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Hand Gesture Controlled Robotic Arm

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Abstract:

Today, robots have become ubiquitous, not just in various industrial sectors but in all walks of life as they minimise human effort and maximise the output and increase the efficiency of work. One such class of robots that is widely used is Robotic Arms. Initially, Robotic Arms were designed to automate pick and place operations but today they have evolved and can perform much more complex tasks like surgeries, agriculture, manufacturing, food processing and prosthetics etc. Despite extensive use of robotic arms in the industry there still remains huge scope for use of robotic arms in household, domestic, and small-scale industrial applications, if they become more ergonomic and easier to be used by a layman. Therefore, this project aims to simplify the use of robotic arms to an extent that even a non-technical person who has no knowledge about robots, can control the robotic arm using hand gestures. Gesture control provides an unprecedented level of accuracy and precision when compared to a keyboard, mouse or joystick in an intuitive. A gesture-controlled robotic arm can completely revolutionise the market for Robots.

***Keywords* — gesture control, robotic arm, motion-controlled, yaw, pitch, roll, servo motors, wireless robots**

I. INTRODUCTION

A gesture-controlled robotic arm is a huge step forward in making robots available to a wider public and serving them in their day-to-day lives. There are a number of roadblocks that prevent robotic arms from being widely adopted by the common man such as the complexity of control and lack of knowledge about programming and control algorithms. This project aims to eliminate all the hassle and hurdles in the path of using a robotic arm by implementing gesture control features to control a robotic arm.

This project would turn out to be handy for people with a restriction on movement or wheelchair-bound. Wireless communication also enables us to control the robotic arm from a remote location, simply with the help of gestures. The reasons are diverse, but they come down to one thing: when technicians, designers, and engineers need to control the way systems work and tools operate, nothing beats the power of gestures. In fact, with our hands and arms, we can achieve a degree of precision and speed that levers, mice, joysticks, and even touchscreens don't provide.[1]

This robotic arm is capable of grasping an object and picking and placing it at the desired position simply by means of hand gestures.

The object is grasped by pinching in the air using our fingers and placed by releasing the fingers. The tightness of the grasp can be controlled by merely controlling the pinching gesture.

II. LITERATURE SURVEY

Da Vinci created designed the first sophisticated robotic arm in 1495. It had four degrees of freedom and an onboard analog computer for supplying power and programming capabilities. Unimate released the first industrial robotic arm in 1961, that subsequently evolved into the PUMA arm. In 1963 the Rancho arm was engineered; Minsky's Tentacle arm featured in 1968, Scheinman's Stanford arm in 1969, and MIT's Silver arm in 1974 [2].

Since then, we have come a long way. We have seen various developments in the like voice control and image processing using a camera for controlling the arm. But voice control did not prove to be reliable enough as voice quality changes from the person and in the case of a camera the image quality varies to environmental conditions. The same thing holds true for Kinect sensors [3].

Therefore, gesture control using wearable devices is a step in the right direction. According to Next Industries, Milano [4], Some experts certainly think that gesture control is the key element of Industry 4.0, and forward-looking companies have already started to integrate gesture controllers into their operations [5].

"Reviews on various inertial measurement unit (IMU) sensor applications." [6] explains the applications of IMU sensors in a comprehensible manner. This helped us in implementing gesture control more intuitively. The reference [7] gave us a good understanding of using the Tinkercad software. In "Resistive flex sensors: a survey" we got a lot of useful insights about flex sensors, their working and their application [8].

III. METHODOLOGY

After having discussed the need for this project let us get to the implementation of it. This project is precisely divided into three major parts:

1) The Robotic Arm
2) The Wearable controller
3) The Wireless Communication Link

Each of the above parts is explained in great depth in the section to follow. Fig. 1 explains the project with help of a block diagram.

Each block refers to a particular component or a set of components that perform an important function in the model.

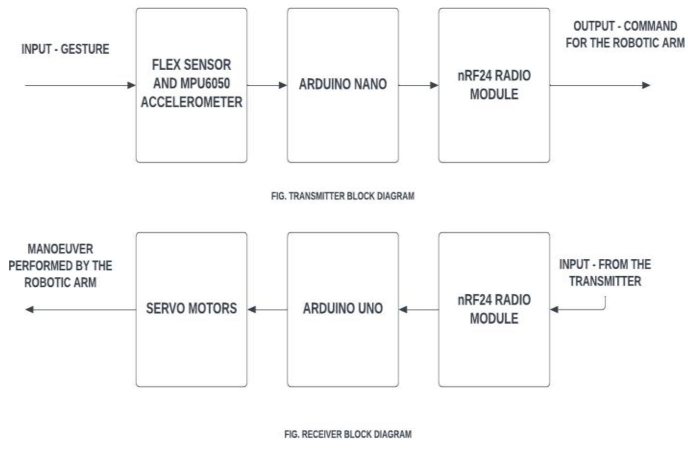

Fig. 1 Block Diagram of the Proposed Model

The first is the transmitter, which is basically a wearable glove type of device. The glove is interfaced with sensors that can read the gestures performed by the human. The gestures are wirelessly transmitted as commands to the robot arm's controller and desired actions are performed.

