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Cost-effective Bionic Parallel Robotic Arm that can be Used for Precise Handling in Industry

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Abstract

In this paper we have discussed about a new technique to develop a cost-effective Bionic Parallel robotic arm that can be used for precise handling in industry. The main objective of our new approach in handling technology as an alternative to the portal systems that is predominant in electromechanical engineering. Unlike these designs, with Bionic robot, the drive unit and the handling system are entirely independent of each other. The working and drive levels are spatially separated by the work surface. The system's drive unit is safely located and protected beneath the work surface, while the controllable pyramid of rods is mounted vertically on top of it.

Keywords: *Robotic Arm, Precise handling, cost-effective Bionic Parallel robotic arm, Robot*

1. Introduction

A **robotic arm** is a type of mechanical arm, usually programmable [1-2], with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot [3]. The links of such a manipulator [4, 5] are connected by joints allowing either rotational motion (such as in an articulated robot)[6] or translational (linear) displacement. It can perform a wide variety of functions and perform the tasks where human cant go. In space as well as in vacuum metallic parts specially those which are subjected to friction specially gears and Barings wear-out very fast. The robotic arm can handled the particles in the chemical laboratories and used it for security purpose. It can also helpful in the medical applications. Through programming arm can handled the whole automatic industrial process. Due to the lightweight of the structure and designed techniques the robotic arm can used for underwater applications in the underwater submarine. The four most advantage of this design could be very high speed manipulation, snippy manipulation due to extremely high weight design and very low inertia.

2. Development of Design

Our proposed robotic arm is working on the principle of Fin Ray Effect. Our design is Consistent lightweight design for maximum flexibility. The arm is accessing the objects in the 3D plan using the flex technique like Fish. Our design is more efficient than historical robotic arm because arm is joint less, Lightweight, energy-efficient, highly dynamic overhead grasping, Rapid, flexible three-dimensional handling of small masses. We adopted a new approach in handling technology as an alternative to the portal systems that are predominant

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in electromechanical engineering. Unlike these designs, the drive unit and the handling system are entirely independent of each other. The working and drive levels are spatially separated by the work surface. The system's drive unit is safely located and protected beneath the work surface, while the controllable pyramid of rods is mounted vertically on top of it. Important steps involving project designing are listed below.

2.1. Function of different parts of the bionic parallel robotic arm

The function of different parts of the bionic parallel robotic arm is shown precisely in the following block diagram in Figure 1 and explained below.

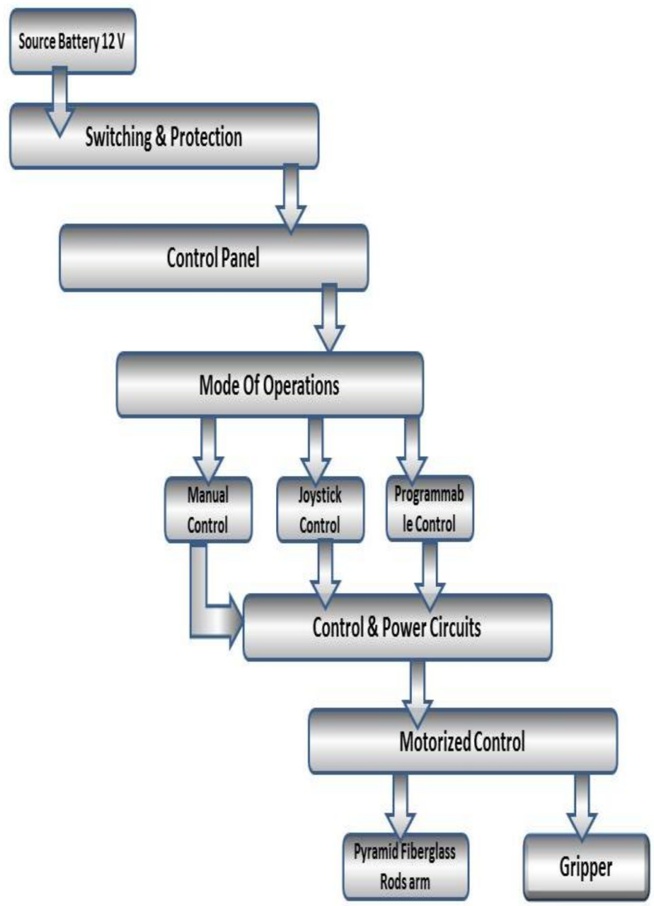

Figure 1. Block Diagram of our proposed designed

2.1.1. Source Battery

The system is operated 12V DC so the battery will used as a source to energize and functionalize the electrical control panel which control the whole operations of bionic parallel robotic arm

