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Comprehensive Survey on Gesture-Controlled Robotic Arm

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Abstract: The current project is based on the development and realization of a wireless hand-controlled robotic arm. This means that the movements and actions made with a person's hand are captured using a special glove equipped with flex sensors transmitted to a robotic arm using wireless communications. Therefore, the wireless hand motion tracking will provide an intuitive, cable-less interface to improve the robot's usability, increase its accuracy, and decrease operator's fatigue. It is expected that the robotic arm could be used for such purposes as pick-and-place tasks and other similar actions.It should be mentioned that the project shows the possibility of developing low-cost wireless gesture recognition for controlling robotic arms by utilizing existing equipment. Such a combination allows not only capturing gestures but also providing their transmission through wireless communication and their processing in order to perform certain actions using servomotors. It should be highlighted that there is room for further improving the project since more degrees of freedom, additional force sensors, or even vision-based gesture recognition can be added.
Keywords— ESP32,pick and place,flex sensor, servo motor.

I. INTRODUCTION

Wireless Hand-Controlled Robotic Arm is a unique robotics invention that aims at replicating the movement of the human hand and duplicating it through a robotic arm via wireless transmission. With the invention, users will be able to control the robotic arm without any physical contact with the robotic system; all they need to do is to make a move of their hand. Technological advancements have revolutionized the manner in which humans interact with automated machines. Itaims to design and develop a low-cost, intuitive robotic system that mimics the real-time movements of a human hand using wireless communication. Automated systems are being invented to duplicate human actions and perform tasks efficiently and effectively. One of such inventions is the Wireless Hand-Controlled Robotic Arm, an automated device that allows the control of a robotic arm using hand gestures without any physical connection between the controller and the robot. The main objective of this invention is to invent a robotic arm that duplicates the movements of the human hand via wireless technology. Users viacan wear a sensory control glove to enable the movement of the finger and hand, which is duplicated via the robotic arm.

II. LITERATURE SURVEY

1) *Sangeeta Karunakar et al. (2023), "3D Printed Robotic Arm using Hand Gestures".*

The authors presented a low-cost solution with high accuracy since their robotic arm had less than 5% error during joint positioning. The proposed model has a user-friendly interface with minimum training time since the operator has only to bend their finger on the glove with embedded flex sensors to move the robotic arm through the wireless Bluetooth channel. On the other hand, it is crucial to note that their robotic arm depends heavily on the calibration of flex sensors. Failure to adjust or calibrate flex sensors correctly leads to errors in arm movements since the gesture performed by the user may be inaccurately recognized by the robot.

2) *Sidhant Sanjay Kulkarni et al. (2025), "Development of a Smartphone-controlled Robotic Arm forAutomated Cotton Harvesting".*

The system provides a low-cost solution for automation, flexibility of movements, and easy control through smartphones. Still, it shows poor accuracy in terms of positioning, is not autonomous since it relies on the input from smartphones and has prototype-level problems like instability of the mechanism and imprecision of gesture recognition. This project demonstrates the possibility of implementing smartphones as controlling devices for 3D printed robotic arms, though it requires further improvements in precision, use of sensors, and some level of autonomy.

3) *O. Adega, E. K. Ojo, et al. (2026), "Design and Simulation of Televised Wireless Hand Gesture-BasedControlled Robotic Arm".*

With the system, the robot arm is made possible to be controlled wirelessly via hand gestures while the operators can see what is happening at the site on a remote television screen. Thus, the system is capable of helping industries enhance their safety since the system makes it possible to operate repetitive or dangerous processes without human operators' involvement or physical tiredness. Nonetheless, a limitation of the system is its weight imbalance which creates fluctuations on the servo and affects its smooth operation.

4) *Michael D. Paskett, Mark R Brinton, et al. (2021), "Portable System for Home Use Enables Closed-Loop, Continuous Control of Multi-Degree-of-Freedom Bionic Arm".*

This paper presents a portable closed-loop prosthetic control system that involves the use of the Ripple Neuro Nomad processor and the DEKA LUKE Arm to enable six-degrees-of-freedom continuous control based on EMG signals and sensory feedback using vibration stimulation and electrical stimulation. As opposed to previous systems, this paper places more emphasis on usability at home by utilizing wireless GUIs in real-time for both experimenters and users in order to make sure that adjustments can be done safely. The authors created models of biological stimulus mechanisms to increase tactile feedback, specifically models based on human mechanoreceptors, and tested their system using a fragile egg test that showed an improvement in performance and timing due to sensory feedback.

