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Gesture Controlled Robotic Arm for Testing and Diagnosis of Novel CORONA-VIRUS

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***Abstract*--- The emergence and outbreak of Novel Corona Virus has been really contagious, which is posing a severe threat to human beings. Most importantly occupational health risk is being faced more by doctors and healthcare workers who go about for direct exposure of patients during testing and hence are easily prone to get infected. Conventional robotic arm that use buttons and joysticks is not really very efficient and hence replacing this with gestures of human stands out as a better choice. This paper aims at Designing and Developing a preliminary prototype of a gesture controlled robotic arm model with Arduino Nano controller using servo motors and gloves with MPU6050 sensor and flex sensor. To provide an enhancement to the physician by sending the live video feed and so as to make the necessary hand gestures in order to meet the objectives and goal of the project and hence minimize the risk of contracting Corona Virus. This results in efficiency of 70 percent over conventional method in which gesture controlled robotic arms use buttons and joysticks. This robotic arm is capable of 4- axis degree of freedom, can grip objects upto 60mm and arm has a reach of 29cm. It can lift the payload upto to 155gms. Hence the prototype constructed is apt and is built according to the requirements. A gesture controlled robotic arm built using Arduino Nano will make the prototype cost efficient, safe and more feasible.**

***Keywords*--- Arduiuno Nano, Flex Sensor, MPU6050 Sensor, Servo motors**

I. INTRODUCTION

The outbreak of Novel Corona Virus pneumonia caused by Corona Virus disease has spread rapidly throughout the globe resulting in public health crisis and economic calamity.

Since doctors and healthcare workers are the first point of contact of the patients they are at a very high risk of getting infected. The project aims at addressing this issue by integrating the technology of robotics and electronics. Collection of specimens from the surface of the respiratory mucosa with nasopharyngeal (NP) swabs are treated as effective ways for the diagnosis and screening. The project aims and aspires to implement this procedure using a low-cost , highly efficient gesture controlled robotic arm. Robotic arm is called as robot manipulator which can perform various functions as human arm and is achieved by precise control based on the gestures of the hand. The gestures captured provide a path for computer to understand and decode the body language of humans. This prototype of the module consists of a robotic arm whose position is controlled through a hand glove. This glove is attached with an MPU6050 Gyroscope and a flex sensor and is worn by the doctor performing the swab test. The Flex sensor is used to control the gripper servo of Robotic Arm and the MPU6050 is used for the movement of robotic in X and Y-axis. The doctor will be isolated in a closed cabin to ensure he doesn't contract the virus but will be at a distance to have a visual access of the entire process. Robots are a rapidly growing part of the modern health care landscape. They are used to perform accurate surgery in tiny places and transport dangerous substances. Also they give us ideal environment to achieve our goal of obtaining swab samples with perfection and accuracy using sensor intelligence. Since the swab equipment have smooth edges and the nasal tract area isn't as critical and sensitive areas, this module has high chances of feasibility when implemented with care and caution.

The objectives of the project are

1. To design a preliminary prototype of a robotic arm model using servo motors and gloves with MPU6050 sensor and flex sensor.
2. To enhance the feasibility by providing visual access to physician using an ESP32 CAM low power microcontroller.
3. To develop the prototype of gesture controlled robotic arm with Arduino Nano controller to achieve

the goal of the project.

Assumptions made / Constraints of the project

The process of specimen collection from the patient needs to be performed in an orderly manner. The NP swab collections involve inserting a specifically manufactured swab into a patient's nasal cavity. Hence the head of the patient is expected to be tilted back (at approximate 70°) so the nasal passage becomes straight and accessible. On inserting the swab that has soft bristles on the end, it is twirled around for a few seconds for absorbing the nasal secretions along the entire passageway. Since the swab travels far back to the nasopharynx it activates the lachrymal reflex and causes an odd sensation. The patient is expected not to jerk from the ideal position due to the reflex since it could hinder the process. Also as the nasal tract is sensitive and such a movement could also cause an injury within.

II. DESIGN METHODOLOGY

1. **ROBOTIC ARM:** Robotic Arm is built using from some 3D printed parts which is attached with servo motors so that the setup looks like a Robotic Crane. It can be controlled by four Potentiometer attached to it one for each servo motor. These servos can be operated by rotating the potentiometers to pick some object or move them from one place to another. This part is executed by finally embedding it with the Arduino code to control servo motors which are serve as joints of Robotic arm.

