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Robotic Finger Control By Flex Sensor

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ABSTRACT

The main aim of the paper is not only used for pick and place of the object and also used for the model of the exoskeleton. The four finger gripper contain ten independent DOF because each and every joint in the finger is connected by separate DC gear motor it will be activated by FLEX sensor. Flex sensor is a one type of sensor is used to determine the bending deflection this deflection value is sent to the pic microcontroller by using this we can control each and every link of the four finger gripper. Normally the human finger contains 25 DOF, but we can't do all the DOF in the robot.

Keywords: DOF, Flex Sensor, DC Geared Motor.

1. INTRODUCTION

The main use of gripper is picked and place the object from one place to another place. Many of the automobile and manufacturing industries used gripper for picking and place the object there are many types of the gripper is used they are mechanical gripper, vacuumed gripper, electromechanical gripper, electrical gripper, elephant trunk, etc...The good actuator will control the gripper to the required various position and angle of the finger. The main design consideration includes DOF, actuator, electrical control, light weight and economic viability

The gripper can be controlled by different sensor they EMG, ECG, myoband, etc... are used to control the motion and angle of the gripper. Normally the EMG, ECG, myoband ect... are high in cost, and also it will not give the accurate angle or position of the gripper but the flex sensor are easily available in the marker cheaper, and we can control the position and angle of the gripper according to the human hand motion, and also we need to consider that how much weight the gripper can pic it will be main depend on the what type of material and what type of motor used to control the gripper

In 2012 the design of five finger gripper robotic arm containing elbow wrist [1] it can be controlled by using Atmega-16 microcontroller using trapezoidal approximation and Newton's backward difference methods. The main aim of the project is not only used for pick and place and also used for the exoskeleton project [2]in 1997 they design three and four finger gripper it can be controlled by the pressure sensor can be mounted on exoskeleton hand. By using pressure sensor input, the commands are applied to PWM drive dc servo motor the exoskeleton hand.

In 2009 proposed the design of humanoid robotic arm (AR hand III) it contains 15 joints, and it can be controlled by embedded motor [4] by using EMG electrode. The uses of EMG electrode is used to determine the muscles movement. If the muscle movement activates, the electrode will activate the embedded motor to move the finger, and also, we can also use myoband. In 2012, the design of humanoid hand can be build by using gear train, mechanical joint and DC gear motor and it can be controlled by torque sensor[6]. The torque sensor can be used to determined force by using the force we can control the gripper by using a human arm.

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In 2014, the low-level control system was shown providing reliable and stable controllers for single joint angles and torques, entire fingers and several coordinated fingers. The paper also describes the grasping mechanism, coordinates movements of hand and arm and determines grasp patterns [5]. At the same year, they developed low coast and user-friendly robotic arm with DOF can be controlled by teleoperated. The teleoperator master used MMI(Man Machine Interface). The MMI has simple motion capture devices that translate motion into analog voltages which bring about the corresponding actuating signals in the robotic arm [8].

2. METHODOLOGY

The methodology is followed to select a suitable mechanism, kinematic calculation, design and fabrication of the robot. The primary step is a design of four finger gripper, force calculation and a select number of link and joint to be used in the robot. The manipulator is designed by using modeling software.

In this methodology we are going to implement the four finger gripper can be controlled by flex sensor by the use of two controllers they are PIC16F877and AT89S52 microcontrollers. The flex sensor is connected to the PIC16F877 microcontroller it contain 40 pins, and it can be divided in to 5 ports they are A, B, C, Dand E ports. A ports contain 6 pin and it is used for input pins and B port consist of 8 pins it is used for relay signal, C port consist of 8 pins which is used for serial communication ,D port is used for LED it consist of 8 pins and E port contain 3 pins and is used for read, write and clean. When we the flex sensor bend it send the analog signal to the PIC16F877 microcontroller, this controller will convert the analog signal into corresponding binary value. So microcontroller read the analog signal digitally the main purpose of the pic microcontroller is used for pic and place and also used for A/D converter. The digital signal send to the AT89S52 microcontroller (ATMEL microcontroller) through serial communication. The ATMEL board doesn’t contain A/D converter and it also contain 40 pins from that 35 pins are used for I/O pins it will be connected to relay switch. The relay switch is a electro-mechanical switch when the PIC send the digital value to the ATMEL it will create the signal and send to the relay switch. When the relay switch is on the corresponding motor will rotate .Each motor contains two switches to control the forward and backward motion of the each and every joint.

