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Implementation of Local & Remote Controlled Robotic Arm

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***Abstract*—This paper's primary aim is to design and create a robotic arm system for lifting. The main objective of this project is to design and construct a lifting mechanism for a robotic arm. The advancement of robotic technology has seen significant improvements in the versatility and precision of robotic arms, making them essential tools in various industries such as manufacturing, healthcare, and space exploration. This paper presents the design and implementation of a robotic arm that can be controlled both locally and remotely, offering enhanced flexibility and operational efficiency. The robotic arm is designed to perform a range of tasks including object manipulation, assembly operations, and precise movements required in sensitive environments. The local control mechanism employs direct user interaction through a control panel or joystick, allowing real-time adjustments and immediate response. Remote control capabilities are integrated using Internet of Things (IoT) technologies, enabling operation from distant locations via a web interface or mobile application. This dual-mode control system ensures that the robotic arm can be operated effectively in various scenarios, providing both convenience and reliability.**

Testing and validation of the robotic arm demonstrate its capability to perform complex tasks with high accuracy and responsiveness under both local and remote control. The system's modular design allows for easy upgrades and customization, making it adaptable to specific user requirements.The Arduino IDE is an open-source computer hardware and software platform that drives servo motors, which in turn control the robotic arm's position. Utilizing wireless command through a Bluetooth module, a smartphone running the Android operating system is also utilized for wireless control. The robotic arm can successfully complete the lifting task, according to the results of its testing and performance validation.

In conclusion, the developed robotic arm showcases the potential for integrating local and remote control mechanisms to enhance operational flexibility. This implementation can serve as a prototype for future developments in robotic technology, pushing the boundaries of automation and remote operations.

***Index Terms*— Robotic Arm, Local Control, Remote Control, IoT, Microcontroller, Servo Motors, Automation, Arduino, Robotic Arm.**

I. INTRODUCTION

A remote-controlled robotic arm is a sophisticated mechanical device designed to manipulate objects or perform tasks from a distance through the use of a control interface. These robotic arms are generally equipped with

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motors, sensors, and actuators that allow precise movement and manipulation of objects in various environments. The introduction of remote-controlled robotic arms has revolutionized many industries, including manufacturing, healthcare, and space exploration. They offer several advantages over traditional manual labor or fixed automation systems, including increased precision, flexibility, and safety. There are two ways to control robotic arms: locally and remotely. An operator who is physically present at the same site as the robot controls a locally controlled robotic arm. Usually, the operator manipulates the arm and carries out different duties using a control panel or joystick. Additionally, the operator has the option of using sensors to track the arm's movements and adjust it as necessary. On the other hand, a remotely controlled robotic arm is one that is controlled by an operator who is located at a different location from the robot. The operator can control the arm using a computer or other remote control device. This type of control is commonly used in situations where it is too dangerous or difficult for a human operator to be physically present with the robot, such as in space exploration or hazardous material handling.An array of applications, such as manufacturing, assembly, building, and exploration, can benefit from the usage of both local and remote controlled robotic arms. These arms can be programmed to execute repetitive operations with great accuracy and speed, thereby decreasing the need for human labor and enhancing efficiency.

When we talk about local control, we mean operating the robotic arm from a close distance, usually with a physical interface like a joystick, keyboard, or touch screen. In settings like manufacturing plants or labs, where the robotic arm is operating in close proximity to the operator, local control is frequently utilized. Conversely, remote control entails operating the robotic arm from a distance, usually through a wireless link. Applications where the robotic arm must operate in dangerous or inaccessible environments, such deep-sea research or space travel, frequently use remote control. Moreover, remote-controlled robotic arms play a crucial role in space exploration, where they are used to manipulate tools, collect samples, and perform repairs on spacecraft and planetary surfaces. Their ability to operate in extreme environments and withstand harsh conditions makes them indispensable for missions beyond earth.

Typically, a robotic arm's control system is made up of both hardware and software components. The sensors, actuators, motors, and other tangible parts that allow the arm to move and carry out its functions are referred to as hardware. The user interface, which enables interaction between the operator and the arm, and the programming code that governs the arm's movements are examples of software components.

Technological developments in robotics have resulted in the creation of advanced robotic arms that possess the ability to execute intricate tasks and operations with extreme precision and accuracy in recent times. These robotic arms have the power to completely transform a number of sectors, such as transportation, healthcare, and manufacturing.

