International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 5, May 2024)

Mechanical Robotic Arm

Mohit kumar[1], Kumar Shubham[2], Sahil Raja[3], Priyam Kumar[4], Kripanshu Khare[5], Dr.Tarun Verma[6]
[1,2,3,4,5]*B.Tech Student, Dept. of Electronics & Communication Eng., Lakshmi Narain College of Technology, Bhopal, India*
[6]*Associate Professor, Dept. of Electronics & Communication Eng., Lakshmi Narain College of Technology, Bhopal, India*

***Abstract*— Mechanical robotic arms represent a significant advancement in the field of robotics, offering versatile capabilities for various applications ranging from industrial automation to assistive technology. These robotic arms consist of multiple interconnected joints and actuators, mimicking the dexterity and range of motion of a human arm. This paper explores the design, functionality, and applications of mechanical robotic arms, emphasizing their importance in modern engineering and robotics research. Through a detailed examination of their components, control mechanisms, and operational principles, this paper aims to provide insights into the development and utilization of mechanical robotic arms across different domains.**

Keywords: Robotic, Arm, Mechanical.

I. INTRODUCTION

Robotic arms have long captured the imagination of engineers, scientists, and enthusiasts alike, owing to their ability to perform complex tasks with precision and efficiency. From assembly lines in manufacturing plants to surgical procedures in hospitals, robotic arms have become indispensable tools in various industries, revolutionizing processes and workflows. Mechanical robotic arms, in particular, stand out for their robustness, versatility, and adaptability to diverse environments and tasks.

A robot is a machine designed to execute one or more tasks automatically with speed and precision. We need robots because robots are often cheaper to use over humans, in addition it is easier to do some jobs using robots and sometimes the only possible way to accomplish some tasks! Robots can explore inside gas tanks, inside volcanoes, travel the surface of Mars or other places too dangerous for humans to go where extreme temperatures or contaminated environments exist. Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. Robotic system has been widely used in manufacturing, military and surgery since the robot can perform many advantages and used as the countermeasure for some job that cannot be conduct by the human excellently. [1].

Robots are used in different fields such as industrial, military, space exploration, and medical applications. These robots could be classified as manipulator robots and cooperate with other parts of automated or semi-automated equipment to achieve tasks such as loading, unloading, spray painting, welding, and assembling. Generally robots are designed, built and controlled via a computer or a controlling device which uses a specific program or algorithm. Programs and robots are designed in a way that when the program changes, the behavior of the robot changes accordingly resulting in a very flexible task achieving robot. Robots are categorized by their generation, intelligence, structural, capabilities, application and operational capabilities.

The fundamental design of a mechanical robotic arm comprises multiple segments or links connected by joints, enabling articulated motion similar to that of a human arm. These joints are typically actuated by motors or other actuators, providing the necessary torque and force to move the arm and manipulate objects in its vicinity. Depending on the application requirements, robotic arms may vary in size, shape, and payload capacity, with some designed for heavy-duty industrial tasks and others for delicate precision work.

One of the defining characteristics of mechanical robotic arms is their programmability and controllability. Advanced control algorithms and sensors allow these arms to perform intricate motions and adapt to changing environments autonomously or under human supervision. Whether following pre-defined trajectories or responding to real-time inputs, robotic arms demonstrate remarkable agility and accuracy in executing tasks with repeatability and consistency.

The applications of mechanical robotic arms are diverse and expansive, spanning across industries such as manufacturing, healthcare, agriculture, and space exploration. In manufacturing, robotic arms streamline production processes, increasing efficiency and quality while reducing costs and lead times. In healthcare, these arms assist surgeons

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 5, May 2024)

in performing minimally invasive procedures with enhanced precision and control, leading to improved patient outcomes. In agriculture, robotic arms automate tasks such as harvesting and sorting, addressing labor shortages and improving productivity. In space exploration, robotic arms play crucial roles in tasks such as satellite servicing, planetary exploration, and assembly of space structures, extending human reach beyond Earth's confines.

In this paper, we delve into the intricacies of mechanical robotic arms, examining their design principles, operational mechanisms, control strategies, and real-world applications. By understanding the capabilities and limitations of these robotic systems, researchers and practitioners can harness their potential to address complex challenges and propel innovation in various domains. Through case studies, experimental demonstrations, and technological advancements, we aim to provide a comprehensive overview of mechanical robotic arms and inspire further exploration in this exciting field of robotics.

