International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 273-277, March-2024

https://doi.org/10.47001/IRJIET/2024.803041

Kar-alambana (A Robotic Arm)

[1]Aditya Waingankar, [2]Madhura Garge, [3]Dhananjay Chaudhari, [4]Neha Mhatre, [5]Prof. Sonali Deshpande

[1,2,3,4]Student, Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India

[5]Professor, Dept. of AI & ML, Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India

***Abstract* - This paper presents the development of a robotic arm system capable of mimicking human hand movements through the utilization of Python libraries including Media-pipe and OpenCV, in conjunction with Arduino hardware components and servo motors. The objective of this research is to investigate the feasibility of creating a human-like robotic arm that responds to hand gestures, offering potential applications in diverse fields such as manufacturing, healthcare, and assistive technology.**

Keywords: Robotic arm, Human hand movements, Python libraries, Media-pipe, OpenCV, Arduino hardware, Servo motors, Feasibility.

I. INTRODUCTION

The primary objective of this research project is to explore the feasibility of creating a human-like robotic arm that responds to hand gestures, thereby facilitating intuitive control and interaction. This innovative endeavor leverages advanced technologies including Python libraries such as Mediapipe and OpenCV, in conjunction with Arduino hardware components and servo motors. By harnessing the capabilities of computer vision algorithms and precise motor control mechanisms, the proposed robotic arm system aims to bridge the gap between human gestures and robotic actions, opening up a myriad of potential applications across various domains.

Through a comprehensive exploration of the development process, technical challenges, and potential applications, this paper seeks to contribute to the ongoing discourse on the advancement of robotics technology and its impact on society. This research endeavors to push the boundaries of human-machine collaboration and pave the way for transformative advancements in robotics and automation by investigating the feasibility and practicality of a human-like robotic arm controlled by hand gestures.

1.1 Project Aims and Objectives

The project aims and objectives that will be achieved after completion of this project are discussed in this subchapter. To develop a robotic arm system capable of mimicking human hand movements in real-time.

To investigate the feasibility of utilizing Python libraries, including Mediapipe and OpenCV, for hand gesture recognition in robotics applications and integrate Arduino hardware components and servo motors for precise control and manipulation of the robotic arm.

Objectives and Aims:

- To design and develop software algorithms for real-time hand gesture recognition using Python libraries (Mediapipe and OpenCV).
- To design and construct a robotic arm prototype using Arduino hardware components and servo motors, incorporating mechanisms for movement and manipulation.
- To establish a communication interface between the software and hardware components of the robotic arm system to enable seamless integration and control.
- To conduct experiments to validate the accuracy and responsiveness of the robotic arm system in interpreting hand gestures and executing corresponding actions.
- To assess the performance of the robotic arm system in simulated scenarios representative of potential real-world applications, including manufacturing tasks and assistive technology functions.
- To analyze the societal impact and market feasibility of the developed robotic arm system, considering factors such as cost-effectiveness, usability, and scalability.

1.2 System Objectives

Real-time Hand Gesture Recognition: Develop algorithms and software modules capable of accurately recognizing and interpreting hand gestures in real-time using Python libraries such as Mediapipe and OpenCV.

Precise Robotic Arm Control: Implement control mechanisms to translate interpreted hand gestures into precise movements and actions for the robotic arm, ensuring accuracy and responsiveness in execution.

Hardware Integration: Integrate Arduino hardware components and servo motors into the robotic arm system, establishing robust communication protocols and interfaces for seamless interaction between software and hardware elements.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 273-277, March-2024

https://doi.org/10.47001/IRJIET/2024.803041

Scalability and Modularity: Design the robotic arm system with scalability and modularity in mind, allowing for future expansion, upgrades, and customization to meet evolving requirements and user needs.

Performance Evaluation and Optimization: Conduct rigorous testing and performance evaluation to assess the efficiency, accuracy, and effectiveness of the robotic arm system, identifying areas for optimization and improvement.