In this gripper, Analog to digital(A/D) and Serial communication are the main part to control the gripper. In A/D converter is the device which is used to convert continuous analog voltage into the digital number that represents the quantity amplitude. There are two main thing is to happen to convert the analog signal to the digital signal they are Quantization and Sampling. In quantization the sinusoidal signal is separated by the amplitude is called quantization and the difference between input and quantization value is called quantization

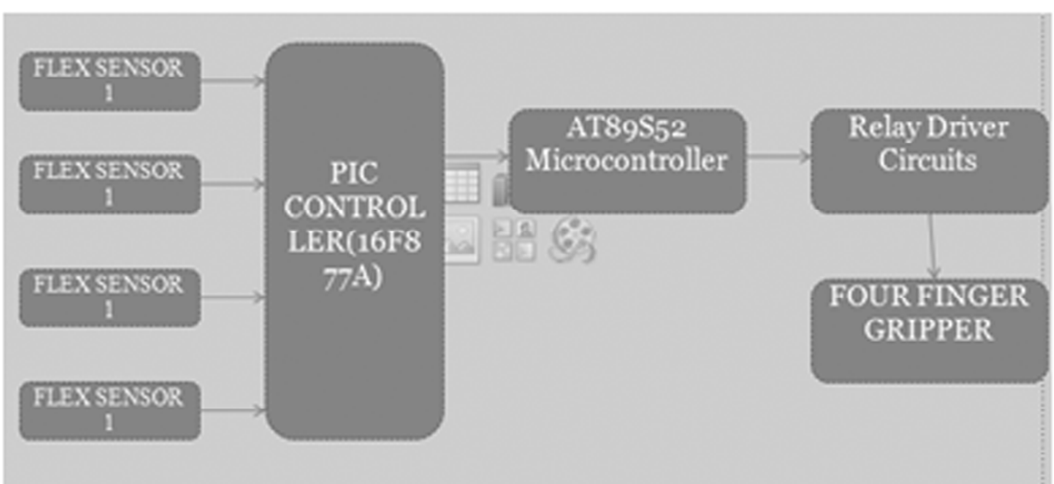

Figure 1: Basic block diagram to control the four finger gripper

error, and the sampling is separated by time by using this we can convert the analog signal into digital signal. Another important factor is serial communication. The asynchronous communication involves stop bit, start bit and parity bit to differentiate between the bits. In a case of asynchronous serial communication, there are no clock signals. We use only start a bit, stop bit and parity bit to differentiate between the data. The transmitter pin transmits the data, and receiver pin receives the data. The ground is connected to common reference. To communicate between the two microcontrollers asynchronous communication is used. The UART cable is connected between the two microcontrollers. RS-232 is a standard for serial communication transmission of data. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pinout of connectors. The RS-232 standard defines the voltage levels that correspond to logical one and logical zero levels for the data transmission and the control signal lines. Valid signals are either in the range of +3 to +15 volts or the range –3 to –15 volts on the "Common Ground" (GND) pin; consequently, the range between –3 to +3 volts is not a valid RS-232 level.

3. DESIGN CONSIDERATION

The first step of the design process to develop a four finger they are fore finger, middle finger, ring finger and the thump. The fore finger, middle finger and ring finger contain 3 DOF, and the thump finger contains 2DOF. Each link will be actuated by using DC gear motor. The design of four finger gripper control by using CATIA modeling software.

4. SIMULATION

Simulation work has to be done in solid work software it will show single finger with three joint motion each joint is connected to separate DC gear motor to control, so the joint are move independently according to the owe axis.

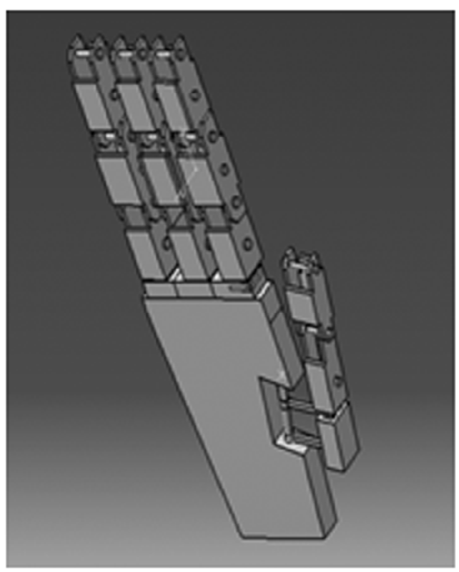

Figure 2: Four finger design

Figure 3: Simulation of single finger gripper

Figure 4: Fabrication of four finger gripper

5. FABRICATION AND COMPONENTS USED

The acrylic sheet material is used to produce the four finger gripper. The acrylic sheet material is commonly used in decorative or functional applications and also used to produce the robotic part application. It is low cost and easily available in the market.