II. LITERATURE SURVEY

X. Zhou et al.,[1] Soft robots enable promising potential terms of safety and flexibility in interacting with the environment. However, soft robots are impeded by insufficient stiffness owing to inadequate mechanical properties. While cable-driven robots, which are widely applied in medical scenarios, such as minimally invasive surgery, benefit from precise motion control compared to soft robots. To maintain flexibility while improving control accuracy and output capacity, a rigid-flexible converged robotic arm is designed in this article using a foldable actuator that combines the benefits of soft and cable-driven robots. The analysis of functional principles and modeling is conducted on the flexible actuator and the rigid-flexible converged robotic arm, respectively. First, the mathematical models of the foldable actuator and the flexible arm are established. Then, an experimental platform and prototypes are built for physical study. The experiments demonstrated that the proposed rigid-flexible converged robot arm has noteworthy flexibility and control performance with rigidity as well as substantial output force, which is able to achieve a maximum output torque of 2300N mm and single joint closed-loop control accuracy of 0.15.

J. Chen et al.,[2] presented a strategy of vibration suppression and disturbance rejection for the flexible joint of a robotic arm based on the equivalent input disturbance (EID) approach. First, the dynamic model of the robotic arm is derived. Internal and external disturbances are treated as an EID on the control input channel. Then, the structure of an EID-based robotic arm conctrol system is developed. A state observer and an estimator are devised to produce an estimate of the EID. An inner compensation is added to reject the disturbances by using the estimate. Next, the damping coefficient of the flexible joint of the robotic arm is analyzed. It is adjusted to suppress mechanical vibration by choosing the proper parameters of the observer and estimator.

W. Thomas et al.,[3] a robotic arm with minimum actuation is designed and analyzed. This design is part of an advanced grasping system for Unmanned Aerial Vehicles (UAVs) and includes a foldable arm, case, novel gripper, and vision system. In this paper, the focus is only on the robotic arm and the case of this system. This system consists of a foldable robotic arm mechanism and a case for keeping the arm inside of it during flight. To minimize the weight of the system, the mechanism includes an arm, gripper, and cage, only using one actuator for all motions. A SolidWorks model of this design was developed, motion analysis in SolidWorks was studied, and a prototype of this design was built and tested. This design can be scaled and attached to most UAVs of various sizes.

S. Rooban et al.,[4] presented a vast requirement for these types of robots in industries to perform repeatable actions like moving objects, welding, painting, packing goods, assembling of parts 3D printing etc., These types of robots are called robotic arm which are used precisely in industries to complete the work easier, quicker with perfection. The robotic arm is formed by connecting all the joints, motors to activate each joint of the robotic arm. Robotic arm is controlled by the micro controllers through program. The robotic arm is generally five to seven degrees of freedom and capable of rotate in all the directions. End effector is connected at the edge of the robot which is used to pick the objects. End effector is like the fingers in our human arm, in robotics how better the program controls the end effector decides the performance of the robotic arm.

T. Liu et al.,[5] In view of the requirements for detection and obstacle avoidance in GIS pipeline, a robotic arm that can be mounted on a pipeline inspection robot to complete detection task is designed. Firstly, mechanical design for the robotic arm is carried out and structural optimization is implemented. According to the simulation results, the robotic arm has a lightweight structure and good mechanical properties. Then a prototype of the robotic arm is built. Afterwards, a research for obstacle avoidance path planning of the robotic arm is conducted, in which process RRT-Connect algorithm is used.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 5, May 2024)

Z. Wei et al.,[6] presented a multi-joint robotic arm with light weight and heavy duty. It has both light and heavy working modes of operation. Firstly, the motion principle is analyzed and the kinematics model is established. Through TRIZ theory, the range of each articulated arm is determined, and then the design of the main load-bearing structure is carried out. The ANSYS simulation analysis is carried out to verify the rationality of the structure. Lastly, the transmission mode and the driven motors are determined and the prototype is produced.

