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Development of robotic arm control using Arduino controller

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ABSTRACT

The advance of Arduino-based technology has spurred innovation in the realm of robotic arm control, offering a cost-effective and accessible platform for enthusiasts and professionals alike. This paper presents the development of robot arm control using an Arduino controller. The work involves the integration of Arduino microcontrollers and sensors to enable precise and dynamic control of a robotic arm. The proposed robot is controlled by 4 servo motors, the motors rotate left, right, front, and back. The paper discusses the challenges encountered during the development process and proposes solutions, paving the way for further advancements in this burgeoning field. With Arduino's widespread availability and affordability, the presented robotic arm control system holds promise for expanding the accessibility of robotics education and fostering innovation in automation technologies. This paper provides a glimpse into the promising synergy between Arduino and robotic arm control, highlighting the contributions and implications of this technology in shaping the future of automation.

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1. INTRODUCTION

The introduction discusses the pervasive role of technology and automation in today's world, highlighting the increasing workload on humans and the need for efficient solutions. It introduces robotics as a key player in reducing human effort, improving precision, and saving time, money, and resources. Robotics involves mechanical engineering, electrical engineering, and computer science, and the programming language Arduino is mentioned for coding robotic machines. The focus is on robotic arms, which mimic human arm movements and find applications in industries for tasks like picking and placing objects. The project described is centered on an Internet of things (IoT)-based robotic arm, highlighting the significance of IoT in modern technology. The project aims to address technical aspects, challenges, and applications of robotic arms, emphasizing their potential use as artificial limbs for individuals who have lost a hand. The keywords include IoT, robotic arm, potentiometer, servo motor, Arduino, and micro-electro-mechanical systems (MEMS). The introduction also briefly discusses the current trend of IoT in various sectors and its application in automating processes, including in the field of robotics [1]–[7].

The authors discussed the widespread applications of robotic arms across various fields, with a focus on their role in the automated industry. Robotic arms assist professionals in tasks like lifting heavy objects, handling hazardous substances, and exploring inhospitable environments, enhancing overall job safety. These arms are programmable devices, resembling human arms, and can be manually controlled or automated. Automated robotic arms operate with minimal or no operator assistance, relying on programs and sensors. The fusion of mechanical and electronics engineering has catalyzed significant progress in automation technology. A prominent outcome of this convergence is the evolution of robot technology, marking a shift towards increased reliance on automated systems. This transformation has revolutionized industries, with the integration of robot systems streamlining processes and reducing reliance on human labor. However, the current market focus is on enhancing and refining these systems to meet the demands of evolving industries. The challenge lies in continually improving these systems to emulate and enhance human capabilities, ensuring a seamless integration of robots into various domains. This paper explores the ongoing efforts and achievements in designing robots that closely resemble human movements, with a special emphasis on the unique and promising realm of gesture-based control [8]–[10].

The present-day industrial focus is on computer-based interaction and robots to enhance productivity and ensure consistent product quality, gaining a competitive edge. Modern robots are characterized by speed, intelligence, accuracy, and improved capabilities, making them increasingly suitable for both high mix-low volume and low mix-high volume production. Collaborative robots, can work alongside humans, share a workspace and use sensor technology to operate safely in hazardous environments [10]–[15].

Robots are commonly employed for dangerous, intricate, and repetitive tasks, reducing human presence. They have gained widespread acceptance globally due to their error-free performance. Beyond industrial applications, robots prove beneficial for home automation systems catering to elderly and physically impaired individuals. Gesture recognition serves as a dynamic interface between robots and users, enabling complex machine operations through hand movements without physical contact. Gesture-controlled robots facilitate the integration of disabled individuals into regular work life, enhancing autonomy in daily activities. This control method also holds practical value in military and defense operations, as well as surgical procedures, providing a solution for time-sensitive situations and remote exploration in diverse environments [16]–[20]. The introduction discusses the significance of robotic systems, particularly robotic arms, in the manufacturing industry, aligning with the fourth industrial revolution. It traces the historical development of industrial robots since 1954, emphasizing their ability to perform various tasks automatically and enhance productivity in manufacturing compared to human labor. The focus then shifts to studies involving pick-and-place robotic arms for industrial applications, with examples of 6-DOF and 3-DOF manipulator robots [21]–[25].

