Design and Fabrication of Octacle Arm

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Abstract- The aim of this work is to develop a flexible robotic arm, OCTACLE which is a mechanical replica of a tentacle. We are copying the movements of an elephant trunk to give the motions to this arm. This arm can be used for robotic jobs, submarines, space excavation deep tunnel excavating etc. It can be used for spray painting in automobiles effectively. In micro level we can use these arms. This arm can be controlled using pendants or using computer programming. This arm has different stages in its body which move individually. Each stage is controlled by different actuator at the control base. In order to improve industrial productivity, it is required to reduce the weight of the arms and/or to increase their speed of operation, the replacement of hydraulic or pneumatic cylinders with electrical dc motors as actuators and power source with lithium polymer batteries, it can be achieved.

Keywords – Octacle Arm, Relay Board, RDL Programming, LI-PO battery

I. Introduction

1.1 Introdcution to Octacle Arm

In order to improve industrial productivity, it is required to reduce the weight of the arms and/or to increase their speed of operation. For these purposes it is very desirable to build flexible robotic manipulators. Compared to the conventional heavy and bulky robots, flexible manipulators have the potential advantage of lower cost, larger work volume, higher operational speed, greater payload-to-manipulator-weight ratio, smaller actuators, lower energy consumption, better maneuverability, better transportability and safer operation due to reduced inertia

Continuum robotic arms are typically made of a flexible backbone, which gives them infinite degrees of freedom. Thus, these robots are hyper redundant, compatible, and underactuated. Continuum robots are inspired by bio- logical manipulators, such as octopus's arms, mammalian tongues, and elephant trunks and are close to ordinary hyper redundant manipulators, such as snakes and spines. Due to their special characteristics, continuum robots can perform a variety of tasks, such as dexterous manipulation, whole arm grasping, and ordinary under actuated grasp.

1.2 CHALLENGES FOR UNDERWATER ROBOT ARMS:

Research into underwater robotic applications is currently a growing field. There are many challenges involved in underwater robotics that are not present in other mediums, such as how the harsh environmental conditions that this environment invokes onto the robot and any equipment that is attached to the robot. In this paper an attachment to an underwater gripper is proposed that adds another Degree Of Freedom to the system, thus allowing the gripper to move along the belly of the robot. Adding this functionality to the gripper has many advantages, some of which involve the robot being able to easily pass a collected object to another robot with minimal interference. This attachment is constructed using 3D printed parts, a waterproofed servomotor and a lead screw to provide linear motion to a commercial gripper.

1.3 HOW OCTACLE ARM SOLVES THE PROBLEM:

Octacle Arm solves many of the problems, mentioned in previous section, let's see how?

- Octacle Arm is made from plastic body, so it provides enough buoyancy force to float.
- The structure of Arm is easily replaceable.
- The structure of arm is plastic made, which makes it Anti-corrosive.

- The Arm can bend around an obstacle in case of collisions.
- The Arm is easy to install, attach and detach.
- The Arm has great reach and large numbers of DOF.
- The control of the Arm requires a minimal optimized program.

II. ELECTRICAL & ELECTRONIC COMPONENTS

2.1 D.C Series Gear Motor (HY-2750B)–

HY-2750B Front and Side view as shown in below.

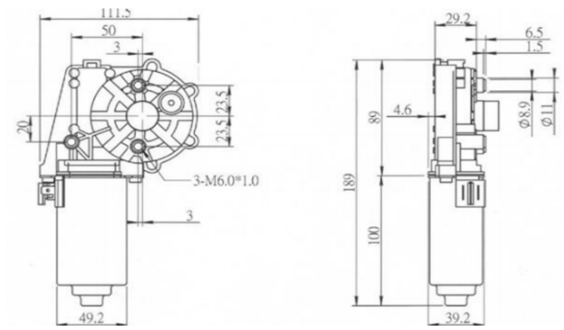

Figure 2.1 HY-2750B Front and Side view

Table 2.1 Motor Specifications

Motor Specification:		
Rated Voltage	DC 12V At Motor Terminal	DC 24V At Motor Terminal
No Load Current	3A MAX	2A MAX
No Load Speed	74±10 RPM	74±10 RPM
Rated Load 3N*m	8A MAX	4A MAX
	62±10 RPM	62±10 RPM
Stall	13±2.5 N*m	13±2.5 N*m
	26A MAX	13A MAX
Insulation Resistance	1M Ohm min	1M Ohm min
Dielectric Strength	AC 600V Between Casing and Terminal For 1 sec	

2.2 8 CHANNEL RELAY BOARD

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current.

