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Design and Development of Gesture ControlledRobotic Arm

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***Abstract*—In the contemporary landscape, robotic hands are pivotal across military, defense, medical, and industrial sectors, replicating human hand gestures for tasks even in hazardous environments like firework manufacturing or bomb diffusion. This paper introduces a groundbreaking approach to wirelessly control robotic hand movements via gesture recognition. By employing servo control, flex sensors, Arduino Nano, and transceivers, predefined gestures captured by the transceiver enable seamless real-time communication between users and the robotic hand, facilitating remote operation. This innovative integration of gesture recognition technology and robotics presents an exciting frontier for enhancing human-machine interaction, offering adaptability and safety across a myriad of applications.**

I. INTRODUCTION

In recent times, there's been a surge in interest towards creating intuitive methods for human-robot interaction, with gesture control emerging as a prominent approach. This technology allows users to communicate with robotic systems using simple hand gestures, making it accessible across various industries, including healthcare and assistive technologies. Gesture-controlled robotic arms, in particular, have gained traction due to their potential to simplify tasks and eliminate the need for complex controls or programming skills.

The primary objective of this project is to develop a highly versatile robotic hand capable of delicately gripping lightweight objects. Control of this robotic hand will be facilitated through wireless communication with a separate controller glove, utilizing a combination of wires, rotary servomotors, and sensors to mimic the mechanical movements of fingers.

The applications of such a robotic hand are diverse, spanning across industries such as medical, laboratory, and defense sectors. In the medical field, a well-designed robotic hand could function as a prosthetic, offering enhanced mobility and functionality. Additionally, in hazardous environments, like those involving toxic substances or bomb disposal, a functional robotic arm could mitigate risks by handling tasks that are dangerous for humans.

Ultimately, the primary aim of this project is to create a gesture-controlled robotic hand tailored specifically for individuals with physical disabilities, aiming to enhance their mobility and independence.

II. LITERATURE SURVEY

To address the requirements of individuals with disabilities, extensive efforts have been dedicated to the control and advancement of robotic arms. The advent of technology in recent years has spurred the introduction of numerous innovative approaches in this domain. Below, we outline some noteworthy contributions in this area.

Vision-based Gesture Recognition has been applied in Service Robotics, resulting in the creation of a cleaning task-performing robot. Researchers devised a hand gesture interface to control a mobile robot with a manipulator, utilizing a camera to track and recognize arm motion gestures. An agile tracking algorithm enables the robot to effortlessly follow individuals through changing office environments. This system allows the robot to autonomously undertake cleaning tasks, guided by camera-based tracking [1].

The Finger Gesture Recognition System utilizes active tracking mechanisms to facilitate interaction with portable devices or computers through finger gestures, with speech as an alternative mode. This system can integrate into Perceptual User Interfaces (PUIs) for applications in Virtual Reality or Augmented Reality environments [2].

In this proposed system, The Accelerometer-based Gesture Recognition has rapidly gained popularity due to its low cost and compact size. It's effective for detecting and recognizing human body gestures, with many studies employing Artificial Neural Networks (ANNs) [3].

A gesture-controlled robotic arm with OpenCV integration provides intuitive control through real-time hand gesture recognition. This technology offers versatility for applications ranging from interactive exhibits to assistive devices. With ongoing advancements, the potential for innovative uses and improved functionality continues to expand [4].

In our proposed work, we have implemented a system where we use flex sensors in the transmitter side and servo motors for the movement of fingers in the receiver side which is controlled by gestures. This proposed method overcomes majority of the shortcomings of previous systems in both cost and efficiency aspect.

III. PROPOSED METHDOLOGY

This section emphasizes the practical implementation and functionality of the proposed model. The architecture diagram of the project is depicted in Figure 1 to illustrate the model comprehensively.

