible, and practical for educational, research, and small-scale industrial applications.

In modern automation systems, real-time communication is a critical requirement because robotic operations often demand immediate response and precise synchronization between the controller and the mechanical components. Real-time communication refers to the instant transmission and processing of commands without noticeable delay, ensuring that the robotic arm reacts accurately to user instructions. This is especially important in applications such as medical robotics, industrial automation, hazardous environment handling, and remote-controlled systems, where even a small delay may reduce efficiency or lead to errors.

Arduino Uno has emerged as a popular platform for robotic control because it provides a simple, user-friendly, and economical solution for interfacing sensors, motors, and communication modules. It supports multiple communication technologies such as serial communication, Bluetooth, Wi-Fi, and RF, making it ideal for implementing real-time robotic arm control systems.

II. LITERATURE REVIEW

Several researchers have explored IoT-based energy monitoring systems with varying degrees of sophistication and application domains. This section reviews relevant prior work and identifies gaps that the proposed system addresses.

2.1) Real time ethernet control communication for robotic arm application by using raspberry-pi

Author :- A Waingankar, PC Bhaskar

Summary :- Communication between raspberry pi and robotic arm. Here in this the code has been written for communication of raspberry pi.

2.2 Open embedded real-time controllers for industrial distributed control systems

Author :- R Delgado, J Park, BW Choi - Electronics, 2019

Summary :- Raspberry Pi 3 is not applicable to EtherCAT application, purpose of being the main controller of an EtherCAT network therefore, applications have been proposed in the literature .

2.3 An Ethercat Based Real-Time Control System Design for Wheelchair-Mounted 6dof Assistive Robotic Arm

Author :- IA Rulik Cote - 2022

Summary:- Literature Review presents the pros and cons of control exceptionally well, as the Raspberry Pi 4 and Jetson Nano into the control computer, we needed to program the onboard

III. SYSTEM ARCHITECTURE AND DESIGN

3.1 Overall System Architecture

The proposed system consists of four primary layers: the sensing layer, the processing layer, the communication layer, and the application layer. Each layer is designed with modularity and scalability in mind, following Agile design principles.

Table 1: System Architecture Layers and Components

SR.No	Component Name	Description	Function
1	Arduino Uno Microcontroller	A microcontroller board based on ATmega328P with digital/analog I/O pins.	Acts as the brain of the system. It reads sensor data, processes it, controls motors and relays, and manages system logic.
2	M996 Servo Motor	A high-torque servo motor used for heavy-duty rotation	Used to rotate or position the solar panel (or robotic arm) for maximum sunlight tracking
3	M90 Servo Motor	A small lightweight servo motor for precise angular movement.	Provides fine adjustments to the panel or robotic arm for accurate positioning.
4	Joystick 1	A two-axis analog input device	Allows manual control of movement
5	Joystick 2	Another analog joystick module.	Used for additional manual control, such as controlling another axis or function of the robotic arm.
6	Robotic Arm Fabrication	Mechanical structure made of links and joints.	Holds and moves the solar panel or performs physical movement tasks.
7	External Power Supply	DC power source	Provides required power to Arduino, motors, and other components.
8	Main Supply	Primary electrical power source or solar-generated output	Supplies energy to the load or system.
9	Switches (Main / Load)	Manual control switches	Used for system ON/OFF and load control
10	Connecting Wires	Electrical connectors	Used for circuit connections
11	Breadboard / PCB	Prototyping board	Helps in assembling and testing the circuit

3.2 Hardware Components

The hardware resources of the project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” refer to the physical components required to design, control, and operate the robotic arm system. These components form the backbone of the system and are responsible for implementing communication, processing signals, and executing mechanical movements. The theoretical understanding of these hardware elements is essential to ensure proper system design and functionality.

3.3 Software Architecture

The software resources of the project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” refer to the programs, coding platforms, and software tools required to design, control, monitor, and operate the robotic arm system. These software components provide the logical instructions that enable communication between the computer, Arduino Uno, and robotic arm hardware. Without software resources, the hardware cannot perform intelligent operations or execute commands in real time.

IV. ROBOTIC ARM DEVELOPMENT METHODOLOGY

4.1 Robotic Arm Framework Adaptation

The development of the proposed system employs a modified Scrum framework adapted for hardware-software co-development. Given the unique challenges of IoT projects, including hardware procurement lead times and firmware testing requirements, the standard two-week sprint cycle was extended to three weeks to accommodate hardware iteration cycles. The project was organized into five sprints, each delivering a functional increment of the system.