5) *Pukar Maharjan, Jae Y. Park, et al. (2020), "A Highly sensitive self-powered flex sensor for prosthetic arm and interpreting gesticulation".*

This systemcan be used in prosthetic hands as well as for the detection of human hand gestures. The sensor converts mechanical energy into electrical signals using finger bending movements. It does not require an external power supply and is sensitive, durable, and relatively easy to fabricate. But the system has certain limitations, including user-dependent variation in its response, limited applicability in terms of movement range and environmental settings, high voltage generation making signal processing difficult, complexity in creating large arrays consisting of several elements, and inability to perform practical tests and calibrations.

6) *Ruijiao Li, Lifeng Wang, et al. (2026), "Scalable Dexterous Robot Learning with AR-basedRemote Human-Robot Interactions".*

This systemuses remote human–robot interactions based on AR was suggested to speed up skill acquisition by integrating robot hardware, AR teleoperation, reliable communications, advanced perception, and pretraining-aided RL framework. Thanks to this technology, rapid learning is ensured by making it possible for humans to train robots via an augmented reality interface, where pretraining and RL further polish the robot's policies for achieving high sample efficiency and success rate on manipulation tasks. Nevertheless, the framework suffers from several limitations, including the sim-to-real challenge when the policies trained in simulation may not be directly applicable in the physical world due to hardware-specific constraints, limited generalizability due to task scope related directly to the AR interface design and implementation.

7) *Arya Patkar, Aishwarya Bichave, et al. (2025), "IoT-based Prosthetic Arm Controlled by HumanGestures".*

This systemcan be operated by human gestures and is made with the use of microcontrollers, flex sensors, servo motors, and the arm frame is created using 3D printing along with a compact battery system. This design proves to be a cost-effective and high-performance solution which is convenient and portable to allow gesture-based control of simple hand movements via an IoT system which is remotely monitorable and easy to connect to. Nevertheless, their approach lacks in several areas, including poor functionality due to limited grasp patterns available, possibility of sensor malfunctioning due to drifts and deterioration, as well as a simplistic testing scheme not thoroughly examining long-term reliability. This paper proves how IoT integration and gesture detection can be used in a low-cost prosthetic arm, but also suggests future research directions to increase its efficiency.

8) *URamani, Dr. T Manjula, et al. (2024), "Design and Implementation of an IoT Enabled Bionic Arm Gesture Control Robot Using EmbeddedSystem".*

This system which includes five flex sensors, a gyroscope, a microcontroller, an NRF wireless module, and DC motors to actuate the movement of the bionic arm. The proposed method attempts to develop a cost-effective gesture-based human-robot interaction model that allows for versatile control of the robotic/bionic arm based on gesture detection from the user's hand position and angle changes.

The paper is valuable in the context of bionic robotics, since it explores a possible integration of IoT and gesture-based control of a bionic arm.

Still, it suffers from some limitations, including insufficient gesture recognition accuracy, especially when it comes to recognizing similar hand gestures, and a lack of detailed information on the specific algorithms applied for data processing and calibration, as well as test conditions.

9) *Ghassan Ali Mohammed Al-Shafali, Kamal Abdulrahman Adam Wady, et al. (2026), "Design and Development of a Low-Cost EMG-Controlled Prosthetic Hand".*

This system presents a cost-effective myoelectric prosthetic arm developed using 3D printing, tendon-driven mechanisms, and EMG-based control signals. The system provides six degrees of freedom and uses surface EMG signals to control finger and wrist movements for daily activities. The study also upgrades the system with an Arduino Mega and ESP8266 Wi-Fi module for wireless communication and improved control performance.Experimental results demonstrate that the developed prosthetic hand achieved a low manufacturing cost of approximately $250, grip force around 3 N per finger, actuation speed of 0.4 s, and multiple grasping patterns suitable for daily activities. Results show that the prosthetic hand is lightweight, affordable, and capable of multiple grasping patterns, making it a promising solution for low-cost assistive prosthetic technology.

10) *NPushpalatha, B Padmini, et al. (2023), "Gesture-based Control of a Bionic Arm–A Prototype Design".*

It is a bionic arm through vision/sensing technology with the help of an Arduino UNO microcontroller and servomotors for achieving intuitive motion control. This model uses a vision-based or sensing-assisted technique that utilizes a camera for gesture recognition to control the movement of the robotic bionic arm in response to specific hand gestures. This model is inexpensive and flexible, with possible applications in the development of artificial limbs and assistive devices, as well as educational purposes. The downside to this model is its heavy reliance on vision input, making it vulnerable to variations in ambient light and occlusion problems. It is also a very basic prototype, which means there are no extensive tests regarding its robustness and real-time performance.

