SURFACE EMG BASED ARM POSTURE CONTROL FOR INDUSTRIAL MECHATRONIC TELEOPERATION

S. Jeniton[1], V. Uvaranjani[2], T.Thirumangai[3], M. Shakila[4], K. Thulasi[5]

[1-5]Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.

Abstract – *This project presents the control of a robot arm, using electromyography (EMG) signals. EMG signals from the muscles of the shoulder and elbow joints are used to predict the corresponding joint angles and therefore the force exerted by the user to the atmosphere through his/her forearm. The user's motion is restricted to a plane. An analysis of various parametric model is carried out in order to define the appropriate form of the model to be used for the EMG-based estimates of the motion and force exerted by the user. A multi-input multi-output (MIMO) black-box state-space model is found to be the most accurate and is used to predict the joint angles and the force exerted during motion, in high frequency. The proposed system is implemented in teleoperation scenarios by inserting the wireless data transfer technology. The experimental results will give the high accuracy of the system with a variety of motion profiles.*

Key Words: Electromyography, EMG signals, Teleoperation

1. INTRODUCTION

Automation is a technology by that a method or procedure is performed with minimum human assistance. Automation or automatic control is the use of various assorted management systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks. The development of Automation mainly involves the use of Robotic Arm of many functions. Robot arms work with an outdoor user or by performing predetermined commands.

2. ROBOTIC ARMS

A Robotic arm could be a form of mechanical arm, typically programmable, with similar functions to a human arm; the arm may be the sum total of the mechanisms or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing rotational motion (such as in articulated robot) or translational (linear) displacement. Although such robotic arms are mostly marketed as hobby or educational devices, application in laboratory automation have been proposed, like their use as auto samplers. Robotic arms in automotive assembly lines perform a variety of tasks such as welding and parts rotation and placement during assembly line. In some circumstances, close emulation of the human hand is desired, as in robots designed to conduct bomb demobilisation and disposal.

Fig- 1 Robotic Arm

3. TECHNICAL DESCRIPTION

The technical description of robotic arms are as follows:

1. ***Number of axes:*** two axes are required to reach any point in a plane; three axes are required to reach any point in space.
2. ***Carrying capacity or Payload:*** how much weight a robot can lift.
3. **Speed:** How fast the robot can position the end of its arm. This may be defined in terms of the angular or linear speed of each axis or as a compound speed.
4. ***Acceleration:*** How quickly an axis can accelerate. A robot may not be able to reach its specified maximum speed for movements over a short distance.
5. ***Accuracy:*** How closely a robot can reach a commanded position. Accuracy can vary with speed and position within the working envelope and with payload.
6. ***Working envelope:*** The region of space a robot can reach.
7. ***Repeatability:*** How well the robot will return to a programmed position. This is not the same as accuracy. It may be that when told to go to certain X-y-z position that it gets only within 1mm of that position.

4. INDUSTRIAL AUTOMATION

Automated factories and processes are too expensive to be rebuilt for every design modification – in order that they got to be extremely configurable and versatile. With a typical automated production line, or process control system, unexpected failures cause significant and expensive downtimes while technicians scramble to diagnose and correct issues.

In the real world, things perpetually arise that decision for human intervention. once therefore referred to as "automated" machines get thrown off course, or become faulty, consultants need to be summoned to step in and troubleshoot the issues, but this expertise is scarce and the most often not available when the problems occur. The promise remote controlled automation is finally making headway in manufacturing settings and maintenance applications. Today, this can be strictly a matter of networked intelligence – currently well developed and wide accessible.

Communications support for a very high order is now available for automated processes: lots of sensors, very fast networks, quality diagnostic software and flexible interfaces-all with high levels of reliability with pervasive access to hierarchical diagnosis and error correction advisories through centralized operations.

5. JOYSTICKS

In recent times, the use of joysticks has become common in several industrial and producing applications, such as; cranes, assembly lines, biological science instrumentality, mining trucks, and excavators. In fact, the use of such joysticks is in such high demand that it's nearly replaced the standard mechanical management lever in nearly all trendy hydraulic management systems. To boot, the foremost remote-controlled aerial vechicles (UAVs) and submersible remotely operated vechicles (ROVs) want a minimum of one joystick to control either the vechicle, the on- board cameras, sensors and/or manipulators. Because of the extremely active, rough nature of such applications, the economic joystick tends to be a lot of strong than the everyday video-game controller, and ready to perform over a high cycle life. This has diode to the event and employment of Hall result sensing to such applications within the Eighties as a method of contactless sensing. Many corporations turn out joysticks for industrial for industrial applications mistreatment Hall result technology.

