IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

HAPTIC GLOVE CONTROLLED ROBOTIC ARM AND HAND

[1]Aavani K A,[2]Leo Micheal Joy,[3]Rishin M K,[4]Santhra Mariya Joshy, [5]Priyamol P

1,2,3,4, Students, Department of Electrical and Electronics Engineering, Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

5 Assistant Professor, Department of Electrical and Electronics Engineering, Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

Abstract:It becomes vital to work in locations where human presence is challenging, dangerous, or even impractical. Anthropomorphic manipulators are helpful in such risky circumstances. Only robots that can recognize the remote presence of an operator by applying the copying kind of control may entirely replace a person when doing difficult jobs in a dynamic environment at this point in science and technology development. Copy control causes the robot to mimic the operator’s actions. The foundation of this control approach is the concurrent creation of laws of motion for all humanoid manipulator mobility levels using a copy-type master. A haptic glove worn by the operator can be used for remote control of the manipulator. With haptic gloves, you may sense virtual items by altering your tactile sensations, which improves your dexterity and control while performing tasks. This greatly expands the possibilities for believable immersion. This can be useful not just in rescue operations but also in the energy and construction sectors, healthcare, and in business. This project aims to create hap- tic gloves. The analysis of literary materials that had already presented haptic gloves helped to accomplish this goal. Software architecture, as well as techniques for haptic glove implementation on the bend and absolute orientation sensors, are suggested.

Index Terms **- Teleoperation,Arduino UNO,Haptic Feedback,Robotic Arm.**

I. INTRODUCTION

Industrial robots have evolved beyond their traditional roles and are now employed in various applications such as collaborative robots, service robots, mobile robots, and autonomous robots. Collaborative robots work alongside humans, service robots provide assistance in different settings, mobile robots navigate and perform tasks autonomously, and autonomous robots operate independently. These advancements create new opportunities and ensure the safety of human workers, particularly in challenging or hazardous environments. Anthropomorphic manipulators, or robotic hands, are essential in risky situations and can perform complex tasks with precision. Copy-type control systems enable these manipulators to mimic the movements of an operator using a haptic glove. This technology allows for remote control and enhances tactile sensations, making it valuable in fields like energy, construction, healthcare, and rescue missions. For example, surgeons can use haptic gloves to remotely control surgical robots during minimally invasive procedures. The development of robots capable of recognizing and applying copy-type control has the potential to replace humans in challenging tasks within dynamic environments. By mimicking the operator's movements, robots can perform difficult jobs autonomously. The concurrent creation of motion rules for all mobility levels in anthropomorphic manipulators, combined with haptic gloves, offers improved dexterity and control. This technology finds applications across industries, including energy, construction, healthcare, and rescue operations.

The objective of the project is to develop an improvised teleoperation system that uses haptic gloves to control a robotic arm with pneumatic feedback. The aim is to create a safe and intuitive system that provides realistic force feedback to the operator, allowing them to control the robotic arm more effectively. The system will also incorporate inertial measurement units (IMUs) and flex sensors to detect the state of the operator's hand, which will enable more accurate control of the robotic arm. The use of haptic gloves will allow the operator to feel the forces exerted by the robotic arm, making it easier to control and manipulate. The pneumatic feedback system will provide a more realistic and natural feel, further enhancing the operator's ability to control the robotic arm. The IMUs and flex sensors will provide additional information about the operator's hand state, enabling the system to adjust and optimize the force feedback and control algorithms. The development of a safe, intuitive, and user-friendly teleoperation system holds immense potential for revolutionizing numerous industries. By enabling operators to control robotic arms with enhanced effectiveness and efficiency, this technology can significantly impact fields such as manufacturing, healthcare, and space exploration. In manufacturing, a reliable teleoperation system would enhance automation processes, enabling precise control over complex tasks and increasing productivity. In healthcare, it could facilitate remote surgeries and interventions, bringing medical expertise to underserved areas. In the realm of space exploration, such a system could enable operators to remotely control robotic arms on distant planets or satellites, advancing our understanding of the universe. Overall, this project aims to unlock new possibilities in various sectors by providing a teleoperation system that is safe, intuitive, and easy to use.

Teleoperation- Teleoperation is the process of controlling a robotic system remotely, and in the case of controlling a robotic arm and hand with haptic feedback gloves, it involves the integration of various components to enable precise and accurate control and feedback. These components, such as the Arduino Uno microcontroller, flex sensors, force sensors, servo motors, ESP32 module, and IMU, work together to create a teleoperation system that allows an operator to remotely control the movements of the robotic arm and hand while receiving haptic feedback through the gloves, providing a realistic and immersive telepresence experience.