11) *Dinesh Patil, Mohith Patil, et al. (2024), "Wireless Control of 4 D.O.F. Robotic Arm using EMG Muscle Sensor".*

A wireless control system for a 4 degrees-of-freedom (DOF) robotic arm utilizing EMG muscle sensors, incorporating Arduino UNO R3 microcontrollers, potentiometers, four SG90 servo motors, and Muscle Bio Amp Patchy v0.2 EMG sensors. This design provided high accuracy in gesture recognition, dual-mode flexibility in operation, and cost-effective prosthetics. Yet, the technology encountered obstacles common to EMG signals, such as noise vulnerability and inconsistency, alongside constraints on the prototype regarding energy limitations and lack of scalability, as well as constraints related to DOF and hybrid inputs.

12) *Szilard Bularka, Mircea Babaita, et al, "Robotic Arm Control with Hand Movement Gestures".*

The technology used Kinect and Leap Motion sensors along with flex and IMU sensors while an Arduino or Raspberry Pi microcontroller was used to process data and control the robotic arm. Some of the positive features of this technology include intuitive control based on natural gestures, enhanced accessibility, improved safety, and cost-effectiveness. On the other hand, some limitations include recognition errors, latency problems, limited range, and environmental sensitivity.

III. CONCLUSION

From primitive EMG-based gesture identification technology to modern IoT-enabled robotic arms which utilize flex sensors, MPU6050 Inertial Measurement Unit (IMU) and communication protocols such as MQTT, there has been a lot of development towards improving interactions of humans with robotic arms for applications in teleoperation, medical assistance, and industrial automation. This review outlines the developments in the field, where researchers have attempted to solve problems related to latency, noise in the signals, and power consumption through incorporation of machine learning methods. Modern technology has made it possible to simulate the complex movement of the hand and improve their performance by increasing the number of degrees of freedom of the robotic arm. It is crucial in future researches to focus on hybrid AI-enabled control, use of edge computing, and biocompatibility in robotic prosthetics.

REFERENCES

[1] Sangeeta Kurundkar, Mansi Lambe, Kaushal Kshirsagar, Vedant Kulkarni and Harsh Lambat, "3D Printed Robotic Arm using Hand Gestures", published in IEEE Xplore, pp.1087-1094, 2023.

[2] Sidhant Sanjay Kulkarni, Yogesh Sopan Dighe and Abhilasha Mishra, "Development of a Smartphone-controlled Robotic Arm for Automated Cotton Harvesting", published in Indian Journal of Agricultural Research, vol.60, pp.109-113,2026

[3] O. Adeaga, E. K. Ojo and Enochoghene, "Design and Simulation of Televised Wireless Hand Gesture-Based Controlled Robotic Arm", published in Nigerian Journal of Engineering, vol. 32, pp.53-59, 2025

[4] Michael D. Paskett, Mark R. Brinton, Tyler S. Davis, Troy N. Tully and George A. Clark, "Portable System for Home Use Enables Closed-Loop, Continuous Control of Multi-Degree-of-Freedom Bionic Arm", published in IEEE Engineering in Medicine & Biology Society (EMBC), pp.1-5, 2021.

[5] Pukar Maharjan, Jae Y. Park, Hyunok Cho and Trilochan Bhatta, "A Highly sensitive self-powered flex sensor for prosthetic arm and interpreting gesticulation" published in IEEE Xplore, pp.665-668, 2020.

[6] Yicheng Yang, Ruijiao Li, Lifeng Wang, Shuai Zheng, Shunzheng Ma, Keyu Zhang, Tuoyu Sun, Chenyun Dai, Jie Ding, and Zhuo Zou, , "Scalable Dexterous Robot Learning with AR-based Remote Human-Robot Interactions", pp.1-9, 2026.

[7] Arya Patkar, Aishwarya Bichave, Priya Chimurkar, Mandar Dumbre and Amol Deshpande, "IoT-based Prosthetic Arm Controlled by Human Gestures", published in IEEE Xplore, pp.1-5, 2025.

