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DEVELOPMENT OF A HAND MOTIONCONTROLLED 360° ROTATING PICK AND PLACE ROBOT

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ABSTRACT: The development of a pick-and-place robotic arm with 360-degree rotation, operated using hand gestures, is presented. Robotic arms are essential in industrial automation due to their ability to improve precision, efficiency, and safety, particularly in hazardous environments.

This system uses an Arduino Mega 2560 microcontroller to control the robotic arm and implements basic kinematic logic to achieve accurate positioning. Dc motors are used for the actuation of various joints and movements, offering precise control over angular displacement, which is essential for the pick-and-place task. Gesture control is implemented using sensors, allowing users to control the robot intuitively and without the need for traditional programming.

The robot is suitable for applications such as sorting, basic assembly, material handling, and assistive technologies. Its gesture-based control enhances accessibility and ease of use, reducing operator effort and improving safety. This project demonstrates a practical and low- cost automation solution with future potential for enhancement using AI-based gesture recognition and advanced motion control systems.

Keywords: Robotic Arm, Pick and Place, 360-Degree Rotation, Hand Gesture Control, Automation, Kinematics, Arduino Mega 2560, Servo Motors.

1. INTRODUCTION

With the rapid advancements in robotics and automation, human-machine interaction has become more seamless and efficient. Robots are increasingly being used to assist humans in various fields, including manufacturing, healthcare, and defence. Among these, assistance robots play a crucial role in performing repetitive, labour-intensive, and hazardous tasks. Such robots are designed to operate autonomously or semi-autonomously, reducing the dependency on human intervention in challenging environments.

One of the key applications of robotic technology is in pick-and-place operations, where precision and speed are essential. Traditional robotic arms often rely on pre-programmed instructions or manual joystick controls, which can be less intuitive. To overcome this limitation, this project focuses on developing a hand motion-controlled robotic system capable of 360° rotation. By using an advanced motion sensor system, this robot enables a user-friendly and efficient way to control the robotic arm using simple hand gestures. This innovation enhances usability and increases efficiency, making it a valuable tool for industries requiring high precision and automation.

As the computer and tech industry was growing in the late 20th century, early versions of pick and place technology emerged as a solution for quickly assembling circuit boards. The original process required the use of two machines. First, the empty board would be fed into a high- speed machine, called a chip shooter that would rotate the PCB around a turret. Here, the board would move rather than the robot. The initial device wasn't precise, so it was used for the placement of large components like capacitors and resistors. The machines worked incredibly quickly, capable of placing 15 parts a second.

Pick and place technology is employed in the PCB assembly process. It is a machine that picks components and places them on the circuit board. The PCB assembly process needs to be precise, and although it can be

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achieved by hand, you would like to employ a robot so that each circuit board is the same when mass producing. Inconsistent products will result in a waste of time and resources, which will end up affecting your bottom line negatively. The productivity with which pick and place robots operate is one significant reason why technology is now so widely available at affordable prices that anyone can access it.

The degree of freedom is an extremely important factor in robotics that is used to define the physical motion capabilities of a robot. A robot is essentially a combination of multiple mechanisms where each mechanism is formed by a set of links and joints. As already discussed, there are different types of joints used in building a robot. The most common lower pair joints include the revolute joint, prismatic joint, helical joint, cylindrical joint, spherical joint, and universal joint. Each joint has its own degree of freedom. Revolute, helical, and prismatic joints have 1 DoF, cylindrical and universal joints have 2 DoF and spherical joints have 3 DoF. When the degree of freedom is determined for a joint, it generally refers to the number of axes the joint offers motion to attached links.

2. REVIEW OF LITERATURE

Ravikumar Mourya, Amit Shelke, Sourabh Satpute, Sushant Kakade, Manoj Botre. [1] This project aims to design and implement a 4-DOF pick-and-place robotic arm with an articulated structure using revolute joints. “Design and Implementation of Pick and Place Robotic Arm” by. It utilizes four servo motors for precise motion control to perform tasks like gripping, lifting, placing, and releasing. The robotic arm is controlled by a serial servo controller circuit with an ATmega16 development board for actuation. Key performance factors include torque, payload, speed, range, repeatability, and cost.