A mechanical apparatus that replicates the motion of a human arm is called a robotic arm. It is controllable from a distance or locally. When we talk about local control, we mean using a control panel that is directly on the robotic arm to operate it. On the other hand, remote control describes using a computer or other wireless device to operate the robotic arm from a distance. A local control robotic arm is typically used in industrial applications where the operator needs to be physically present to manipulate the arm. The operator can use the control panel to move the robotic arm up, down, left, right, and forward and backward. The local control panel typically has buttons, levers, and knobs that are used to control the movement of the arm.

Remote control robotic arms, on the other hand, are used in situations where the operator needs to manipulate the arm from a distance. This can be achieved using a computer, a smartphone, or a wireless device. Remote control robotic arms are used in a wide range of applications, including manufacturing, medicine, and exploration.

II. LITERATURE SURVEY

For this progress this endeavour, many researches have been conducted by various researchers. They employ different technologies and serve a distinct function, though. The technology and application of several of these articles are described below. Robot automation with android control has been developed by Jorge Kazacos Winter. His project's primary goals were ever to wireless transfer data between a smart phone and the robotic arm, build the robotic arm and its communication system at a low cost, adhere to the open source movement. The styled the robot's architecture using 3D design approaches, supported by software for parametric modelling. The style can be employed to supply the 3D printer, allowing it to produce the robot's components one by one in sections. For this robot, he utilized an Arduino microcontroller and Wi-Fi technology. In his paper, M. Selvam proposes to create a robotic surveillance system with a wireless camera. His proposal included the use of Bluetooth to establish a link between the robot and smartphone. Robotic surveillance was given through a wireless night vision camera. The video that the camera has captured is subsequently sent over a radio frequency signal to the TV set. surveillance. The robotic unit was handled with 8051 micro-controllers. A pick-and-drop robot was created by B. Santosh Kumar and Ranjith , its safe usage in the remote detonation of a bomb. They used two motors for the robotic arm and two other motors for the robot's wheels to manage movement. Bluetooth is used to establish connectivity. Most of project focused on both commercial and military use. Arpit Sharma, Ritesh Verma, Saurabh Gupta, and Sukhdeep Kaur Bhatia has have used the smart phone such that it can use Bluetooth technology to control a robot. Motion sensors are used by the phone, which also captures gestures sent from an Android mobile device. Moreover, Bluetooth and an accelerometer are incorporated in. A robotic arm that utilizes an Atmega microcontroller has been described as being designed and developed. The robotic arm reacts to the gesture and can be programmed to follow a specific path and perform a specific task.[5] The robotic arm imitates the input gesture when the system detects the user's arm movement. A glove has many potentiometers embedded in it that recognize the gesture. Potentiometer movement affects how the servo motors driving the arm's different components are placed. In this article, a 3- DOF Jaco robotic arm and Leap Motion controller communication interface is developed. To enable the highest suitable mapping between user hand movement and the Leap Motion controller, an algorithm was created. The system should enable better control of the robotic arm movements and more natural human-computer interaction. The use cases for this human-robot interaction was introduced in the context of ambient assisted living. It has been suggested that one to developed robotic arm used to controlled by the natural movements of the human arm and using information is gathered using accelerators. The ardunio mega served as the foundation for the development of this arm. Last but just not least, it is likely that this arm prototype will solve the issue of picking up or placing harmful or un harmful things that are placed distant to the user. A robotic arm controlled by an Arduino mega microcontroller has been developed and designed. The robotic arm responds to the gesture and can be programmed to follow a particular path and perform a specific task. The robotic arm resembles the input gesture when the system detects the user's arm movement. A glove has many potentiometers embedded in it that recognize the gesture. Potentiometer movement regulates how the servo motors driving the arm's different components are placed.

TABLE I: COMPONENTS

Component	Component Function
Circular Disc	Rotating Base with caster wheels
U bracket	Manipulator Support link
Servo bracket	Servomotor Support Link
Gripper	Pick and Place link

III. METHODOLOGY

Developing a methodology for a remote-controlled robotic arm involves several key steps to ensure its successful design, implementation, and operation. By using the given instructions to assemble the robotic arm kit, and attaching the all servo motors to the joints of the arm along with power supply and wires to join the servo motors to the microcontroller along with the Arduino IDE or a graphical programming environment like Scratch or Block, create the code for the robotic arm. The software should contain details in response to input from the joystick or a smart phone app, move the arm in different directions. Make sure the robotic arm moves in the desired directions by trying it with the joystick or a smart phone app. To enable remote control of the robotic arm using a smart phone app, combine the Bluetooth module with the micro controller along with the code. Using a software development kit (SDK) for the Bluetooth module, evaluate the robotic arm’s performance under various load conditions and operational scenarios, then assess the system’s responsiveness and reliability in both local and remote modes. This methodology ensures a structured approach to developing a versatile and reliable robotic arm with both local and remote control capabilities, adaptable for various industrial and research applications.