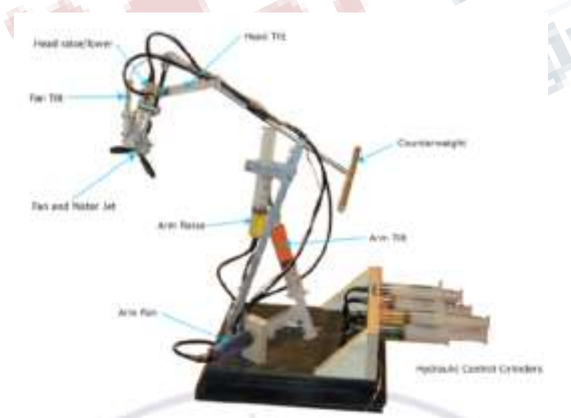

Fig 2.1

2. **MPU6050 SENSOR:** It is based on Micro-Mechanical Systems (MEMS) technology and has a 3-axis accelerometer, a 3-axis gyroscope, and an in-built temperature sensor. It can be used to measure parameters like Acceleration, Velocity, Orientation, Displacement, etc. This sensor is placed horizontally on the gloves that will be mounted on the physicians hand for gesture imitation. It processes the movements of the hands and captures motion in X, Y and Z axis at the same time. This data is given as a live feed to Arduino Nano which further processes it to make is servo motor compatible . MPU6050 sensor interfaced with Arduino is shown in **Fig.2.2** below .

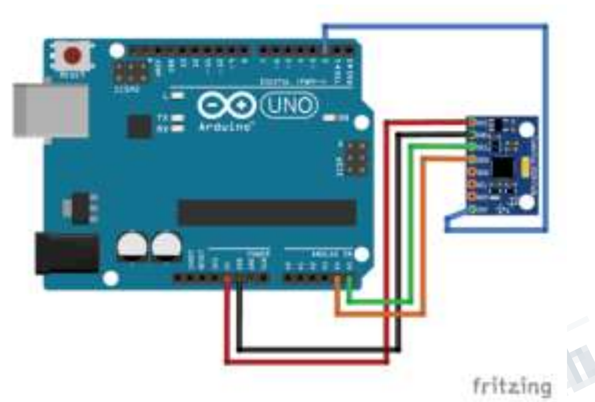

Fig 2.2

3. **FLEX SENSOR:** The ex sensor will be mounted alongside the MPU6050 sensor for the same purpose of motion sensing however it is used to control the gripper of the arm which is responsible for insertion and management of the sterile swab. They are nothing but a variable resistor whose resistance propotional to the bending action of the sensor. The flat profile provides nominal resistance and bending it 45 degrees increases the resistance and bending it to a complete 90 degrees provides maximum resistance value to the Arduino. These motions cause the servo motor attached to the gripper rotates and the gripper opens and closes correspondingly. The below **Fig 2.3** shows resistance increases as bending of flex sensor increases.

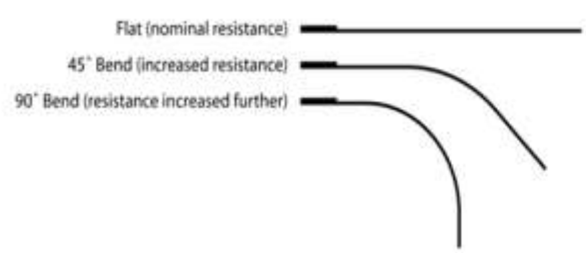

Fig 2.3

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4. **ESP32 CAM:** This module is used to customize the prototype specifically for Covid diagnosis. It increases the level of enhancement by providing the physician with a better visual aid. It is a chip with Bluetooth(BLE), Wi-Fi, GPIO pins, 2MP camera and a big sized SMD led programmed using USB to TTL converter. This feature of the prototype is extremely important since the doctor will be seated in an isolated cabin away from the patient and the insertion of the swab is a very delicate process that needs careful monitoring with close proximity. The ESP32 camera **(Fig 2.4)** module helps us achieve this virtual proximity for a monitored insertion and specimen collection with the atmost concern of the patient safety. This module is connected to TTL module **(Fig 2.5)** to interface with the computer for live video feed.

