SOLAR POWERED PROSTHETIC ARM STIMULATED BY EMG SIGNAL USING LabVIEW

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Abstract - *Designing a most efficient prosthetic arm is a challenging task for rehabilitation engineers, due to concepts like, complex anatomical structure of upper limb, the source used to power the prosthetic arm and the affordability of the prosthesis. In this paper LabVIEW plays an important role of decision making and efficient control of the prosthetic arm, using EMG signal for the process of picking and placing of the objects. Reflection sensor helps in the detection of the object placed in front of the prosthesis. Solar panel serves as a natural source to power the device, which drives a DC motor for all possible applications. It gratifies our need in low cost and also gives maximum utilization with long durability.*

Key Words: *Prosthetic arm, Solar panel, LabVIEW, EMG signal*

1. INTRODUCTION

Upper limb amputees all over the world, face various problems in their daily life, which gives them mental depression. Their inability can be overcome with the help of prosthesis, which gives natural appearance. Though various types of prostheses are available, cost of these rehabilitation devices are expensive and so it becomes non-affordable for all amputees. The cost of the prosthetic device depends mainly on the battery and materials used for the designing of this prosthesis, and this can be overcome by using a natural power source and low cost durable material for the construction of prosthetic arm. The efficient performance of this upper limb prosthesis stimulated by EMG signal is controlled using LabVIEW software.

2. METHODOLOGY

The limb functioning in a normal person is shown in Fig-1. When an object is placed in front of the prosthetic arm, reflection sensors detects the object and send the signal to the control unit (PIC) as shown in the Fig-2. The respective output from controller section is processed and fed to PC were LabVIEW decides on how to pick the object and in turn generates a corresponding digitized output. This output signal is given to the controller, which stimulates the relay driver, and it in turn drives the DC motor, and this results in the movement of prosthetic arm.
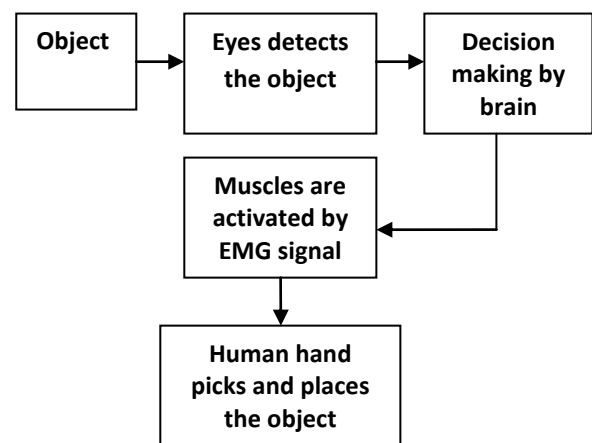

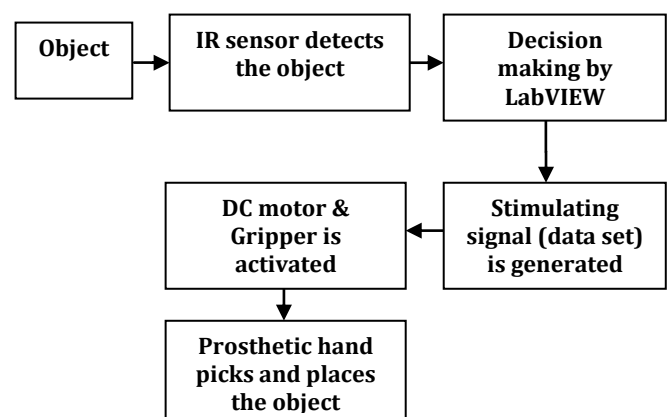**Fig -1:** Limb functioning in a normal person

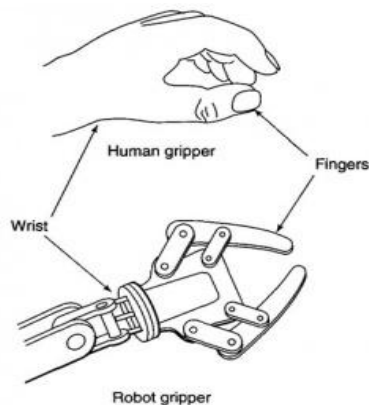**Fig -2:** Flow diagram of the proposed work