Fig- 2 Simple joystick

Another technology employed in joystick style is that the use of strain gauges to make force transducers from that the output is proportional to the force applied instead of physical deflection. Miniature force transducers are used as additional controls on joystick for menu selection functions. Some larger makers of joysticks ready to customize joystick handles and grips specific to the OEM wants whereas little regional makers usually target marketing normal product at higher costs to smaller OEMs.

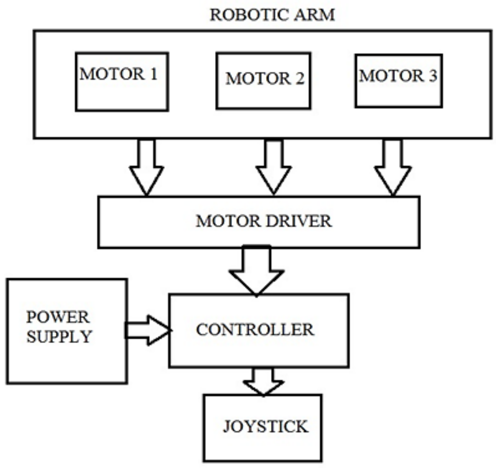

Fig- 3 Block Diagram of Existing System

6. Drawbacks of Existing System

MANUAL HANDLING OF CHEMICALS:

Many industries in which employees manually handle chemical and hazardous substances, particularly small scale industries and certain Medium scale industries which are not capable of using Automated Robotic Arms for handling hazardous substances. Hazards involving chemical handling can lead to serious injuries, occupational diseases and even death. In particular, workers may be at a risk of injuries from chemical flammability/reactivity, contact with corrosive organs or systems. Workers are at a risk of developing occupational diseases, such as contact dermatitis, occupational asthma and occupational cancers.

Fig- 4 Silica deposition in lungs

Long- term exposure to chemicals such as Silica dust, engine exhausts, tobacco smoke, and lead have been shown to increase the risk of heart disease, stroke, and high blood pressure. Exposure to radiation like Microwaves, lasers, X-rays, and gamma rays has severe health hazards.

7. PROPOSED SYSTEM

In the proposed system, we implement the robotic arm to control the postures for industries application. An analysis of various models is carried out in order to define the acceptable sort of the model to be used for the EMG-based estimates of the motion and force exerted by the user. A multi-input multi-output (MIMO) black-box state-space model is found to be the most accurate and is used to predict the joint angles and the force exerted during motion, in high frequency. In the robotic arm, for control the action by using RF module. To get the signals from the EMG, for controlling the motion through wireless. It is efficient method to control the operation and reduce the man power. In chemical industry, it's very useful for humans; there is more harmful powder and gases in the industries. We can avoid the accident.

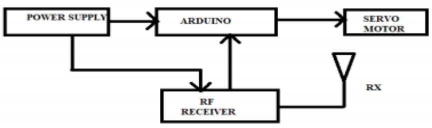

Fig: 4.1 Block diagram of Robotic Arm

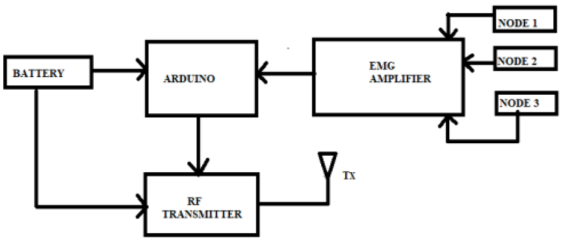

Fig- 5 Block Diagram of EMG setup

8. HARDWARE DESCRIPTION

a. Arduino UNO

Arduino is a single-board microcontroller to make use of electronics in multidisciplinary projects comes additional accessible. The hardware consists of a open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller. The Arduino software is easy-to-use for beginners, yet flexible enough for advanced user Programmers - can start tinkering just following the step by step instructions of a kit, or sharing concepts online with alternative members of the Arduino community.

