IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-8, Special Issue-1, Feb 2020 E-ISSN: 2347-2693

Implementation of PID control Based Hybrid Model for Gesture Controlled Robotic Arm

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Available online at www.ijcseonline.org

Abstract— Human beings have been developing and designing since the stone age. They have worked for the betterment of society ever since. However, it is always not possible for them to attend a situation at a given time in person. Hence, the solution we came up with is a gesture-controlled robotic arm where we are controlling the device from a distant location. The project comprises mainly of two parts, viz, the sending and receiving part. In the sending part, we are using an MPU6050 3-axis gyroscope plus a 3-axis accelerometer sensor compiled with an Arduino nano micro-controller and an IR transmitter based bend sensor is used. Similarly, for transferring information, we are using an RF module. In another part. The thing that is happening in the robotic arm moves up, down, left, or right along with gripping according to the hand movement made by the user. Following the direction of the movement, the gripping process is brought about. The applications of this project can be found in the fields of biomedical, defense, industrial, and many others. Like in the medical field, during times of surgery, the doctors can carry out the operation even in his absence at that particular location. Also, in the field of defense, our robotic arm can be of great importance, like diffusing a bomb without the intervention of humans. Thus, in this era of science and technology, where the world says nothing is impossible, few factors provide limitations to this. So, by using this project, we tried to give a hand to reduce the problems of society.

Keywords— Gesture, robotic arm, RF transmitter, receiver, Arduino nano.

I. INTRODUCTION

A robotic arm is a programmable device that converts electrical energy to mechanical energy, which can work as a human arm. The robotic arm is an essential part of almost all fields. A robotic arm performs with precision and maintains consistency. The advantages of robotic arms are those that do not degrade with time; all it needs is the maintenance from time to time. In hazardous areas and places that cannot be accessed by humans, this robotic arm is a boon to them. The basic working principle of this arm is that it works on the gestures made the user, that is, whatever the action the user indicates with his/her hand, the robotic arm replicates it. The motive of this paper is to introduce a new layout that helps the user to control and program a robot.

II. RELATED WORK

In "Human Controlled Remote Robotic Arm (HCRRA)" [1] Amithash E.Prasad and Murtaza Tambawala concluded that the user could work at a reasonable distance from the arm and hence safety can be guaranteed while doing any hazardous task. They were able to configure serial interfaces and manage two serial interfaces at the same time.

"Accelerometer-Based Control of an Industrial Robotic Arm" [2], Pedro Neto, J.Norberto Pires, and A.Paulo Moreira have concluded, that the MEMS movement and XYZ accelerometer has improved their work based on their sensors analog output voltage.

Karamchandani et. Al "The Gesture Replicating Robotic Arm" [3] made Conclusion- They concluded that there would be a software that will be able to detect movements of human hand without the intervention of accelerometer and will not need any artificial intelligence.

"Teaching and Learning of robot tasks via observation of human performance" [4] by Rudiger Dillmann have concluded - that a humanoid robot will be created, they will have the ability to learn from action sequences from a human demonstrator, which in turn will enable the robot to execute the tasks respectively.

Aleotti et. Al "Position teaching of a Robot Arm by Demonstration with a wearable input device"[5] c- They concluded that it would be easier to train robot manipulators by demonstration. They aimed to provide human mapping motions to the robotic arm domain, which in turn would not restrict the motion of the human.

III. METHODOLOGY

Robotic Arm: It is an integration of many fields such as modern mechanics, electrical, electronics, computer science and technology, mathematics, and science. It is the combination of base, elbow, and the gripper, which holds and releases the object simultaneously. Servo Motor does the linkage as well as it helps in the movement of the arm. The linkage can be considered to form a kinetic chain. Base helps in the angular movement of the arm and the elbow helps in the vertical and horizontal movements.

Microcontroller: ATmega 328 is a microcontroller that is a single chip, used as the hardware. It is the brain of the machine, to which all other body parts, components have confederated. Those types of microcontrollers are used in this project, one used in the Transmitting end and one at the Receiving end.