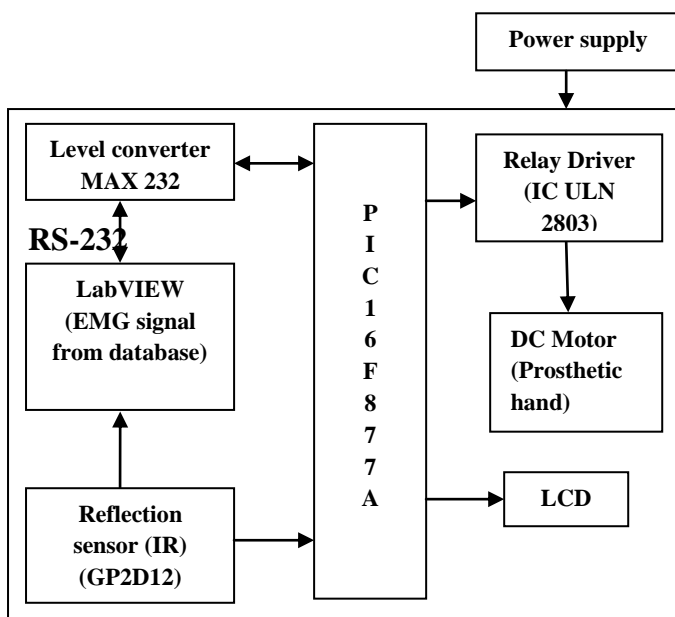**Fig -3:** Human fingers and Mechanical gripper

3. BLOCK DIAGRAM

Fig - 4: Over all block diagram representing the working of the prosthetic arm

The reflection sensor sense the object placed in front of it. The reflection sensor used here is the IR sensor (GP2D120) which transmits infra-red rays from the IR LED. It detects the object and the ray reflected back is received by the IR photodiode and a corresponding output voltage is generated by the sensor. The output voltage of the sensor is then send to PIC16F877A, which process the signal and send to level converter (MAX232). The level converter converts the signal to digital form suitable for PC (LabVIEW) via RS232. LabVIEW decides on how to pick and place the object depending on its position, shape and

size. Force applied to lift each object varies depending on the feature of the object. Depending on the decision made, LabVIEW generate a corresponding EMG signal to pick and place that particular object. The EMG signal generated is then transferred through RS232 serial communication port to the level converter (MAX232) which is an integrated circuit. The signals from an RS-232 serial port are converted to signals suitable for use in TTL compatible digital logic circuits (PIC). The output from the microcontroller initiates the relay driver which generates high level signal to drive the DC motor for all possible movements of the prosthetic arm.

3.1 Power Supply

The power supply for the hardware part can be obtained using two different sources. The first source is a 230V power supply, which is further divided into 5V and 12V power lines. PIC microcontroller, level converter, and the reflective sensor will work in 5V DC supply, were as relay driver, relays and the motors will work in 12V AC supply. The 5V supply is obtained by using a voltage regulator (IC.7805) which is given to the reflective sensor, pin-16 of the level converter, and the shorted pins 11 and 32 of the PIC microcontroller. The 12V unregulated (the voltage obtained before the use of regulator in the circuit) voltage from the power supply is given to the pin-10 of the relay driver and six relays, connected in series.

The second source is a solar panel which is connected to a 12V battery, which can also be used to power the device.

3.2 Mechanical Hardware

The mechanical hardware design of LabVIEW controlled prosthetic arm consists of three parts namely (1) Thumb finger (2) Fore finger (3) Geared DC motor. The mechanical gripper which has the appearance of these two fingers helps in picking and placing of the objects, this mechanical gripper has three joints similar to our natural finger. The movement of the two fingers is controlled using an individual geared DC motor. The prosthetic arm contains all the hardware with motors and the necessary allied mechanisms for the motion of the fingers. 3 single geared DC motors are involved in the controlling of prosthetic arm. The mechanical fingers can open and close for a maximum distance of 10cm. Control functions like opening and closing of the fingers are operated by the hardware placed in the wrist, and that which controls the arm movements like left & right turn and up & down movement is placed at the elbow part. The entire hand is mounted on a stand. The mechanical gripper which opens and closes for picking and placing the objects is controlled using a DC motor (100 rpm; 12V; 1 amp). The up and down movement of the arm in 90 degree is controlled using a DC motor (45 rpm; 12V; 1 amps). The right and left movement of the arm is controlled using a DC motor (10

rpm; 12V; 1 amp). Totally 6 relays are used for controlling each 3 motors, and 2 relay is used for each motor, and all the relays are powered using 12V.

