Design of Gesture Controlled Arm - An Overview

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Abstract- The Design of Gesture Controlled Arm project aims to explore the potential of gesture control technology in robotics by designing a functional and reliable robotic arm that can be controlled using hand gestures. The system will use machine learning algorithms and computer vision techniques to recognize and interpret hand gestures, allowing users to control the arm's movement and perform a variety of tasks, such as picking and placing objects. The project will involve designing and fabricating the robotic arm, developing the gesture recognition system, and integrating the two systems to create a cohesive and efficient solution. The project's outcome will demonstrate the practical application of gesture control technology in robotics, potentially opening new avenues for automation in various industries. The project's success will also provide valuable insights into the design and development of advanced robotic systems, paving the way for future advancements in the field.

Keywords - Gesture control, Robotic arm, Industries.

I. INTRODUCTION

Robotic arms have become an essential part of modern industrial automation, performing complex tasks with speed, precision, and efficiency. However, controlling these arms requires specialized skills, and traditional control interfaces like joysticks and buttons can be cumbersome and limit the user's range of motion. Gesture control technology presents a promising alternative, allowing users to control the robotic arm using natural hand gestures.

The "Design of Gesture Controlled Arm" project aims to develop a gesture-controlled robotic arm that can perform a range of tasks using hand gestures. The system will use machine learning algorithms and computer vision techniques to interpret and recognize hand gestures, making it easier for users to control the arm. The project seeks to explore the potential of gesture control technology in the field of robotics and demonstrate its practical application in industrial and household settings.

The project will involve designing and developing a prototype of the gesture-controlled robotic arm, integrating different components such as sensors, microcontrollers, and motors. The system will be tested and optimized for accuracy and efficiency, and its performance will be evaluated through various experiments and demonstrations. The project is expected to provide valuable insights into the design and development of advanced robotic systems, paving the way for future advancements in the field.

Flex Sensors are fixed to gloves as shown in **Fig 1**, and servo motors are assembled to the robotic arm as shown in **Fig 2**.

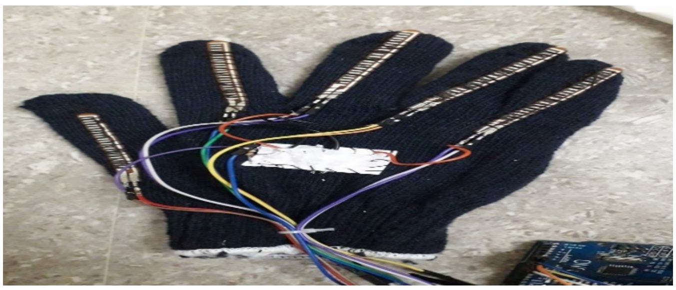

Fig1. Gloves With Flex Sensor.

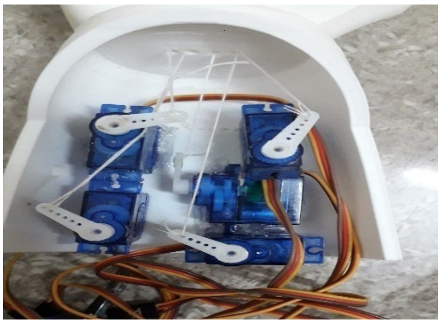

Fig2. Servo Motors Fixed.

The gesture control arm has various potential uses and applications in different domains. Here are some examples:

Industrial Automation

The gesture control arm can be utilized in industrial settings to assist workers in performing tasks that require precise manipulation or remote operation.

Assistive Robotics

Individuals with physical disabilities can benefit from the gesture control arm as an assistive device.

Healthcare and Rehabilitation

In healthcare settings, the gesture control arm can be used for rehabilitation purposes.

Education and Research

The gesture control arm can serve as an educational tool to introduce students to robotics and programming concepts.

Virtual Reality and Gaming

When combined with virtual reality systems, the gesture control arm can enhance the immersion and interaction in gaming and virtual environments.

Entertainment and Performances

The gesture control arm can be employed in entertainment industries, such as theatres, exhibitions, or theme parks.