A. The Robotic Arm

The 3D design of the robotic arm was created using the Tinkercad web app. Tinkercad is a free-of-charge, online 3D modeling program that runs a web browser. Then the 3D design was 3D printed using thermoplastics (which is one of the most common 3D printing materials for robotic parts production). The 3D model of the robotic arm has the base, shoulder, elbow, wrist, and gripper joints.

The actuator is a component that functions as the joint of the robot, which allows a robot to move the arm up and down or rotate, and it converts energy into mechanical motions. Fig. 3 shows the final 3D design.

The revolute joint is a one-degree-of-freedom kinematic pair used frequently in machines, they are also called pin joint or hinge joint. These joints constrain the motion of two bodies to pure rotation along a common axis. Revolute joints are used in numerous applications such as door hinges, mechanisms and other uni-axial rotation devices.

A prismatic joint provides a linear sliding movement between two bodies and is often called a slider. It can be formed with a polygonal cross-section to resist rotation. The relative position of two bodies connected by a prismatic joint is defined by the amount of linear slide of one relative to the other one. This one parameter movement identifies this joint as a one-degree of freedom kinematic pair. Prismatic joints provide single-axis sliding often found in hydraulic and pneumatic cylinders. Fig. 2 shows difference with between two types of robotic joints.

This design has 5 degrees of freedom with 360 degrees of motion along three axes and 180 degrees along two axes.

Components used in this part are 3D printed parts, servo motors, an Arduino Uno, and an nRF24L01 radio module. Fig. 4 shows the different stages in the development of the project. Starting from procuring 3D printed parts using Anycubic Photon Mono Se 3D printer.

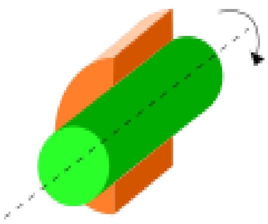

Fig 2 a) Revolute Joint

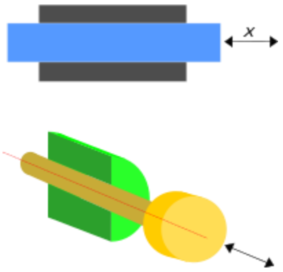

Fig 2.b) Prismatic Joint

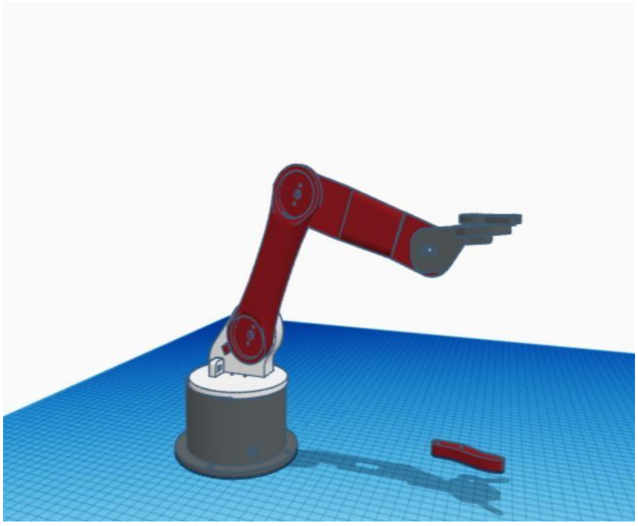

Fig 3. 3D Design of Our Robotic Arm

Fig.4 Robotic Arm at Different Stages (3D printing, cutting, assembly, action)

B. *The Wearable Controller (Glove)*

The wearable controller (referred to as a glove for simplicity's sake) is the most essential part of this project as it is used to read the gestures made by humans and transmit them to the robotic arm so that it mimics the exact movements of our hands.

The glove is interfaced with a couple of flex sensors and an IMU sensor (MPU6050). The flex sensors are used to sense the bend of our fingers and associated that with the movement of the gripper. The IMU sensor is basically a sensor fusion of two different devices on a single chip. These devices are:

1)Accelerometer - It measures the proper acceleration of the arm relative to the body of a human.

