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Tele-Replication of Human Hand Movements

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Abstract - *This paper presents a method for remote control of an anthropomorphic robotic arm for applications requiring precise movements such as surgery. The reason for implementing this project is to provide specialized surgical assistance in time- sensitive conditions. Special emphasis has been given to reducing the cost of replication of human hand movements by minimizing the degrees of freedom at every joint and making the operation more intuitive for the user by designing a user-friendly console. The system discussed in this paper is designed to handle lighter tools but the same principles can be applied to scale up the design.*

Key Words: *Tele-replication, zig-bee, remote communication robotic-arm, replication movements*

1. INTRODUCTION

Remotely operated mechanical arms are getting widely accepted in several industries. Protective gear worn by humans working in hazardous conditions restricts movement and mo- bility. A unique category is that of the robotic arms used for performing critical operations in hazardous conditions. Such robotic arms use cases can be extended to medical applications like performing minimally invasive surgery where an arm like this can eliminate tremors caused by human hands. The authors display the modality of achieving an anthropomorphic robotic arm capable of performing an incision using a scalpel in the desired location. Certain difficulties are faced in con- ceiving and developing algorithms that are used to execute complex movements for anthropomorphic robotic arms. In the case of tele-replication of human arm motion, the most widely used and natural way of tele- replication is to use an exoskeleton over the body. For tele- replication of hand and finger motion, sensor-based systems like those implemented in virtual-reality gloves are preferred. Apart from that, a lot of technology currently in use also makes use of expensive sensors and is high in cost. Five- finger dexterous hand DLR/HIT are some of the expensive sensors/actuators available today but more affordable instru- ments are still required in developing countries. Movements in the human arm do not have to be replicated as it is to perform an action.

We have designed a user-friendly console that can be used to control the robotic arm to make it perform precise movements.

2. STRUCTURE

There are two separate physical structures that make up the system. An input console that is controlled by the user. A ceiling mounted robotic arm that performs the desired movements. ZigBee is used for communication between the two for prototyping purposes, but faster and longer range communication methods can be used in its place depending on the availability and feasibility of connection.

2.1 Input console

The input is made of two metal segments of equal lengths joined together. Two degrees of freedom of movement between them. The joint between them houses two po- tentiometers perpendicular to each other to record the movement. This whole segment is then mounted on a base where one potentiometer perpendicular to the base records movement of the lower part in one direction.

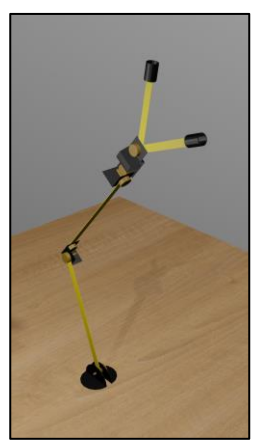

Fig. – 1: Input Console

The values of these three potentiometers are inversely mapped to the motors placed in shoulder joint and elbow joint of output such that if the console is pushed down, o to the side, the arm at the output will move in the same manner.

Scissor like setup is connected to the top of upper metal segment with three potentiometers perpendicular to each other to record movements in the three axis. These values are mapped directly to the three motors placed at the wrist join in output.

2.2 Output console

The output has two metal segments of equal length connected by a joint with two motors which is mounted on a ceiling with one motor.

This is similar to human hand except only one degree of freedom is possible in the shoulder.

A setup to hold the surgical instrument is connected to this setup with three motors at the wrist.

2.3 Video Streaming

A camera is mounted on the ceiling at eye level. It will send a live video stream to the operator which can be viewed on a screen or on a Virtual Reality headset.

2.4 Communication through ZigBee

- The two Xbee modules are set up as coordinator and router respectively.
- The router is in transparent mode, and is used to send data from the input console to the controller at the output.
- Angle data is collected every 10 ms.
- The coordinator is in API mode, and receives data from the router.
- This data is used by the controller to position the arm.

3. WORKING

Potentiometers placed at the console joints are used to record movements made by the user. Signals collected from the console is decoded, transmitted wirelessly with the help of ZigBee and implemented in the mechanical arm system. Not all movements of human arm is implemented but only the movements necessary to perform precise operations.