II. LITERATURE SURVEY

Arkenbout et al. [1]propose a new design tool for steerable instruments that uses a gesture-based control interface. The authors compare the performance of two different control interfaces, one with 2DOF and another with 4DOF, to determine which design is more effective for controlling steerable instruments. The authors concluded that the 4DOF control interface is a more effective design for controlling steerable instruments, as it provides the surgeon with more intuitive control over the instrument. The authors also noted that their design tool could be useful for designing new steerable instruments and improving the control interface of existing instruments.

AnandaSankarKunduetal. [2]propose a solution that allows users to control the wheelchair using hand gestures, which they claim is more natural and intuitive. The paper concludes with a discussion of the potential applications of the proposed system, such as in healthcare, rehabilitation, and personal mobility. The authors also identify some limitations of the system, such as the need for calibration and the limited range of hand gestures that can be detected.

Rajesh KannanMegalingam et al. [3]discusses the development of a wireless robotic arm control system for agricultural applications using hand gestures. The authors proposed a novel approach for controlling the robotic arm with hand gestures, which can be used for various applications such as crop harvesting, pesticide spraying, and other agricultural tasks. The system consists of two main components: a gesture recognition module and a robotic arm control module. In conclusion, the paper presents a novel approach for controlling a robotic arm using hand gestures for agricultural applications. The system is based on image processing and Arduino technology and has demonstrated good performance in experiments. The proposed system can have significant implications for the agriculture industry, where automation and efficient control systems can help increase productivity and reduce costs.

Xiaoqian Mao et al. [4]discuss the potential benefits of using Google Glass as a control interface for NAO, which include the ability to control the robot hands-free and the possibility of natural language interaction. However, the authors also identify the issue of drift in the head gesture reference signal, which can occur due to movements of the user's head that are not intended as commands. The paper concludes with a discussion of the limitations of the proposed method is limited by the accuracy of the Google Glass sensors and the assumptions made in the filter design. They also suggest that future work could explore the use of other sensors or alternative control interfaces to improve the performance of the system.

Shujie Deng et al. [5]review related work on multimodal interaction and mid-air gesture control. They highlight that combining different modalities, such as gaze and gesture, can improve user experience and reduce the cognitive load required for interaction. Previous studies have shown that using gaze input alone can enhance interaction efficiency, and that combining gaze with gesture input can lead to better performance and user satisfaction. However, few studies have investigated the impact of using gaze-informed gesture control specifically for manipulating 3D virtual objects. In conclusion, the paper by Shujie Deng et al. presents a study on the impact of using gaze-informed mid-air gesture control in manipulating 3D virtual objects. The study shows that combining gaze and gesture inputs can lead to better user performance, satisfaction, and reduced cognitive load during interaction. The authors suggest that their findings have implications for the design of more effective and efficient multimodal interfaces for virtual object manipulation.

Hui Liang et al. [6] explored different ways to control virtual puppets, including voice commands, motion tracking, and gesture control. Gesture control has gained traction in recent years, as it offers a natural and intuitive way for users to interact with virtual objects. In conclusion, the paper by Hui Liang et al. presents an innovative approach to virtual puppetry storytelling using gesture control and stereoscopic devices. The proposed system combines the advantages of gesture control and stereoscopic devices to create a more immersive and interactive experience for users.

Lalithamani et al. [7] proposed system's architecture, including the image acquisition and processing pipeline, gesture recognition algorithm, and user interface design. The author also describes the experimental setup and presents the results of the evaluation of the system's performance. In conclusion, Lalithamani's paper provides an innovative solution to the problem of hand gesture recognition for PC interaction, demonstrating the potential of using a single camera to capture and analyze hand gestures. The paper's experimental results show that the proposed system has high accuracy and low computational requirements, making it a promising approach for future research in this field.

Rajesh KannanMegalingam et al. [8]Introduce the concept of gesture control as a potential solution. They highlight the advantages of using hand gestures as an input method, including the ability to perform actions without physical contact, ease of use, and flexibility. The authors discuss the potential applications and benefits of the proposed system, including improved mobility and independence for individuals with mobility impairments. They also highlight the limitations of the system, such as the need for further optimization and customization to accommodate individual user needs.