Table -1: Features of the DC motor

S.no	Movement	Speed (rpm)	Voltage (V)	Current (A)
1	Open & Close	100	12	1
2	Left & Right	45	12	1
3	Up & Down	10	12	1

3.3 Electronic Hardware Design
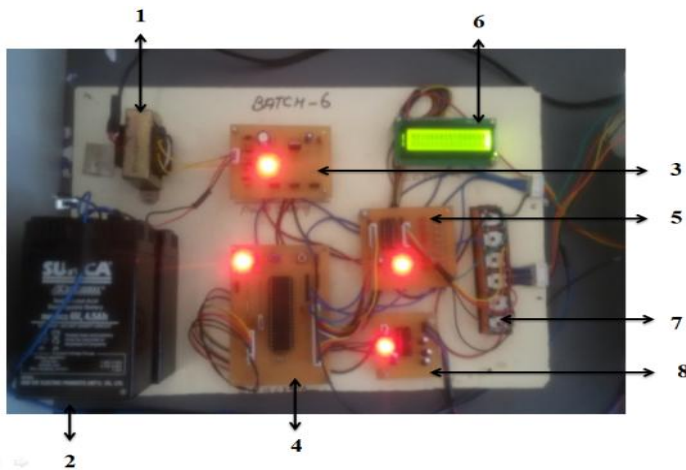
Fig -5: Electronic Hardware unit (1) 12V Transformer (2)12V Battery (3)Rectifier (4) PIC 16F877A Controller board (5) Relay driver board (6) LCD display (7) Series of 6 relay (8) Level converter (MAX232) board

The main parts of the electronic hardware design include (1) Reflective Sensor (2) PIC microcontroller (3) Level Converter (4) Relay driver (5) LCD display. The working of the mechanical hardware design is controlled using these electronic circuits. When an object is placed in front of the prosthetic arm, reflection sensor (GP2D12) sends IR rays towards the object. Depending upon the intensity of the rays reflected back, the sensor generate a corresponding analog signal, which is given to PIC (16F77A). PIC converts this input analog signal into digital signal and given to the level converter (MAX232). The level converter converts low level signal into high level signal for processing in LabVIEW. The output signal from PC is an high level signal and this will be converted into low level signal compactable for TTL circuit. The corresponding output generated by PIC stimulate the relay driver circuit (IC ULN 2803), which in turn stimulate those respective relays and activate the corresponding DC motor, to perform the desired operation. LCD display is mainly used for displaying the function status of the PIC microcontroller.

3.4 Software Design

The goal in software design is to have a simple, minimal computation control strategy. The design of the control program is divided into two different sections (1) PIC microcontroller programming (2) LabVIEW module. In this paper, the prosthetic arm is trained for a particular set of functions with predefined set of EMG signals. An object is placed at a small distance in front of the prosthetic arm which is at rest position. Initially reflective sensor emits IR rays and starts searching for the object at each level (Height), by slowly descending down. When the IR rays strikes the object, the rays are reflected back and depending upon the intensity of the ray reflected back sensor generates an analog signal, which will be digitized by PIC and then given to LabVIEW. The programming in LabVIEW was done to generate particular set of EMG signal depending on the height at which the pre-defined object is sensed. LabVIEW decides on which set of EMG signal is to be given depending on the object detected. The output from LabVIEW commands the PIC about the range of expansion of the gripper for holding the object. PIC stimulates the relay driver to drive the DC motor at the wrist part which controls the function of expansion and contraction of the gripper. Default programming is done in PIC for picking and placing of the objects.