Fig- 6 Arduino UNO

b. Servo Motor

A servo motor is associate device which might push or rotate in degree of an object with nice preciseness. If you would like to rotate the item at some specific angles or distance, then you employ servo motor. It's simply created to run through servo mechanism. If motor used is DC powered then it's known as DC servo motor, and if its AC powered motor then it's known as AC servo motor. We will get a really high torsion servo motor in an exceedingly little and lightweight weight packages. Thanks to these options they're being employed in several applications like toy automotive, RC helicopters and planes, Robotics, Machine etc.

Fig- 7 Servo Motor

c. RF Module

The RF module operates at Radio Frequency. The frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This modulation is known as Amplitude Shift Keying (ASK). Transmission through RF is better than IR (infrared) because of RF can travel through larger distances suitable for long range applications. Also, while IR mostly operates in line-off sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver. Next, RF transmission is more strong and reliable than IR transmission.

The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.

Fig- 8 RF module

d. EMG Sensor

Electromyography (EMG) is a diagnostic procedure that evaluates the health condition of muscles and the nerve cells that control them. These nerve cells are known as motor neurons. They transmit electrical signals that cause muscles to contract and relax. An EMG translates these signals into graphs or numbers, helping doctors to make a diagnosis. Muscle tissue conducts electrical potentials similar to the way nerves do and the name given to these electrical signals is the muscle action potential. Surface EMG is a method of recording the information present in these muscle action potentials.

Fig– 9 EMG Sensor

e. Robotic Arm

A Robotic arm is a mechanical arm, programmable, with similar functions to a human arm; the arm may be the sum total of the mechanisms or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing rotational motion or linear displacement. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effecter and it is analogous to the human hand. The availability of low cost robotic arms increased substantially. Although such robotic arms are mostly marketed as hobby or educational devices, application in laboratory automation have been proposed, like their use as auto samplers.

f. Motor Driver l293D

The L293D is quadruple high-current half-H drivers. It's designed to supply bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs and vice-versa. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

9. SOFTWARE DESCRIPTION

ARDUINO IDE:

The Arduino IDE is minimalistic, it provides a near-complete environment for most Arduino-based projects. It is a user interface for the software tools which actually compile and upload the program. The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

10. PRINCIPLE OF ELECTROMYOGRAPHY (EMG)

When contractions and relaxation occurred, the human brain will generate commands through neurons that responsible for different movements of human skeletal system. These commands are carried through the nervous system which will generate an electrical activity in the muscles. The electrical potential that has been generating by the muscle will record and this called electromyography.

The electromyography (EMG) signal is a measurement of electrical currents generated in muscles during its contraction. It is a result of the summation of all Motor Unit Action Potentials (MUAP) in the region near the electrodes. The motor unit is the smallest functional unit of the muscle that consists of a somatic motor neuron and muscle fiber it innervates. For fine force, the number of motor unit will be small, as forces increasing the muscle fibers will produce a large amount of motor units.

When a muscle fiber contracts, the nerve will be stimulate causes the muscular membrane depolarizes and propagates an action potential down the length of the muscle fiber. The condition when the voltage controlled sodium channels called depolarization. Charged sodium ions enter the membrane and initiate the action potential. The positively charged sodium will enter the membrane and trigger the action potential. Other charged ions such as calcium, potassium, and chloride also play a vital role in producing and propagating the action potential.

11. TECHNIQUES OF EMG

There are two methods to measure the electrical activity of the muscular system, which is by using fine wire electrodes and surfaces electrode. Fine wire electrode is a needle electrode that will be inserted inside the territory of a discharging motor unit records from all the muscles fibers active within its uptake area. This procedure can measure voluntary motor activity and also be able to assess the insertional activity. Since it will be inserted inside the body, this kind of procedure only can be done by a person with the proper knowledge of the musculature.

The common method of measurement of muscular activity is called Surface Electrode (sEMG).This electrode is located at the surface of the skin and will examine the summation of all electrical activity from the surface above the muscle on the skin Signal acquisition of sEMG is simple than the needle electrode, this reason makes the sEMG become the popular method of capturing the signal of the muscle.