2. BLOCK DIAGRAM

Figure 1 shows the block diagram interaction of components creating a robotic arm controlled by an Arduino board involves assembling the mechanical structure, connecting servo motors for joint movements, and integrating electronic components. After assembling the robotic arm, servo motors are connected to the Arduino board, typically using jumper wires. A suitable power supply is essential to provide power to both the Arduino and the servo motors. With the Arduino IDE installed on a computer, a custom program is written to control the servo motors, specifying the desired angles for each joint. This program is then uploaded to the Arduino board using a USB cable. Testing and calibration follow, ensuring the robotic arm moves accurately according to the specified angles. For enhanced functionality, optional sensors like accelerometers or gyroscopes can be incorporated to provide feedback. Advanced features such as wireless control through modules like Bluetooth or Wi-Fi can also be implemented. Continuous refinement and exploration of additional capabilities can further enhance the overall functionality of the Arduino-based robotic arm control system. The Arduino-based control of a robotic arm is made possible through the integration of servo motors, crucial components that facilitate precise joint movements. Connected to the Arduino board, these servo motors act as the muscle of the robotic arm, responding to programmed instructions that dictate the angles and positions of each joint. The Arduino platform, with its user-friendly IDE, allows for the creation of a tailored code that translates desired movements into actionable commands for the servo motors. Through careful calibration and testing, the robotic arm's range of motion can be fine-tuned to ensure accurate and coordinated actions. The servo motors play a pivotal role in executing these movements, providing the necessary mechanical force to articulate the various segments of the arm. This integration of servo motors with the Arduino platform not only simplifies control but also opens the door to additional functionalities, such as incorporating sensors for feedback or enabling wireless communication for remote operation. In essence, the synergy between Arduino and servo motors forms the foundation for the dynamic and controlled motion of the robotic arm.

The mechanical structure of a robotic arm, orchestrated by Arduino-based control, serves as the physical framework that enables precise and coordinated movements. Comprising segments and joints, the arm's design is a critical consideration for its range of motion and overall functionality. Each joint, typically actuated by servo motors, plays a specific role in allowing the arm to articulate and reach various positions. The integration of this mechanical structure with Arduino control is pivotal, as it transforms the theoretical concept of the robotic arm into a tangible, dynamic entity. The Arduino board acts as the central intelligence, interpreting commands and orchestrating the movement of the arm's segments through the servo motors. This collaboration between the mechanical structure and Arduino-based control not only defines the arm's physical capabilities but also opens avenues for customization and expansion. The mechanical design, coupled with precise control from Arduino, establishes the foundation for a versatile and programmable robotic arm capable of executing tasks with accuracy and efficiency.