The word "robot" is derived from the Czech word "robots," which is usually defined as "forced labour." This description of the most of robots is true. The majority of robots on the earth are made for hard, boring manufacturing work. They main measures that are difficult, dangerous, or taxing for people. The robot is controlled by the Computer by rotating specific stepper engines linked to each joint (a few bigger arms use hydrodynamics or pneumatics). Step engines move in distinct augmentations, which is very different from conventional engines. This allows the PC to perform the same development repeatedly while precisely moving the arm. The robot has movement sensors built in to make sure it moves the right amount. Robocops are really stylish and have joints that may be likened to the wrist, elbow, and shoulder of a human arm. Typically, the shoulder is linked to a stiff base design rather than a flexible body. There are six different ways that this kind of

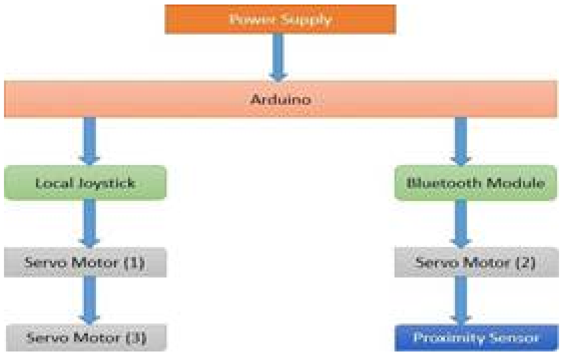

Figure 1. Block diagram

robot can turn, or six levels of opportunity. According to correlation, there are seven possible degrees of variation in a human arm. Your robotic arm is moved from one position to another by your arm. The mechanical arm's other function is to move an end effector from one location to other. Mechanical arms can be connected with a wide range of end effectors, each of which is suitable for a specific application. One common end effector is an upgraded hand that can carry and handle a wide range of thing.

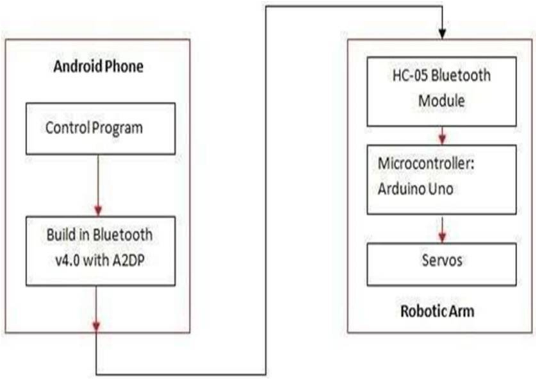

Figure 2. Flow diagram

A. Bluetooth HC-05 module

The Bluetooth HC-05 module is a small electronic device that allows wireless communication between two devices. It is a serial port module that can be used with microcontrollers or other electronic devices to enable wireless data transfer.

The HC-05 module uses Bluetooth 2.0 technology and operates at a frequency of 2.4 GHz. It has a range of up to 10 meters and can support a maximum data transfer rate of 2.1 Mbps. The module is compatible with various operating systems, including Windows Implementing a robotic arm can be controlled by locally and remotely requires several components, including the physical robotic arm, the control electronics and the communication modules. Here are some steps to consider when implementing such a system: Design the robotic arm: First, you need to design the robotic arm. This can involve selecting the right motors gears and linkages to create a robotic arm that can move in a desired way. You may also need to design custom parts using 3D modelling software and then print them using a 3D printer.

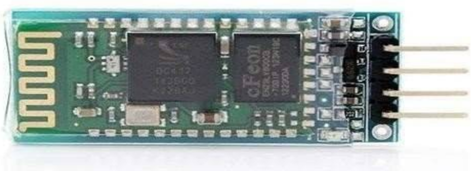

Figure 3. Bluetooth-HC module

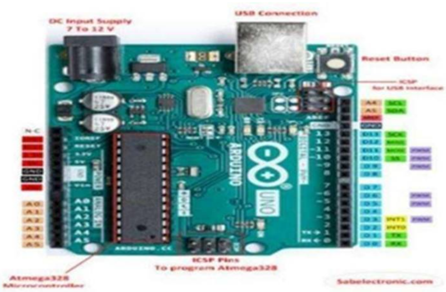

Figure 4. Arduino Uno Module

1. Select the control electronics: Once you have physical arm, you need to select the appropriate control electronics. This may include a microcontroller or a raspberry pi. You will also need to select motor drivers and sensors that can read the position of the arm and provide feedback to the controller.
2. Program the controller: You will need to program through controller to interpret the commands from the remote control and move the arm accordingly. This may involve using a programming language like C++ or Python to create a custom control algorithm.
3. Add communication modules: To unable remote control you will need to add communication modules to the system this may be include Bluetooth or wifi modules that allow the arm to receive commands from a remote controller such as smart phone or a computer.
4. Implement safety futures: When working with robotic arms, safety is crucial, should implement safety futures such as emergency stop button and limit switches, to prevent accidents and injuries.