Arduino UNO -The Arduino Uno microcontroller plays a crucial role in the teleoperation system for controlling a robotic arm and hand with haptic feedback gloves. Its simplicity, versatility, and user-friendly programming interface make it an ideal choice for controlling the robotic hand movements. The flex sensors in the haptic feedback gloves generate analog signals that are processed by the Arduino Uno, allowing for precise control of the rotation of servo motors embedded within the robotic arm and hand. The combination of Arduino Uno and flex sensors enables intuitive and natural interaction between the operator and the system, resulting in accurate control of the robotic arm and hand movements.

Haptic Feedback- Haptic feedback is a crucial aspect of the teleoperation system for controlling a robotic arm and hand. It allows the operator wearing haptic feedback gloves to experience a realistic sensation of touch and manipulation performed by the robotic arm and hand. The force sensors located within the robotic arm and hand measure the forces exerted during interactions with objects, and this data is transmitted to the operator via servo motors embedded within the gloves. The servo motors simulate the forces by generating appropriate vibrations and resistance, providing haptic feedback to the operator. This haptic feedback enhances the operator's perception and understanding of the robotic arm and hand's actions, enabling more precise and immersive control over the system.

Robotic Arm-The robotic arm is a key component of the teleoperation system designed for controlling a robotic arm and hand. It consists of servo motors, sensors, and mechanical links that enable it to replicate human-like movements and perform tasks. The servo motors actuate the joints of the robotic arm, allowing it to extend, retract, rotate, and flex its segments. The sensors embedded within the arm provide feedback on its position, orientation, and applied forces. This information is crucial for precise control and coordination of the arm's movements. The robotic arm serves as the physical extension of the operator's actions, translating their input into corresponding motions, and enabling them to manipulate objects remotely. Its versatility, dexterity, and ability to mimic human arm movements make it an essential component of the teleoperation system, providing a means for the operator to interact with the environment in a remote and intuitive manner.

II. SYSTEMOVERVIEW

Teleoperation is a field of robotics that allows a human operator to control a robot remotely, performing tasks that may be too dangerous, difficult, or impossible for humans to do directly. Teleoperation systems typically consist of a robotic arm and hand, a haptic feedback glove, and various sensors and communication devices. The robotic arm and hand are designed to mimic the movements and dexterity of a human arm and hand, while the haptic feedback glove provides the operator with tactile sensations that allow them to feel the position, force, and movement of the robotic arm and hand. The use of teleoperation systems has become increasingly important in a wide range of industries, including space exploration, manufacturing, and hazardous material handling. These systems have the potential to improve efficiency, reduce costs, and increase safety in a variety of applications. In this project, we explored the design and implementation of a teleoperation system using a robotic arm and hand and a haptic feedback glove. We examined the various components of the system, their functions, and their interactions. Through this project, we gained a deeper understanding of teleoperation systems and their potential for improving human-robot interaction.

Teleoperation using a robotic arm and hand controlled by haptic feedback gloves is an exciting and rapidly advancing field in robotics. This technology involves the use of a teleoperated robotic arm and hand that can be controlled by an operator wearing haptic feedback gloves. The gloves provide the operator with tactile sensations that mimic the feeling of touching and manipulating objects, allowing for more intuitive and natural control of the robotic arm and hand. The system provides an immersive experience for the operator, giving them a greater sense of presence and control over the robotic system. This technology has a wide range of potential applications, particularly in environments that are dangerous or difficult for humans to access. For example, this system could be used in deep-sea exploration or in hazardous material handling, where it would enable operators to control the robotic arm and hand from a safe distance. Additionally, this technology has applications in medical robotics, where it could be used in telemedicine or in surgical procedures. As this technology continues to develop, we can expect to see more advanced haptic feedback systems and more complex robotic systems that can perform a wider range of tasks.