Chaitanya [2] In 2017, a team led by developed a pick-and-place robotic system for industrial automation. “Pick and Place Robotic Arm Using Arduino”. The project implemented a Robot -Arduino-based robotic arm with two degrees of freedom, controlled via RF signals. Featuring an Omni-wheel-supported chassis, it aimed to reduce human intervention and enhance precision in tasks like packaging and surveillance. Additional functionalities such as line following and obstacle avoidance were proposed for greater versatility.

R.Neeraja, Dr.Sanjay Dubey, S.B.Arya, Neeraj Moota. [3] “Implementation of Pick and Place Robot”. This project develops a Pick-and-Place Robot controlled via an Android phone using an XLR8 Development Board, Bluetooth module, and motor drivers. The robot moves in all directions and performs pick-and-place actions through the “Arduino Bluetooth Controller” app, making it accessible for disabled individuals. Robots enhance safety and efficiency by reducing human intervention in various tasks.

Prof. S.D Rajgure, Aakash D Chougale, Ajit N Bhatkande, Suraj A Bhamare, Swaroop S Chougale. [4] “A Review on Design and Development of Pick and Place Robotic Arm”. This project models a pneumatic robotic arm for automating material handling between extrusion and belt grinding machines. Designed using forward and inverse kinematics reliability, reducing labor costs and ensuring quality control.s, it picks and places cylindrical objects like steel bars. Pneumatic systems with compressed air offer a cost-effective alternative to hydraulic and servo-based arms. The arm performs gripping, lifting, moving, placing, and releasing with high speed.

PranavChavan, Atharva Deshmukh,RahulBachute. [5] This project focuses on the development of a pick-and-place robotic arm to enhance industrial automation by increasing productivity and reducing human effort. The robotic arm consists of interconnected rigid links with movable joints, resembling human-like movements at the shoulder and elbow. It features a wrist joint that holds a tool or gripper, enabling precise handling of objects. Designed for efficiency and reliability, this system contributes to uniform product quality.

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Laxmish P, Pramod. M. M, Latesh. E. Gouda. [6] "Implementation of Pick and Place Robotic Arm Using Speech Processing and IoT" .This paper presents a 360-degree rotating pick-and-place robot for precise industrial automation, reducing human errors. It integrates speech processing using Google Assistant and IoT to control devices through voice commands. The system enhances connectivity across platforms, demonstrating the potential of IoT in human-robot interaction .

Varsha M. Magar, Kunal KakajiSuroshe, Hrishikesh Pravin Patil, Dinesh Vilas Sathe, Harshada Raju Khairnar. [7] "Six Wheel Drive Pick and Place Robot using Arduino". This project focuses on a six-wheeled pick-and-place robotic vehicle designed for industrial and non-industrial applications. With a six-degree-of-freedom robotic arm and modular design, it enables adaptability for various tasks. The system is useful for repetitive industrial processes and challenging terrains where human intervention is difficult. Additionally, a built-in storage area allows bulk object handling, improving operational efficiency.

Sharath Surati, Shaunak Hedaoo, Tushar Rotti, Vaibhav Ahuja, Nishigandha Patel. [8] "Pick and Place Robotic Arm: A Review Paper" This review paper explores various aspects of robotic arms by analyzing successful research on manipulators. Robotic arms enhance efficiency, precision, and safety in industries, operating in hazardous conditions like high temperatures and pressures. As part of flexible automation, they can be easily updated and modified. The study examines different controllers and methodologies used to determine degrees of freedom for pick-and-place tasks, aiding in robotic arm design.

SubhakantaSahoo , Narayan Nahak , Pramod kuDas , Sunil kuSethiRamchandra. [9] "DESIGN AND FABRICATION OF PICK AND PLACE
ROBOT WITH ARM MECHANISM". This project focuses on designing a pick-and- place mechanical arm for a workstation handling lead battery loading and packing. Industrial robots, including robotic manipulators, enhance productivity and ensure uniform quality. These arms function as kinematic chains with movable joints, resembling human anatomy in some configurations. The robotic arm's end effector, such as a gripper or tool, enables precise task execution, advancing automation and robotization in industrial applications.