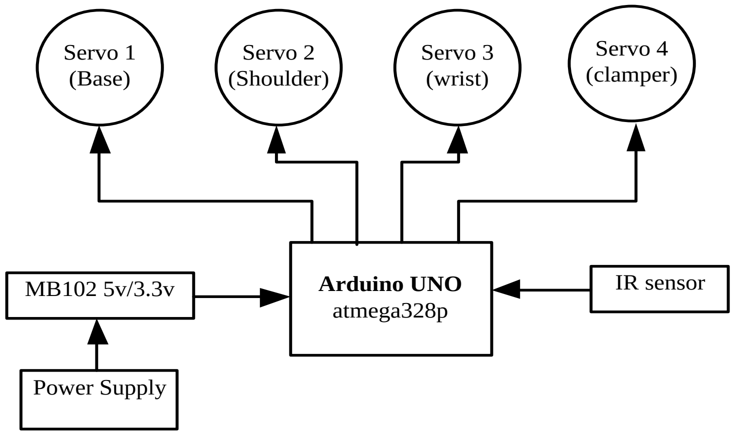

Figure 1. Block diagram interaction of components

Controlling a robotic arm using Arduino involves a sophisticated interplay of hardware and software, with the power supply playing a crucial role in ensuring smooth and reliable operation. The Arduino board serves as the brain of the robotic arm, executing pre-programmed instructions or responding to real-time inputs from sensors. To power the system, a stable and appropriate power supply is essential. This typically involves providing power to the Arduino board, motor drivers, and, most importantly, the motors responsible for the robotic arm's movement. Voltage and current requirements vary based on the specific components used in the robotic arm, and it is crucial to select a power supply that meets these specifications. Additionally, voltage regulators or motor drivers may be employed to manage the power distribution and protect sensitive components from voltage spikes. A well-designed power supply system ensures the reliability and efficiency of the Arduino-controlled robotic arm, allowing it to perform precise and controlled movements in various applications, such as manufacturing, automation, or educational projects.

Jumper wires play a vital role in the realm of Arduino-controlled robotic arm systems, serving as the connective tissue that links different components together. These wires, typically equipped with male and female connectors, facilitate the seamless transmission of signals and power between the Arduino board, sensors, motor drivers, and various other electronic modules within the robotic arm setup. In the context of robotic arm control, jumper wires are instrumental in establishing the necessary connections between the microcontroller and the motors responsible for the arm's movements. They are also utilized to link sensors, such as encoders or limit switches, to the Arduino for feedback and control purposes. The color-coding of jumper wires aids in distinguishing between different functionalities, streamlining the wiring process and enhancing overall system organization.

The Arduino integrated development environment (IDE) serves as the programming hub for the control and coordination of robotic arms powered by Arduino technology. This user-friendly software provides a platform for writing, compiling, and uploading code to the Arduino microcontroller that governs the robotic arm's movements. Programmers and enthusiasts can leverage the Arduino IDE to create custom scripts and algorithms, defining the arm's behavior, motion sequences, and responses to external stimuli. The IDE supports a simplified C/C++ programming language, making it accessible even for those with limited coding experience. Within the Arduino IDE, users can harness a variety of libraries and functions tailored for robotics, enabling the seamless integration of sensors, motors, and other electronic components into the control scheme. Additionally, the IDE provides a serial monitor for real-time debugging and monitoring of sensor data or debugging information, essential for refining and troubleshooting the robotic arm's functionality. The Arduino IDE acts as a crucial interface between the programmer and the hardware, streamlining the development process for Arduino-based robotic arms. It empowers users to translate their creative ideas into executable code, facilitating precise control and automation of the robotic arm's tasks with ease and efficiency. In an Arduino-based robotic arm control system, the interaction between components can be visually represented through a block diagram. The diagram illustrates the flow of information and signals among key elements of the system. At the center of the diagram is the Arduino microcontroller, which serves as the brain of the robotic arm. This core component processes the code written in the Arduino IDE, translating it into commands for the robotic arm's movement.

The microcontroller interfaces with various components to execute these commands. The Sensors, such as encoders or limit switches, provide feedback to the Arduino about the position and status of the robotic arm. This information is crucial for ensuring accurate and controlled movements. Motor drivers receive signals from the Arduino and regulate the power supplied to the motors. They act as intermediaries between the microcontroller and the motors, translating digital signals into the necessary power levels. The motors are responsible for driving the different joints and actuators of the robotic arm. They receive power and control signals from the motor drivers, allowing precise movement based on the commands from the Arduino. The power supply provides the necessary voltage and current to the Arduino, sensors, motor drivers, and motors. It ensures that the entire system operates within its specified electrical parameters. Jumper wires establish physical connections between the components, enabling the smooth transmission of signals and power. They link the Arduino to sensors, motor drivers, and other electronic modules, forming the physical backbone of the control system. The block diagram visually encapsulates the collaborative interplay of these components in an Arduino robotic arm control system, illustrating how information flows from the Arduino to the various peripherals, and vice versa, to enable precise and coordinated robotic arm movements.