Figure 2.7 RDL 8 Channel Relay Board

FEATURES

- 8 SPDT Relay channels (7A 250V,12A 120V,10A 125VAC, 10A 28VDC).
- Power supply:12VDC 1AMP
- Current consumption: 400 mA.
- LED indication for relay & power supply.
- TTL output.
- Status LEDs.
- Android apk file will be given.
- High quality PCB FR4 Grade with FPT Certified.

2. 3 ULN2803 IC

ULN2803 is the IC used in RDL Relay Board. It is a High voltage, high current Transistor Array IC used especially with Microcontrollers where we need to drive high power loads. This IC consists of an eight NPN Darlington connected transistors with common Clamp diodes for switching the loads connected to the output. This IC is widely used to drive high loads such Lamps, relays, motors etc. It is usually rated at 50v/500mA.

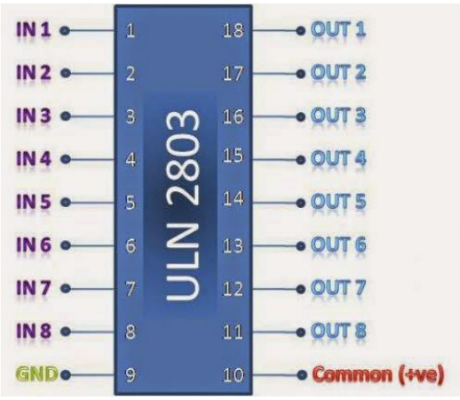

Figure 2.14 IC ULN2803 Pin Diagram

PURPOSE OF ULN2803: Most of the Chips operates with low level signals such as TTL, CMOS, PMOS, NMOS which operates at the range of (0-5) v and are incapable to drive high power inductive loads. However, this chip takes low level input signals (TTL) and uses that to switch/turn off the higher voltage load that is connected to the output side.

2.4 POWER SOURCE

Features:

Lead Acid batteries have changed little since the 1880's although improvements in materials and manufacturing methods continue to bring improvements in energy density, life and reliability.

BATTERY-12V12AH 12V 12Ah Sealed Lead Acid Battery is a general-purpose battery with up to 5 years in standby service or more than 280 cycles at 100% discharge in-cycle service. It is rechargeable highly efficient, leak proof and maintenance free

III. MECHANICAL COMPONENTS

3.1 STEEL WIRES

Steel wire is used for a wide range of applications such as wire for tyres, hoses, galvanized wire and strands, ACSR strands and armoring of conductor cables, springs, fasteners, clips, staples, mesh, fencing, screws, nails, barbed wire, chains etc. Electroplated steel is also widely used like copper plated wire for welding application, aluminum clad steel wire is applied for OHL conductors and OPGW applications.

Figure 1. Steel Wire

3.2 REGULATOR WHEELS

- Regulation wheels we used are among the parts of power window winder motors set
- They are made of poly vinyl chloride.
- 5mm diameter Regulation wheels have been used.
- They provide grooves for the steel cables to firmly set.
- The grooves and the steel cables have to be of similar size for proper use.
- They don’t corrode
- They are water resistant.
- Easily replaceable.
- Regulation wheels are supported by mounting house for structural support for cables.

Figure 3.2 Regulator Wheels

3.3 NON-TORSIONAL BENDABLE HOSE:

- Non torsional bendable hose used in the project is poly vinyl chloride made
- Non torsional bendable hose provides structural support for bendable hose, so that the bendable hose doesn’t go under twist or torsion.
- 2 mm diameter pipe has been used
- The length of Non torsional bendable hose is same as the octacle arm.

Figure 3.3 Non-Torsional Hose

3.4 FLEXIBLE HOSE:

- Flexible hose used in the project is made of polyurethane.
- It can be easily purchased from market under the name gas pipe.
- The diameter of the pipe is 1.2 mm

• The length of the pipe is same as the length of the octacle arm.

• The Flexible hose is provided for the flexibility and strength to the structure limb/arm.

• Flexible hose has been tucked under the non-torsional hose.