Dr. V. V. S. Harnadh Prasad, K.V. Dhanrajsekhar. [10] "Design and Analysis of a Pick and Place Robotic Arm". This paper focuses on designing a space-efficient pick- and-place robotic arm for industrial applications. These robots streamline production by repeatedly moving objects through various operations. Using Autodesk Fusion 360, stress and displacement analysis is conducted to evaluate performance. The study highlights the advantages, applications, and efficiency of pick-and-place robots in industrial settings

Mahesh, Mahajan, Saurabh Gaikwad, Vaishnavi Kalmase,Shweta Padwal. [11]
DESIGN & DEVELOPMENT STUDY OF PICK AND PLACE MECHANIZED
SYSTEM This project focuses on developing a low-cost, automated pick-and-place system to enhance efficiency in small-scale manufacturing. Many industries still rely on manual handling, leading to time-consuming operations and reduced productivity. By integrating electronic, electrical, and mechanical components, this system ensures precise handling of materials like thin sheet metal and paper. With multiple speed control options.

Akarsh Kesharwani, Ayush P. Chaudhary, Bhanu Pratap Singh, Ved Kumar, Padmavathi M., Dr. Pavithra G., Dr. Sindhu Sree M., Dr. T. C. Manjunath. [12] " A Study on Hand Motion Controlled Robotic Arm". This study develops a Hand Motion Controlled Robotic Arm (HMCR) for intuitive human-robot collaboration in industries like manufacturing, healthcare, and rescue operations. It explores hardware design, motion tracking, and user interface, assessing accuracy and usability through experiments. The research advances human-robot interaction, enhancing accessibility and efficiency across various applications.

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Samuel Kariuki , Eric Wanjau Ian Muchiri Joseph Muguro Waweru Njeri and MinoruSasaki. [13] "Pick and Place Control of a 3-DOF Robot Manipulator Based on Image and Pattern Recognition".The chess-playing robotic system enhances human- robot interaction using a 3-DoF manipulator with image and speech recognition. It maps chessboard coordinates via image processing and centroid detection, achieving an 8.64%-word error rate in voice commands. An inverse-kinematics algorithm computes joint angles for precise pick-and-place operations.

Dodla Mandeep, Mettu Ranjith, Paka Sumanth, Pola Ravi Kumar, Chetla Venu Gopal, Dr K. Siva Prasad. [14] "Design, Analysis and Fabrication of Pick and Place Robotic Arm with Multipurpose". This project focuses on designing and fabricating a cost-effective pick-and-place robotic arm using a Raspberry Pi controller. It features a gripping mechanism and revolute joints for smooth object handling. SolidWorks Soft Motion software is utilized for designing Cartesian and articulated robotic arms with various grippers.

Shruti Vrushabh Kokile, Samiksha Sachin Magdum, Manasi Adinath Patil, Sanika Nitin Patil, Ms. A.A. Chaugule. [15] "DEVELOPING ROBOTIC ARM USING JOYSTICK FOR PICK AND PLACE OPERATION" This project focuses on developing a joystick-controlled robotic system to reduce human labor using simple and affordable components. The robot, capable of movement and pick-and-place operations, enhances productivity while minimizing mishaps. Inspired by human anatomy,