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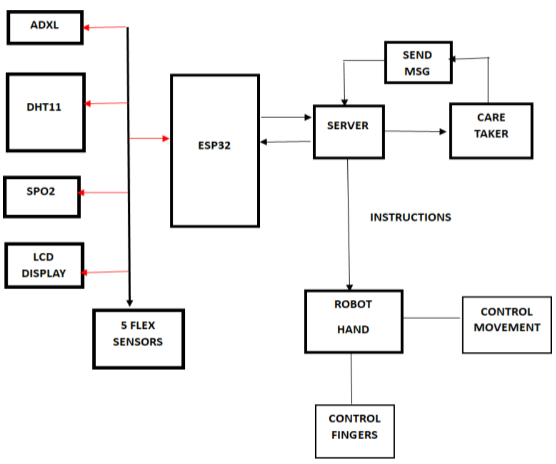

fig: 1 Proposed Block Diagram

The diagram consists of major components, they are: ESP32, Temperature Sensor, SPO2, Flex Sensors, Accelerometer, Servo Motors and 3D Printed Robotic Hand. Figure 1 depicts the block diagram of the wireless hand gesture-controlled robotic arm system. Flex bend sensors serve as the input, while servo motors act as the output components. Initially, the flex bend sensors send resistivity readings to the first Arduino, located within the transmitter circuit. Subsequently, the transmitter transceiver forwards the signal wirelessly to the receiver circuit, which includes the second Arduino. This Arduino then relays the signals to the servo motors, directing them to perform the designated tasks.

The robotic glove contains the circuitry responsible for controlling the robotic hand. It includes an Arduino programmed to transmit necessary data using a transmitter module. Simultaneously, the flex sensor detects finger movement and sends the degree of movement to the Arduino. The module then receives feedback from the arm and sends newly processed signals back to it.

IV. TECHNICAL REQUIREMENTS

Components required are ESP32, Temperature Sensor, SPO2, Flex Sensors, Accelerometer, Servo Motors and 3D Printed Robotic Hand:

ESP32 Development Board

The ESP32 development board is a versatile microcontroller platform with built-in Wi-Fi and Bluetooth, ideal for IoT projects. It features dual-core processing and GPIO pins for interfacing with sensors and actuators, compatible with the Arduino IDE and supporting programming in C and Micro Python.

A. Temperature Sensor

A temperature sensor measures the ambient temperature of its surroundings. It converts temperature into an electrical signal, typically voltage or resistance, proportional to the temperature. Common types include thermistors, resistance temperature detectors (RTDs), and thermocouples.

B. SPO2

A pulse oximeter sensor is a medical device used to measure the oxygen saturation level (SpO2) in the blood and pulse rate. It's commonly clipped onto a fingertip, but can also be attached to other extremities like toes or earlobes. The sensor works by emitting light wavelengths into the body and measuring the amount of light absorbed by oxygenated and deoxygenated blood.

C. Flex Sensors

The versatility of flex sensors makes them valuable for creating interactive and responsive systems that can adapt to physical changes in their environment. When the sensor is bent, the resistance of the conductive material changes, and this change in resistance. Flex sensors are commonly used in various applications, including robotics, wearable devices, and medical equipment.

D. Servo Motors

The MG995 servo motor is a popular and widely used servo motor in hobbyist and robotics projects. The MG995 typically offers a torque output of around 10-15 kg/cm (or 138-208 oz/in), which is quite impressive for its size and price range Specifications. The MG995 servo motor is a digital servo motor that operates at a voltage of 4.8V to 7.2V. It offers a torque output ranging from approximately 10 to 15 kg/cm.

E. Accelerometer

An accelerometer is a sensor used to measure acceleration forces. These forces can be static, like the constant force of gravity pulling at the surface of the Earth, or dynamic, like the force experienced when moving or vibrating.

F. Arduino UNO

The Arduino Uno is a compact and versatile microcontroller board based on the ATmega328P or ATmega168 chip.

G. LCD Display

LCD (Liquid Crystal Display) technology utilizes liquid crystal molecules manipulated by electrical currents between two glass layers to produce images. It offers thin, lightweight displays with low power consumption, making them versatile for various applications like smartphones, TVs, and monitors.

V. RESULTS

While each finger could contract individually, some exhibited better performance than others; notably, the thumb showed inferior performance. However, the robotic hand successfully replicated hand signs executed by the operator wearing the glove. Furthermore, it accurately imitated hand motions with minimal observed delays.