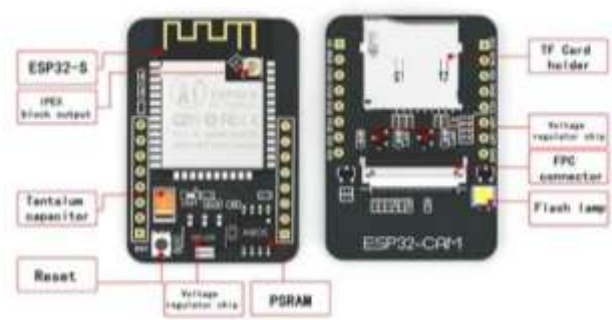


Fig 2.4

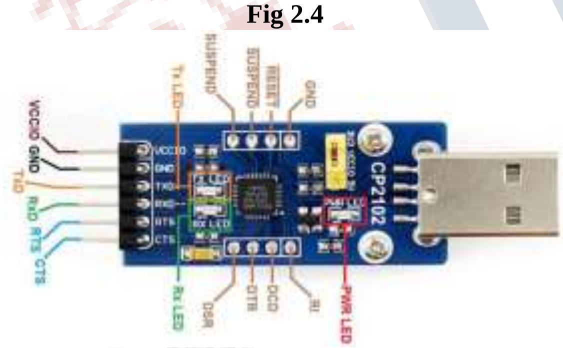


Fig 2.5

5. **GLOVES:** The gloves is a tailor-made component of the prototype that will be worn by the physician. The objective of our model of gesture imitation is performed by this glove module. It is attached with the Flex sensor for gripper servo motor control and the MPU6050 sensor for movement control of bot in X and Y and Z-axis. Hand glove sensors are wired to microcontroller via breadboard using connectors. The Arduino process the input analog data and outputs it to the servo motor for imitation of arm. The **Fig 2.6** below shows the Glove that is mounted upon with MPU6050 sensor and Flex Sensor worn on a human hand

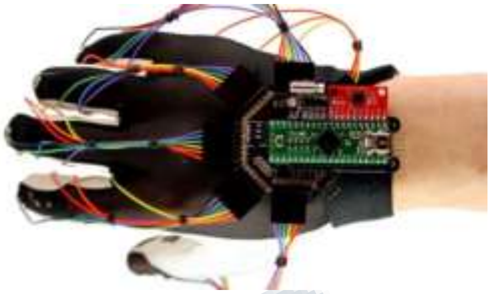


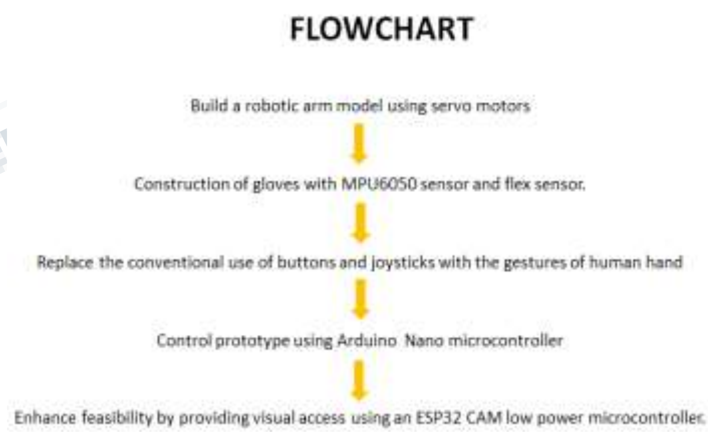
Fig 2.6

All these components are connected together to obtain the final prototype of the model.

6. **CODE:** After the prototype is rigged up the source code is entered in Arduino Software IDE. All the necessary library files like

• Wire.h - this library is used for I2C communication between Arduino Nano and MPU6050

• servo.h - for controlling servo motor rotation is included in the firmware. After the creation of the code and configuration it is deployed onto the microcontroller for execution.



III. IMPLEMENTATION

Robotic Arm Prototype

The programmable robotic arm is implemented using the 3D printed parts which is capable of 4-axis degree-of-freedom. It can grip objects up to 60mm wide and the arm has reach of 29cm. It can lift the payload up to 155gms. First 3 axis contains NRS-995 dual bearing heavy duty metal gear servo motors and remaining two motors are NRS-585 for smoother operation. Axis 2 and 3 enables

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gripper to maintain its angle constant with the surface while moving up and down. Robotic Arm can perform Left, Right, Up and Down motions, while keeping gripper parallel to the surface. Gripper part performs Twist motion and Gripping action.

Circuit Connection between Flex sensor and Arduino Nano

Flex sensor has two terminals. One terminal is connected to A0 pin of arduino nano and other terminal is connected to Ground. A 10kohm resistor is connected between A0 and Vcc. According to ex sensor movement resistance value will vary which gets reflected in the movement of gripper.

Circuit Connection between MPU6050 Sensor and Arduino Nano

MPU6050 is a accelerometer sensor which is connected to the hand gloves. According to the movement of hand gloves, sensor gives the exact axis' values of gloves location which can be seen as an output in the Arduino environment.