III. PROPOSED METHODOLOGY

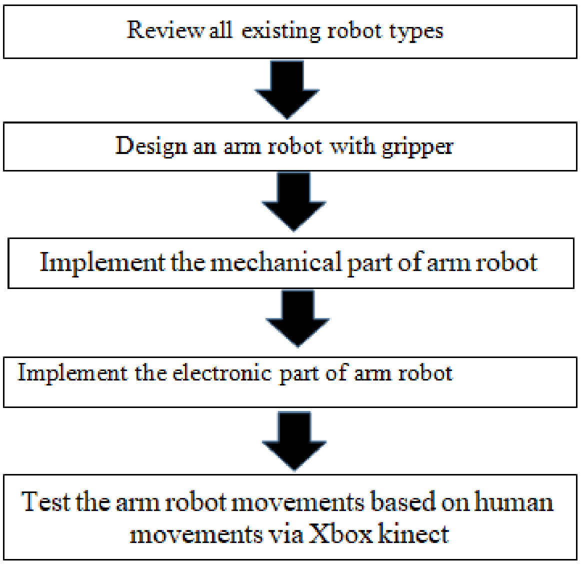

Figure 1: Methodology of Arm Robot

It depicts a flowchart outlining the design process for a robotic arm. Here's a detailed description of the process:

1. **Review all existing robot types**: This initial step involves studying different robotic arm designs to understand their strengths and weaknesses.
2. **Design an arm robot with gripper**: Here, the designers conceptualize the robotic arm's physical structure, including the gripper, a device at the end of the arm used for grasping objects.
3. **Design an electronic part of the arm robot**: This stage involves designing the electrical components that will power and control the robotic arm's movements.
4. **Implement the mechanical part of the arm robot**: Once the design is finalized, the next step is to build the physical structure of the robotic arm.
5. **Implement the electronic part of the arm robot**: In this step, the electrical components are integrated into the robotic arm.
6. **Test the arm robot movements based on human movements via Xbox Kinect**: Finally, the robotic arm's functionality is tested using an Xbox Kinect, a motion detection device, to mimic human movements and see if the arm responds accordingly.

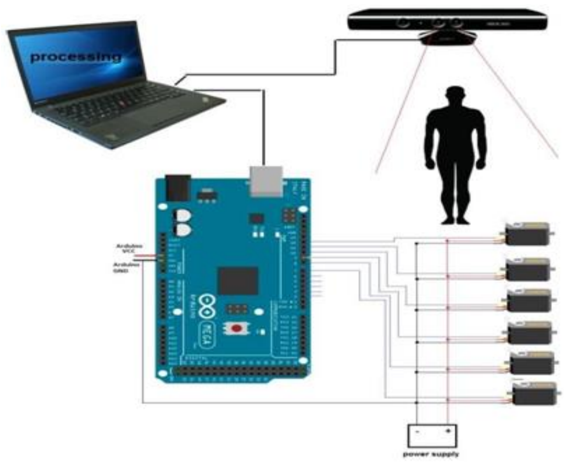

Figure 2: Robot Arm Electronic Circuit

The electronic circuit of arm robot is shown in figure 2. The human stand in front of the kinect, then the processing software divide the body into joints and send the angle of these joints to the arduino. The arduino mega send the control signals which represent the angles to the servos to apply the required movements.

Arduino has become very popular in the world in recent times. In this project the arduino mega is used to communicate with processing and control the arm robot servos. The causes of the spread of Arduino at such a rapid rate are: 1) it can be used on all platforms due to the simplicity of the development environment with driver usage. 2) With the help of the advanced library, even complex operations can be easily solved. 3) There is a lot of hardware support that is compatible

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 5, May 2024)

with Arduino and can work together. 4) Communication with the environment is easy because it is open source.

IV. RESULTS AND DISCUSSION

The first step of designing a robot is to decide the dimension and workspace configuration according to the requirements. The next step is to decide the specification of each actuator. The arm is attached to a base which is the most bottom part of the robot. It is important to mention that the base ought to have considerably heavy weight in order to maintain the general balance of the robot in case of grabbing an object. Although the idea of using stepper and gear motors is brilliant, but physical movement of the robot is done by using servo motors. The advantage of the servos is that they can be programmed to return to their initial position. Since the servo motors operate using the signals received from the microcontroller, they could be programmed according to the requirements.

Figure 3 presents is robot arm diagram-

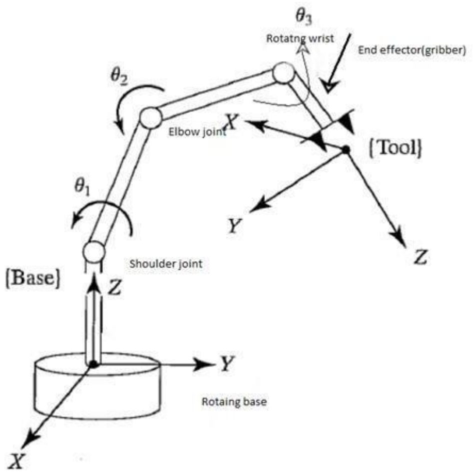

Figure 3: Robot Arm Diagram

The developed robot in this study is a stationary articulated robotic arm with 5 DOF which includes base, shoulder, elbow, gripper, including two revolute joints (wrist, Base). Before starting construction on the robotic arm the 5 servo motor controller should be built first. Before we begin construction, we assembled a servo motor bracket in order to determine function before assembling them into a robotic arm.