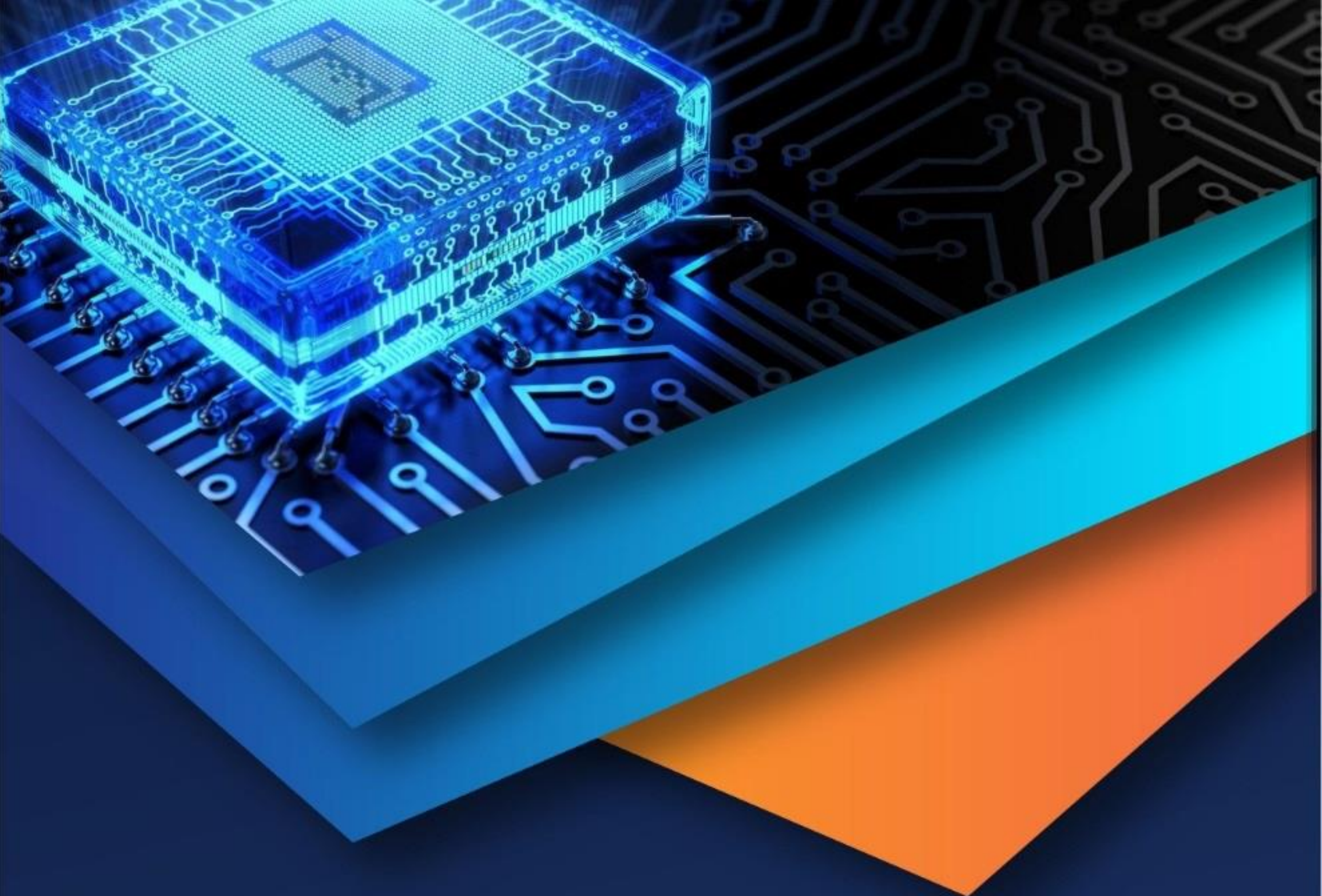
[8] U. Ramani, Dr. T. Manjula, S. Abirami, J Rini Angeline Vinshia, G. G. Sreeja and Dr. M. Thilagaraj, "Design and Implementation of an IoT Enabled Bionic Arm Gesture Control Robot Using Embedded System", published in IEEE Xplore, pp.252-255, 2024.

[9] Ghassan Ali Mohammed Al-Shafali, Kamal Abdulrahman Adam Wady, Fakeraldeen Mohammed Abdalla Ali and Youssouf Fadile Raye Bowou, "Design and Development of a Low-Cost EMG-Controlled Prosthetic Hand", published in ADBA Computers and Electronics in Medicine, vol.3, pp.48-56, 2026.

[10] N. Pushpalatha, B. Padmini Devi, S. Rathinamala, Sheikameer Batcha, V. Yesvanthkrishna and Gomathi V, "Gesture-based Control of a Bionic Arm–A Prototype Design", published in IEEE Xplore, pp.856-859, 2023.

[11] Dinesh Patil, Mohith Patil, Meet Nathwani, Shilpa Sondkar and Shivanand Nemane, "Wireless Control of 4 D.O.F. Robotic Arm using EMG Muscle Sensor", published in IEEE Xplore, 2024.

[12] Roland Szabo, Szilard Bularka, Marius Otesteanu and Mircea Babaita, "Robotic Arm Control with Hand Movement Gestures", published in IEEE Xplore, pp.543-546.



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