4.2 Sprint Breakdown

Table 2: Robotic Arm System Development

Sprint	Duration	Goals	Deliverable
1	Weeks 1–3	Hardware selection, circuit design, basic sensor interfacing	Hardware prototype v1
2	Weeks 4–6	Firmware development, Wi-Fi connectivity, basic data logging	Working sensor node
3	Weeks 7–9	Cloud integration, Blynk dashboard, MQTT setup	Cloud-connected system
4	Weeks 10–12	Load control module, automated alerts, relay integration	Smart load controller
5	Weeks 13–15	System optimization, testing, UI refinement, documentation	Final deployable system

V. IMPLEMENTATION

5.1 Firmware Development

The output from Arduino Uno is sent to servo motors in the form of Pulse Width Modulation (PWM) signals. PWM is a technique used to control the angular position of servo motors by varying pulse duration. Each servo motor is connected to a specific joint of the robotic arm and controls one type of movement. For example, one motor may rotate the base, another may lift the arm, while another may control the gripper.

When the servo motors receive PWM signals, they rotate to the commanded angle and cause the robotic arm joints to move accordingly. These joint movements combine to produce complete arm actions such as lifting an object, rotating it, and placing it at another location. Because the command processing and motor response occur almost instantly, the system achieves real-time communication and control.

VI. RESULTS AND DISCUSSION

6.1 Result- The project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” was successfully implemented and demonstrated effective real-time control of the robotic arm through instant communication between the user and the system. The developed robotic arm responded accurately to commands sent from the control device, showing smooth and reliable movement in all programmed directions.

During testing, the communication between the computer/mobile device and Arduino Uno was established successfully through the selected communication module, such as USB, Bluetooth, or Wi-Fi. The transmitted commands were received without noticeable delay, proving that the system achieved real-time data exchange efficiently. Arduino Uno processed the incoming signals correctly and generated appropriate PWM outputs to drive the servo motors.

6.2 Robotic Arm Process Outcomes

The project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” offers several advantages in terms of automation, control accuracy, flexibility, and cost-effectiveness. These advantages make the system highly useful in modern robotic and industrial applications.

6.3 Comparison with Existing Systems

VII. CHALLENGES AND LIMITATIONS

The project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” is effective for basic automation and learning purposes, but it also has certain limitations due to hardware constraints, communication challenges, and system design. These limitations must be considered for further improvement and advanced applications.

VIII. FUTURE SCOPE

The scope of the project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” is broad and significant in the fields of robotics, automation, and embedded systems. This project focuses on developing a robotic arm that can receive commands and respond instantly through real-time communication, enabling accurate and efficient control of robotic movements. It provides a practical platform for understanding modern robotic technologies and their real-world applications.

The project mainly covers the design, development, and implementation of a robotic arm controlled by Arduino Uno microcontroller. The system includes communication between the user and robotic arm through wired or wireless technologies such as serial communication, Bluetooth, Wi-Fi, or RF modules. This enables users to control the robotic arm remotely or directly with minimal delay.

One major scope of this project lies in industrial automation. Robotic arms are widely used in manufacturing industries for repetitive tasks such as pick-and-place operations, assembly line work, packaging, welding, painting, and material handling. This project can serve as a model for developing low-cost automation systems for small and medium-scale industries.

In educational institutions, this project has wide scope as a learning and research tool. Engineering students and researchers can use it to study robotics, embedded systems, programming, motor control, and wireless communication technologies. It provides hands-on experience in designing real-time robotic control systems.

IX. CONCLUSION

The project “Real-Time Communication for Robotic Arm Application Using Arduino Uno” successfully demonstrates the design and implementation of an efficient robotic control system capable of performing real-time operations. By integrating Arduino Uno, communication modules, and servo motors, the system achieves instant response to user commands and accurate movement of the robotic arm.

This project proves that real-time communication plays a vital role in robotics by enabling fast, reliable, and synchronized interaction between the user and machine. The robotic arm can perform various tasks such as rotating, lifting, gripping, and placing objects with precision, making it suitable for automation applications in industries, education, healthcare, and hazardous environments.

Arduino Uno provides a low-cost, flexible, and easy-to-program platform that makes robotic development simple and accessible. The use of communication technologies such as USB, Bluetooth, Wi-Fi, or RF enhances system versatility and remote control capability. The project also offers valuable learning experience in embedded systems, robotics, motor control, and wireless communication.

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