LudgerOvermeyeret al.[9] introduce to the challenges faced by operators in controlling AGVs in an industrial environment, such as high cognitive workload, multiple tasks, and complex control interfaces. The authors propose the use of multimodal interfaces as a solution to these challenges, which would enable operators to interact with AGVs using speech and gesture recognition, as well as a touch screen display. Overall, the paper provides a comprehensive overview of the use of multimodal interfaces for controlling AGVs and the potential benefits of EEG measurements in evaluating cognitive workload. The study's results are promising and could have implications for the development of more efficient and user-friendly interfaces for controlling AGVs in industrial environments.

Shiva Bandhyopadhyay et al. [10] proposed the concept of gesture recognition and its applications in the automotive industry. The authors discuss the current challenges associated with gesture recognition and how it can be improved by providing audio feedback to the user. They provide an overview of various sonification techniques and their effectiveness in conveying information to the user. The authors conclude the paper by discussing the potential applications of sonification in the automotive industry, including improving safety and reducing driver distraction. They also highlight the need for further research to explore the effectiveness of different sonification techniques in different contexts and environments.

WaseemAfzalet al. [11] The gesture controlled robotic arm is designed, having four fingers that are moveable and a thumb, which opposes the motion of other fingers, and wrists, above are the rotating joints. Servo motors are used of actuators which acts as tendons and ligaments similar to human muscles. The movements of each finger and joints are initiated by servo motors. The motion of the servo motors are controlled with the help of 5 flex sensors, that are attached to the gloves, that tracks the movement of fingers, Finger movements of the robotic arm are controlled by the cables. This can be operated even from a distant location using a wireless models.

ToshikaFegadeet al.[12] the Robotic arm is made of aluminum, that can be controlled by hand gestures, servo motors are used to control the parts of the arm. while using remotes, it would be difficult and requires more practice to analyses 3D motion of the projection. To avoid that kind of inconvenience, gesture controlled / gesture recognition technologies are used, which is a newly introduced technology. Initially the implementation become so simple, since these hand gestures are detected using the sensory, that are attached to the gloves, small transmitting device must be attached to that glove, which includes flex sensors and odorometer. Arduino microcontroller is used to control the whole Unit. This system also uses 2 cameras, that has the capability of streaming real time, live videos to multiple laptops, wirelessly. movable surface that can be controlled Also the robot is placed on a movable surface that can be controlled wirelessly.

Ibrahim A. Adeyanjuaet al.[13] A robotic hand for sign language communication with other persons, with hearing disabilities or speaking disabilities. The model comprises of three models, i.e. input unit, control unit and the output unit. The input unit comprises of an Android mobile application, with speech recognition capabilities, where the control unit consists of Arduino ATMEGA microcontroller board. The hand is constructed with the materials from scrap, like bathroom slippers, rubber, straw pipe and tiny rope that is attached with three servo motors, which is designed to perform some set of actions, as a human hand. In future, this prototype can be extended, to a fully robotic human body having two hands.

Chern-Sheng Lin et al.[14] A study has been conducted to utilize the hand gestures tracked by the kinetic depth sensor, in order to control the movements of real-time robotic arm. Input unit consists, of a kinetic depth which is used to take photos of the body and track the motion of the skeleton and get essential data. From that images of the human body as well as the motion of joints are received and converted to relative position of the robotic or. The gesture information is converted to each angle of the robotic arm's mater. Also, the gesture control system might deal with heavy electronic components to be wearied, that can cause an inconvenience for the users, while moving.

BenjulaAnbu Malar M B et al. [15] A basic robotic chassis has been introduced, that can be controlled. Using the accelerometer with the hand movements, apart from the usage of buttons or any other input devices. This also comprises of sensors with polysilicon surface and the circuit for signal controlling to measure and manipulate the acceleration. The static acceleration due to gravity by just can be measured by tilting the device. The coordinates are generated based on the hand positions, and their parameters are necessary and according to the condition met by these, the necessary Arduino code is executed. In some of the fields like defense, industrial robotics, and surgeries, it might be difficult and complex to control the motion of the robot using buttons, as sometimes the user might get confused in switch controls, so in those cases gesture control plays a major role.

