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ROBOTIC SURGICAL ARM FOR MINIMALLY INVASIVE SURGERY CONTROLLED USING COMPUTER VISION

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Abstract – The influence of robots to assist human activities have increased drastically in the recent decades. The motive of this project is to provide a relationship between man and machine through the interaction of the human hand and the robotic arm. The arm consists of five degrees of freedom and an end effector to allow interaction with the real world. Now the duty of the controller appears and is controlled using servo motors connected in the joints of the arm. As before, the arm is controlled by a keyboard or joystick, and it takes a lot of practice and calculation to maneuver the arm into the desired position. Gestures can be explicitly captured and node points of the joins can be mapped and this motion can be achieved in the surgical arm as well.

***Key Words*:** surgical arm, computer vision, arm control, less blood loss, minimal scars, faster recovery

I.INTRODUCTION

This project aims to perform surgeries through thin and small robotic surgical arms holding an instrument. So that the patient's body need not be wide cut, for a surgeon's arm to go through, instead a small opening is enough for this robotic surgical arm. The robotic arm can only be controlled by a person, the surgeon, it will not function on its own or through automation. Since no human body is the same a predefined automation process cannot be set hence, with the presence of the surgeon, the robotic arm can function as per the patient's body requirements. A robotic arm is a programmable robotic hand that consists of linear and rotating joints to achieve controlled movement. In the military, articulated robotic arms are used in demining robots, saving countless lives. The robot is remote-controlled by deminers from a safe distance to scan for explosive devices without putting themselves in danger. Therefore, the robot is usually equipped with a camera as the "eye" of the robot, providing a view of the surrounding situation, so that the operator can control the robotic arm through the camera to check and eliminate the explosive device. Today, most human-computer interactions (HCI) rely on mechanical devices such as keyboards, mice, gamepads, or joysticks. In recent years, there has been growing interest in a class of computational vision-based methods to recognize human gestures in a natural way. The main purpose of this algorithm is to measure the configuration of the hand at each instant. To facilitate this process, many gesture recognition apps use uniquely coloured gloves or markers on the hands or fingers. Additionally, different hands can be located efficiently and even in real time using a controlled background. Both of these conditions place restrictions on user and interface configuration.

II. LITERATURE SURVEY

[1] The paper titled "Design of Simple One-Arm Surgical Robot for Minimally Invasive Surgery" proposed by Artur Sa et. al., in the year 2019, designed a surgical arm that has the maximum degree of movement and is controlled by a joystick. Since this arm model design has the maximum degree for joint movements, this specified model is used in this project.

[2] The paper titled "Modular robotic system for minimally invasive Telesurgery" proposed by Víctor Fernando Muñoz Martínez in the year 2005, proposed research on minimal robotic arms specialized in handling the camera during laparoscopic surgery operations, assisted by the surgeon. This arm is managed by voice control, via a wireless communication network, or using a joystick.

[3] Hussein Mohammed Ali, Yasir Hashim, Ghadah Alaadden Al-Sakk presented a six degree of freedom robotic arm has been designed and implemented for the purpose of this research. The design controlled by the Arduino platform receives orders from the user's mobile application through wireless controlling signals, that is Bluetooth. The arm is made up of five rotary joints and an end effector, where rotary motion is provided by the servomotor.

III. PROPOSED METHODOLOGY

The surgical arm has a video capturing camera through which the surgeon's hand movements are captured. As per the predefined hand gestures movements, the arm moves, and functions according to the movement and positioning of the surgeon's hand. Real-time control using Computer Vision ensures better movement sensitivity and easiness of surgeries. The following introduces the design and implementation of

