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Gesture Controlled Robotic Arm Using Leap Motion

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ABSTRACT

Robot plays a vital part in making our lives more facile. The scope of this paper is to provide a relation between human and machine by the interaction of human hand and robotic arm. The idea converges towards the conception of a robotic arm identical to human hand with gesture that is more precise. The arm consists of five Degree of Freedom (DOF) and an end effector, which allows the interaction with the real world. The construction of the robotic arm adapts the principles of inverse kinematics and torque equilibrium. Now the obligations for the controller arise and along the way settled with the exploration of leap motion sensor. As earlier, robotic arm was controlled by the keypad or joystick which required a lot of practices and calculations to manipulate the robotic arm to reach desired position. The exploitation of the leap motion results in explicitly acquiring for hand gesture and provides set of points. This innovation enables more perceptive five DOF control with an end effector. The results showed the reduction in the complexity approach and gain in control accuracy.

I. INTRODUCTION

These days, robots became an availing hand for human being. Robot can perform any task with more precision and accuracy. This is very difficult to perform for human being in very less amount of time, such as used in industries for war heads, surgeries, placing heavy parts agriculture field in case of hazardous conditions, for land mine detection, bomb disposal etc. since the invention of first robot ever a mechanical steam-operated bird “the pigeon” which was designed by a Greek mathematician “archaist” for about 2300 years back. Archaist designed this bird out of wood and powered its movement through steam; it was able to fly up to 200 meters before it runs out of steam1 . Even though in the field of medical surgeries robots have shown their vital role in the form of ’da Vinci Surgical system’, it is a manipulator with multiple robotic arms, which grant doctor to operate from a safe distance with the help of a joystick. The ‘da Vinci’ allows into consideration of a quicker and more exact surgery2 . Now days, due to the advancement of technology robots can even explore without relying on a human. They have replaced human beings in extreme work conditions, which are dangerous for human beings to perform, as in industries due to the use to robots the productivity rate has increased tremendously. The advancement of robotics have also been used in our daily life and in helping of aged people, as elderly people face difficulty in performing daily life activities. Activities of Daily Living (ADLs) represent the everyday tasks individual usually ought to be ready to severally accomplish3 . People with injuries i.e. Upper limb injury, spinal injury, Polio, hemiplegia face problems in performing ADLs using human-computer interfaces technology several attempts have been made to propose stroke rehabilitation system by human-computer community, at last an interactive glove has been proposed for the stroke rehabilitation. This system includes exercises as curling of fingers, moving hand back and forth. The most common approach to create an interactive system is to perceive the motions from profundity information without processing the full posture, by applying machine learning strategies to some significant components removed from the depth data1. Mainly most of the field of technology uses robots these days i.e. field of surgeries, medical rehabilitation, manufacturing industries, bomb diffusion etc

II. METHODS AND MATERIAL

Methods:

1. 2D Design of the Robotic Arm:

The initial step of the project involved creating a 2D drawing of the robotic arm. This sketch is crucial for conceptualizing the design, outlining dimensions, and visualizing the basic structure of the arm, including its joints, base, and any necessary mechanical linkages. The 2D design was created using CAD (Computer-Aided Design) software, ensuring that all the proportions and mechanical constraints were clearly defined before moving on to the next stage.

2. 3D Modeling Using Fusion 360:

Once the 2D blueprint was completed and finalized, the next step was to transform the 2D design into a 3D model. This was done using Autodesk Fusion 360, a powerful CAD/CAM/CAE tool that allows for precise 3D design and simulation. In this phase, various components of the robotic arm such as the base, joints, grippers, and any necessary connectors were modeled. The software also allowed for the testing of movement ranges, mechanical fits, and identification of potential issues.Fusion 360's integrated simulation capabilities also helped in analyzing the mechanical forces and material properties to ensure structural integrity.

3. 3D Printing of the Robotic Arm Model:

After finalizing the 3D model in Fusion 360, we moved to the 3D printing phase. The model was exported into a format suitable for 3D printing, such as STL.A 3D printer was used to create the physical parts of the robotic arm. The material for printing could vary, but typically PLA or ABS plastic is used for such projects due to its durability and ease of printing.The printing process required careful calibration of the printer settings (like temperature, speed, and layer height) to ensure that the printed parts matched the design and had smooth surfaces for proper assembly.

4. Assembly of Electronic Components:

Once the physical parts of the robotic arm were printed and prepared, we moved on to the assembly of electronics. This involved installing the servos or stepper motors that control the movements of the joints, base, and gripper.The wiring and circuitry were carefully designed to ensure proper power distribution and signal control. Components like motor drivers, sensors (if applicable), and power supplies were integrated.To control the robotic arm's movement, we used microcontrollers like the Raspberry Pi. It was connected to the motors through motor drivers, allowing precise control of the arm's movement and position.Safety measures were also considered in this step, such as using proper insulation for wires and ensuring that the electronics were properly secured to avoid damage during operation.