However, the amplitude of the signal is small which lies in the range of 0 – 10mV peak to peak causes the possibilities to be effected by noise is higher. By comparing these two methods, the needle electrode has the advantages in terms of accuracy and consistency of measurement since it is not just assess the voluntary motor activity but also able to assess what is labeled insertional activity. However this procedure only can be done by a person with the proper knowledge of the musculature.

12. EMG SIGNAL

The effect of using surface electrodes should also be noted by the user. For example, an unfiltered and unprocessed signal detecting of MUAP is called a raw EMG signal. When the muscle relaxed, the noise-free EMG baseline can be seen. To reduce noise, the user must ensure the quality of the amplifier, the environment noise and the quality of the given detection condition.

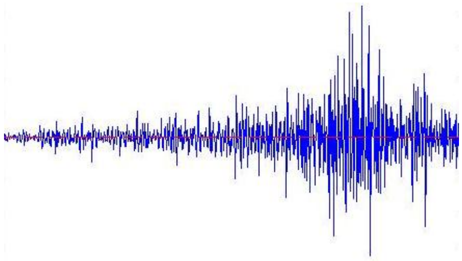

Fig- 10 Example of raw EMG signal

The averaged baseline noise must below than 3 – 5 microvolts. EMG spikes shape is very random, which means that each recording burst will not produce the exact shape. Strong superposition spike will produce when two or more motor unit fire at the same time and the location between the motor unit and 14 the electrodes is near. Raw EMG range is 0.1μV to 20mV and from 2Hz to 2kHz.

13.MAXIMIZING THE FIDELITY OF THE EMG SIGNAL

It is desirable to obtain an EMG signal that contains the maximum amount of information and the minimum amount of noise. Thus, the maximization of the signal-to-noise ratio should be done with minimal distortion to the EMG signal. Therefore, any detecting and recording device process the signal linearly. In particular, the signal should not be clipped, that is, the peaks should not be distorted and no unnecessary filtering should be performed. Because the power line radiation (50 or 60 Hz) is a dominant source of electrical noise, it is tempting to design devices that have a notch-filter at this frequency. Theoretically, this type of filter would only remove the unwanted power line frequency, however, practical implementations also remove portions of the adjacent frequency components. Because the dominant energy of the EMG signal is located in the 50- 100 Hz range, the use of notch filters is not advisable when there are alternative methods of dealing with the power line radiation.

14. ELECTRODE AND AMPLIFIER DESIGN

The most critical aspect of the electronics apparatusis electrode design, which will be used to obtain the signal. The fidelity of the EMG signal detected by the electrode influences all subsequent treatment of the signal. It is very difficult (almost impossible) to improve the fidelity and signal-to-noise ratio of the signal beyond this point. Therefore, it is important to devise an electrode unit that provides minimal distortion and highest signal-tonoise ratio. The following characteristics are important for achieving this requirement. Differential amplification In order to eliminate the potentially much greater noise signal from power line sources, a differential detecting configuration is employed. The premise is simple. The signal is detected at two sites, electronic circuitry subtracts the two signals and then amplifies the difference. As a result, any signal that is "common" to both detection sites will be removed and signals that are different at the two sites will have a "differential" that will be amplified.

Any signal that originates far away from the detection sites will appear as a common signal, whereas signals in the immediate vicinity of the detection surfaces will be different and consequently will be amplified. Thus, relatively distant power lines noise signals will be removed and relatively local EMG signals will be amplified. This explanation requires the availability of a highly accurate "subtractor". The accuracy with which the differential amplifier can subtract the signals is measured by the Common Mode Rejection Ratio (CMRR). A perfect subtractor would have a CMRR of infinity. A CMRR of 32,000 or 90 dB is generally sufficient to sup- press extraneous electrical noises. Current technology allows for a CMRR of 120 dB, but there are at least three reasons for not pushing the CMRR to the limit: 1) Such devices are expensive. 2) They are difficult to maintain electrically stable, and 3) the extraneous noise signals may not arrive at the two detection surfaces in phase, and hence they are not common mode signals in the absolute sense.