2.1.2. Switching and Protections

The selector switches have used to control the mains supply to the control panel and for every electronic printed circuit board (PCB). Fuse will also use for the protection of against over load current in case of any abnormality in the electrical control and power circuit.

2.1.3. Control Panel

Control panel consists of pulse width modulation controller board, Pulse width modulating power supply, Probes for controlling the movement of arm and Fin gripper, ammeter for monitoring the current of whole circuit, voltmeter for monitoring the voltage of battery and LCD to display the information.

2.1.4. Modes Of Operations

There are three modes of operations in the system for different applications in the different industrial fields.

- **Manual Control**

In this Mode, movement of the arm is control by adjusting the probes setting for accessing the objects placing at different locations. The gripper can also be control by the probe.

- **Joystick Control**

In this mode the movement of the joystick controls the robotic arm to approaching the objects. In this mode four motors of the drive unit is drive the arm simultaneously. Push button attached on the top of the joystick for open or close Fin gripper to hold the masses and vice versa.

- **Program Control**

The system is control through programming by using microcontroller 2051. This mode is use in the industrial process or for particular functions

2.1.5. Control And Power Circuits

The pulse width modulation technique is used to controlling the base unit servo motors and fin gripper motor to functioned the bionic parallel robotic arm.

2.1.6. Motorized Control

Four motors are install in the base drive unit, those are individually interface the fiberglass rods through efficient and meaningful mechanical system for moving the arm

2.1.7. Pyramid Fiber Glass Rods Arm

The structure of the arm is design in such a way that four rods install to utilizing the Fin Ray Effect. This arrangement of the pyramid fiber glass rod helps to move linearly.

2.1.8. Fin Gripper:

The adaptive, highly versatile Fin Gripper constitutes the interface between the object and the actuators. Design to catch the objects from one place to another.

2.2. Flow Chart

The detailed system flow chart having all the sub-systems involved is provided. The sub-systems of the main systems are in the same colored as in the given Figure. As it is clear there is nested loop/s in each system. This Figure 2 shows the complete picture of all the tasks involved.

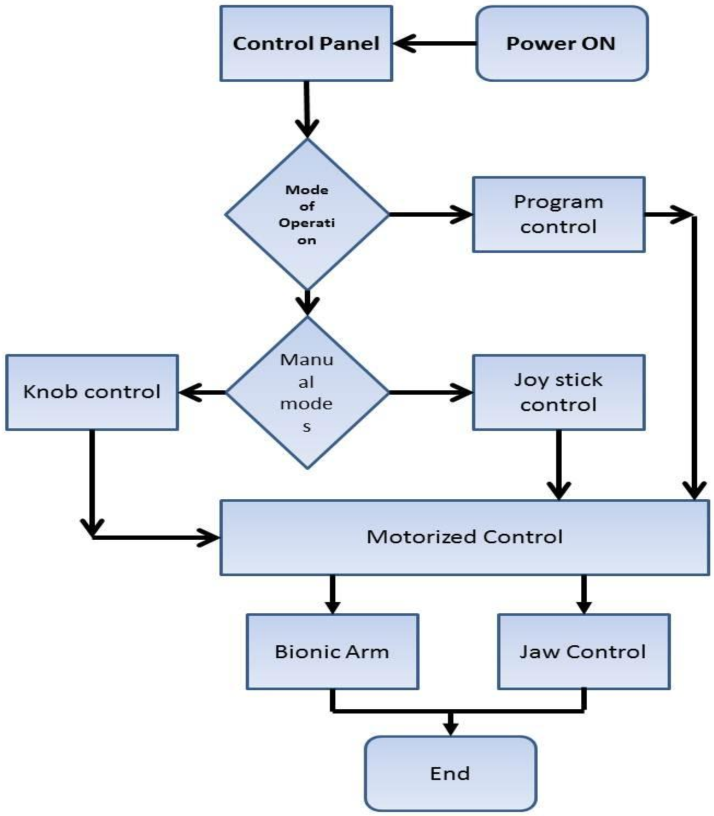

Figure 2. Flowchart of our Proposed Designed

3. Designing

After performing research and different experiments we decided to perform modification described below.