Figure 3.4 Flexible Hose

3.5 PVC CLIPS:

• The PVC Clips used in the project are made of poly vinyl chloride

• Dimensions are as follows,

  o 20mm fit tube diameter.

  o (Approx.): 8mm/0.3”.

  o Clamp width of 15 mm/0.6”.36

  o Weight 70 grams.

• PVC Clips have been used to provide guideway for the steel cables.

• They also provide an attachment with the non-torsional hose using stainless steel nails.

• PVC Clips have u shape, which makes it bend when stress exceeds it operating range. So, they are reliable and most often do not break.

• Instead of breaking PVC Clips bend which makes it ideal for using in the project.

FIGURE 3.5 CLIPS

IV. SOFTWARE

4.1 RDL PROGRAMMABLE BOARD

This section explains about, how to use USB relay board USB and windows applications (and Programmable Relay Board Software).

USB 8/4 Channel Relay Board :

This is Eight/four Channel relay board controlled by computer USB port. The usb relay board is with 8/4 SPDT relays rated up to 7A each. You may control devices 230V / 120V (up to 8/4) directly with one such relay unit. Suitable for home automation applications, hobby projects, industrial automation.

Features

• 8/4 SPDT Relay channels (7A 250V,12A 120V,10A 125VAC, 10A 28VDC).
• Power supply: 12VDC 1AMP
• Current consumption: 400 mA.
• LED indication for relay & power supply.
• Design based on highly proven IC ULN2003 as driver.
• Raspberry Pi and Beagle bone Compatible.

BLOCK DIAGRAM USB 8 Channel Relay Board to PC

Features

Under instruction, one can add /clear relay states. For example,01010000 means relay 2 and relay 4 will be turned ON and corresponding graphical view will be displayed.

Setting the timer, time(ms) = resolution x value, this is the counter value set so that when a program is started, relays will be turned on/off for specified timer value.

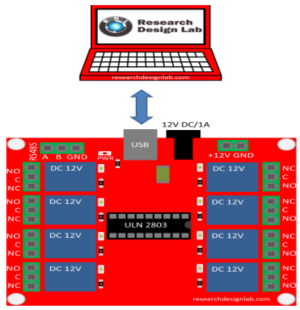

Figure 4.1 USB 8 Channel Relay Board to PC connection

Programmable Relay Board Software

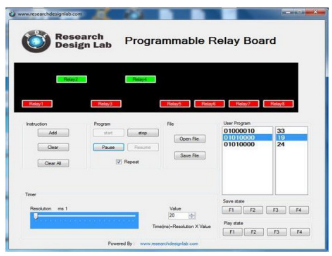

Figure 4.2 Programmable Relay Board Software

V. SYSTEM WORKING AND CALCULATIONS

5.1 WORKING:

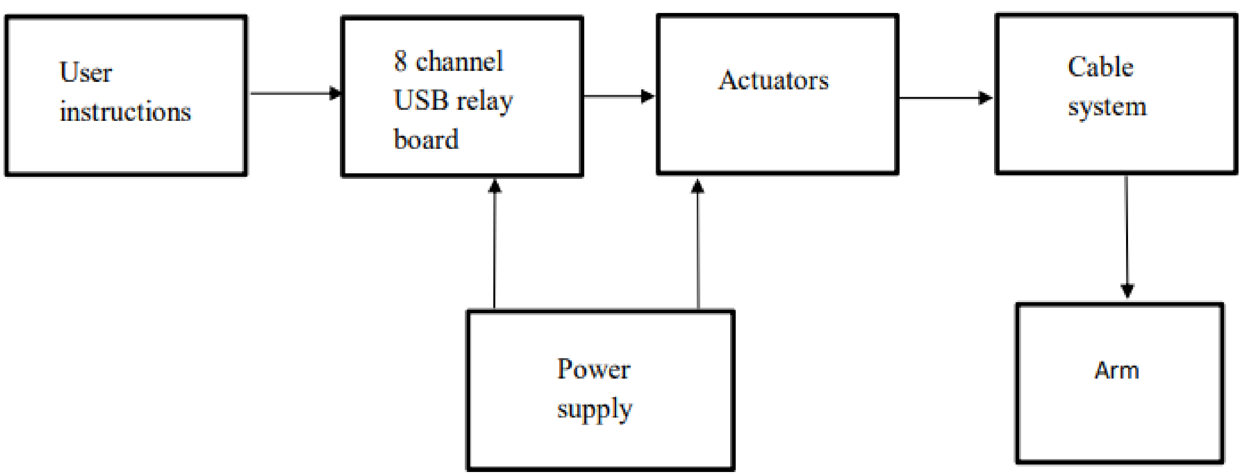

Figure 5.1 Block Diagram of Octacle Arm

CONSTRUCTION:

The construction of Octacle arm consists of the following

1. User instructions (The user instructions to the Octacle arm are given by an 8-channel relay controlling software called RDL programming software)

2. Power Supply (power supply used in project is a 12v 12ah LI-PO battery it supplies power to the Actuators and Relay board)
3. 8 channel Relay Board (This board controls all the servos. It is powered by a LI-PO battery. The instructions from RDL programming software are fed to the Relay board)
4. Actuators (Actuators for the Octacle arm are series gear D.C motors. Relay board gives the instruction and accordingly motors move clockwise or anti clockwise according to the instructions. Time, Resolutions can also be adjusted to provide delay for motor working.)
5. Cable system (it consists of steel cables guided using poly vinyl chloride clips, wounded on to regulation wheel.)
6. Arm (Arm is the housing for the cable mechanism and it has a flexible body which bend in the direction of actuated motor)

WORKING

A program of configuration is written in the RDL Programming software. This program contains information on motor movements in clockwise and anti-clockwise direction. Each command in the set of instruction contains information on resolution (which is: time x delay) and clockwise and anti-clockwise direction.

This program is fed into or dumped into the 8-channel servo control relay board. Relay board has 8 relays, 2 for each motor, both the NO and NC of 2 relays are connected using jumper cables, now the remaining C pin of 2 relays are connected to motor live and neutral wires. Relay board accordingly to the program will give polarities to the motor for clockwise and anti-clockwise movements.

The 12v 12ah D.C power supply is provided to D.C series gear motors as well as RDL Relay board for the working of the Octacle arm.

A regulation wheel is attached to the D.C motor onto which steel wires are wounded. The motor shaft rotates along with regulation wheel, now steel cable is wounded along the grooves of the regulation wheel and steel wire is dragged, this is called "CABLE DRAG MECHANISM".

The arm consists of a bendable pipe at the core, a non-torsional pipe on it, PVC clip with the help of steel nails is attached to them. PVC clips have holes drilled in them; they act as guide way for the steel wire which is wounded on to the regulation wheel. These all form arm in this paper. Different combinations of actuators move the arm in different possible direction.

5.2 CALCULATIONS

The Backbone Kinematics

In this section, the finger backbone kinematics is derived. The backbone is considered as a rod with two circular elements, as depicted in Figure 3. The rod is divided into these two elements, based on an external force, considered as a contact force Fc, applied to an arbitrary contact point. However, the contact point is assumed not to be changed, so that the lengths of the two elements are constant. The backbone can also be subjected to an external tip force and moment and the robot actuation forces/moments. In this paper, the robotic finger is considered to be inextensible. Thus, for typical tendon driven and electric actuators, the actuation forces can approximately be represented by a single torque, applied at the fingertip [1, 4, 37, 38]. The kinematics variables of the backbone are illustrated in Figure 4. The backbone is considered as a thin, one-dimensional curve. Each element of the backbone is specified with s, which represents the length from the finger base to the specified point. A XY Cartesian coordinate can be defined at each point of the backbone, as X(s) and Y(s), as the Y-axis is tangent to the backbone direction. At the finger base, where$s$ = 0, the coordinates are specified as Xb and Yb, which will be used as the reference coordinate.

2.1. Position and Orientation. As depicted in Figure 4, The position vector of each point of the backbone is specified by r(s). At each point of the backbone, the orientation of the backbone at each point can be determined by a rotation matrix R(s), as

$$\mathrm{R}(s) = \left[\mathrm{X}(s)\ \ \mathrm{Y}(s)\right]_{2\times 2} = \begin{bmatrix} \cos\theta(s) & -\sin\theta(s) \\ \sin\theta(s) & \cos\theta(s) \end{bmatrix},$$

where $\theta(s)$ is the angle of X(s)-Y(s) coordinates relative to$b$Yb, say the backbone bending angle at s. As mentioned before, the robot is divided into two circular elements. As depicted in Figure 4, the first element is defined from the base to the contact point, and the second 47 element is from the contact point to the fingertip. The lengths of these two elements are, respectively, $L1$ and $L2$.The centers of the circular element are depicted in the figure. The bend in angles of the two elements are represented by $\theta 1$ and $\theta 2$. These two angles determine the shape of the backbone.