3. ARDUINO IN TINKER CAD DESIGN

Figure 2 shows the Arduino in Tinkercad. In Arduino robotic arm control systems, communication with servo motors is a fundamental aspect of achieving precise and coordinated movements. Servo motors are commonly used in robotic arms due to their ability to provide accurate angular control. The Arduino communicates with servo motors using a pulse width modulation (PWM) signal. PWM is a method of encoding information in the form of pulses, where the width of each pulse corresponds to a specific control signal. To control a servo motor, the Arduino generates PWM signals through its output pins. These PWM signals are sent to the signal input wire of the servo motor. The signal contains information about the desired position or angle of the servo motor shaft. The servo motor interprets the PWM signal and adjusts its shaft position accordingly. Typically, the Arduino library for servo motors simplifies the coding process by abstracting the details of PWM signal generation. Programmers can use the Arduino IDE to write code that specifies the angle or position at which the servo motor should rotate. The code then generates the corresponding PWM signal, and the Arduino outputs this signal to the servo motor. This interaction is integral to achieving precise and controlled motion in each joint or actuator of the robotic arm. the Arduino communicates with servo motors through PWM signals, enabling it to command the motors to move to specific positions. This communication mechanism is essential for orchestrating the coordinated and accurate movements required for effective robotic arm control.

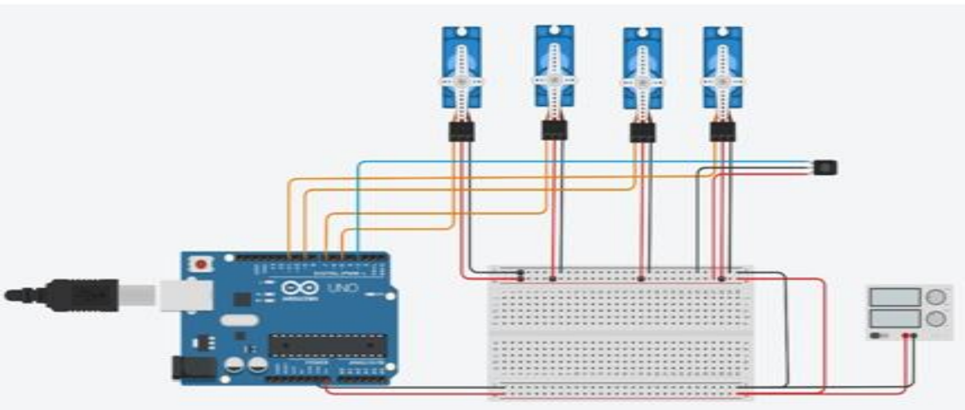

Figure 2. Arduino in Tinkercad

4. MECHANICAL DESIGN

Figure 3 shows the testing robot arm base waist. The robotic arm structure is the physical framework that defines the form and functionality of a robotic manipulator. Comprising various interconnected components, this structure is designed to mimic the flexibility and dexterity of a human arm. Typically, a robotic arm consists of multiple joints or links, each capable of rotational or translational movement, and is often equipped with end effectors for specific tasks. The joints are connected by actuators, commonly motors or servos that drive the arm's movement. Figure 4 shows the testing robot arm shoulder. The structure is organized into segments, such as the shoulder, elbow, and wrist, allowing for a range of motion similar to the human anatomy. These segments are connected by joints that enable the robotic arm to articulate in multiple degrees of freedom. Material selection for the structure is crucial, as it affects the arm's strength, weight, and overall performance. Figure 5 shows the testing robot arm clamper. Furthermore, the end effectors, located at the terminus of the robotic arm, are designed to carry out specific tasks such as gripping, welding, or 3D printing. The structure may also include sensors, such as encoders or accelerometers, to provide feedback on the arm's position and orientation, contributing to precision and control. Figure 6 shows the testing robot arm waist forward and clamper. In essence, the robotic arm structure is a sophisticated mechanical system engineered for versatility and adaptability. Its design is paramount in determining the range of tasks the robotic arm can perform and influences its overall efficiency in diverse applications, ranging from manufacturing and assembly lines to medical procedures and research. Figure 7 shows the arm robot with a DC motor, rotating at 360°. This robot picks up more weight compared to servo motor robot.