3.1. Drive Base Unit

On the bases of different experiment it was decided to design a basement with aluminum material which will provide strength, heavy-duty portable to the design. Basement is based on square type aluminum rods. All motors and shafts are connected in it. The interfacing mechanism of 3D initial design is given in Figure 3.

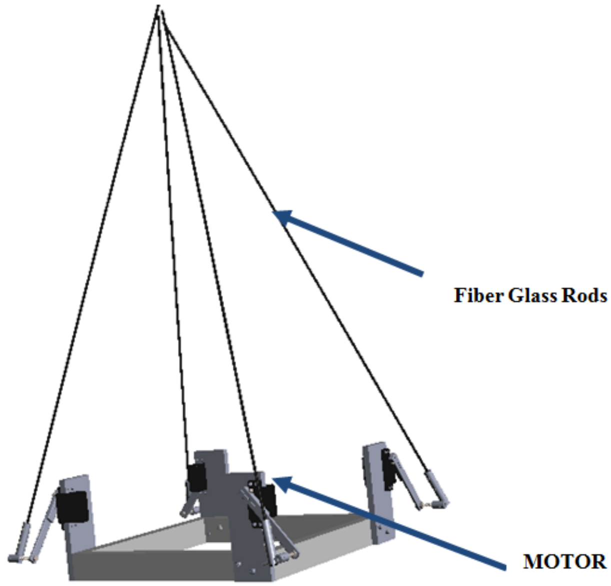

Figure 3. 3D Initial Design of Base drive Unit and Arm Structure

The movable structure comprises four driven fiberglass rods and a further four movable, guided fiberglass rods that serve to reinforce the overall system. The four rods are arranged in a pyramid and are interlinked in a flexible and articulated manner by means of further short rods in a star configuration.

The inspiration came from nature: thin material cross-sections and the bracing of structures by means of lightweight, stable transverse links are just as much part of nature's repertoire as are flexible and moveable structures. The entire unit is designed as a 3D structure with Fin Ray Effect. Derived from the tail fin of a fish, this structure enables the tip of the pyramid to be deflected by up to 90 degrees for a maximum operating range. Since the structure is pliable and flexible, it is ideal for tasks in human-machine interaction. The particular strengths of Bionic Robotic Arm are applications in sorting or as a “third” hand.

3.1.1. Analysis

We analysis after overview of base drive unit that if we increasing required more flexibility in the arm than we have to increase the length of fiber glass rod and if we want to increasing the load capacity than we have to increase the diameter of fiber glass rod. Let the diameter of fiber glass rod is D , the length of fiber glass is L, bending flexibility of fiber glass rod is B and load capacity is K than we can explain it relation with following equation.

$B \propto L$

$B \propto 1 / D$ so as

$B \propto L / D$

According to the industrial requirement, we can design base unit in such a way that it will implement in every applications with respect to available hardware characteristics. For testing purpose fiber glass rod length would be 1m. And base would be 10” * 10”.

3.2. Shaft Designing

Shaft is made up of purely steel because it bears the stress or load of motor. In the initial design when we use the motor directly with rods. It breaks the teeth of the motor and similarly motor bear so much load and also slipped. Designing of interfacing mechanism of servo motor & fiberglass rod for final structure & 3D Design of Interface mechanism of Servo Motor is given in Figure 4.