Elam Cheren.Set al.[16]A hand gesture controlled robotic arm has been constructed, which is generally a programmable type. The movements can be controlled by the glove attached to the human hands and the glove is incorporated with flex sensors, and transceiver. The transmitter circuit consists of transceiver to transmit signal between the human hand and the robot. The analog signals from the flex sensor are sent to the Arduino, and based on the code written in Arduino, the position of the motors are controlled, the motors are directly connected to the relay output, and with this setup the robot can be used for pick and place purposes. It can be also used in hazardous operations like handling explosives.

KarthikBankapur et al. [17]Bibliometric analysis on hand gesture-controlled robot Hand-gesture controlled system is recently emerging field in research and studies. It is widely used technology in many fields like robotics, industries and medical. Hand-gesture recognizing system was introduced with flex sensors, transceivers, and Arduino. The system comprises of gloves with multiple flex sensors that is connected to microcontroller fixed on it. Hand consists of 5 servo motor that can perform actions like grasping, opening and closing. The flex sensor measures the movement of fingers, whereas the movement of arm is measured usingpotentiometer. SG90 and MG996R servo motors are used to control the movements of the fingers and thumb joints, where the torque of SG90 servo is 2.5 kg/cm and MG996R servo is. 10 kg/cm.

Abidhusain Syed et al. [18] Flex sensor Based Robotic arm controller using micro controller sensors are essential input devices, that plays a major role in robotics, which is used to determine the current data, or receive the input signals based on the state. Flex sensors are associated with flexibility, reliability, and repeatability. These actions are controlled by microcontroller like Arduino. The system consists of three units. The first one is controller unit or input unit, that is assisted by a wearable glove with flex sensors. The processing unit consists of 3 axis accelerometer, microcontroller, and analog to digital converter with stepper motor driver. The output unit consists of 4 servo motors and one stepper motor. These flex sensors are just voltage resistors, consists of a thin flexible substrate and that works as a voltage divider.

K Rishika Ravi et al.[19] Robotics is a new technology that is being applied in a variety of contexts, including industrial settings, military applications, and hazardous situations. This study uses an accelerometer and Arduino microcontrollers to describe basic robot arms that are controlled by hand movements. The robot arms are extremely accurate and capable of partial autonomy.

Gaurav Kamat et al. [20] Robotic arms can reduce the amount of work humans have to do, creating a new opening for technology to be applied to new projects. It also covers the reach of current technology and the range of its applications.

Ashutoshzagade et al. [21]a robot called the Gesture Controlled Vehicle can be moved around by using small hand motions. The throttle is controlled by an accelerometer sensor, while the forward, backward, left, and right movements are controlled by accelerometer sensors attached to a hand glove. The differential mechanism causes the car to rotate on its own axis without moving forward or backward by causing both the fourth and rear wheels on either the left or right side to move anticlockwise and the other pair to rotate in a clockwise way. A robotic arm with gesture control that uses a flex sensor is designed and proposed.

Dr. C.K. Gomathy et al.[22] Robotics is primarily concerned with creating systems that are modular, adaptable, redundant, fault tolerant, and sensor based to automate tasks while reducing human effort. Regular and often carried out tasks, such collecting and placing items from one location to another, are automated.

N Nissi Kumar et al. [23]this study suggests a low-cost microcontroller-based robotic arm that has an accelerometer and microprocessor to help with tasks including holding objects and remotely controlling devices. This procedure can be improved by manufacturing an arm in 3-D to serve as a prosthetic replacement.

Sadhana Kumar et al. [24]this paper examines the advantages and disadvantages of various robotic arm system designs to assess current implementations and identify prospective research and development topics. This paper aims to assess current implementations and to identify prospective research and development topics.

AkashUgale et al. [25]with leap motion technology and its use in a cutting-edge robotic arm that operates only on human command and doesn't need any additional assistance from external devices, advanced robotics is the technology of the future. This arm might be a huge help in search and rescue activities, especially in the event of natural disasters.