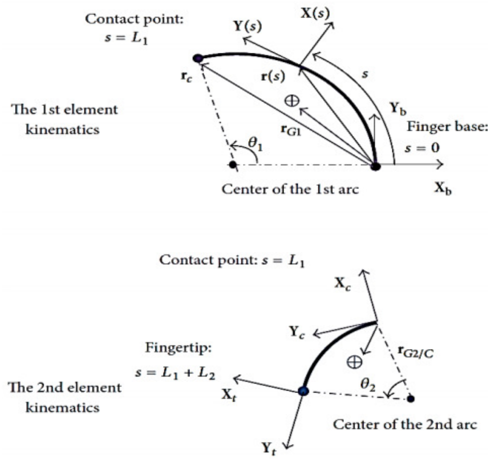

Figure 5.2 Backbone Kinematics

Thus, the backbone is a two-degree-of-freedom system, with generalized variables $\theta 1$ and $\theta 2$.Thetwo circular elements are illustrated with more details in Figure 5. The position of the contact point is represented by rc. XcYc and XtYt are the local coordinates at the contact point and the fingertip, respectively. The centers of mass of the elements are depicted in the figure. Position of the 1stelement mass center is represented by r$G1$; the position of th2nd element mass center, relative to the XcYc coordinate, is represented by r$G2/C$. For a circular 48 curve, as depicted in Figure 5, the bending angle (s) is linearly increasing by s. Thus, for the first element of Figure 5, (s) is determined as

$$\theta(s) = \frac{s}{L_1}\theta_1.$$

Likewise, for the second element, the bending angle is determined as

$$\theta(s) = \theta_1 + \frac{s - L_1}{L_2}\theta_2$$

In the 1st element, r(s) can be determined [1, 2, 37] as

$$\mathbf{r}(s) = \frac{L_1}{\theta_1}\left[\cos\left(\frac{s}{L_1}\theta_1\right) - 1 \ \ \sin\left(\frac{s}{L_1}\theta_1\right)\right]^T$$

Likewise, in the 2nd element, the position relative to the XcYc coordinates, rr Cell(s), can be determined as

$$\mathbf{r}_{\mathrm{rel}}(s) = \frac{L_2}{\theta_2}\left[\cos\frac{s - L_1}{L_2}\theta_2 - 1 \ \ \sin\frac{s - L_1}{L_2}\theta_2\right]^T$$

Then, using the rotation matrix Rc, r(s) can be determined as

$$\mathbf{r}(s) = \mathbf{R}_c\mathbf{r}_{\mathrm{rel}}(s) + \mathbf{r}_c,$$

Where rc is given by substituting $s = L1$ in (4), as

$$\mathbf{r}_c = \frac{L_1}{\theta_1}\left[\cos\theta_1 - 1 \ \ \sin\theta_1\right]^T$$

And Rc is given from (1), substituting $\theta(s) = \theta 1$, as

$$\mathbf{R}_c = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix}$$

For the fingertip, the position vector rt is determined by substituting s = 1+ $L2$ in (5) and (6), as

$$\mathbf{r}_t = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix}\frac{L_2}{\theta_2}\begin{bmatrix} \cos\theta_2 - 1 \\ \sin\theta_2 \end{bmatrix} + \frac{L_1}{\theta_1}\begin{bmatrix} \cos\theta_1 - 1 \\ \sin\theta_1 \end{bmatrix}$$

Finally, for further use, the positions of elements centers of mass are derived. In this paper, the backbone is considered to have a uniform mass distribution. Thus, from basic mechanics, the mass center of the 1st element can be determined as

$$\mathbf{r}_{G1} = \frac{\int_0^{L_1}\mathbf{r}(s)\,ds}{L_1} = \frac{L_1}{\theta_1^2}\begin{bmatrix} \sin\theta_1 - \theta_1 \\ 1 - \cos\theta_1 \end{bmatrix}$$

