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Design and Development of Robotic Arm with 4-Degree of Freedom

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***Abstract* -- A Master — Slave link up is a novel method of controlling the motions of a robotic arm in which the motions of the human (master) arm are transmitted to the robotic (slave) to achieve the same motion in a different location i.e. the motions of the slave arm controlled by the master arm. It eliminates the need for complex computer programs. eliminates the need for computers and computer systems to control the motions of the robotic arm. It also does not need feedback control as that is achieved with the help of human senses (e.g. eyes). The resulting vicarious interactive participation in activities. The carrying out of physical work, will bring benefits to a wide range of risers. Examples include the emergency and security services, entertainment and education industries, and those of restricted mobility such as the disabled or elderly. A master arm consisting of a linked structure made up of Aluminum is manufactured. A robotic (slave) arm made up of acrylic is also manufactured. A circuit to Link two together to obtain motions of the robotic arm that are the same as that given to master arm is designed and manufactured. The link up is achieved and the desired goal is attended.**

I. INTRODUCION

Robotics has gained importance in recent times because it enables us to perform functions faster with greater accuracy and efficiency. Due to this, vast research has been carried out in this area and also interest in this held is constantly increasing. It has wide applications in assembly and manufacturing in Industries, in Space research, in Nuclear reactors, etc. however the limitation of robotics lies in its flexibility. Robots need to be programmed in advance which is costly, tedious and time consuming. Our interest is in robotics and in the development of a solution to this problem has motivated us to enter this field with the main goal of acquiring more knowledge about robotics and in particular master—slave technologies before entering in technologically fast changing word We have decided to develop a simple model for achieving master—slave connection while displaying only limited degrees of freedom. This model developed helps us to understand the capabilities and limitations of simulation and finds wide applications in industry such as robotic arms used for welding, spray painting, etc. Also in electronics such as assembly of circuit boards.

II. HUMAN ARM

A human arm has several degrees of freedom (DOF). The human shoulder consists of a ball-and-socket Joint, as shown in figure 1, which gives us three degrees of freedom. A human wrist also is capable of giving us 3 degrees of freedom. Each finger is capable of providing 4 degrees of freedom. In all a human arm provides over 20 degrees of freedom. All of these motions are achieved with the help of Muscle. As shown in the Figure 2.

Fig. 1 Human arm [1]

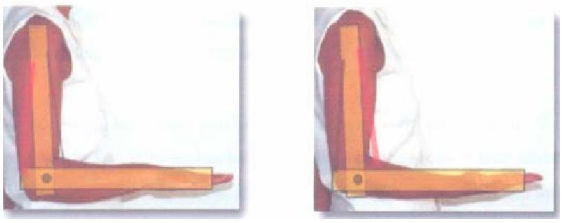

Fig. 2 kinematic representation of human arm[1]

The human muscles work in pairs. Muscles can provide motion only by contraction. As seen in the Figure, when the red muscle contracts, the forearm moves upwards at the same time the black muscles must expand to allow the forearm to move. Similarly in order to move the Forearm downwards, the black muscle contracts and the red muscle expands. Muscles provide flexibility and smooth motion. Human muscles have the innate capability to become stronger when the need arises. When faced with a situation where they require more power. muscles expand providing more force at the cost of more energy . In a situation where they do not require more strength. the muscles reduce in size lowering the strength providing capacity but saving energy required. Thus muscles are smart enough to know how much power is required to accomplish any given task. however. the decision regarding the motion of muscles is made by the human brain i.e. the muscles are

controlled by the Human Brain and the central nervous system.

The human brain is an excellent control system. In any situation wherein we see a point in space where we want our arm to reach, the human brain calculates all the possible ways of reaching there and then decides the optimal solution i.e. the one which is the easiest way to reach there which will require the minimal effort. It does the calculations so list that we do not even realize that we are doing it. A human brain gives us the optimal solution for any problem that it encounters the First time every time. It works on a feedback loop with the eyes and sense of touch act as sensors. however, human arms have their Imitations, not in their control but in their physical strength. A human arm also has low productivity i.e. they require more time to do a particular task as compared to robotic arms. A human arm gets tired easily and loses its accuracy in operations where repetition is required in a short period of time.