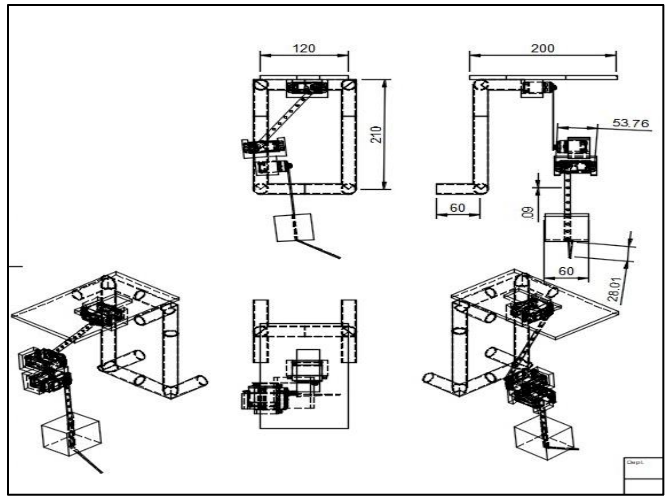

Fig. – 3: Plan of output console eveloped in autocad

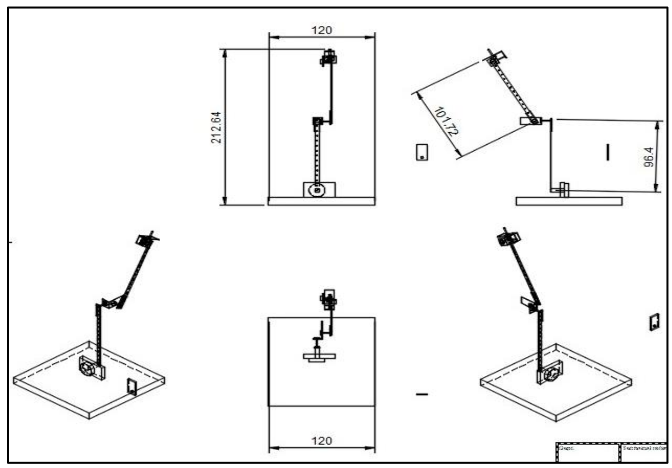

Fig. – 4: Plan of input console eveloped in autocad

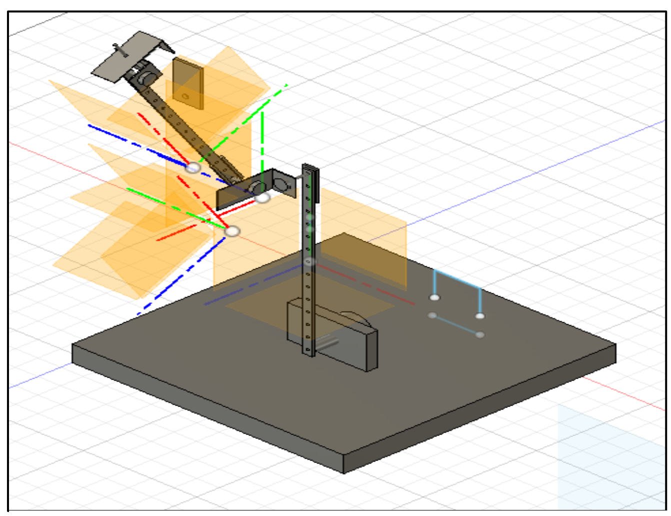

Fig. – 5: Input console in fusion 360

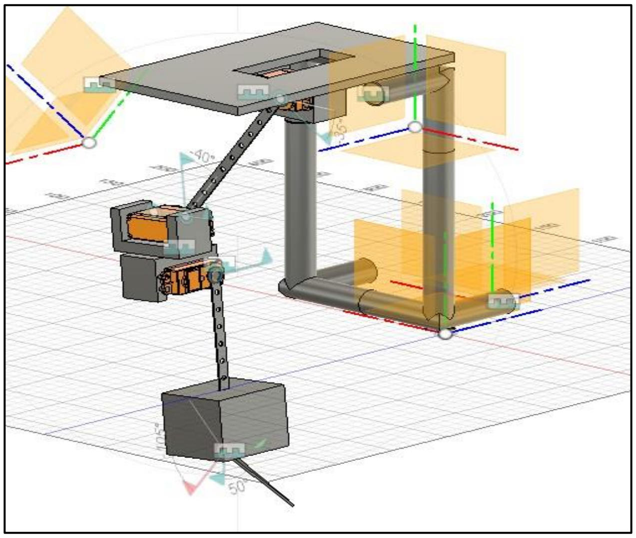

Fig. – 6 : Input console in fusion 360

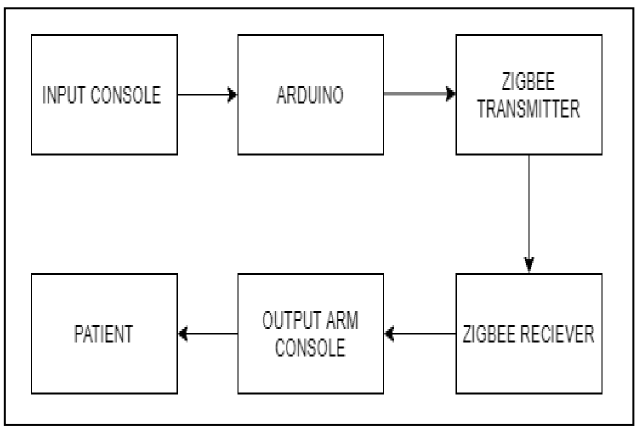

Fig. – 7: Block Diagram

4. CONCLUSION AND FUTURE SCOPE

This paper focuses on reducing the cost of robotic arm. In the case of tele-replication of human arm motion usually an exoskeleton is used. For tele-replication of hand and finger motion, expensive sensors like virtual reality gloves, kinect, or IMU-based Motion Capture suits are used. Apart from that, a lot of technology currently in use also makes use of expensive sensors and is high in cost. By using potentiometers to sense movement we drastically reduce the cost of the system.

We use a mechanical structure that senses and replicates only limited degrees of freedom at every joint that can together create the desired movement for our use case instead of creating an arm that replicates human arm movements as it is. This helps in reducing the cost further by removing redundant movements, and by making modules of the arm that can be removed and attached, one can change the degrees of freedom at every joint depending on use case. Better communication between the two controllers can be developed and 3d printed parts can be created along with springs, end stops to enhance the mechanical behaviour of the system.

By reducing the cost of the proposed system we are able to create a basic model for replicating human hand movements that can be scaled up depending on the use case. It can be used in hazardous environments by making the body of the arm with material that is resistant to the environment. Similar technology can be used in gaming consoles to create games that engage the users.

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