The below Figure 2.7 shows the connections between Arduino, Flex Sensor and MPU6050 Sensor

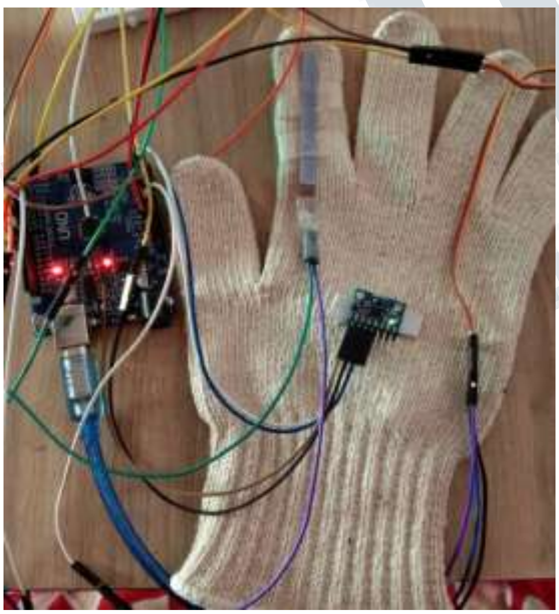

Fig 2.7

Circuit Connection between Servo Motors and Arduino Nano

Four servo motors are connected to Arduino nano with each servo connected to an input, VCC and ground of the controller. The values from MPU6050 sensor helps in driving the servo motors through the controller which provides control of the 3-axis along X,Y,Z. X-axis value control the left and right movement of the arm, Y-axis values helps in the up and down movement of arm and Z axis value helps in forward and reverse movement of the arm The ex sensor mounted on one finger of the glove gives the fourth degree-of-freedom by governing the movement of the gripper. On bending the finger the gripper opens its claws to allow picking of an object and reverting the finger back to flat profile helps in the gripper to have a hold on the object. **Figure 2.8** shows how Servo Motors are operated by Arduino Nano.

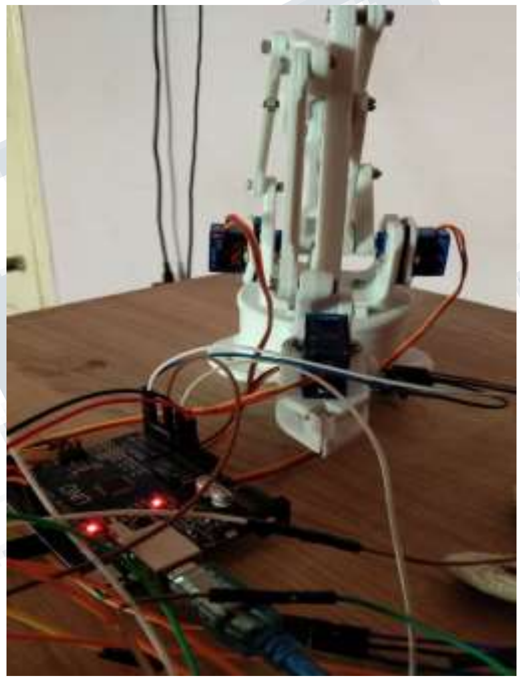

Fig 2.8

Circuit Connection between ESP32 cam and TTL

Wifi.h header file is used from the in-built library. ESP32 have built in wifi module which is used to connect ESP32 to wifi via code by giving SSID and password. Wifi.begin command helps in testing whether wifi connected to module or not. After a secure connection is established all pins are initialized and the serial monitor feed is set to have a baud rate of 115200. Executing PC should also be in the same network as the ESP32. After the entire setup is achieved copy the link available in the serial monitor and paste it on any web browser. In browser we get to see the video being captured by ESP32 cam. ESP32 is attached in front of arm in order to get a clear view of the nasal tract.

The below Figure 2.9 shows a picture of ESP32 module connected to TTL convertor

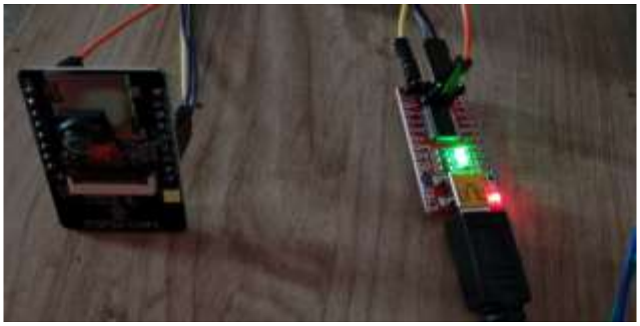

Fig 2.9

Software

Arudino IDE is used to code the arduino nano. Wire.h and servo.h are inbuilt libraries used. In setup function, the communication between the MPU6050 and arduino nano is built and it is used to initialize all servo motors. In loop function, the values from MPU6050 sensors are continuously read which are given to arduino Nano (input to arduino nano). Arduino further maps MPU6050 sensor values to servo motor PWM pin (output from arduino nano). From ex sensor we get resistance value. This rersistance value is mapped to the gripper by the Nano board.