3. METHODOLOGY

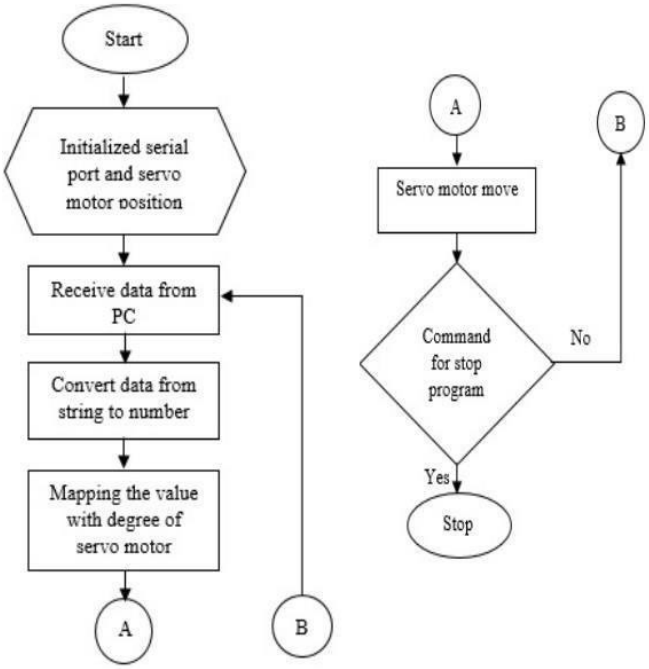

Figure 1 Microcontroller working

Problem Definition

In several fields like industrial automation, medical care, and transportation, there is increasing need for machines that can undertake repetitive or risky tasks with great accuracy and low human intervention. Conventional robotic systems tend to demand heavy coding or manual control, thus not being user-friendly enough for ordinary people.

The primary goal of this project is to create a 360° rotating pick-and-place robotic arm driven by real-time hand gestures, utilizing an Arduino Mega 2560, servo motors, and inverse kinematics for accurate movement. The system will enhance usability by eliminating the necessity for complicated programming,

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enabling users to control the robot using natural hand movements. The aim is to present a functional prototype that illustrates possible uses in automation and remote operation, with a basis that can be developed further in the future by integrating AI, sophisticated sensors, and flexibility for more advanced environments.

Servo motor

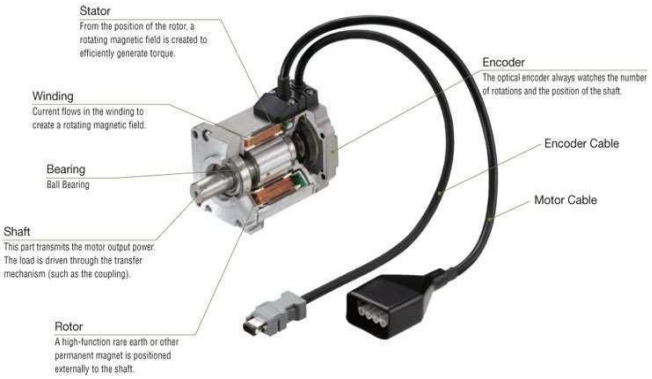

Figure 2 servo motor demonstration

Motor driver.