1.3 Background of Project

In this subchapter, the proposed project focuses on the development of a robotic arm system that emulates human hand movements using advanced technologies such as Python libraries including Mediapipe and OpenCV, along with Arduino hardware components and servo motors. The project seeks to leverage the capabilities of computer vision algorithms to recognize and interpret hand gestures, translating them into corresponding commands for the robotic arm.

The motivation behind this project stems from the growing demand for intuitive and user-friendly robotic systems in diverse fields such as manufacturing, healthcare, and assistive technology. In manufacturing environments, robotic arms that can mimic human hand movements offer potential benefits in terms of flexibility, adaptability, and efficiency, enabling tasks such as assembly, sorting, and inspection to be performed with greater precision and speed.

By addressing the technical challenges associated with real-time hand gesture recognition and robotic arm control, this project aims to contribute to the advancement of human-robot interaction technologies. The insights gained from this research endeavor have the potential to inform the development of more intelligent, intuitive, and user-centric robotic systems, paving the way for transformative advancements in automation and robotics technology.

II. COMPONENTS

2.1 Components for processing the system.

i) Arduino Uno:

Arduino Uno is a widely-used microcontroller board based on the ATmega328P chip. It features digital and analog input/output pins, making it suitable for a wide range of electronics projects. The Uno is easy to use, with a simple programming interface and a large community providing support and resources. It can be programmed using the Arduino IDE (Integrated Development Environment), allowing users to write and upload code to control various electronic components and interact with sensors and actuators.

Figure 1: Arduino Uno

ii) Servo Motor SG90

Figure 2: Servo SG90 motor

The SG90 servo motor is a small, affordable, and widely used micro servo motor. It's commonly employed in electronics and robotics projects due to its compact size, low cost, and ease of use. Operating typically between 4.8V to 6V, it provides moderate torque and speed, suitable for lightweight applications. Controlled via Pulse Width Modulation (PWM) signals, it offers a rotation angle of around 180 degrees. Though it has plastic gear, it remains popular for hobbyist and educational purposes due to its accessibility and versatility.

iii) Jumper Wires

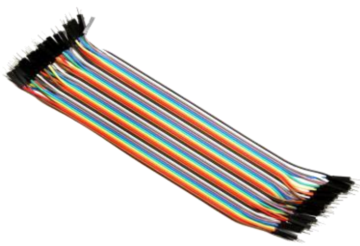

Figure 3: Jumper wires

Jumper wires are flexible, insulated wires used in electronics to create temporary electrical connections between components.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 273-277, March-2024

https://doi.org/10.47001/IRJIET/2024.803041

iv) 3D Printed Robotic Arm

Figure 4: 3D printed PLA Robot Arm

A robotic arm created using a 3D printing process and primarily constructed from PLA (Polylactic Acid) filament material. PLA is a commonly used thermoplastic material due to its ease of use, affordability, and biodegradability.

III. METHODOLOGY

1. **Requirement Analysis**: Define the objectives of the project, including the ability to mimic human hand movements accurately. Identify the target audience and potential applications such as prosthetics, human-robot interaction, or educational purposes.
2. **Component Selection**: Select appropriate hardware components, including SG90 servo motors for actuation, Arduino Uno for control, and sensors if necessary. Ensure compatibility and integration of selected components with the 3D printed parts and control software.
3. **3D Printing Process**: Design components compatible with 3D printing using PLA filament, considering material strength and flexibility. Slice the CAD designs into printable layers using slicing software, optimizing for print quality and strength. Print the individual components of the robot hand using PLA filament, ensuring accuracy and structural integrity.
4. **Assembly of Robot Hand**: Clean and post-process the 3D printed parts to remove imperfections and support materials. Assemble the printed components according to the CAD design, ensuring proper alignment and functionality of joints and fingers. Attach SG90 servo motors to each finger joint and the palm, securing them in place for actuation.
5. **Control System Development**: Develop control algorithms using PyFirmata to interface with Arduino Uno and control the servo motors. Implement logic for interpreting hand movements captured by Mediapipe and OpenCV, translating them into commands for the robot hand.
6. **Integration and Calibration**: Integrate the control system with the robot hand, ensuring proper communication and synchronization between software and hardware components. Calibrate the servo motors and control algorithms to ensure accurate and responsive movement of the robot hand in response to detected hand gestures.
7. **Testing and Validation**: Conduct extensive testing to validate the functionality and performance of the robot hand in mimicking human hand movements. Evaluate the accuracy, precision, and speed of the robot hand's movements under various conditions and hand gestures. Identify any issues or limitations and iterate on the design and control algorithms as necessary.