Likewise, for the 2nd element mass center, we have

$$\mathbf{r}_{G2/C} = \frac{\int_{L_1}^{L_2} \mathbf{r}(s)\,ds}{L_2} = \frac{L_2}{\theta_2^2}\begin{bmatrix}\sin\theta_2 - \theta_2 \\ 1-\cos\theta_2\end{bmatrix}$$

Then, substituting in (6) yields

$$\mathbf{r}_{G2} = \mathbf{R}_c \frac{L_2}{\theta_2^2}\begin{bmatrix}\sin\theta_2 - \theta_2 \\ 1-\cos\theta_2\end{bmatrix} + \mathbf{r}_c = \begin{bmatrix}\cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1\end{bmatrix}\frac{L_2}{\theta_2^2}\begin{bmatrix}\sin\theta_2 - \theta_2 \\ 1-\cos\theta_2\end{bmatrix} + \frac{L_1}{\theta_1}\begin{bmatrix}\cos\theta_1 - 1 \\ \sin\theta_1\end{bmatrix}.$$

2.2. Velocities. The velocity of each point of the backbone can be derived by direct differentiation. For the 1st element, differentiating (4) with respect to time gives

$$\dot{\mathbf{r}}(s) = \frac{d\mathbf{r}(s)}{dt} = \frac{L_1}{\theta_1^2}\begin{bmatrix}1-\cos\frac{s\theta_1}{L_1} - \theta_1\frac{s}{L_1}\sin\frac{s\theta_1}{L_1} \\ \theta_1\frac{s}{L_1}\cos\frac{s\theta_1}{L_1} - \sin\frac{s\theta_1}{L_1}\end{bmatrix}\dot{\theta}_1$$

For the 2nd element, differentiating (6) gives

$$\dot{\mathbf{r}}(s) = \dot{\mathbf{R}}_c\mathbf{r}_{\mathrm{rel}}(s) + \mathbf{R}_c\dot{\mathbf{r}}_{\mathrm{rel}}(s) + \dot{\mathbf{r}}_c,$$

where $\dot{R}\ c$ is given by differentiating (8), as

$$\dot{\mathbf{R}}_c = \begin{bmatrix}-\sin\theta_1 & -\cos\theta_1 \\ \cos\theta_1 & -\sin\theta_1\end{bmatrix}\dot{\theta}_1$$

Differentiating (5) yields

$$\dot{\mathbf{r}}_{\mathrm{rel}}(s) = \frac{L_2}{\theta_2^2}\begin{bmatrix}1-\cos\frac{s\theta_2}{L_2} - \theta_2\frac{s}{L_2}\sin\frac{s\theta_2}{L_2} \\ \theta_2\frac{s}{L_2}\cos\frac{s\theta_2}{L_2} - \sin\frac{s\theta_2}{L_2}\end{bmatrix}\dot{\theta}_2.$$

Substituting $s = L1$ in (13) gives

$$\dot{\mathbf{r}}_c = \frac{L_1}{\theta_1^2}\begin{bmatrix}1-\cos\theta_1 - \theta_1\sin\theta_1 \\ \theta_1\cos\theta_1 - \sin\theta_1\end{bmatrix}\dot{\theta}_1$$

The fingertip velocity is determined by differentiating (9), as

$$\dot{\mathbf{r}}_t = \begin{bmatrix}-\sin\theta_1 & -\cos\theta_1 \\ \cos\theta_1 & -\sin\theta_1\end{bmatrix}\frac{L_2}{\theta_2}\begin{bmatrix}\cos\theta_2 - 1 \\ \sin\theta_2\end{bmatrix}\dot{\theta}_1 + \mathbf{R}_c\frac{L_2}{\theta_2^2}\begin{bmatrix}1-\cos\theta_2 - \theta_2\sin\theta_2 \\ \theta_2\cos\theta_2 - \sin\theta_2\end{bmatrix}\dot{\theta}_2 + \frac{L_1}{\theta_1^2}\begin{bmatrix}1-\cos\theta_1 - \theta_1\sin\theta_1 \\ \theta_1\cos\theta_1 - \sin\theta_1\end{bmatrix}\dot{\theta}_1.$$