5. Programming with Raspberry Pi:

The Raspberry Pi served as the brain of the robotic arm. We developed a program to control the robotic arm's actions and movements using Python or other programming languages.This phase involved writing code to control the servos or motors, including specifying how much each joint should rotate or move based on user input or pre-programmed instructions.Libraries such as RPi.GPIO or PiCamera (if using a camera for object detection) were used to simplify the interfacing between the Raspberry Pi and the hardware.Testing and debugging were a critical part of this step, where we tested the program to ensure the robotic arm was functioning smoothly. We tested various movements, including the arm's ability to pick, place, and rotate objects, and made adjustments to the code to enhance precision and performance.

6. Final Testing and Calibration:

After programming, the robotic arm was tested under different scenarios to ensure accuracy and responsiveness. We checked the functionality of each joint and calibrated the arm to move precisely as expected. Fine-tuning was done at this stage, particularly with motor speeds, angle adjustments, and grip strength, to optimize the arm's performance.

7. Future Improvements:

To make the robotic arm more autonomous or intelligent, future improvements may include integrating sensors such as cameras for computer vision, or using AI algorithms for object detection, path planning, and dynamic control based on real-time input.Additionally, adding a user-friendly graphical interface or voice control could enhance usability

Materials:

1. Stepper motors
2. Controller
3. Motor drivers
4. Leap motion sensor
5. 3D print components

III. BASIC COMPONENTS

Main components :

1. **CONTROLLER(ESP-32)**

ESP32 is a chip that provides Wi-Fi and (in some models) Bluetooth connectivity for embedded devices in other words, for IoT devices. While ESP32 is technically just the chip, the modules and development boards that contain this chip are often also referred to as "ESP32" by the manufacturer.

2. **STEPPER MOTORS**

Commercially, stepper motors are used in floppy disk drives, flatbed scanners, computer printers, plotters, slot machines, image scanners, compact disc drives, intelligent lighting, camera lenses, CNC machines, and 3D printers.

3. **MOTOR DRIVERS**

A motor drive controls the speed, torque, direction, and resulting horsepower of a motor. Dc drives typically control a shunt-wound dc motor, which has separate armature and field circuit

4. **LEAP MOTION SENSOR**

In the world of computing, leap motion is one of its kinds. A leap motion is a controller that detects the movement of a human hand. The leap motion controller is a little USB fringe contrivance, which brings controlling of vir tual reality into being, Utilizing two monochromatic IR cameras and three infrared LEDs; as shown in Figure 3 the gadget watches a generally hemispherical range, to a separation of around 1 meter4. As the hand movement are detected 3 infrared emits light with the wavelength of 850 nm. The leap motion sensor has definitely diminished in estimate throughout the years. Jump Motion has lessened to a minimal size of 13 mm x 13 mm x 76 mm and just weighs 45 grams2.

IV. ADVANTAGES

Here are some of the key benefits of a research report on:

1. Intuitive and Natural Control

Gesture control allows users to manipulate the robotic arm using hand movements, mirroring natural human actions. This approach simplifies the learning curve compared to traditional input devices like joysticks or keyboards, making it more accessible for operators with minimal technical training .

2. High Precision and Accuracy

The Leap Motion sensor boasts sub-millimeter accuracy, with reported precision as low as 0.7 mm under experimental conditions . This high level of accuracy is crucial for tasks requiring fine motor skills, such as delicate assembly operations or surgical procedures

3. Enhanced Safety and Hygiene

By enabling touchless control, gesture-based systems reduce the need for physical contact with machinery, thereby minimizing the risk of contamination and enhancing hygiene—an essential factor in environments like hospitals and clean rooms

4. Cost-Effectiveness

Compared to other 3D sensing technologies, the Leap Motion sensor is relatively affordable. Its compact design and plug-and-play functionality make it an economical choice for integrating gesture control into robotic systems

V. FUTURE SCOPE

1. Enhanced Human-Robot Interaction (HRI)

Gesture control facilitates intuitive and natural interaction between humans and robots. Future systems are expected to incorporate advanced gesture recognition algorithms, enabling more complex and nuanced commands. This evolution will make robotic arms more accessible and user-friendly across diverse user demographics

2. Integration with Brain-Computer Interfaces (BCIs)

Recent breakthroughs have demonstrated the feasibility of controlling robotic arms using brain signals. For instance, researchers at UC San Francisco developed a BCI that allowed a paralyzed individual to control a robotic arm through thought alone . Combining gesture control with BCIs could lead to more seamless and efficient control mechanisms, particularly beneficial for individuals with mobility impairments

3. Advancements in Artificial Intelligence (AI)

The incorporation of AI into gesture-controlled systems will enable robotic arms to learn and adapt to user-specific gestures and tasks. Machine learning algorithms can enhance gesture recognition accuracy and allow the robotic arm to perform complex tasks autonomously, improving efficiency and reducing the need for manual programming

4. Applications in Healthcare and Rehabilitation

Gesture-controlled robotic arms are increasingly being utilized in medical settings for rehabilitation and assistive purposes. Future advancements may include more responsive and adaptive systems that can tailor rehabilitation exercises to individual patient needs, enhancing recovery outcomes

VI. APPLICATIONS

1.Healthcare & Assistive Technology

- **Surgical Precision**: Systems like the ZEUS robotic surgical system translate surgeons' hand movements into micro-movements for minimally invasive procedures, enhancing precision and reducing tremors .