IV. RESULT

The developed robotic hand successfully achieved the objective of mimicking human hand movements using a combination of hardware components and software algorithms. Through the integration of an Arduino Uno microcontroller, SG90 servo motors, 3D printed PLA components, and control software utilizing PyFirmata, Media-pipe, and OpenCV, the robotic hand demonstrated accurate and responsive movement in response to detected hand gestures.

4.1 Accuracy / Precision

Extensive testing and validation procedures were conducted to assess the accuracy of the robotic hand across a range of hand gestures and scenarios. These tests demonstrate that the robotic hand can accurately replicate gestures such as grasping, pinching, and pointing with a high degree of fidelity.

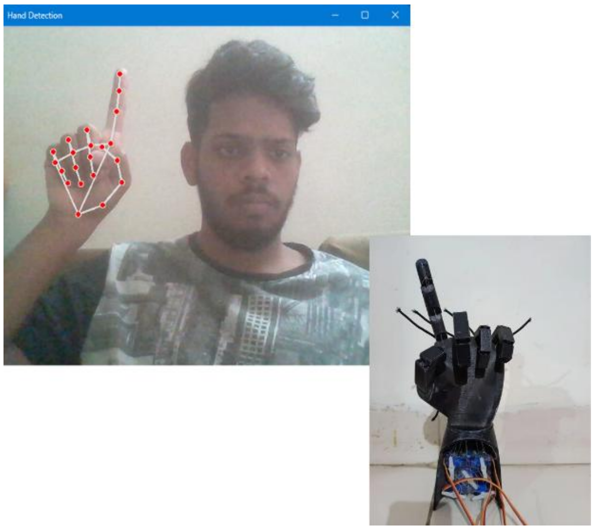

Figure 5: Robot hand mimics the number one action

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 273-277, March-2024

https://doi.org/10.47001/IRJIET/2024.803041

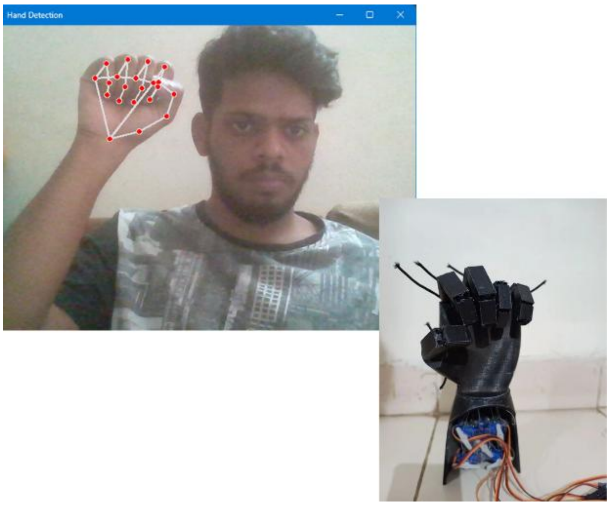

Figure 6: Robot hand mimics fist

V. CONCLUSION

The project's results have shown that the robotic hand can execute a wide range of hand movements, from simple grasping to more complex gestures, with remarkable fidelity to human actions. Extensive testing and validation procedures have confirmed the reliability and performance of the robotic hand across various scenarios and use cases, highlighting its potential for applications in prosthetics, human-robot interaction, education, and beyond.