Overall implementing a local and remote control and robotic arm requires expertise in mechanical, , electronics ,programming and communication it is a complex system that requires careful planning and testing to ensure that its work safely and reliably.

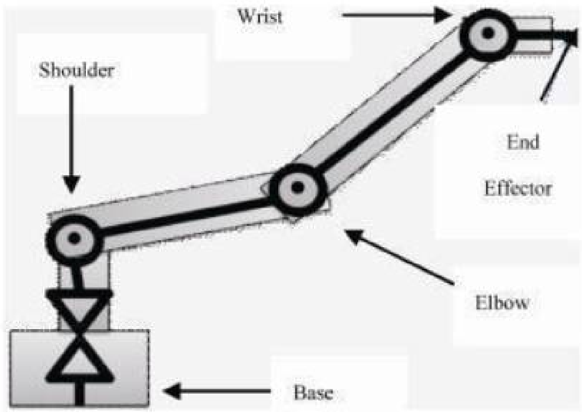

Figure. 5. Free Body Diagram of the Robot Arm

As shown in Fig. 5, the design does not contain the end effector since a commercially supplied gripper is utilized instead. This is due to the fact that the end effector is one of the most intricate components of the system, making using a commercial one considerably simpler and less expensive than building one yourself. The robotic arm's work zone is seen in Figure. This is an example of a four-degree-of-freedom (6 DOF) robot arm's workspace. The robot's mechanical design was restricted to six degrees of freedom due to the fact that this configuration permits the majority of required movements while maintaining the robot's competitive costs and complexity.
As a result, the joints' ability to rotate is limited in cases where the shoulder's two axes are rotated, but the elbow and wrist's single axis. Electrical motors are usually used to actuate the robot arm joints. The servo motors were selected because they had encoders built in, which tell the motors automatically when they get feedback and change position.

IV. RESULTS

A remote controlled robotic arm is controlled by an operator who is not physically present near the robot. The designed Robotic arm module is as shown in Fig.6. The hardware components of a remote controlled robotic arm include:

1. Actuators: These are the same as for the local controlledrobotic arm.
2. Joints: These are the same as for the local controlled robotic arm
3. Sensors: These are used to transmit data about the movement and position orientation of the robotic arm to theoperator. They include cameras, encoders, and accelerometers.
4. Remote controlled interface: The remote control interface is used by the operator to send instructions to the robotic arm it can be a joy stick, computer interface or a mobile device.
5. Communication equipment: Communication equipment is used to transmit the data from sensors to the operator and the instruction from robotic arm to the operator. This can bedone using wired or wireless communication methods.

6. Power supply: The power supply is same as for the localcontrolled robotic arm.

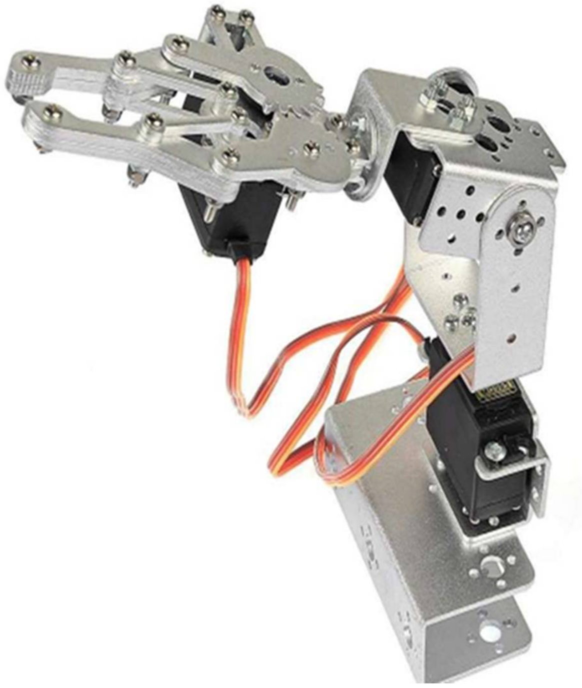

Figure 6: Designed Robotic Module

Healthcare: Surgical treatments and rehabilitation are two tasks for which robotic arms are utilized. Surgery can be performed more precisely and accurately with the use of local and remote controlled robotic arms, which lowers the possibility of complications.