The project involved creating a teleoperation system that utilizes haptic feedback gloves to control a robotic arm and hand. The system was designed in two stages, the first involving the movement of the robotic hand, and the second providing haptic feedback to the operator. This approach allowed for intuitive and natural control of the robotic arm and hand, with the operator receiving tactile sensations that mimic the feeling of touching and manipulating objects. The use of haptic feedback gloves in teleoperation systems has significant implications for improving human-robot interaction and increasing the efficiency and safety of various industries, particularly in hazardous or inaccessible environments.The second stage of the teleoperation system involves the integration of force sensors located within the robotic arm and hand to provide haptic feedback to the operator. These sensors measure the force with which the arm and hand interact with objects or perform movements, such as bending the fingers. The force signals are transmitted to an ESP32 module connected within the haptic feedback gloves, which is responsible for controlling the rotation of the servo motors embedded within the gloves. The servo motors, like those controlled by the Arduino in the previous stage, provide haptic feedback that simulates the sensation of touch and manipulation of objects by the operator. This stage further enhances the intuitive and natural control interface of the teleoperation system, improving the operator's situational awareness and overall performance. The incorporation of haptic feedback in teleoperation systems has the potential to revolutionize various fields, including telemedicine, space exploration, and remote maintenance and repair tasks, among others.

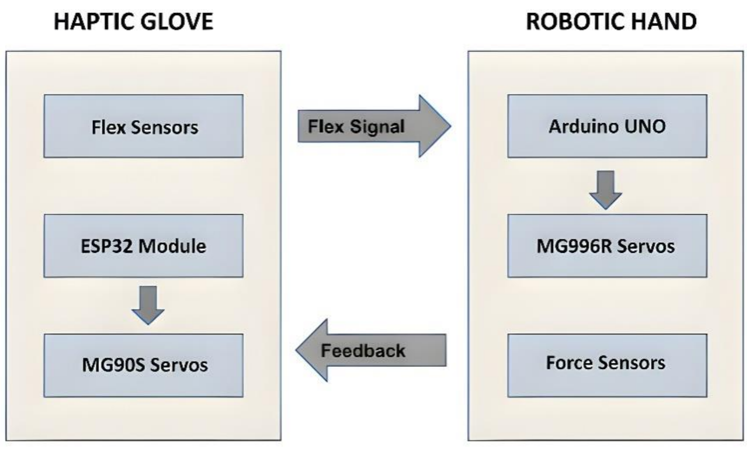

Fig 1. : Block Diagram of the Teleoperation System

The application of teleoperating robotic arms with haptic feedback gloves has a wide range of potential uses across various industries. In the field of telemedicine, for instance, doctors can use such a system to perform minimally invasive surgical procedures from a remote location, reducing the need for patient transportation and allowing for access to specialized medical care. Additionally, in the manufacturing industry, robotic systems controlled through haptic feedback gloves can aid workers in performing precise tasks while minimizing the risk of injury or fatigue. In the field of exploration, teleoperation systems can enable the control of robotic systems in inaccessible or hazardous environments, such as space, the deep sea, or disaster zones. Other potential applications of this technology include remote maintenance and repair tasks, military and defence operations, and virtual and augmented reality systems.

The project is focused on the design and implementation of a teleoperation system using a robotic arm and hand controlled by haptic feedback gloves. The system's goal is to enable humans to perform tasks that may be too dangerous, difficult, or impossible to perform directly. The system is designed in two stages: the first stage involves controlling the movement of the robotic arm and hand, while the second stage provides haptic feedback to the operator, enabling them to feel the position, force, and movement of the robotic arm and hand. The system has the potential to revolutionize various fields, including space exploration, manufacturing, hazardous material handling, and telemedicine.

III DESIGN AND SIMULATION

The Tinkercad software is utilized for the simulation of a haptic feedback glove, providing a comprehensive platform for online 3D modeling that operates within a web browser and is offered at no cost. The haptic feedback glove includes five flex sensors and servos for tactile sensations and movement in a virtual environment. Controlled by an Arduino Uno, the system processes flex sensor input to drive servo movement. Simulation testing verifies if the servos rotate correctly based on the flex sensor inputs, demonstrating the system's functionality. The servos rotate accurately to the desired angles, while the flex sensors detect finger movement and transmit the information to the board. This progress is crucial in developing a functional haptic glove that offers users a tactile sense of touch and movement in a virtual environment. Accurate control of the robotic hand with haptic feedback gloves requires understanding the relationship between flex sensor resistance, voltage, and finger bending. This information is crucial for mapping finger positions to specific resistance values, which ultimately control the robotic hand's motion. To achieve this, the team conducted experiments, recording resistance changes across the flex resistor at various finger positions such as flat, 45-degree, and 90-degree angles. These experiments aimed to establish an accurate equation that relates the bend position of the sensor to its corresponding resistance value.

Tinkercad software has enabled efficient and cost-effective simulation of a haptic feedback glove for robotic hand control. By incorporating five flex sensors, five servos, and an Arduino Uno microcontroller board, the glove can accurately control the robotic hand's motion. Calibration of the flex sensors is crucial for precise control, and an established equation relates resistance values to the degree of bending. Future enhancements include adding hall effect sensors and servos for grasp force feedback, improving the user experience. The successful design and simulation of the haptic feedback glove demonstrate technology's potential in enhancing human-machine interactions, particularly in virtual reality and robotics.