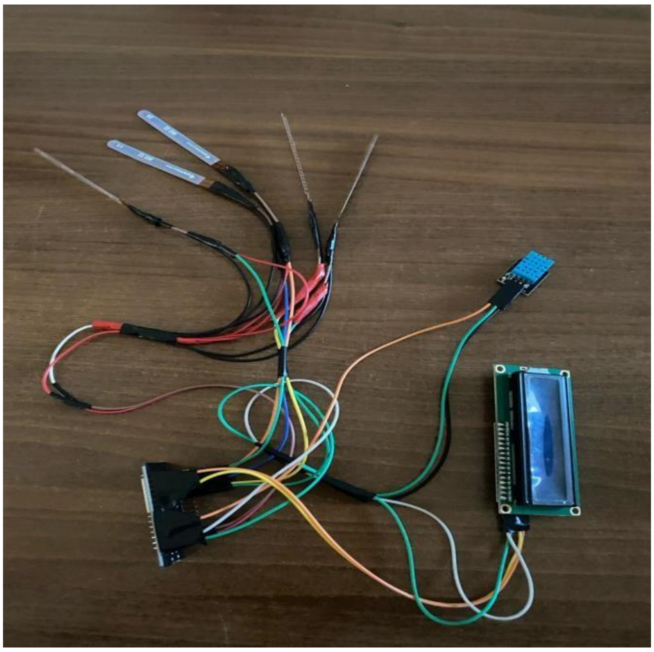

fig: 2 Transmitter

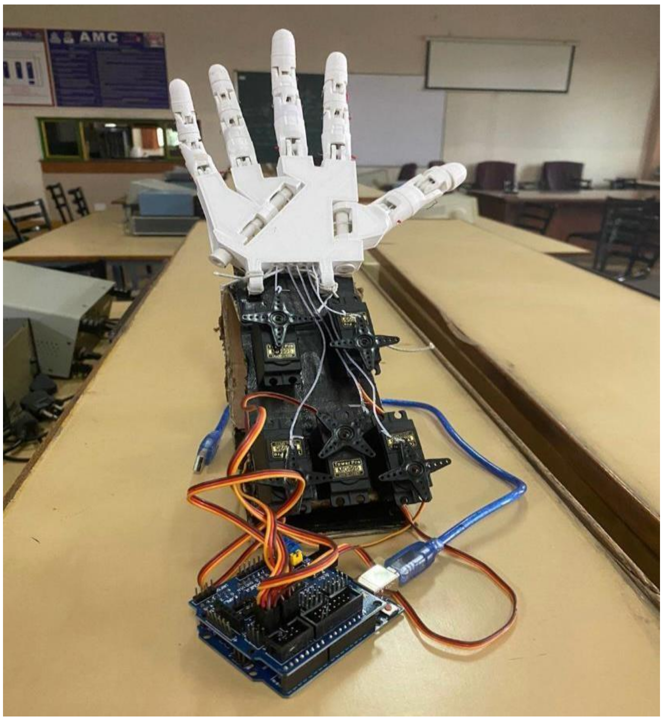

fig: 3 Receiver

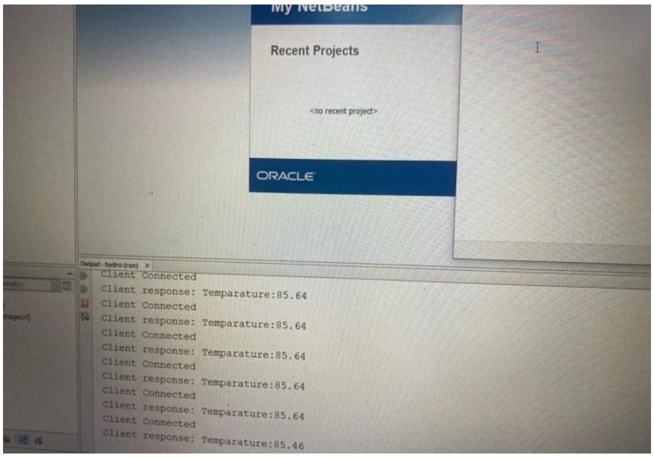

fig: 4 Simulation Result

table 1.gesture control

Parameters	Accuracy	Response Delay
Forward	100%	5s
Backward	100%	5s
Left	100%	5s
Right	100%	5s
stop	100%	5s

Table 1 represents the response of the gesture control module of the Robotic Hand respectively. It shows the accuracy and response delay data for all possible operations.