Differentiating (10), the first mass center velocity is

$$\dot{\mathbf{r}}_{G1} = \frac{L_1}{\theta_1^3}\begin{bmatrix}\theta_1\cos\theta_1 + \theta_1 - 2\sin\theta_1 \\ \theta_1\sin\theta_1 - 2\cos\theta_1 - 2\end{bmatrix}$$

And for the second mass center, differentiating (12) gives

$$\dot{\mathbf{r}}_{G2} = \begin{bmatrix}-\sin\theta_1 & -\cos\theta_1 \\ \cos\theta_1 & -\sin\theta_1\end{bmatrix}\frac{L_2}{\theta_2^2}\begin{bmatrix}\sin\theta_2 - \theta_2 \\ 1-\cos\theta_2\end{bmatrix}\dot{\theta}_1 + \mathbf{R}_c\frac{L_2}{\theta_2^3}\begin{bmatrix}\theta_2\cos\theta_2 + \theta_2 - 2\sin\theta_2 \\ \theta_2\sin\theta_2 - 2\cos\theta_2 - 2\end{bmatrix}\dot{\theta}_2 + \frac{L_1}{\theta_1^2}\begin{bmatrix}1-\cos\theta_1 - \theta_1\sin\theta_1 \\ \theta_1\cos\theta_1 - \sin\theta_1\end{bmatrix}\dot{\theta}_1.$$

Finally, for angular velocities, differentiating (2) and (3), $\dot{(s)}$ is

$$\dot{\theta}(s) = \begin{cases}\frac{s}{L_1}\dot{\theta}_1, & 0 < s < L_1 \ \text{(1st element)} \\ \dot{\theta}_1 + \frac{s-L_1}{L_2}\dot{\theta}_2, & L_1 < s < L_2 \ \text{(2nd element)}\end{cases}$$

2.3. Jacobians.

In this section, for further use, some velocities are resolved using Jacobian

$$\dot{\mathbf{r}}_c = \mathbf{J}_c\left[\dot{\theta}_1\ \ \dot{\theta}_2\right]^T, \qquad \dot{\mathbf{r}}_t = \mathbf{J}_t\left[\dot{\theta}_1\ \ \dot{\theta}_2\right]^T,$$

$$\dot{\mathbf{r}}_{G1} = \mathbf{J}_{G1}\left[\dot{\theta}_1\ \ \dot{\theta}_2\right]^T, \qquad \dot{\mathbf{r}}_{G2} = \mathbf{J}_{G2}\left[\dot{\theta}_1\ \ \dot{\theta}_2\right]^T$$

matrices, as

$$\mathbf{J}_c = \frac{L_1}{\theta_1^2}\begin{bmatrix}1-\cos\theta_1 - \theta_1\sin\theta_1 & 0 \\ \theta_1\cos\theta_1 - \sin\theta_1 & 0\end{bmatrix}$$

where from (17)

$$\mathbf{J}_t = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix},$$

$$J_{11} = \frac{L_2}{\theta_2}\left((1-C_2)S_1 - S_2C_1\right) + \frac{L_1}{\theta_1^2}\left(1 - C_1 - \theta_1 S_1\right)$$

$$J_{12} = \frac{L_2}{\theta_2}\left((C_2-1)C_1 - S_2S_1\right)\frac{L_1}{\theta_1^2}\left(\theta_1 C_1 - S_1\right),$$

$$J_{21} = \frac{L_2}{\theta_2^2}\left(1 - C_2 - \theta_2 S_2\right)C_1 - \left(\theta_2 C_2 - S_2\right)S_1,$$

$$J_{22} = \frac{L_2}{\theta_2^2}\left(1 - C_2 - \theta_2 S_2\right)S_1 + \left(\theta_2 C_2 - S_2\right)C_1,$$

and from (18) where, for abridgment, $C1$, $S1$, $C2$, and $S2$, respectively, represent cos $\theta 1$, sin$\theta 1$, cos$\theta 2$, and sin$\theta 2$,