3. ROBOTIC ARM

Robotic arms are electro—mechanical devices which are used to help humans work fast, with accuracy and precision. They are used widely in various fields for increasing efficiency, flexibility, accuracy and to reduce the time required to perform any operation. Examples include the assembly operations, welding, spray painting, hazardous environments, military applications, space explorations and innumerable other fields However, the limitation of all these applications is that the robots must he Preprogrammed i.e. the exact motion of the robotic arms must he known in advance. Also Programming has its limitations. Robots cannot he program med to deal with all the challenges and situations that they may face. A variable motion robotic arm can he developed. Wherein a robot is capable of looking at a desired point in space and then using Inverse Kinematics to reach that point. Inverse Kinematics is a method wherein all the parameters of the motors are *known,* the starting point of the robotic arm and the end point of the robotic arm with the workspace is known. Inverse Kinematics then calculates all the possible ways of reaching the desired point with the desired orientation. However the problem is that it gives many solutions which may not he optimal. Also calculating for several degrees of freedom (as in the case of human arms which have over 20) it becomes difficult and requires tremendous processing power. Although there have been several attempts to develop Artificial Intelligence whereby a robot can sense its surroundings and adjust its actions accordingly. it too has its limitations

4. TELEPRESENCE

Telepresence is the experience of being fully present at a live real world location remote from one's Own physical location. Someone experiencing transparent telepresence should therefore be able to behave, and receive stimuli, as though at the remote site. Controlling the motions of a robot from afar with the help of cameras is not Telepresccnce. But, being able to sense the environment, respond to stimuli and act through the robot as if the human is present there itself is the idea of Telepresence. The resulting vicarious interactive participation in activities, and the carrying out of physical work. will bring benefits to a wide range of users. Examples include the emergency and security services, entertainment and education industries, and those of restricted mobility such as the disabled or elderly. To achieve telelepresence we need to find a way to link the human (master) arm and the robotic (slave arm) in such a way so as to be able to mimic each other's motions and 'feeling's'. This is generally done by incorporating a vision system within the robot. so that the human may see the remote location, as well as other sensors such as tactile sensors to simulate the sense of touch.

5. DESIGN OF CIRCUIT

The linking of the human brain with a robotic arm is done so in the same manner that we would mimic the motions of someone else arm i.e. by comparing the position of our arm with their arm. The motions are converted into equivalent electrical current values with the help of simple single—turn rotary potentiometers as sensors. These values are then compared with the help of an Operational Amplifier. The output of this comparison is sent to the motor driver chip which actuates the motors accordingly.

A. single turn rotary potentiometer

A potentiometer is a variable resistor that can be used as a voltage divider, it is an electrical device which has a user-adjustable resistance It is a three terminal resistor with a sliding contact in the center known as the wiper. If all three terminals are used, it can act as a variable voltage divider If only two terminals are used it acts as a variable resistor its shortcoming is that of corrosion or wearing of the sliding contact, especially if it is kept in one position.

B. LM324 quad operational amplifier

LM324 quad operational amplifier shown in Figure 3. The comparator gives an output of HIGH when the current value of one of the inputs is greater than the other and gives an output of LOW when the other current value is greater. The advantage is that there are 4 operational amplifiers in single package and power drain suitable for use of batteries. It operates from single power supply over wide ranges of voltage split power supplies can also be used

C. SN7404 inverter

This device contains six independent inverters shown in figure 4 below. The inverter simply inverts the current from HIGH to LOW and from LOW to HIGH

D. L293D DC *driving motors*

Since we are using bi-directional DC motors, the popular L293D motor driver IC for bi-directional control is good choice The L293D can drive 2 DC motors or one bi-polar stepper motor(4-windings) Figure 5(a) and 5(b) show s 2 DC motor control through L293D.

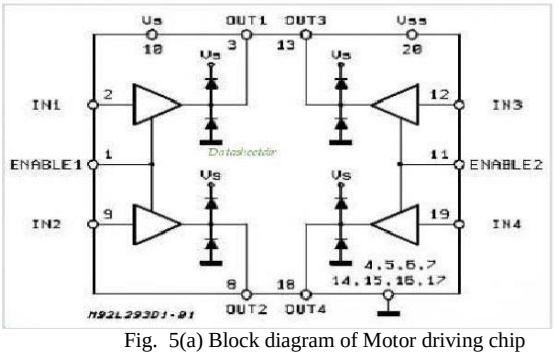

Fig. 5(a) Block diagram of Motor driving chip

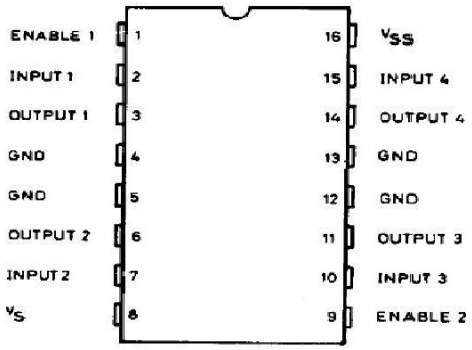

Fig. 5(a) Block diagram of Motor driving

E. working of circuit

The circuit shown in figure 6 above is having a 6—Volts Bi—Polar power supply (Batteries) hut we require a 5 volts bipolar power supply for the working of the potentiometer. Comparator and the inverter and also for the enabling of the motor driver chips. In order t o reduce the voltage we have used 2 diodes in series which offer a volt age drop of 0.5 volts each. The potentiometers are used to sense the motion of the human arm and also to sense the motion of the slave arm at the same point. The two values obtained are compared with the help of a comparator. The output of the comparator is split and sent to an inverter and a motor driver chip. The output of the inverter is given to the second directional pin of the motor driver chip. Thus. when one of the current values is greater. the motor rotates in one direction. when the other value is greater the motor rotates in the other direction and when both the values are the same the motor does not move. Thus when the master arm is moved in any direction, the slave arm also moves in the same direction