VI. CONCLUSION

The integration of flex sensors and the ESP32 module in a Gesture controlled robotic hand marks a notable advancement in human-robot interaction. This innovative system adeptly interprets hand gestures, enabling precise robotic movements with potential applications in prosthetics, industrial automation, and assistive technologies. The project's success highlights the feasibility and promise of leveraging accessible technologies to elevate user experience and propel robotics research forward.

VII. FUTURE SCOPE

The gesture-controlled robotic hand using flex sensors and the ESP32 module holds promise for further evolution. Advancements in sensor technology and artificial intelligence algorithms may refine gesture recognition accuracy and responsiveness, enhancing user interaction. Integration with emerging technologies like wearable devices or brain-computer interfaces could unlock new possibilities for intuitive control methods. Moreover, exploring applications in fields such as healthcare, gaming, or interactive art could open up new avenues for innovation and societal impact. Additionally, collaborative efforts across interdisciplinary fields may drive the development of more sophisticated and versatile robotic hand systems, pushing the boundaries of what is achievable in human-robot interaction.

REFERENCES

1. Hui Li, Haoqi Guo,"Design of Bionic Robotic Hand Gesture Recognition System Based on Machine Vision,"2022 3rd International Conference on Computer Vision, Image and Deep Learning & International Conference on Computer Engineering and Applications (CVIDL & ICCEA).

2. Athens, Greece, "Robotic Arm Control with Hand Movement Gestures," 2021 41st International Conference on Telecommunications and Signal Processing (TSP).

3. M. Rajagopalaswamy,M. Sivapalanirajan,D. Vairamuthu,S. Prince Joshwa,T. Vigneshkumar,M. Willjuice Iruthayarajan,"Accelerometer Based Hand Gesture Recognition," 2022 10th International Conference on Emerging Trends in Engineering and Technology - Signal and Information Processing (ICETET-SIP-22).

4. Jedidiah Paterson, Ahmed Aldabbagh,"Gesture- Controlled Robotic Arm Utilizing OpenCV,"2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA).

5. Wang, B., And Yuan, T., "Traffic Police Gesture Recognition Using Accelerometer", IEEE 2021 SENSORS Conference, Lecce-Italy, pp. 1080- 1083.

6. Swarnaprabha Jena, Sworaj Kumar Nayak, Saroj Kumar Sahoo, Sibu Ranjan Sahoo, Saraswata Dash, Sunil Kumar Sahoo,"Accelerometer Based Gesture Controlled Robot Using Arduino," IEEE 2022 International Symposium on Innovations in Intelligent Systems and Applications (INISTA) - Trabzon, Turkey (2022.07.2-2012.07.4).

7. Dr. R. V. Dharaskar, S. A. Chhabria, Sandeep Ganorkar, "Robotic Arm Control Using Gesture and Voice",IEEE 2020 In International Journal of Computer, Information Technology & Bioinformatics (IJCITB), Vol.1, Issue 1,pp. 41-46.

8. L. Chen, Y. Wu, Z. Du, T. Tao, and F. Zhao, "Development of an industrial robot controller with open architecture," in IEEE 2022 International Conference on Cybernetics and Intelligent Systems (CIS) and IEEE Conference on Robotics, Automation and Mechatronics (RAM), 2021, pp. 754–757.

9. S. Perrin, A. Cassinelli and M. Ishikawa, "Gesture Recognition Using Laser-Based Tracing System", 2020 In Automated Face and Gesture Recognition. Proceeding, Sixth IEEE Conference, pp. 541- 546.

10. Ahmad Bazli Bakri,Ramli Adnan,Fazlina Ahmat Ruslan,"Wireless Hand Gesture Controlled Robotic Arm Via NRF24L01 Transceiver,"2019 IEEE 9th Symposium on Computer Applications & Industrial Electronics (ISCAIE)