- **3D DESIGN:**

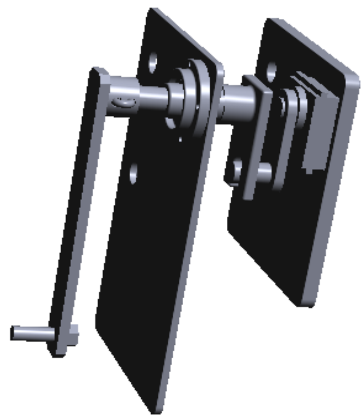

Figure 4. 3D Design of Interface mechanism of Servo Motor

3.3. Rod Joints

Special joints used in the end of both fiber rods and shaft. These joints are made up of aluminum material with 3 mm and 5 mm holes in it. The main purpose of this hole is to fit the Fiber rod and tight from the L-key bolts. Shaft and Servo Motor coupling Mechanism of 3D design in given in Figure 5.

Figure 5. 3D Design for Shaft locking and Gripping Mechanism

3.4. Joystick Design

The bionic Robotic arm should be control in three ways

- Through Programming
- Through Joystick (Initial 3D design is in Figure 6)
- Manually

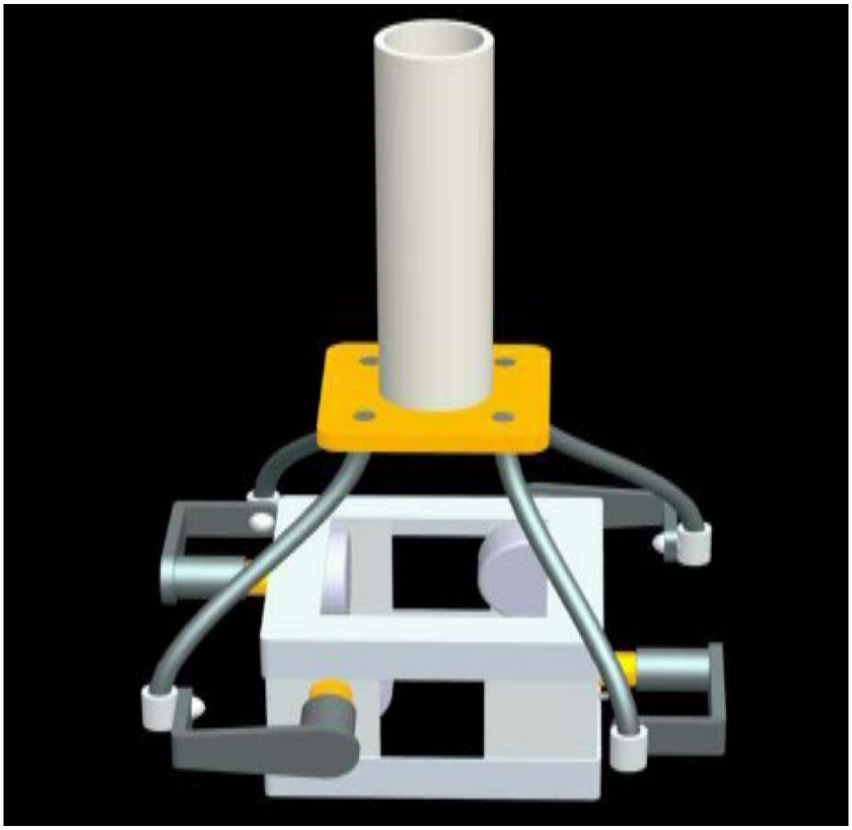

Figure 6. Joystick (Initial 3D design)

4. Fin Gripper Design

The adaptive, highly versatile Fin Gripper constitutes the interface between the object and the actuators. Fin Gripper consists of a mechanical actuator and four gripping fingers, which are designed as an adaptive structure with Fin Ray Effect.

This arrangement allows secure handling of differently shaped organic objects ranging from flower bulbs, via peppers to apples and pears, fruit and vegetables. An adaptive gripper is also highly useful in many industrial applications. A "third" hand that can pass a screwdriver, a wrench or a component for installation is an ideal helper for all kinds of assembly tasks. With Fin Gripper, this type of manipulation can be carried out without problem.

The aim of this development was to achieve a maximum scope of operation with a minimum weight of the moving parts. Reduction of the moving mass enhances energy efficiency. Bionic robotic arm is a vivid example of the forms that energy efficiency may take in the future of automation technology. This is made possible by Electric linear actuators, electric motors, robotic control, pneumatic valves, sensor technology and control technology. Fin gripper 3D mechanism is in Figure 7.