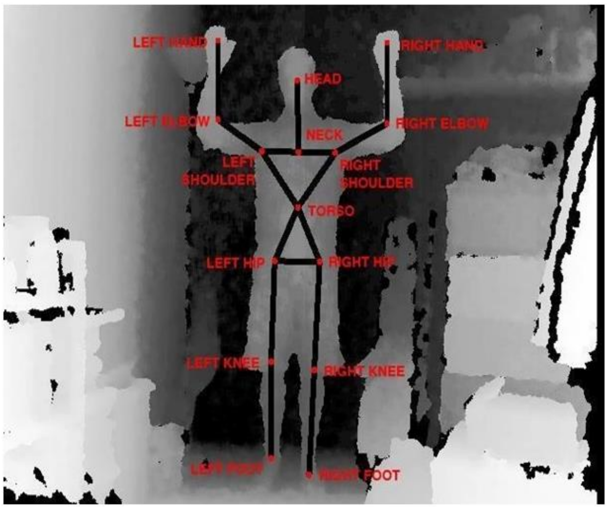

Figure 4: skeleton included body joints

The processing program have to give response for 5 joint of the body so when we connected the robot with power all joint successfully give desirable motion at the robot arm except the last joint, so when left shoulder move the base of the arm rotate in either directions and when the left elbow move the shoulder of the arm move, and when the Right shoulder move the elbow of the arm of the arm move, and when the Right elbow move the wrist of the arm rotate in either directions according to the angle.

Figure 5: skeleton included body joints

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 13, Issue 5, May 2024)

V. CONCLUSION

This project concludes the Kinect tool not just for games because we have used it for controlling different types of machines. During the period of the software of the project we found that the processing language (JAVA) has made a revolution in the technology domain. This project is a prototype of an immense number of projects that we can use it in a lot of purposes like military, medical, social, educational, and industrial and we can use it for people with special needs. We also conclude that we merge more than programming language to achieve some processes to run the project as we have done in our project, we have merged the processing program (JAVA) with Arduino program (C) by using serial port .

REFERENCES

1. X. Zhou, C. Wu, S. Cai and G. Bao, "A Pneumatic-Actuated Flexible Robotic Arm With Rigid Backbone for High-Precision and Safe Manipulation," in IEEE/ASME Transactions on Mechatronics, doi: 10.1109/TMECH.2024.3392828.
2. J. Chen, Y. Du, E. Zhu, B. Li, Z. Han and M. Fang, "Vibration Suppression and Disturbance Rejection for Flexible Joints of Robotic Arm Using Equivalent Input Disturbance Approach," *2023 IEEE International Conference on Unmanned Systems (ICUS)*, Hefei, China, 2023, pp. 1357-1361, doi: 10.1109/ICUS58632.2023.10318293.
3. W. Thomas, P. Wegrowski, J. Lemirick and T. Deemyad, "Lightweight Foldable Robotic Arm for Drones," *2022 Intermountain Engineering, Technology and Computing (IETC)*, Orem, UT, USA, 2022, pp. 1-6, doi: 10.1109/IETC54973.2022.9796899.
4. S. Rooban, I. J. S, R. Manimegalai, I. V. S. Eshwar and R. U. Mageswari, "Simulation of Pick and Place Robotic Arm using Coppeliasim," *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2022, pp. 600-606, doi: 10.1109/ICCMC53470.2022.9754013.
5. T. Liu *et al.*, "Mechanical Design and Path Planning of A Robotic Arm for GIS Pipeline Inspection," *2020 IEEE International Conference on Mechatronics and Automation (ICMA)*, Beijing, China, 2020, pp. 1371-1376, doi: 10.1109/ICMA49215.2020.9233665.
6. Z. Wei and Y. Li, "Design and Simulation of Robotic Arm with Light Weight and Heavy Load," *2019 2nd World Conference on Mechanical Engineering and Intelligent Manufacturing (WCMEIM)*, Shanghai, China, 2019, pp. 537-540, doi: 10.1109/WCMEIM48965.2019.00114.