5.1. Actuated by flex sensor

Flex sensor is one type of sensor is used determine the resistance value. The flex sensor technology is based on carbon resistive element it contains variable printed resistor over a thin flex sensor. When the sensor produced the resistance depend on the output corresponding to the bending radius of the flex sensor. The flex sensor contains two pins one pin is connected to the 5V, and another pin is connected to the GND and the flex sensor give the analog value to the pic micro controller (16F877A)

5.2. PIC Controller(16F877A)

The main used of pic controller is used for converting analog signal to digital signal the controller board contains five parts they are A, B, C, D and E. It contains 35 input/output pin to interface with the external world. It has 14 channels of Analog to digital converter with 10-bit resolution. It has In-circuit serial programming option, watchdog timer, and PWM. When A port is used for the input port, B port is used for external interrupt source, C is used for serial communication, D is used for LED, and E is used for read, write and clean. Normally the controller consist of three type of memory they are ROM, RAM, and EEPROM the pic controller contain 8 kb ROM and 256 bytes of EEPROM of memory it operates at the frequency of 0-20 MHz and 2.0-5.5 V for the power supply.

5.3. AT89S52 Microcontroller

The Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

5.4. DC Gear Motor

All the joints of the hand including the base are controlled by geared DC motors with 5 volt power supply, 10rpm, and 1Kg-cm torque. A DC motor is a rotating electric machine where the stator of a permanent magnet DC motor is composed of two or more permanent magnet pole pieces. The rotor is composed of windings which are connected to a mechanical commutator. The opposite polarities of the energized winding and the stator magnet attract, and the rotor will rotate until it is aligned with the stator. Just as the rotor reaches alignment, the brushes move across the commutator contacts and energize the next winding. Notice that the commutator is staggered from the rotor poles. If the connections of a DC motor are reversed, the motor will change directions

6. FORWARD AND INVERSE KINEMATIC

6.1. Forward kinematic

Before proceeding to forward kinematics, a LINK COORDINATE DIAGRAM (LCD)is draw for a finger. Then coordinate frames are assigned to each link using D-H algorithm. In the given case, Each finger consist of 4 DOF by using that coordinate frame diagram is assigned is shown in Fig. 3.5 below. where L_1, L_2 and L_3 are the length of the each link and θ_1, θ_2, θ_3 and θ_4 are the active joint variable and are known. All link length are known. In order to find the position of the finger forward kinematic is used. This is followed by derivation of transformation matrix.

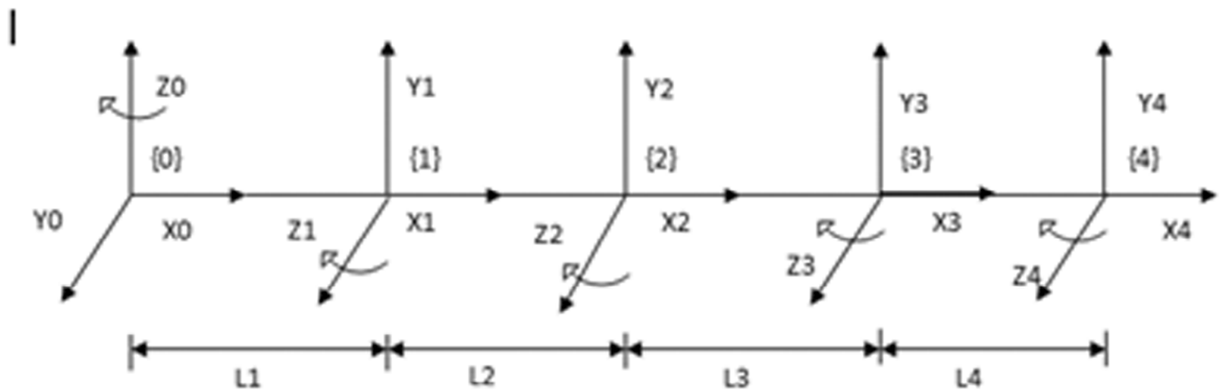

Figure 5: Frame assignment diagram for the single finger

Table 1
DH table for single finger

Link	a_i	α_i	d_i	θ_i	q_i
1	L_1	90	0	θ_1	θ_1
2	L_2	0	0	θ_2	θ_2
3	L_3	0	0	θ_3	θ_3
4	L_4	0	0	θ_4	θ_4

$$i-1_{T_i} = \begin{bmatrix} \cos\theta i & -\sin\theta i \cos\alpha i & \sin\theta i \sin\alpha i & ai\cos\theta i \\ \sin\theta i & \cos\theta i\cos\alpha i & -\cos\theta i \sin\alpha i & ai\sin\theta i \\ 0 & \sin\alpha i & \cos\alpha i & di \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow 1$$

apply all the value in the equation 1

$$ {}^{0}T4 = \begin{bmatrix} c_1 c_{234} & -c_1 s_{234} & s_1 & L_4 C_1 C_{234} - L_3 C_1 C_{23} + L_2 C_1 C_2 + L_1 C_1 \\ s_1 C_{234} & -S_1 s_{234} & -C_1 & L_4 S_1 C_{234} - L_3 S_1 C_{23} + L_2 S_1 C_2 + L_1 S_1 \\ 0 & 0 & 0 & L_3 S_{23} + L_2 S_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow 2 $$