A. Aerospace: In the aerospace sector, robotic arms are utilized for jobs like spacecraft and satellite assembly and maintenance. These tasks can be more easily and accurately completed in zero gravity conditions by local and remote operated robotic arms.

B. Search and Rescue: Heavy lifting and debris removal are two activities that robotic arms are employed for in search and rescue operations. By completing jobs in dangerous environments and gaining access to hard-to-reach locations, local and remote controlled robotic arms can lower the risk to human rescuers.

C. Agriculture: Agriculture uses robotic arms. These jobs can be completed more precisely by local and remote controlled robotic arms, which lowers labor expenses.

D. Defence and Security: Robotic arms are used in defence and security applications for tasks such as bomb disposal, surveillance, and reconnaissance. Remote-controlled robotic arms equipped with cameras, sensors, and manipulators enable military personnel and law enforcement agencies to safely handle and neutralize explosive devices and investigate hazardous environments.

V. CONCLUSIONS

In conclusion, remote-controlled robotic arms represent a ground breaking technology with a multitude of applications across diverse industries and fields. These sophisticated mechanical systems offer unparalleled precision, dexterity, and versatility, enabling them to perform tasks in environments that are hazardous, inaccessible, or impractical for human operators. The design and development of a robotic arm for use in light material lifting are addressed in this work. In the interests of lowering expenses and production time, the robotic arm is developed by an AutoCAD computer-aided design software. The ABS (Acrylonitrile Butadiene Styrene) used to construct the robotic arm and PLA used to construct one of the links between the bodies and motor. We encountered a problem with the 3D printing process when manufacturing an overhanging portion that severely flawed the joining part.

Using coding on an Arduino Uno, the servo motor is controlled. The robotic arm's range of motion is restricted to 180 degrees due to the servo motor's restrictions. The servo motors are controlled via an Arduino Uno board

through coding. The local and remote controlled robotic arms will have their own unique challenges and limitations, such as communication delays, potential safety hazards and limitation of 180 degrees.
From manufacturing and healthcare to space exploration and disaster response, remote-controlled robotic arms play a vital role in enhancing efficiency, safety, and productivity. They revolutionize assembly lines, enable minimally invasive surgeries, facilitate scientific exploration in space, aid in search and rescue operations, and tackle challenges in nuclear decommissioning, mining, agriculture, defence, and security.

FUTURE WORK

The future work of remote-controlled robotic arms is poised to explore several exciting avenues, driven by ongoing advancements in technology and the evolving needs of various industries. Here are some potential directions for future research and development:

A. Enhanced Autonomy

Future remote-controlled robotic arms may incorporate advanced artificial intelligence (AI) and machine learning algorithms to enable greater autonomy and decision-making capabilities. These systems could autonomously plan and execute tasks, adapt to changing environments, and learn from experience to optimize performance.

B. Haptic Feedback and Telepresence

Integrating haptic feedback systems into remote-controlled robotic arms could provide operators with a sense of touch and tactile feedback, enhancing their ability to interact with objects and environments remotely. Additionally, advancements in telepresence technology could enable operators to experience a more immersive and intuitive control interface, further bridging the gap between human operators and robotic systems.

C .Multi-Agent Collaboration:

Future work may focus on developing collaborative robotic systems, where multiple remote-controlled robotic arms work together synergistically to accomplish complex tasks. These multi-agent systems could exhibit coordination, cooperation, enabling them to tackle challenges that exceed the capabilities of individual robots.

D. Soft Robotics and Flexibility

Research into soft robotics and flexible materials could lead to the development of remote-controlled robotic arms with enhanced flexibility, adaptability, and safety. These soft robotic systems could interact more seamlessly with delicate objects and environments, opening up new possibilities in industries such as healthcare, food handling, and agriculture.

E. Human-Robot Interaction and Collaboration

As remote-controlled robotic arms become more prevalent in various domains, research into human-robot interaction (HRI) and collaboration will be essential. Future work may explore intuitive control interfaces, collaborative task planning algorithms, and mechanisms for effective communication and coordination between human operators and robotic systems.

F. Space Exploration and Planetary Robotics

In the realm of space exploration, future work may focus on developing remote-controlled robotic arms tailored for extra-terrestrial environments. These robotic systems could assist in the construction of habitats, infrastructure maintenance, resource extraction, and scientific exploration on other planets and moons.
Overall, the future of remote-controlled robotic arms holds tremendous promise, with opportunities to enhance autonomy, versatility, and collaboration while addressing emerging challenges.

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