The below **Fig 3.0** shows a complete working model of Robotic arm with camera and Glove.

Fig 3.0

IV. RESULTS

Robotic Arm Movements

On execution of the above code after uploading it to the Arduino Nano microcontroller the following movements of the Robotic Arm was observed. These movements were accurate imitation of the hand gestures implemented by the motion sensors. The following figures depict the various movements of the arm achieved :

1. Left-ward movement by varying the X-axis in the negative direction as shown in **Fig 3.1.**

Fig 3.1

2. Right-ward movement by varying the X-axis in the positive direction. as shown in **Fig 3.2**

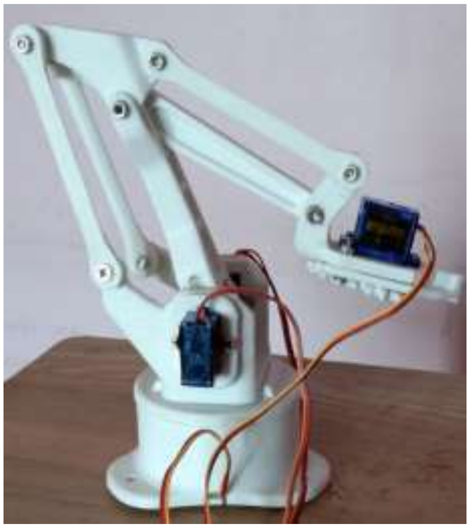

Fig 3.2

3. Forward movement by varying the Z-axis in the positive direction as shown in below **Fig. 3.3**

Fig 3.3

4. Backward movement by varying the Z-axis in the negative direction as shown in **Fig 3.4**

Fig 3.4

5. Up-ward movement by varying the Y-axis in the positive direction as shown in **Fig 3.5**

Fig 3.5

6. Down-ward movement by varying the Y-axis in the negative direction as shown in **Fig 3.6**

Fig 3.6

V. CONCLUSION

This Robotic model prototype is customised to perform Covid diagnosis by performing swab test with the ultimate aim of shielding the frontline workers from the extensive exposure of infection. This is achieved with improved precision and higher dexterity which is a default constraint in the medical environment. This model has a high potential of replacing the present conventional method of diagnosis thereby reducing the risk factor by 70 percent as all the human tasks are mimicked with this prototype. MPU6050 sensors and Flex sensors placed on the gloves provide 4-axis movement that allows the physician to have a greater degree of freedom and efficiency. To facilitate the process of swab insertion all the way to the nasopharynx, ESP32 camera module is focused to the nasal area of the patient for visual clarity. The camera module is interfaced with the computer with a TTL convertor for live monitoring of the arm movements by the concerned physicians. The servos provide precise rotation of the gripper to perform a twirling action of the swab while reverting it out of the nasal tract without causing any injury. The robotic arm prototype is a classic model with an efficiency of 80 percent with respect to gesture imitation. The factors that are hindering higher efficiency is the extreme sensitivity of the sensors used. This however could be overcome with careful and observed gestures of the human hand with no unecessary jerks. Further the nasal tract which is the region of interest is a very delicate area and needs to operated with high caution and attention. For the intended movement of the swab the patient needs to be comfortably

seated with resistance to the possible reflexes which otherwise could be catastrophic. Finally, the prototype can perform precise movements even beyond the human range of motion and be present with patients for as long as necessary. Also their capabilities to automate repetitive tasks incline us to make more research in this field and provide a solution for a global cause.

VI. FUTURE SCOPE

Incorporating robotics in medical field is a concept of high scope productivity. Its potential of allowing physicians to perform operations and functions that were traditionally not possible due to minimal technology draws a lot of attention. This prototype is a machine with complex robotics integrated with electronics to provide the best solution for present scenario medical needs. This device can be further enhanced by increasing the efficiency of the gesture imitation.

As the prototype already uses Wifi module to obtain its commands this feature can be expanded to store the patient biometrics and health status data on the cloud platform.

The results of the diagnosis could also be updated to the cloud which enables a global reach of data among the citizens. On linking this real-time data to applications like Arogya Setu people can be aware of the risk in their surrounding and opt for necessary precautions. This results in not only the safety of the individual but also inhibiting the potential spread that could happen through them.

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