Dr. KatherasanDuraisamy et al. [26] Many industries, including the military, the defence sector, operating rooms, pick-and-place operations, and industrial automation, use robotic hands. Using servo control, flex sensor, arduinonano, and receive rand transmitter, gesture recognition is used to wirelessly control the hand's movements.

V.Priyanka et al. [27] Robotic arms are mechanical arms designed to carry out specific tasks. Artificial arms are becoming more and more necessary in today's society for a variety of inhuman circumstances where human interaction is challenging or impossible. People take things up without considering the process. As a result, cable and wireless controls are used to manually operate the robotic arm. In this research, numerous robotic arm control techniques were examined, and various downsides were also discussed.

AkshatMathur et al. [28]In this project, a wirelessly operated robotic arm system is proposed for tool handling, pick-and-place operations, and other uses where a human's reach is impractical or hazardous. The movements of the manipulator and the human hand are coordinated.**Table 1** Shows Comparison of Methodologies Adopted in The Survey.

Table 1. Comparison of Methodologies Adopted in The Survey

TITLE	**AUTHOR**	**YEAR OF PUBLICATION**	**METHODOLOGY**	**SENSOR USED**
A gesture-based design tool: Assessing 2DOF vs. 4DOF steerable instrument control	E. A. Arkenbout, J. C. F. de Winter, A. Ali, J. Dankelman, P. Breedveld	2018	Gesture-based design tool	-
Harnessing Audio in Auto Control	Benjamin Bressolette, SébastienDenjean, Vincent Roussarie, MitsukoAramaki, SølviYstad, and Richard Kronland-Martinet	2018	Audio-based control	audio sensor
Understanding the impact of multimodal interaction using gaze informed mid-air gesture control in 3D	Shujie Deng, Nan Jiang, Jian Chang, ShihuiGuo, Jian J. Zhang	2017	Gaze-informed mid-air gesture control	Eye tracker, depth camera, and Leap Motion controller
Hand Gesture Recognition Based Omnidirectional Wheelchair control using IMU and EMG sensors	AnandaSankarKundu, OisheeMazumder, Prasanna Kumar Lenka, SubhasisBhaumik	2019	Hand gesture recognition-based omnidirectional wheelchair control	IMU and EMG sensors
Gesture Control Using Single Camera For PC	N.Lalithamani a	2015	Camera-based gesture control	Single camera
Exploitation of multiplayer interaction and development of virtual puppetry storytelling using gesture control and stereoscopes	Hui Liang ,Jian Chang, Shujie Deng, Can Chen, Ruofeng Tong, Jian Jun Zhang	2016	Multiplayer interaction-based virtual puppetry storytelling using gesture control and stereoscopic devices	Leap Motion controller (for gesture recognition) and stereoscopic devices

Eliminating drift of the head gesture reference to enhance google glass-based control of an NAO humanoid robot	Xiaoqian Mao, Xi Wen , Yu Song , Wei Li and Genshe Chen	2017	Head gesture-based control with drift elimination	Inertial Measurement Unit (IMU) sensors
IR sensor based Gesture Control Wheelchair for Stroke and SCI patients	Rajesh KannanMegalingamVenkatRangan, Sujin Krishnan, AthulBalanEdicheryAlinkeezhi	2016	IR sensor-based gesture control wheelchair	IR sensors
Hand Gesture Based Wireless Robotic Arm Control for agricultural application	Rajesh KannanMegalingam, Shiva Bandhyopadhyay, GedelaVamsyVivek, Muhammad JunedRahi	2017	Hand gesture-based wireless robotic arm control	-
Multimodal speech and gesture control of AGVs including EEG based measurements of cognitive workload	LudgerOvermeyer, Florian Podszus , Lars Dohrmann	2016	Multimodal speech and gesture control of AGVs including EEG-based measurements of cognitive workload	EEG-based measurements
Gesture Control Robotic Arm Using Flex Sensor	Waseem Afzal, Shamas Iqbal, Zanib Tahira1, MehtabEjaz Qureshi	2017	Flex sensor-based gesture control robotic arm	Flex sensors
Wireless Gesture Controlled Semi-Humanoid Robot	ToshikaFegade, YogeshKurle, SagarNikale, PrafulKalpund	2016	Wireless gesture-controlled semi-humanoid robot	-
Design and prototyping of a robotic hand for sign langua	Ibrahim A. Adeyanjua, Sheriffdeen O. Alabi a,	2023	Locally sourced materials	-
The Manipulation of Real-Time Kinect-Based Robotic Arm Us	Chern-Sheng Lin, Pei-Chi Chen,	2020	Kinect-based	Kinect
Hand Gesture Control Robot	BenjulaAnbu Malar M B, Praveen R,	2019	Gesture recognition using OpenCV	Leap Motion, Flex sensors
Hand Gesture Controlled Robot Arm	Elam Cheren.S, Madhubala.S,	2020	Flex sensors, Microcontroller, Bluetooth	Flex sensors, Microcontroller
Bibliometric analysis on Hand Gesture Controlled Robot	KarthikBankapur, Himmat Singh	2021	Bibliometric analysis	-
Flex Sensor Based Robotic Arm Controller Using MicroCont	Abidhusain Syed, ZamrrudTaj H. Agasbal	2012	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Hand Motion Controlled Robotic Arm	K Rishika Ravi, Komala K V	2021	Flex sensors, Microcontroller, Arduino	Flex sensors, Microcontroller