For abridgment. From (19), we have

$$\mathbf{J}_{G1} = \frac{L_1}{\theta_1^3} \times \begin{bmatrix} \theta_1\cos\theta_1 + \theta_1 - 2\sin\theta_1 & \theta_1\sin\theta_1 - 2\cos\theta_1 - 2 \\ 0 & 0 \end{bmatrix},$$

$$\mathbf{J}_{G2} = \begin{bmatrix} J_{G2\_11} & J_{G2\_12} \\ J_{G2\_21} & J_{G2\_22} \end{bmatrix},$$

$$J_{G2\_11} = \frac{L_2}{\theta_2^2}\left(-\left(S_2 - \theta_2\right)S_1 - \left(1 - C_2\right)C_1\right) + \frac{L_1}{\theta_1^2}\left(1 - C_1 - \theta_1 S_1\right),$$

$$J_{G2\_12} = \frac{L_2}{\theta_2^2}\left(\left(S_2 - \theta_2\right)C_1 - \left(1 - C_2\right)S_1\right) \times \frac{L_1}{\theta_1^2}\left(\theta_1 C_1 - S_1\right),$$

$$J_{G2\_21} = \frac{L_2}{\theta_2^3}\left(\left(\theta_2 C_2 + \theta_2 - 2S_2\right)C_1 - \left(\theta_2 S_2 - 2C_2 - 2\right)S_1\right),$$

$$J_{G2\_22} = \frac{L_2}{\theta_2^3}\left(\left(\theta_2 C_2 + \theta_2 - 2S_2\right)S_1 + \left(\theta_2 S_2 - 2C_2 - 2\right)C_1\right).$$

VI. RESULTS AND DISCUSSION

6.1 RESULTS AND DISCUSSIONS

The targets of this paper are as follows,

- Easy installations

  The Octacle arm has many individual components, which are easy to install and replace. All being light in weight and were easy to replace, install and service/maintain

- Minimum cost

  Only the parts of mass production are used. They provide cost efficiency for the fabricator and profits on bulk sales for the seller also.

- Flexible arm

  The octacle arm made of flexible parts like non torsional pipe and Pvc clips etc. It can bend around any corner of obstacle. The most unique feature of the work in fact is the flexibility of the robotic arm. It was all possible because of high torque series D.C motors, high strength steel wires and non-torsional hoses.

- Easily programmable

  Using, RDL programming software has made configuring virtual servos easy and fast to work with.it is very reliable and can support up to 8 servos

• Fast reflexes

It can reach any point within hemisphere of its arm length within less time and with high accuracy properly optimized configuration program by RDL relay control board.

• Easy replacements

Components used in the octacle arm are of mass production made so they are mostly affordable and easily available in the markets around the world. The construction of the octacle arm is made to conveniently replace any component which is faulty.

6.2 Octacle arm benefits

The array of flexible parts with the D.C servo motors has solved numerous problems,

- Improves the underwater excavations and robotic arms.
- Under water vehicle arms
- Space rovers.

6.3 additional challenges

- Octacle Arm will need to be added to current IOT technologies for better usage.
- The bendable hose of octacle arm while installing was hard to straight out. Aluminum Non-Torsional Hose has to be used in upcoming progresses.
- Frequent opening and fitting of the housing of project for changing the battery. Allowance should be provided in the progress for it

VII.CONCLUSION

In this work, we have presented a new and complete approach in controlling for continuum robots. The approach extends previous scholars work by adding servos and relay board for bending two sections of the arm. The approach allows for simple adaptation to a wide class of existing designs, through the inclusion of a “shape to actuator” module. Using an LI-PO battery eliminates overall weight in comparisons with hydraulic/pneumatic power sources. D.C series motor provided ample accuracy of motor of desired movement of arms by cable drag mechanism.

Novel examples of such modules for electrically actuated two stages are described. The resulting Calculations are relatively simple and amenable to computation in real time, enabling real-time kinematic control at the velocity level. New components according to the increase in technology have been used like the series gear D.C motor which is a replacement to the hydraulic and pneumatic cylinders in the old works have been replaced with the deployment of Rdl relay control board which has opened a dimension in the use of relay boards in controlling motors of high torque.

Rdl Programming software provided the necessary touch for the motor configuration to be operated. Its optimization was very appreciable and reliable to be used. Use of mechanical components like non-torsional hose and bendable pipe was very unusual for a project, but they provided the required amount of flexibility and cost to use efficiency, they also are very reliable and in case of any mishaps they are easily replicable.

Mechanism of octacle arm will become aspect of importance in the robotic industries in upcoming decades. Implementations on two stage spatial continuum OCTACLE ARM is summarized

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