2)Gyroscope – This is a device used to measure the tilt of the hand relative to the body.

The MPU6050 provides coordination of both these devices in the form of a single MEMs-based chip. When interfaced with Arduino Nano the MPU6050 can be programmed to produce three components of the motion. These three components are called the yaw, pitch and roll motions. We future associate each of those components of motion with the movement of a joint in the robotic arm in our program. The yaw motion controls the base joint, the pitch motion controls the shoulder joint and the roll motion controls the elbow joint as depicted in Fig. 5. The instructions in the form of gestures are read by the Arduino and the corresponding manoeuvre commands are wirelessly sent to the robot using the radio module. Fig. 5 shows the setup of the wearable glove.

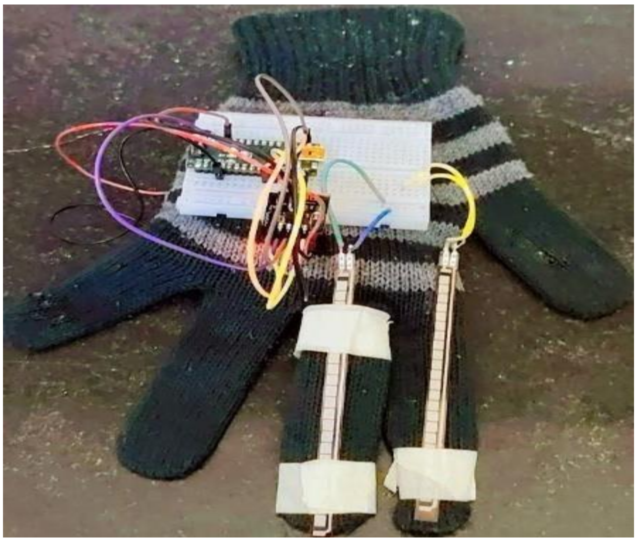

Fig. 5 Wearable Controller (glove)

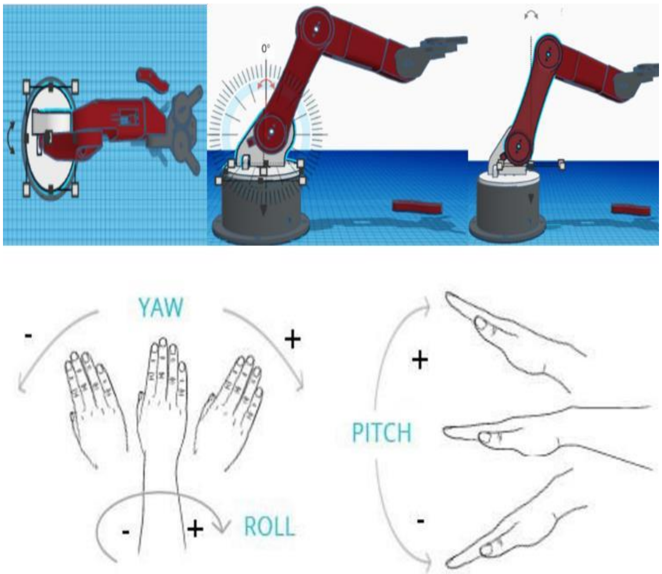

Fig. 6 Yaw Pitch and Roll Motions of The Hand Correlated With The Movement

C. Wireless Communication Link

Another vital part of this project is the wireless communication link which enables the glove to talk to the robotic arm without any physical connection. This wireless link is established with the help of two nRF24L01 radio modules. One is interfaced with Arduino on the glove essentially as a transmitter and the other with the Arduino on the robotic arm essentially as a receiver (though a single module can act as both transmitter and receiver if required). The interfacing is done with a wired SPI protocol connection. Wireless communication takes place through radio waves. This can be any frequency in the 2.4 GHz ISM band, or to be more precise, it can be between 2.400 to 2.525 GHz (2400 to 2525 MHz). Each channel takes up bandwidth of less than 1MHz. This gives us 125 possible channels with 1MHz spacing.

IV. CONCLUSIONS

The outcome of the project is pretty impressive as the robot is able to respond to hand gestures with a great degree of accuracy and precision. This method of integrating gesture control with modern robotics can prove to be game-changing in many applications and domains.

There is a huge for this technology in various verticals of robotics like household robots, industrial robots, defense robots, etc. Some of the areas for future improvement include the use of better IMU sensors, which are well-calibrated and include a magnetometer along with a gyroscope and accelerometer. These could provide more accurate and stable yaw, pitch, and roll readings.

The record and play which is available in most generic robotic arms can be implemented in this project as well to make it more useful in automation applications.

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