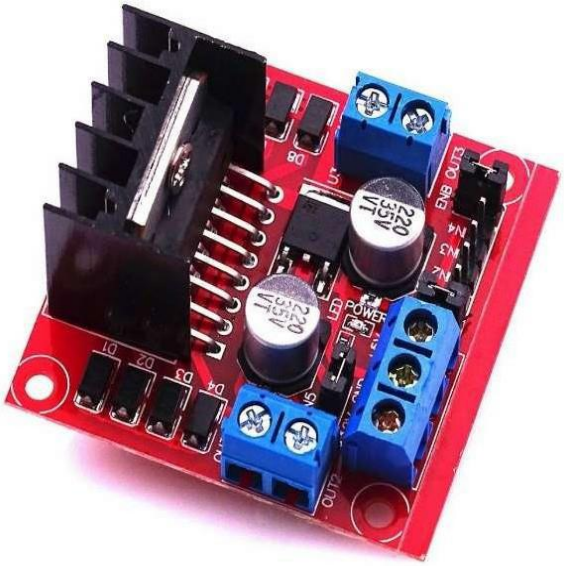

Figure 3 Motor driver

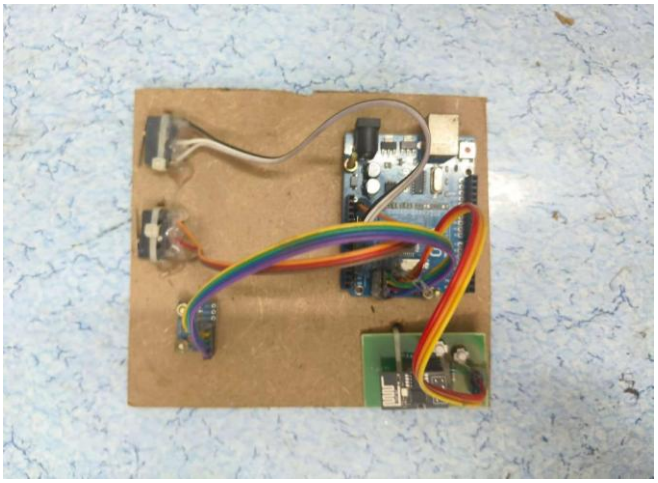

Figure 4 Gesture control unit

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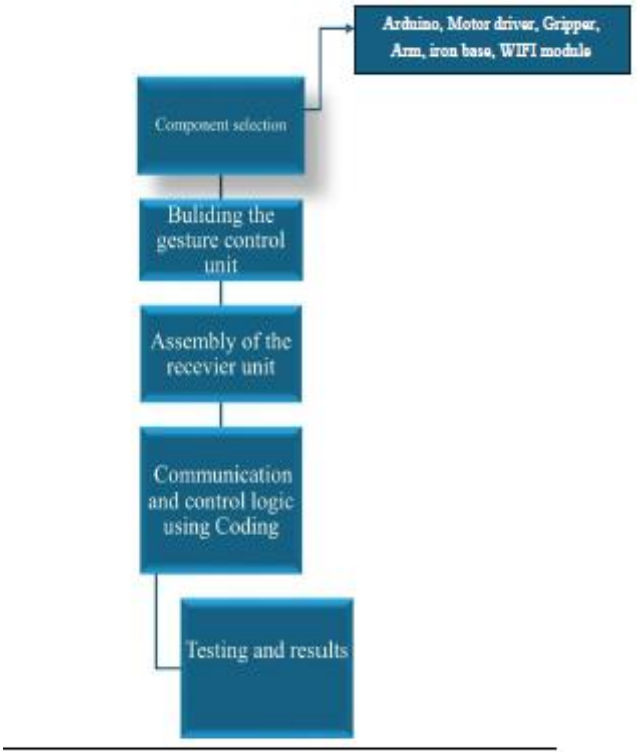
List of components & specifications

S. No	Name of component	Specifications	Quantity
1	Arduino UNO	ATmega328P microcontroller	1
2	ESP8266 Wi-Fi Module	ESP-01 with onboard antenna	1
3	L298N Motor Driver Module	Dual H-Bridge, up to 2A per channel	2
4	12V DC Geared Motor	12V, high torque	1
5	Power Supply Battery	12V Rechargeable Battery	1
6	Switches	Tactile/limit switches	2
7	Robotic Arm Base Structure	Iron + HDPE material	1
8	Gripper	HDPE material	1
9	Jumper Wires	Male-to-male / Female-to-male	2
10	Breadboard or PCB	For prototyping and connections	1
11	Mounting Board	iron board for fixing components	1

Table 3.1 List of components

Step by step methodology



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4. Development and construction