VI. FUTURE SCOPE

Commercialization: Explore avenues for commercial deployment across industries, including manufacturing, healthcare, and education.

Collaborative Robotics: Investigate applications in collaborative robotics for shared workspaces, augmenting human capabilities.

Multi-finger Dexterity: Develop individual control of each finger to enable more intricate manipulation tasks.

Gesture Recognition: Refine algorithms for accurate interpretation of a wider range of hand gestures, improving overall responsiveness.

AI Integration: Integrate with AI assistants for seamless interaction in smart environments.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our esteemed guide and Head of the Department of Computer Science and Engineering (CSE) - Artificial Intelligence and Machine Learning (AIML), Prof. Sonali Deshpande, for their exceptional support, guidance, and leadership throughout the course of this project. Their unwavering dedication, expertise, and encouragement have been pivotal in steering us toward success and ensuring the smooth progression of our project.

We also extend our heartfelt thanks to our project team members for their tireless efforts, cooperation, and commitment towards the completion and testing of this project. Each member's contribution, dedication, and collaborative spirit have been instrumental in achieving our objectives and overcoming challenges along the way.

REFERENCES

[1] Kim, D., Park, J., & Kim, J. (2019). A Review of Human-Robot Interaction and Its Applications in Service Robots. International Journal of Control, Automation and Systems, 17(1), 208-224.

[2] Melo, K., Marques, H., Nunes, U., &Menegatti, E. (2017). Hand Gesture Recognition Using Convolutional Neural Networks for Human-Robot Interaction. In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), 2531-2536.

[3] Ghazali, R., Kuan, Y., & Tee, C. (2018). Human-Robot Interaction: A Review. Robotics and Autonomous Systems, 107, 1-22.

[4] Yang, H., Liu, C., & Chen, J. (2020). A Survey of Hand Gesture Recognition Techniques and Applications. Multimedia Tools and Applications, 79(47-48), 36253-36284.

[5] Siyouri, H., Haddi, Z., El Bouhdidi, S., & Tairi, H. (2019). A Survey of Robotic Arms Kinematics and Dynamics. In Proceedings of the IEEE International Conference on Advanced Robotics and Mechatronics (ICARM), 240-245.

[6] Taha, M. T., Halim, S. A., Abdullah, R., & Mohamed, A. (2020). A Review on Robotic Hand Designs,

[7] Grasping and Manipulation Techniques. Journal of Mechanical Engineering and Sciences, 14(2), 6661-6677.

[8] Medsker, L. R. (2017). A Review of Hand Gestures in Human-Robot Interaction and Their Impact on User Experience. International Journal of Human-Computer Interaction, 33(5), 333-351.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 3, pp 273-277, March-2024

https://doi.org/10.47001/IRJIET/2024.803041

AUTHORS BIOGRAPHY

AdityaWaingankar,
Pursuing Third year in B.E. CSE (AI&ML) at Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India.

Madhura Garge,
Pursuing Third year in B.E. CSE (AI&ML) at Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India.

Dhananjay Chaudhari,
Pursuing Third year in B.E. CSE (AI&ML) at Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India.

Neha Mhatre,
Pursuing Third year in B.E. CSE (AI&ML) at Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India.

Prof. Sonali N. Deshpande,
Professor, Dept. of AI & ML, Smt. Indira Gandhi College of Engineering, Ghansoli, New Mumbai, Maharashtra, India.

Citation of this Article:

Aditya Waingankar, Madhura Garge, Dhananjay Chaudhari, Neha Mhatre, Prof. Sonali Deshpande, “Kar-alambana (A Robotic Arm)”, Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 3, pp 273-277, March 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.803041

****