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using computer vision to control the robotic arm with Arduino through the gesture mechanism, including the characteristics of the robotic arm, extension, direction and speed of the arm. To understand the geometry of the robot arm, its orientation angle must be calculated. It is important to know the length of each link and where the arm starts and ends in the work area, then reference the bottom of the robot arm or another point. This movement is described by a kinematics, which is of two types, forwards and backwards. If the robot's origin is in three-dimensional space (0,0) and cannot reach the origin, it is called a singularity. The robotic arm's extension must reach objects beyond its base to use it to locate and control the position of its wrist. This prototype robot arm has 6 degrees of freedom. For the first 3 joints, waist, shoulder and elbow, MG945 servo motors were used. While for the other 3 joints, wrist roll and wrist suture and clamps, smaller MG90S micro servos are used. The movement of the pruning motor is based on the rotation range of the servo motor, which rotates the whole robot arm on its basis of 0 degree and 180 degree angle $\theta1$. The shoulder movement requires the most strength in the robotic arm because it supports the weight of the entire arm. It goes up and down according to the angle $\theta2$. The movement of the elbow motor is the type of movement that the robotic arm is most comfortable to handle. The movement of the central scroll motor consists of rotating the arm on its axis through an angle $\theta4$ between 0 and 180 degrees.

IV. BLOCK DIAGRAM

Three servos in each three joints have been connected to the analog pins. The LM393 comparator has four pins which are A0 (analog pin), ground, VCC (can be 3.3v/5v depending on module) and D0 (digital output pin). According to the pin configuration, the pins are connected to the aforementioned Arduino Nano. The servo has three pins VCC, GND and Signal, VCC and Ground are connected to their respective pins, and the signal pin is connected to pin D5 of the Nano board. The LM393 comparator sensing block is connected by wires as power and ground pins to measure the strength of the current flowing through the sensing block and send the information to the comparator.

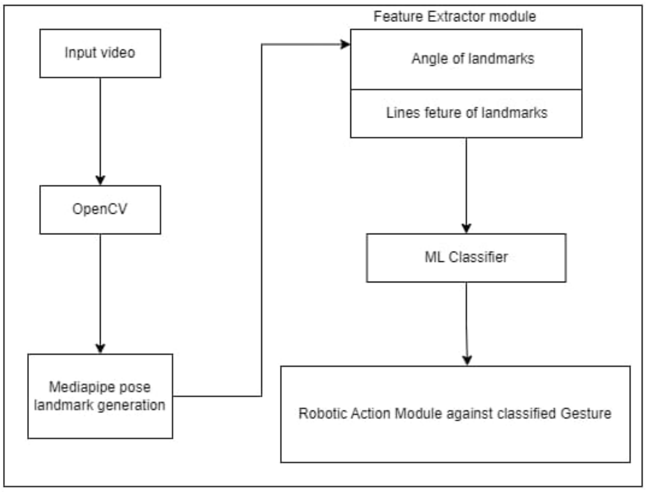

Figure 1: Block diagram of the information flow

The stepper motor which provides the full rotational movement had four pins and the Arduino Mega had enough analog pins to connect all them. This ensured reliable power supply and an external battery with a buck converter was used to provide equal distributed power to all the components. A House casing for all the circuit ensured reliable connectivity and the motors had sufficient power requirement met as per the need.

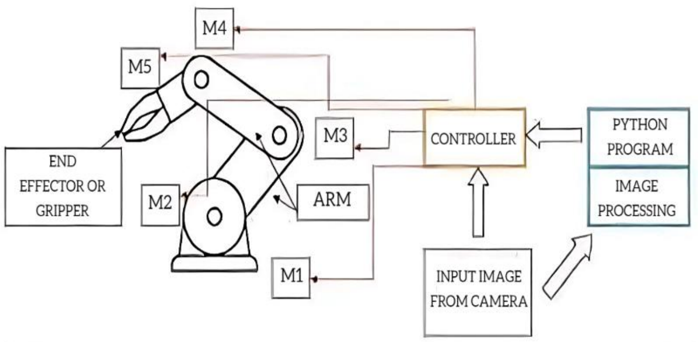

Figure 2: Block diagram of the mechanical flow

V. SIMULATION

Each of the servo motors were simulated in software to measure the resultant motion expected and the power distribution to the system. This simulation allowed the prediction of the efficient circuit model that was required to get best efficient result of the circuit.