4. RESULTS

When an object is placed in front of the prosthetic arm, the IR sensor sense the object and the corresponding signal generated is processed by LabVIEW. The object detected by LabVIEW along with its height calculation and the range of gripper expansion required for holding the object will be displayed in the front panel of LabVIEW. The output from the LabVIEW is given to PIC 16F877A to instruct the PIC on the amount of gripper expansion needed for gripping the object. As a result of which the mechanical gripper will pick the object and turn to an angle of 90 degree and place the object. When no object is placed in front of the prosthetic arm, initially the sensor will search for the object. If it doesn't find any object, it comes back to rest position and "NO OBJECT DETECTED" command will be displayed in LCD. The height of the object placed can also be calculated using this prosthetic arm.

In this paper, the prosthetic hand designed is trained for picking and placing of three objects of varying dimension.
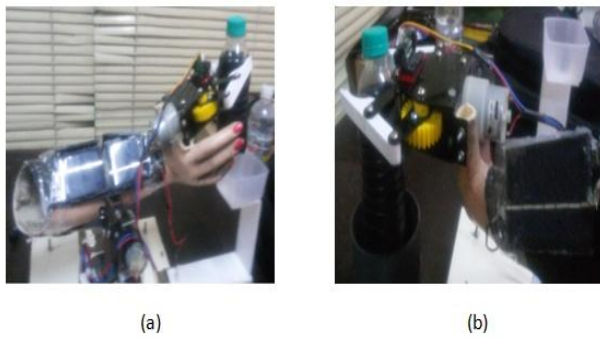
Fig -6: Displacement of prosthetic arm for (a) Picking and (b) Placing of water bottle

From the **Fig.6** we can see that once the object is correctly identified, the mechanical gripper expands to a specified dimension which is comparatively greater than that for pen and lesser than that of ball. When the gripper holds the object tight then it picks and places the object in the desired location.
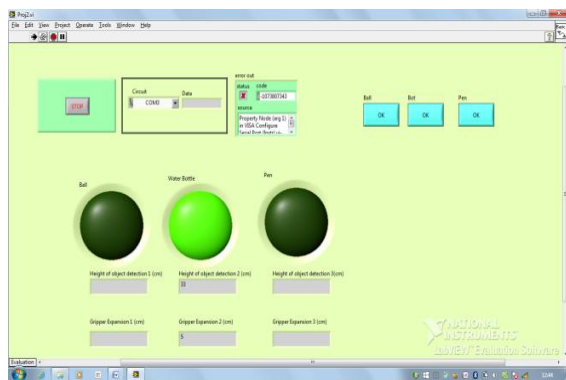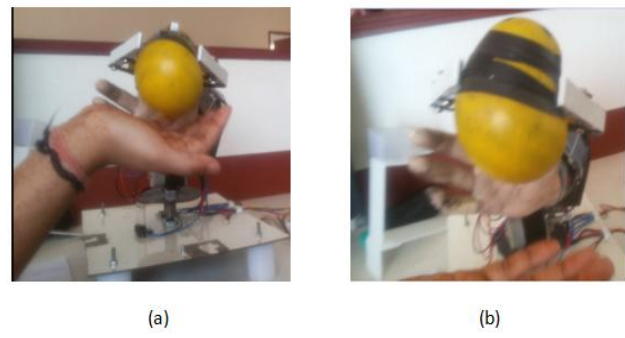

Fig -7: LabVIEW front panel simulation output for bottle

Fig.7 shows the stimulated output for water bottle and the glowing LED represents the object detected, below which the data for height of detection and gripper expansion are displayed below in the LabVIEW front panel.

From the **Fig.8,** once the object is correctly identified, the mechanical gripper expands to a specified dimension which is comparatively greater than the range required for gripping other objects. When the gripper holds the object tight then it picks and places the object in the desired location.
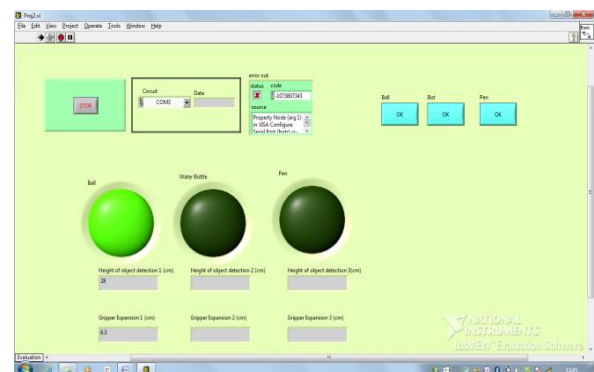
4.1 Height Calculation

h1 = Total height up to which gripper rises
h2 = Height of the stand from the ground level
h1 – h2 = h3 (This represents the scanning area)