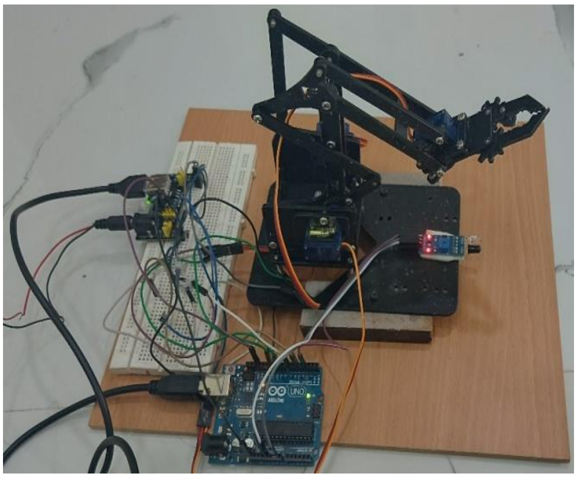

Figure 3. Testing robot arm base waist

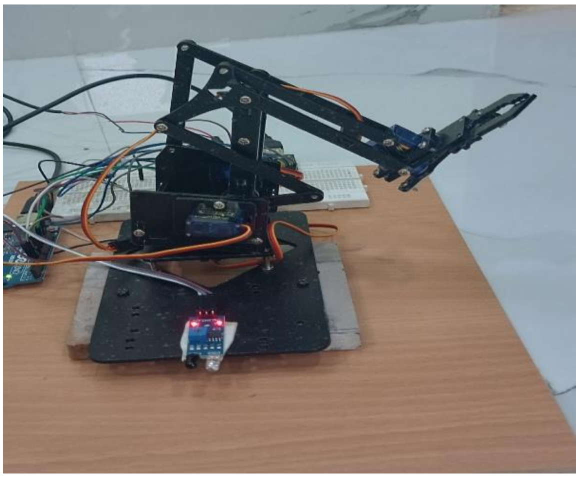

Figure 4. Testing robot arm shoulder

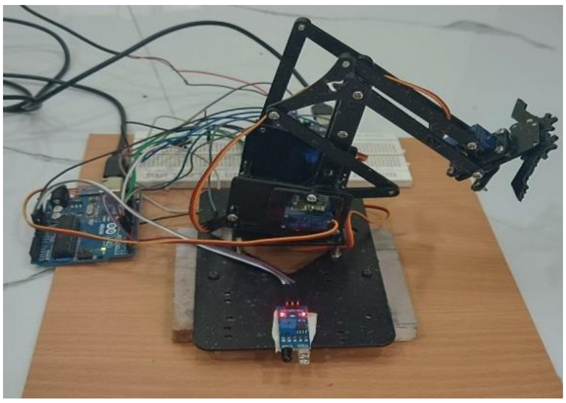

Figure 5. Testing robot arm clamper

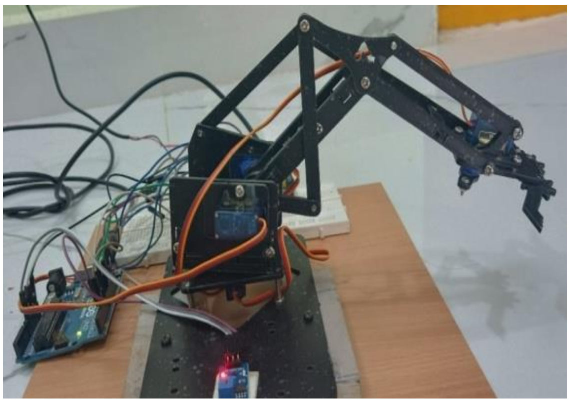

Figure 6. Testing robot arm waist forward and clamper

Figure 7. Arm robot with DC motor

5. CONCLUSION

In conclusion, the Arduino-based robotic arm control system represents a significant stride in the fusion of accessible technology and automation. The utilization of Arduino as the core microcontroller has not only simplified the programming and control aspects but has also democratized the field of robotics, making it approachable for both enthusiasts and professionals. From observation, it is clear now that robotic arm movement is accurate, precise, easy to control, and user-friendly. The robotic arm overcomes the previous problems, now it can pick up and place hazardous objects very smoothly and precisely.

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