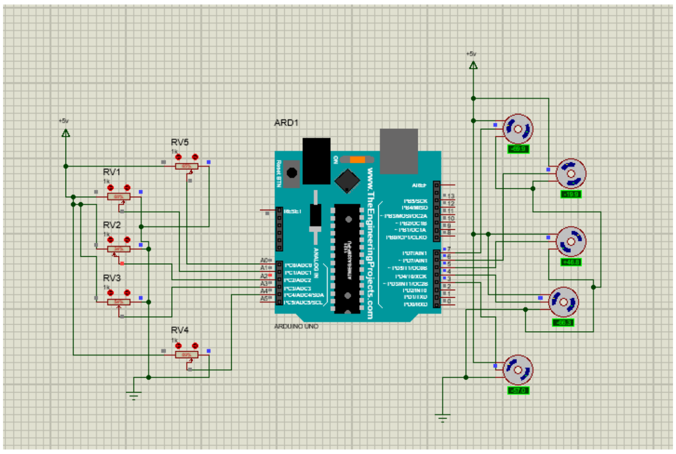

Figure 3: Simulation result

The servos were tested connected to the analog pins of the microcontroller. The SG90 was capable of handling the load for this prototype model and produced good weight to movement ratio. POT's were used to simulate the result for the controlling of the servo and the stepper was controlled using POT values.

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VI. RESULTS AND SCOPE OF THE PROJECT

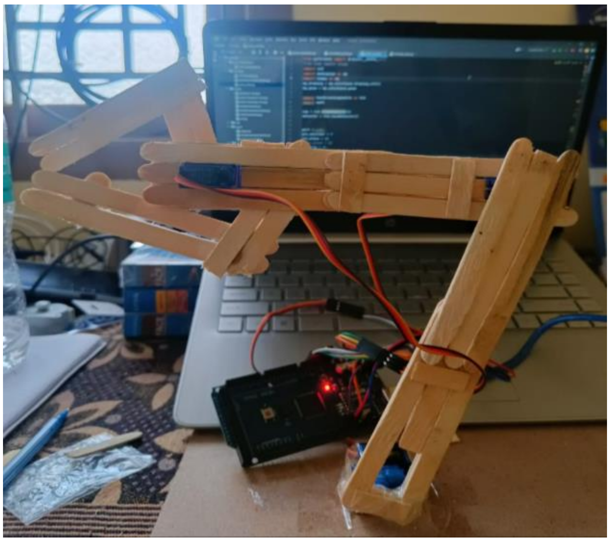

Figure 4: Sample stick model of the robotic arm

To achieve reliable recognition, it is very important to detect features extracted from the images that are being captured, even with changes in image scale, noise, and illumination. These points are usually located in high contrast areas of the image, such as the edges of objects. Gesture recognition is initially performed by independently matching each keypoint to a database of keypoints extracted from the training images. Many of these initial matches will be incorrect due to blurry features or features caused by background clutter. Hence a series of array containing all the pints in real time were transferred simultaneously to the controller. And this made each and every movement possible. Therefore, clusters of certain features that match the object and its pose are first identified, as these clusters have a higher probability of being correct than a single feature match. Each image is then processed and examined by performing a detailed fit to the model and using the results to control the Arm. To remove extra jitter and motion irregularities a set of range degrees can be set like a set of five degrees and movement within these ranges can be made smooth and without sudden movements.