C_{234} = $\cos\theta_2\cos\theta_3\cos\theta_4$-$\sin\theta_2\sin\theta_3\cos\theta_4$-$\cos\theta_2\sin\theta_3\sin\theta_4$-$\sin\theta_2\cos\theta_3\sin\theta_4$

S_{234} = $\cos\theta_2\cos\theta_3\sin\theta_4+\sin\theta_2\sin\theta_3\sin\theta_4+\cos\theta_2\sin\theta_3\cos\theta_4+\sin\theta_2\cos\theta_3\cos\theta_4$

S_{23} = $\cos\theta_3\sin\theta_2+\sin\theta_3\cos\theta_2$

C_{23} = $\cos\theta_2\cos\theta_3$-$\sin\theta_2\sin\theta_3$

equation 2 give the position of the link

Forward kinematic for the thumb

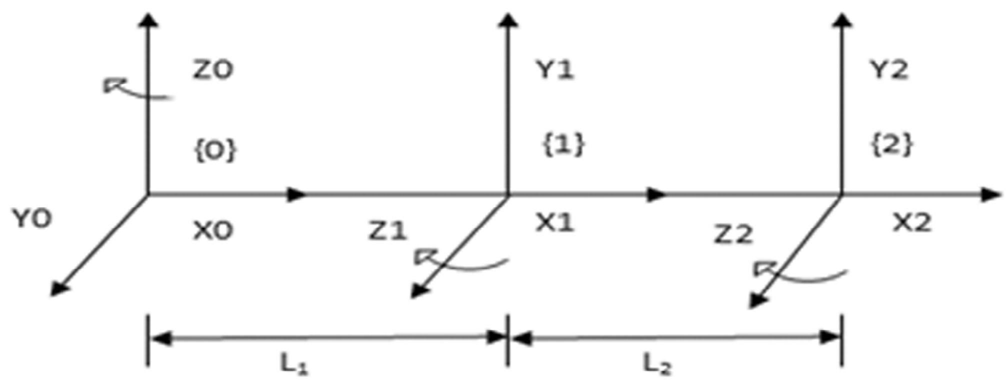

Figure 3: Frame Diagram of thumb finger

TABLE2
DH table for thumb

Link	a_i	α_i	d_i	θ_i	q_i
1	L_1	90	0	θ_1	θ_1
2	L_2	0	0	θ_2	θ_2

$$ {}^{0}T_2 = \begin{bmatrix} c_{14}c_{24} & c_{14}c_{24} - c_{14}s_{24} & s_{14} & l_{24}c_{14}c_{24} + l_{14}c_{14} \\ s_{14}c_{24} & s_{14}c_{24} - s_{14}s_{24} & c_{14} & l_{24}s_{14}c_{24} + l_{14}s_{14} \\ s_{24} & c_{24} & 0 & l_{24}s_{24} \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow 3 $$

6.2. Inverse kinematic

Inverse kinematic problem is used to determine the angle or joint variables, given the geometry and position to orientation of the gripper end point

Inverse kinematic for single finger

θ_1 = atan2(r_{21}, r_{11})

θ_{234} = atan2(r_{22}, r_{21})

$\theta_2 = atan2(r_{24}, r_{14})-w,$

$\theta_3 = atan2(r_{22}, r_{21})-(\theta_{2+} \theta_4)$

$\theta_4 = (\theta_1 + \theta_2)-atan2(r_{21}, r_{11})$

Inverse kinematic for thumb finger

$\theta_1 = Atan2(r_{22},r_{12})$

$\theta_2 = Atan2(r_{31},r_{32})$

6.3. Force calculation

The main aim of the project is able to hold an object up to 2 Kg

$m = 2 kg$

$w = m*g$

$w = 2*9.81$

$= 19.62 N$

$F = W/ \mu*n$

$\mu = 0.3(assume)$

$= 19.62/0.3*4$

$F = 16.35 N$

7. CONCLUSION

The four finger gripper explain above achieved all the 10 independent DOF by using a flex sensor. The flex sensor is used because it is affordable and easily achieved in market as well as easy to use. While concentrating future modification of this gripper we can use EMG, ECG, Myoband etc.. all the DOF can be achieved.

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