Accelerometer: Acceleration forces are measured by an accelerometer. The accelerometer is an electro-mechanical device. Change in speed can be measured from acceleration or velocity divided by time. Due to gravity, it measures gravitational force or acceleration. By combining many components, it is made up, among them, two are piezoelectric effect and capacitance sensor. It has multiple axis determination technique to most determine two-dimensional movement with an option of 3D positioning, labeled as X, Y, and Z. It measures the angle at which the device is tilted concerning the earth. Each axis which is measured represents a separate Degree of Freedom from the sensor.

Communication System: This part is the heart of the entire project. Without a competent and reliable communication system, no system can work. Similar is the case with this project too. The RF module is the communication equipment required in this project, which shall be communicated through satellite communication. This Module is employed to transmit various hand information created by the user wirelessly to the receiver, that decodes the received information and per that the arm moves.

Flex Sensor: It is used to calculate the amount of defection otherwise bending. Plastics, carbon etc. type materials can be used to design a flex sensor. On a plastic strip, a carbon surface is arranged. So when the sensors are turned, the resistivity of the sensor will be changed. So it also called bend sensors. Mainly it measures the variation in resistance of the bending material. When the sensor is flat, the resistance of the sensor would be nearly 30k when the sensor is at 90 degrees, and the resistance would be nearly 50k. They are usually in the thin strip form. One resistor is required in the circuit. 10K to 100K resister would work for the circuit, but use a 10K resistor is used here. It is used here for the bending purpose of the hand.

Servo Motor: It is an electrical device used to rotate specified objects. The servo motors play an important role, which has excellent precision. It works consequently to the information given by the accelerometer.

IV. MECHANISM

Here our target is to build a robotic arm that uses the six degrees of freedom that means turntable, forearm, biceps, grips, hand, and gripper. A servo builds each joint except for the bicep joining; we are using two servos.

We have used six digital PI controller and found 2 – DOF-PID controller from MATLAB Simulink library. The sample control time is 0.1s (10 Hz).

Tune 2DOF PID Controller Command Line Example

C2 =>>

$$u = Kp\,(b*r-y) + Ki\,\frac{1}{s}\,(r-y) + Kd*s\,(c*r-y)$$

With Kp = 1.26, Ki = 0.255, Kd = 1.38, b = 0.665, c = 0

2-DOF PID controller is continuous-time along with parallel form.

C2dr =>>

$$u = Kp\,(b*r-y) + Ki\,\frac{1}{s}\,(r-y) + Kd*s\,(c*r-y)$$

With Kp = 1.72, Ki = 0.593, Kd = 1.25, b = 0, c = 0

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Tune2DOFPIDControllerCommandLineExample

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Continuous-time 2-DOF PID controller in parallel form.

C2dr =>>

$$u = Kp\,(b*r-y) + Ki\,\frac{1}{s}\,(r-y) + Kd*s\,(c*r-y)$$

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Continuous-time 2-DOF PID controller in parallel form.

$$C2dr = \quad u = K_p\,(b*r-y) + K_i\,\frac{1}{s}\,(r-y) + K_d*s\,(c*r-y)$$

with Kp = 1.72, Ki = 0.593, Kd = 1.25, b = 0, c = 0

Continuous-time 2-DOF PID controller in parallel form.