IV HARDWARE IMPLEMENTATION

The development of a haptic feedback glove for controlling a robotic hand is a notable achievement in teleoperation. By integrating haptic feedback capabilities, users can experience touch and improve the precision of robotic hand movements. This section focuses on the 3D printing and hardware implementation of the haptic feedback glove and robotic hand system, covering important design and implementation considerations. The InMoov project by Gael Langevin introduced an open-source humanoid robot with a 3D-printed skeleton, including the head, torso, arms, and legs. It aimed to make robotics accessible to anyone with basic electronics knowledge and a 3D printer. The project gained attention for its intricate InMoov hand, which featured individual finger servos and advanced controls. Leveraging the expertise and open-source designs of the InMoov hand, the team developed a highly functional haptic feedback robotic hand. This approach allowed for cost-effectiveness and encouraged collaboration within the robotics community.

The 3D-printed hand and arm structures were carefully designed for optimal functionality and user-friendliness. The hand featured a flexible design for easy mounting on the user's hand, with individual servo motors for each finger. The modular arm structure allowed for customization and modification. 3D printing enabled the creation of intricate and precise geometries, resulting in a highly functional and responsive robotic hand that accurately responded to haptic feedback signals from the gloves.

The hardware setup of the haptic feedback robotic hand system is depicted in the figure, showcasing the various components and their interconnections. The system comprises two primary components: the haptic gloves embedded with flex sensors connected to an Arduino Uno, and the robotic hand with servos. Currently, the team is focused on developing the robotic hand movement aspect of the system.

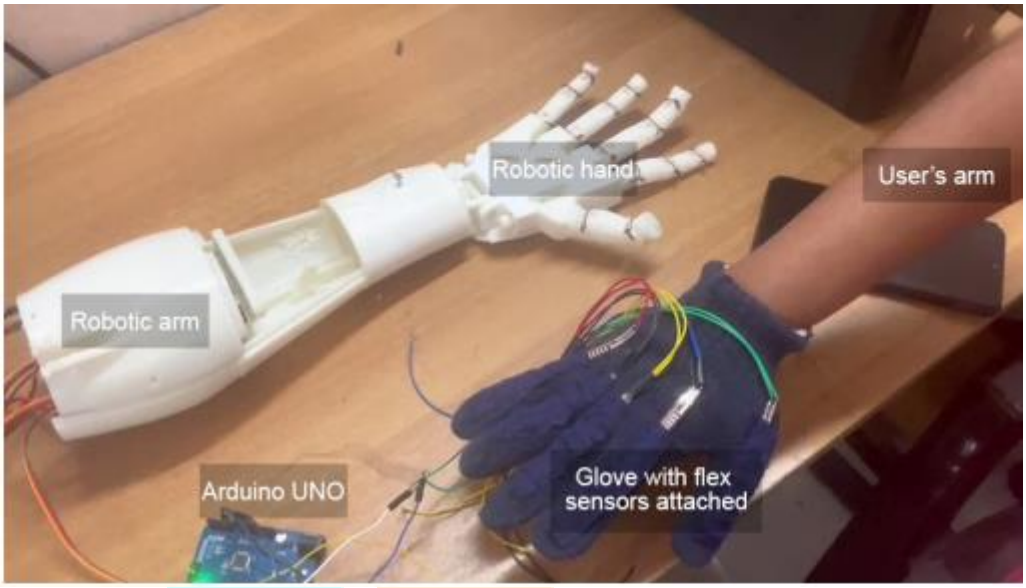

Fig 2. Robotic Hand With Gloves

The haptic gloves are equipped with flex sensors, which are housed in a specialized pouch located within the gloves. The flex sensors detect the degree of flexion in the user's fingers and transmit corresponding signals to the Arduino Uno. The robotic hand is connected to servos using fishnet strings, which are tensioned by the rotation of the servos as dictated by the Arduino code. The tension in the strings results in the movement of the robotic hand and arm, enabling the user to control the robotic hand movements in a precise and intuitive manner. Overall, the hardware setup of the haptic feedback robotic hand system is designed to enable effective teleoperation and improve the user's sense of control and precision in the manipulation of the robotic hand. The use of flex sensors and servos, combined with the Arduino Uno, allows for an efficient and responsive system that can accurately detect and respond to user inputs.