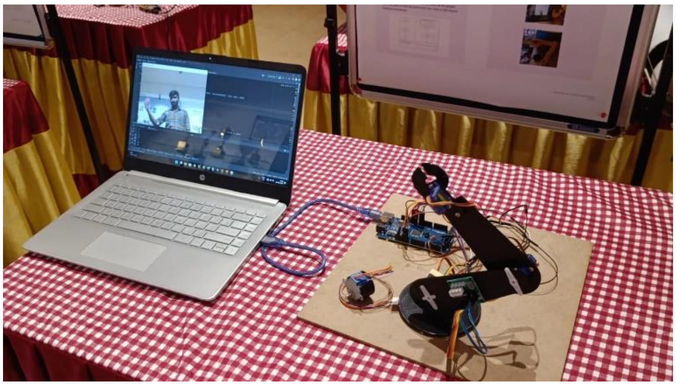

Figure 5: 3D printed complete arm in action.

VII. CONCLUSION

Hence with the developed surgical arm, surgeries can be performed with high accuracy, nevertheless ensuring less blood loss and faster recovery time. With the help of this robotic arm mild surgeries in the areas of Spine, Hair, Eye, Hip and Knee. It can also be used for targeting beams of high-dose radiation in tumor-causing Cancer. A low-cost computer vision system that can run on a general-purpose computer equipped with a low-power USB webcam is one of the main goals of this work and has been successfully implemented. We experimented with around 30 gesture images and got higher average accuracy. The best grading rate of 97% is achieved under different lighting conditions. But the downside of this method is that the hand must be positioned correctly relative to the webcam for the entire hand area to be captured. If the hands are not positioned correctly, gestures cannot be recognized correctly. The gestures performed in this method involve only one hand, which reduces the number of gestures that can be performed with both hands. Real-time control of robots via hand gestures is a novel approach with countless applications.

REFERENCES

[1] "Control of robot arm by using reference arm and LabVIEW", Revista Tecnica De La Facultad De Ingenieria Universidad Del Zulia, 2016.
[2] D. Dirksz, J. Scherpen and M. Steinbuch, "A Port-Hamiltonian Approach to Visual Servo Control of a Pick and Place System", Asian Journal of Control, vol. 16, no. 3, pp. 703-713, 2014.
[3] "IoT Based Pick and Place Robot", International Journal of Recent Trends in Engineering and Research, vol. 4, no. 3, pp. 217-223, 2018.
[4] S. R.Nair, "Design of a Voice Controlled Robotic Arm for Picking and Placing an Object", IOSR Journal of Engineering, vol. 02, no. 04, pp. 670-673, 2012.
[5] P. Ramaiah, M. Venkateswara Rao and G. Satyanarayana, "A Microcontroller Based Four Fingered Robotic Hand", International Journal of Artificial Intelligence & Applications, vol. 2, no. 2, pp. 90-102, 2011.
[6] David G. Lowe, "Distinctive image features from scale-invariant key-points", International Journal of Computer Vision, Vol.60, Issue No. 2,pp. 91-110, 2004.
[7] Mokhtar M. Hasan, and Pramod K. Mishra: "Hand gesture Modeling and recognition using Geometric Features: A Review": Canadian journal on image processing and computer vision vol.3, Issue No.1, March 2012.
[8] S. Waldherr, R. Romero and S. Thrun, "A gesture based interface for human-robot interaction", In Autonomous Robots in Springer, vol. 9, Issue 2, pp. 151-173, 2000.
[9] K. Brahmani, K. S. Roy, Mahaboob Ali, "Arm 7 Based Robotic Arm Control by Electronic Gesture Recognition Unit Using Mems", International Journal of Engineering Trends and Technology, Vol. 4, Issue 4, pp. 50-63, April 2013.
[10] J. Yang, W. Bang, E. Choi, S. Cho, J. Oh, J. Cho, S. Kim, E. Ki and D. Kim, "A 3D Hand drawn Gesture Input Device using Fuzzy ARTMAPbased Recognizer", In Journal of Systemic, Cybernetics and Informatics, Vol. 4 Issue 3, pp. 1-7, 2006.