- **Rehabilitation Robotics**: Robotic devices assist in therapy for individuals with motor impairments, such as those recovering from strokes, by aiding in movement training and performance assessment .
- **Feeding Assistive Robots**: Robotic arms controlled via voice commands or gestures aid individuals with limited mobility in feeding themselves, promoting independence .

2. Industrial & Manufacturing Applications

- **Assembly Line Operations**: Gesture-controlled robotic arms are employed in small assembly lines, allowing operators to control robotic equipment through natural hand movements, enhancing efficiency and reducing training time .
- **Hazardous Material Handling**: In environments dealing with dangerous substances, gesture-controlled robots can perform tasks like bomb disposal or handling radioactive materials, minimizing human exposure to risks

3. **Entertainment & Consumer Electronics**

- **Interactive Experiences**: Gesture-controlled robots are utilized in theme parks, museums, and gaming environments to create immersive and engaging user experiences **.**
- **Home Automation:** In consumer electronics, gesture-controlled robots facilitate touchless navigation of devices like X-ray panels and MRI machines, enhancing user interaction

4.Research & Development

- **Brain-Controlled Prosthetics**: Innovations like muscle implants allow amputees to control prosthetic limbs using brain signals, enhancing the functionality and natural movement of prosthetics .
- **Third-Thumb Devices**: Experimental devices controlled by toe movements are being developed to augment human dexterity, enabling users to perform tasks typically requiring two hands

VII. RESULTS

We have constructed a demo to show the predominance of our strategy, all things considered, applications.Thegraphs reading from that application is submitted below:

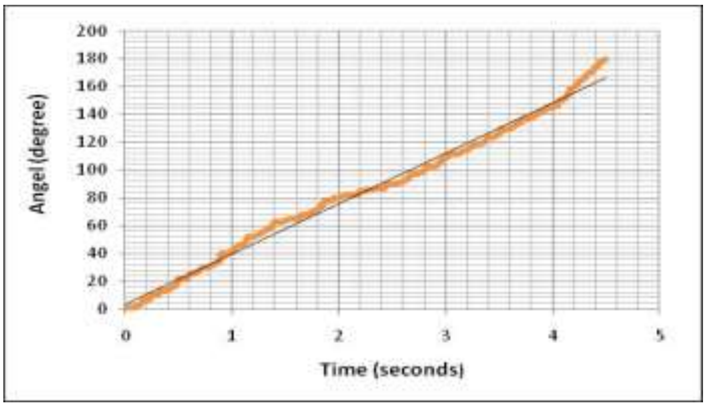
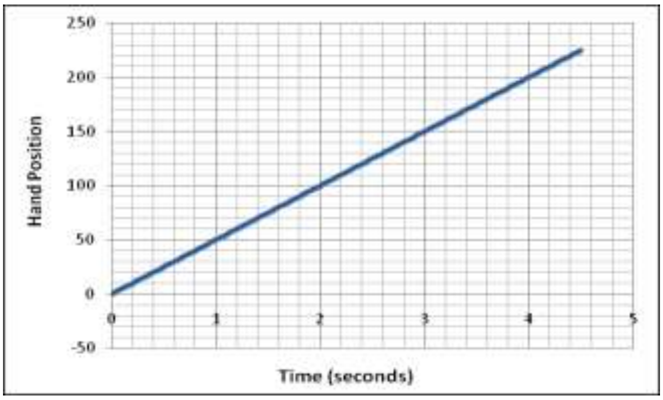


Figure contains the graph of angles in degrees versus time in seconds by the robotic arm.



The graph of angular position of hand in degrees versus time in seconds.By comparing the graphs of Figure 1 and Figure 2 we conclude that the robotic arm follows the human hand with less error.

VIII. CONCLUSION

In conclusion, the gesture-controlled robotic arm employing the Leap Motion sensor represents a significant advancement in human-robot interaction technology. Its ability to interpret hand movements with precision and translate them into robotic actions opens up new possibilities for intuitive control in various industries, from manufacturing to healthcare. While further enhancements in accuracy and gesture recognition could improve its usability, the potential benefits make it a promising tool for increasing efficiency and accessibility in robotics applications

IX. REFERENCES

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