Flex sensors are a type of variable resistor that exhibit changes in resistance in response to changes in their bending angle. This characteristic has led to their nickname, "Flexible Potentiometers." These sensors are typically available in two sizes: 2.2 (5.588 cm) and 4.5 (11.43 cm) in length. A conductive ink-based flex sensor is constructed using a phenolic resin substrate that is coated with conductive ink. A segmented conductor is then added to create a flexible potentiometer. The most straightforward way to read the output of a flex sensor is to combine it with a static resistor to create a voltage divider circuit. The resulting voltage drop across the pull-down resistor can be measured by an analog-to-digital converter (ADC) in a microcontroller. It is important to note that the output voltage measured is the voltage drop across the pull-down resistor, not the flex sensor itself.

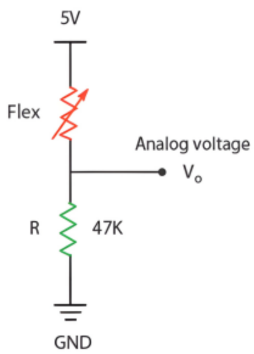

Fig 3. Voltage Divider Circuit For Flex Sensor

To calculate the output voltage (Vo) of a flex sensor, the voltage divider equation can be used.

$$Vo = Vcc \cdot Rflex / (R + Rflex)$$

When the flex sensor is bent to its maximum angle of 90°, the resistance increases to approximately 100K, resulting in an output voltage of approximately 0.31V, as previously mentioned. As the bend radius increases from 0° to 90°, the resistance of the flex sensor increases, causing the voltage drop across it to increase as well. This, in turn, causes the voltage drop across the pull-down resistor to decrease, leading to a decrease in the output voltage.

Specifically, when the flex sensor is flat at 0°, its resistance is relatively low, around 25k. Using the voltage divider equation with a 5V supply and a 47k pull-down resistor, the output voltage can be calculated as:

$$V_o = 5V \times 47k\Omega /(47k\Omega + 100k\Omega) = 1.59V$$

Thus, the output voltage when the flex sensor is flat is approximately 1.15V, which is relatively low compared to the 5V supply voltage. As the sensor is bent, the resistance of the sensor increases, causing the output voltage to decrease accordingly. When the flex sensor is bent to its maximum angle of 90°, its resistance increases to approximately 100k. Using the voltage divider equation with a 5V supply and a 47k pull-down resistor, the output voltage can be calculated as:

$$V_o = 5V \times 47k\Omega /(47k\Omega + 25k\Omega) = 3.26V$$

Thus, the output voltage when the flex sensor is bent to its maximum angle of 90° is approximately 0.31V. This is because as the resistance of the flex sensor increases, the voltage drop across it increases as well, causing the voltage drop across the pull-down resistor to decrease. Since the output voltage is the voltage drop across the pull-down resistor, it also decreases accordingly.

V CONCLUSION

Robot teleoperation is a revolutionary field that enables workers to carry out duties in hazardous areas securely. With this project, we intend to develop an intuitive teleoperation system that can be used with very little training. The grasp quality can be easily judged with the help of pneumatic actuators. Various components used are costly and rather sophisticated. With some research, we believe that we can find viable replacements for such components and bring down the overall cost significantly, thus making such a system even more affordable. Users are better able to distinguish between secure and insecure grasps with haptic feedback. Other techniques for gasp feedback can also be tested to improve responsiveness. The robotic hand configuration and the robotic arm’s behavior presented the two biggest difficulties in picking and placing objects. We are currently developing the robotic hand’s opposability and other features. By simulating tasks with the haptic glove, we are also exploring the teleoperation problems. We will increase the effectiveness of the entire teleoperation system by investigating and enhancing each component separately.

REFERENCES

[1] M. Dascalu, M. S. Teodorescu, A. Plavitu, L. Milea, E. Franti, D. Coroama, and D. Moraru, ”Tele-Operated Robotic Arm and Hand with Intuitive Control and Haptic Feedback”, American Journal of Aerospace Engineering, vol. 1, issue 4, pp. 21-27, 2014.

[2] Q. Zhu et al., ”Teleoperated Grasping Using a Robotic Hand and a Haptic-Feedback Data Glove,” 2020 IEEE International Systems Conference (SysCon), Montreal, QC, Canada, 2020

[3] Chou Wusheng; Wang Tianmiao; Hu Lei,”Design of data glove and arm type haptic interface”,11th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 2003. HAPTICS 2003. Proceedings, pp. 422-427, 2003.