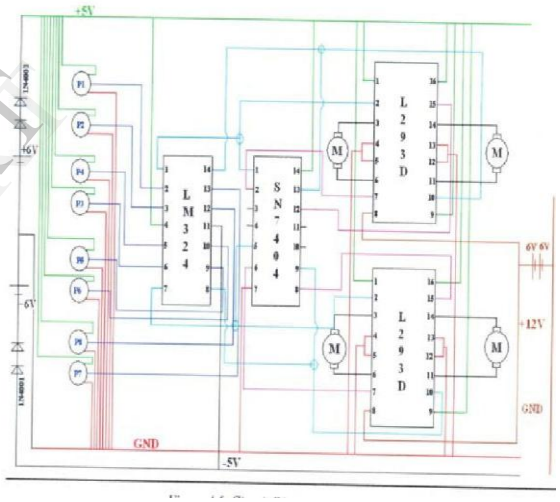

Fig. 6 circuit design [1]

6. SLAVE ARM

The slave arm is a rigid linked structure which has sensors (single turn rotary potentiometers) attached to it at various points as shown in the figure 8 below. The slave arm is used to achieve the motion dictated to it by the human (master) arm. The sensors measure the motions of the slave arm and convert it into equivalent current values which are sent to the circuit. It is made up of acrylic as it is light, sturdy and aesthetically appealing It is capable of providing 4 degrees of freedom of motion. Difficulties were faced in replicating the motions of a human arm like the Ball and Socket Joint which is why only two motions of the shoulder are achieved by the slave ann. It also provides the motion of the elbow and the roll motion of the wrist.

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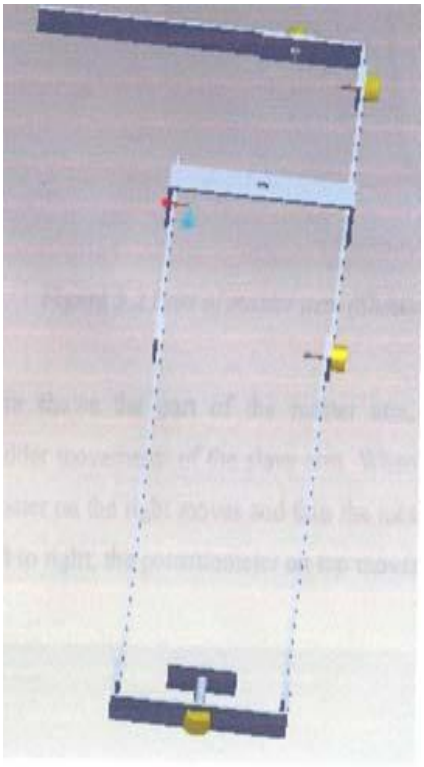

Fig. 7 Master arm

7. CONCLUSION

Master arm and slave arm were manufactured and the motions of the slave arm were transferred to the salve arm with the help of circuit developed. The capabilities and limitations of the system were observed

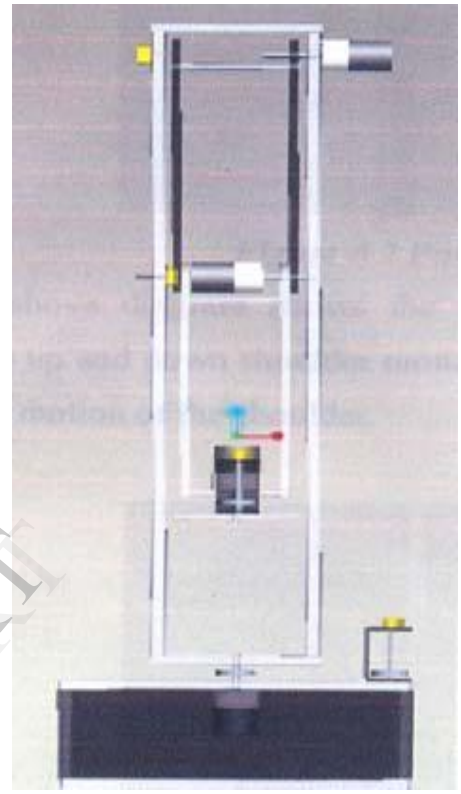

Fig. 8 Slave arm

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