Review Paper on Gesture Controlled Robotic Arm Using IoT	Gaurav Kam	2022	IoT	Flex sensors, Microcontroller
A Study OnGesture Control Arduino Robot	Ashutoshzagade, VishakhaJamkhedkar	2018	Flex sensors, Microcontroller, Arduino	Flex sensors, Microcontroller
The Gesture Controlled Robot	C.K. Gomathy, G. Niteesh, Mr K. SaiKrishn	2021	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Robot Arm with Gesture Control	N Nissi Kumar	2022	Flex sensors	Flex sensors
A Study on Gesture Controlled Robotic Arms	Rishank S Nair, Sadhana Kumar	2018	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Overview on Latest Gesture Controlled Systems for Roboti	AkashUgale D M Chandwadkar	2016	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Survey on Robotic Arm Controlling Technique	V.Priyanka, E.Thangaselvi	2017	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Gesture Controlled Robotics Hand	Dr.KatherasanDuraisamy	2022	Flex sensors, Microcontroller	Flex sensors, Microcontroller
Gesture Based Wireless Control For A Robotic Manipulator	Mr.Arockia Vijay Joseph	-	Gesture recognition using OpenCV	Leap Motion, Flex sensors

III. CONCLUSION

In conclusion, this journal has explored the fascinating field of gesture-controlled robotic arms and the significant advancements made in this area. The integration of gesture recognition technology with robotic arms has opened up new possibilities for human-robot interaction, revolutionizing various industries and enhancing the quality of life for individuals with limited mobility.

Through an in-depth analysis of the existing literature, it has become evident that gesture-controlled robotic arms offer numerous advantages over traditional control methods. By utilizing natural and intuitive hand movements, users can manipulate robotic arms with precision and ease, eliminating the need for complex programming or extensive training. This technology has the potential to improve productivity, efficiency, and safety in various fields, including manufacturing, healthcare, and assistive technology.

The research presented in this journal has highlighted the advancements in gesture recognition algorithms, sensor technologies, and human-robot interfaces, which have played a vital role in the development of gesture-controlled robotic arms. These advancements have enabled more accurate and reliable gesture recognition, allowing for seamless interaction between humans and robots.

However, it is essential to acknowledge that there are still challenges and limitations to overcome in the field of gesture-controlled robotic arms. These include the need for further research and development to improve gesture recognition accuracy, address complex gesture combinations, and enhance the robustness of the system in different environments. Additionally, ensuring user safety and addressing ethical considerations surrounding the use of such technology are of paramount importance.

In conclusion, gesture-controlled robotic arms hold immense potential for transforming human-robot interaction and improving various aspects of our lives. With continued research, innovation, and collaboration between academia, industry, and end-users, we can expect to witness further advancements in this field, ultimately leading to the widespread adoption of gesture-controlled robotic arms in real-world applications.

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