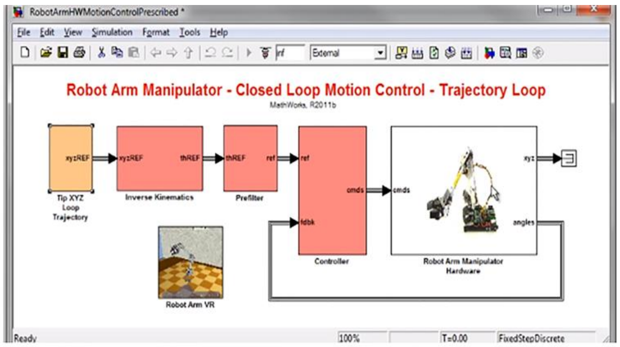

Fig: 1 Robotic Arm manipulator – closed loop motion control-trajectory loop

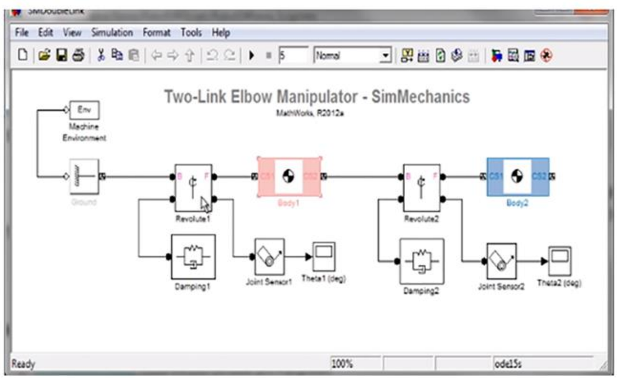

Fig: 2 Two link elbow manipulator

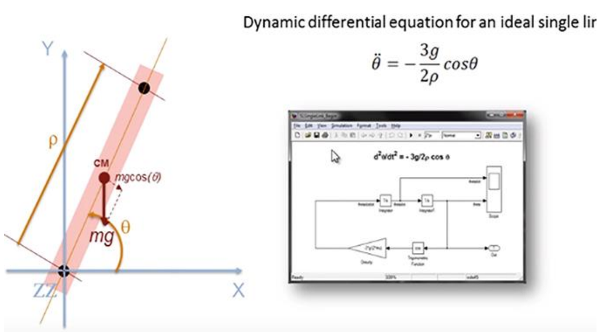

Fig: 3 Dynamic differential equation for an idea link

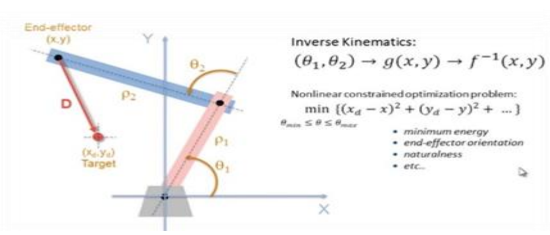

Fig: 4 Kinetic equation

V. RESULTS AND DISCUSSION

The human personnel is required to undertake specific tasks in order to avoid the risk caused due to the hazardous environment. Gesture controlled robots are designed to dispose of nuclear wastes. Hand gestures are used to control the robotic arm movements. Hand gestures are sensed using accelerometer sensors, which are used to find out the position of each finger. Servomotors are used as actuators to move the robotic arm. The communication between hand gesture and the robotic arm is done using satellite remote control. The arm movement will respond as the hand moves. In Arduino coding, the following outputs are generated the desired coding. According to the logic, the robotic arm will pick up objects by moving its axis, if we are considering the system is in the factory.

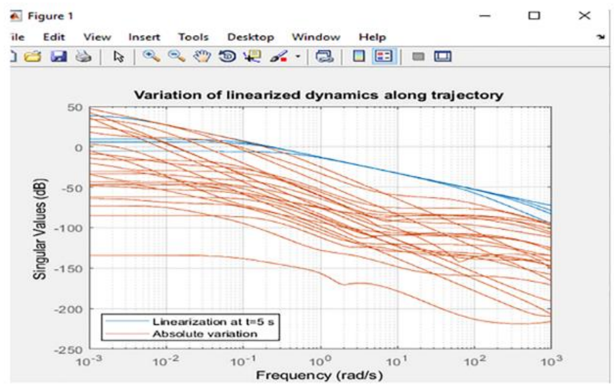

Fig: 5 variations of linearized dynamics along the trajectory

On the case of dynamics for very low and high, we can see in the graph the variation drop is nearly less than 10%, These 10 rad/ s bandwidths are nearly acceptable. For target, gain cases small variations near the target gain cross over frequency, and we can conclude that we can control the arm with a single set of PI.