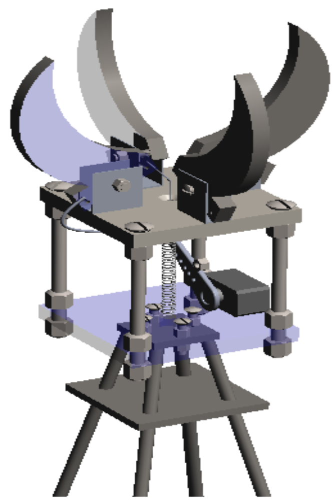

Figure 7. 3D Design of Fin gripper Mechanism

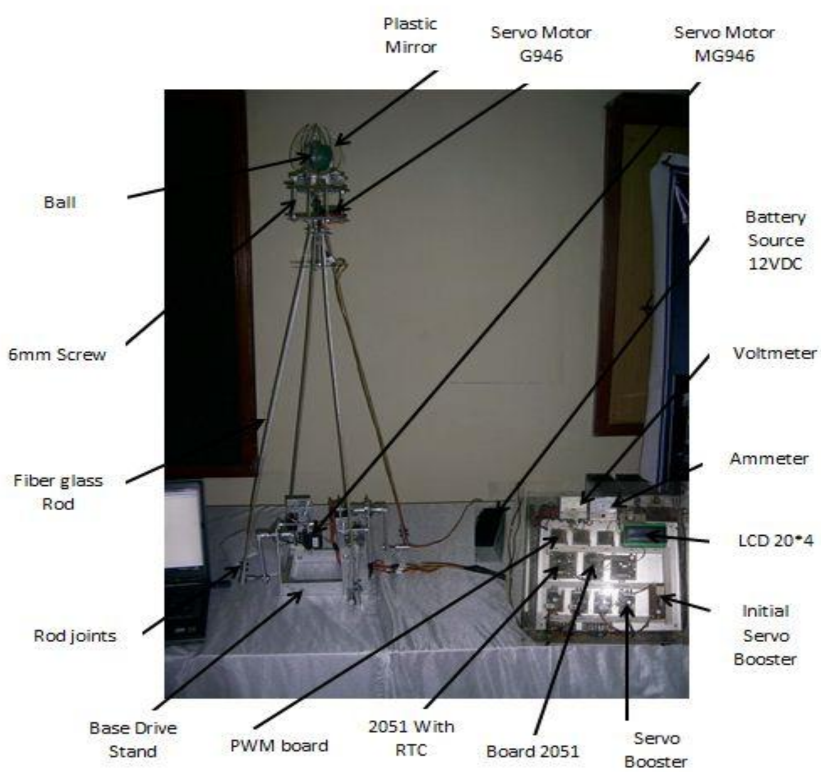

Figure 7. Final Design of Bionic Parallel robotic arm

5. Conclusion

Size of electronic components plays a very major role here as, our aim is to create a smart, light weight flexible and effective arm. To handle this problem, circuits were designed very small in physical dimensions using advance circuit designing techniques and multilayer PCB (Printed Circuit Board).Another problem was that where we should place electronic(Microcontrollers, PWMs etc.) Parts. Different ideas were considered in this case But in the end we can make the separate control unit which can control the arm which consists of 5 motors to make the design more suitable. Interfacing kit is carrying a LCD (Liquid Crystal Display) Ammeter and Voltmeter. The result of the parallel design is a robot that has increased stability and arm rigidity, with faster cycle times than serial technology. As such there is less flexing of the arms which results in high repeatability. In addition, with serial linked robots, the end-of-arm flexing errors are cumulative, while in a parallel link structure they are averaged. However, one disadvantage of parallel robots is they tend to have a relatively large footprint-to-workspace ratio, for example, the hexapod parallel robot, easily take up a sizable work area. Another limitation of the parallel configuration is that it has a small range of motion due to the configuration of the axes when compared to a serial link machine.

Acknowledgments

We dedicate our project to our dear parents, who are sacrificing their present for our future. Without their prayers, support and efforts of teachers and parents our dream to become engineer could have never come true.

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