Fig -8: Displacement of prosthetic arm for (a) Picking and (b) Placing of ball
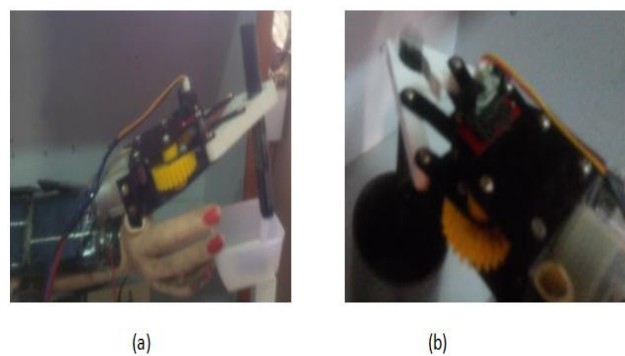
Fig -9: Displacement of prosthetic arm for (a) Picking and (b) Placing of pen

Fig -10: LabVIEW front panel stimulation output for ball

In case of a water bottle, the arm initially move to its maximum height of 30cm from ground level, and then slowly descend down 20 times, were each step is 0.5cm. When the arm descends down it will sense the object at its initial point, the height of the object can be calculated using the formula

Height of the object = (Height at which object is detected from the ground level) – (Height of the stand from the ground level)
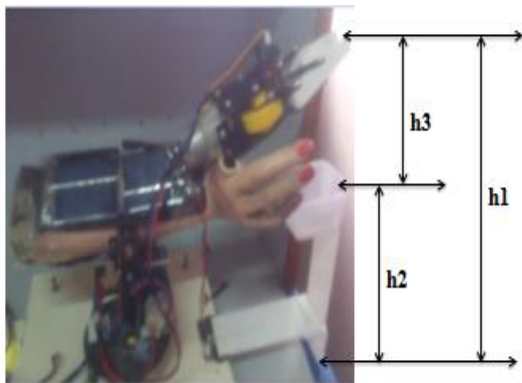
Fig -11: Object height detection

Table -2: Features of the Prosthetic arm

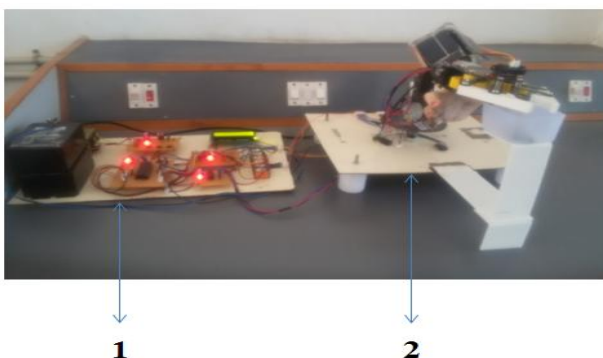| Object	Height at which object is detected from the ground level (cm)	Gripper Expansion (cm)	Height of The object (cm)
Gripper	34	10	-
Bottle	33	5	12
Ball	28	6.5	7
Pen	30.8	0.5	9.8
No object	Will be in rest position	Closed position	-

Fig -12: Hardware prototype (1) Electronic hardware, (2) Mechanical hardware

5. CONCLUSION AND FUTURE SCOPE

The prototype of the hardware is designed which helps the patients who have lost their upper arm in accidents or any other causes.

The prototype is a working model and the idea was implemented successfully. However it requires some modifications before it can be commercially used. The quality of the material used to construct the mechanical setup can be upgraded and the electronic components used can be miniaturized.

Image processing technique can be used to determine the objects present in front of the prosthetic arm.

Tactile sensor can be incorporated to determine the force required to pick and place any object.

LabVIEW Robotic Module software can be used for designing Intelligent Robotic System.

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