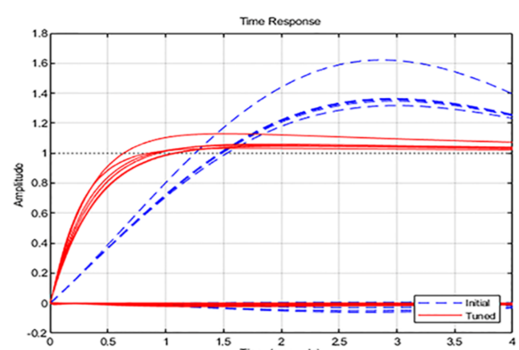

Fig: 6 Time response of the system

Now we are trying to linearize the curves using MATLAB command tLinearize command at 3s. Now we are creating a

Tuner interface. The controller is tuned automatically by Simulink using the sLTuer function. After checking the output of the motor, we are marking the plant output using the addPoint command. In this case, the desired bandwidth is 1 second, so our main challenge is to make our bandwidth into the limit of 3 seconds. In this chart, fig 4, the final value is nearer to 1. So the model's output increased.

Six curves are setting nearer the y =1 and represents the curves settling nearer to y=0 by using cross-coupling terms. There is a apparent improvement in the controller output. However, the biceps are taking a long time to settle.

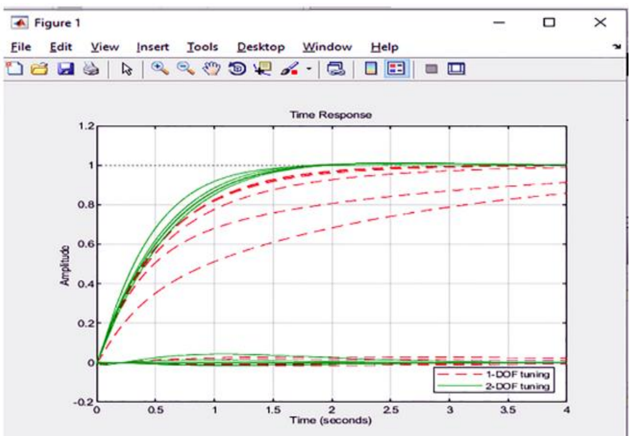

Fig: 7 Improved Time response

Now we are trying 2-degree freedom for PID controllers.
2 DOF PID controllers at the command line include the setpoint weighting on the proportional and derivative terms. Through this controller, we can achieve better disturbance rejection. As we can see in fig-7, the time response improved than the fig-6.

Here, Final: Peak gain = 0.766, Iterations = 13, Achieved target gain value Target Gain=1, shown in fig: 8.

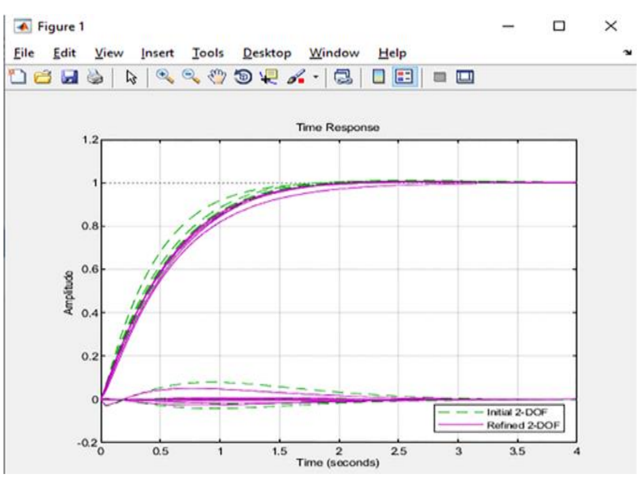

Fig: 8 improved time response curve.

VI. CONCLUSION AND FUTURE SCOPE

Nowadays, humanoid Robots are used to perform surgeries in an accurate and precise manner where surgeons from different countries make their decision, what to do next on the patient body. A small error can be the reason for taking a man to the mouth of death, as well as also the reason for the enormous amount of blood loss. So the Robotic surgeries are getting smaller to reduce the amount of blood loss. In some cases, like MIRS(Minimally invasive robotic surgery), it is being performed by Tele- Operated robotic tools instead of using manual instruments. In such cases, the robot will not be replaced by surgeons. However, surgeons with improved capabilities will perform the intricate, precise surgical manipulations. In the field of defense, it also finds its purpose in diffusing bombs and thereby reducing human causalities.

ACKNOWLEDGMENT

Our member's cooperation made this project successful. We want to thank our faculties for their constant support in this project and our seniors for their expert advice. Lastly, to God Almighty for favoring us throughout this project.

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