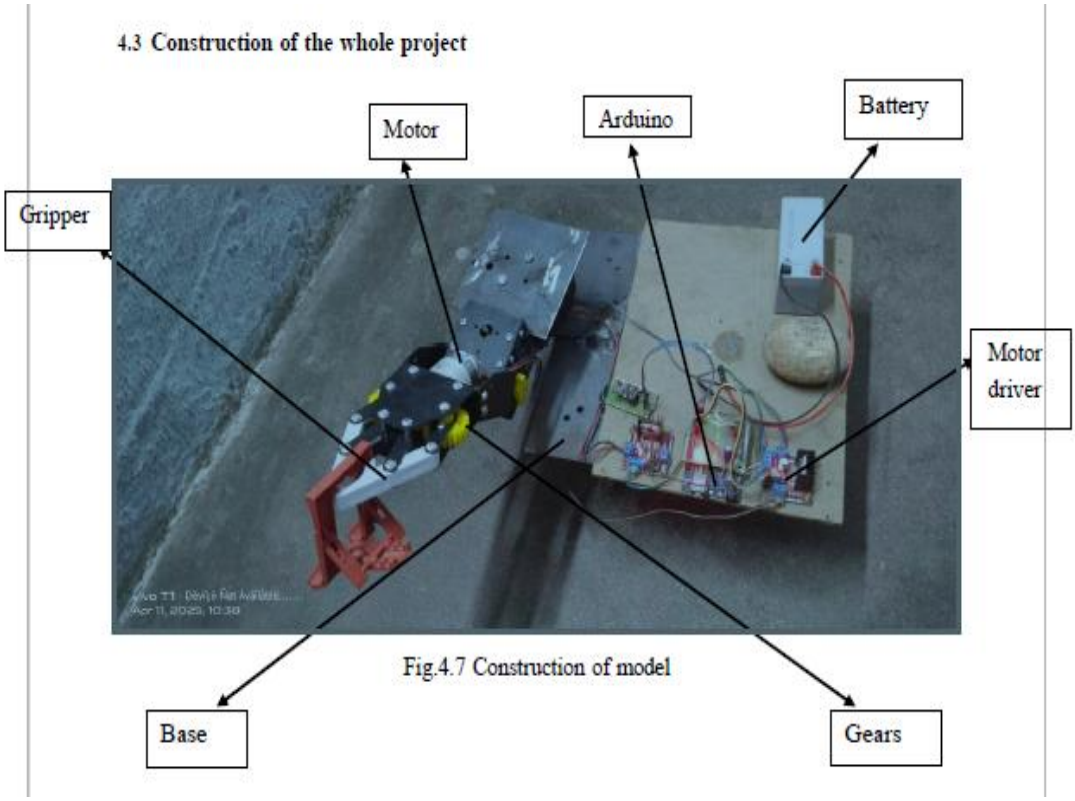

Fig.4.7 Construction of model

5. WORKING AND RESULTS

This project involves the development of a robotic arm system capable of 360° rotation and pick-and-place functionality. The system is controlled using hand gestures, making it intuitive and user-friendly, with applications in industrial automation, hazardous environments, and smart systems.

The project is divided into two main sections:

1. Gesture Control Unit (Transmitter)
2. Robotic Arm Unit (Receiver)

1. When the user tilts or moves their hand, the accelerometer or tilt switches detect the change in orientation or motion.
2. The sensors output analog signals corresponding to the direction of tilt.
3. The Arduino UNO reads these analog signals and maps them to specific robotic actions (e.g., move left, rotate gripper, open/close arm).
4. The command is then transmitted wirelessly via the nRF24L01 module to the receiver unit on the robotic arm base.
5. This process is repeated in real-time, allowing smooth and immediate control of the robot through hand gestures.

6. CONCLUSION

The project “Development of a Hand Motion-Controlled 360° Rotating Pick and Place Robot” has been successfully implemented using Arduino-based embedded control. The system responds to hand gestures using the MPU6050 sensor and transmits commands wirelessly via the NRF24L01 module. These inputs are processed on the receiver side to control various motors for base rotation, arm movement, and gripping

action. This robot demonstrates how gesture-based control can be achieved with simple hardware and code, without requiring advanced technologies like AI or IoT.

6.1 Conclusions

- Key Outcomes: Designed and implemented a gesture-controlled robotic arm with full 360° rotation and pick-and-place capability.
- Utilized Arduino Mega 2560, MPU6050 sensor, motor drivers, and NRF24L01 wireless module for seamless operation.
- Enabled real-time, wireless control through natural hand motions — no physical buttons or advanced programming needed.
- Achieved precise motor control and smooth arm movements using simple embedded code.
- System is cost-effective, easy to build, and suitable for educational demonstrations and small-scale automation.
- Operates without the need for AI, IoT, or vision systems, keeping the setup simple yet effective.
- Project provides a strong base for further development and experimentation in robotic control systems.

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