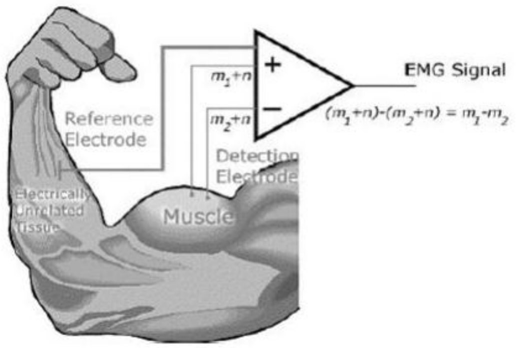

Fig- 11 Differential Amplifier Configuration

15. SERVO MOTOR

The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor. Servo Mechanism It consists of three parts:

- Controlled device
- Output sensor
- Feedback system

It is a closed loop system where it uses positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal. Here reference input signal is compared to reference output signal and the third signal is produces by feedback system. And this third signal acts as input signal to control device. This signal is present as long as feedback signal is generated or there is difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

a) Working principle of Servo Motors

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly and a controlling circuit. First of all we use gear assembly to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal.

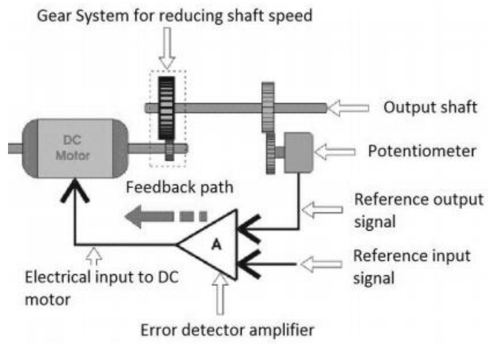

Fig- 12 working of Servo Motor

This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

b) Controlling Servo Motor

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU. Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°. Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears. High speed force of DC motor is converted into torque by Gears.

We know that WORK= FORCE X DISTANCE, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.

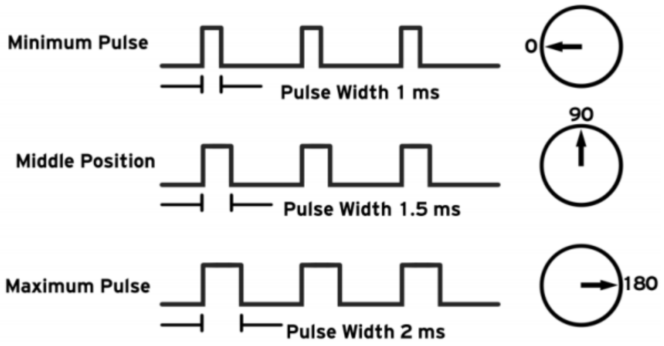

Fig- 13 Principle of Servo Motor

Servo motor can be rotated from 0 to 180 degree, but it can go up to 210 degree, depending on the manufacturing. This degree of rotation can be controlled by applying the Electrical Pulse of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. Pulse of 1 ms (1 millisecond) width can rotate servo to 0 degree, 1.5ms can rotate to 90 degree (neutral position) and 2 ms pulse can rotate it to 180 degree. All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper servo shield should be designed.

c) Advantages

If a heavy load is placed on the motor, the driver will increase the current to the motor coil as it attempts to rotate the motor. Basically, there is no out-of-step condition. ¬ High-speed operation is possible. Tower Pro SG-90 Features

- Operating Voltage is +5V typically
- Torque: 2.5kg/cm
- Operating speed is 0.1s/60°
- Gear Type: Plastic
- Rotation : 0°-180°
- Weight of motor: 9gm
- Package includes gear horns and screws

16. EXPERIMENTAL RESULT

Robotic arm control using joystick was successfully constructed and tested.

The output depends on the force applied on the joystick. Hence, high level of accuracy in robotic arm cannot be obtained. The experimental setup for existing system is shown in the figure.

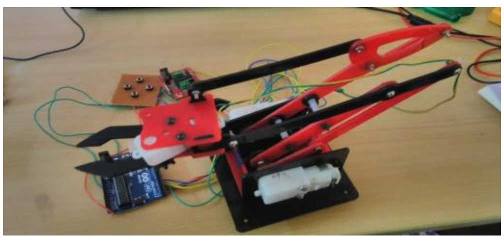

Fig- 14 Experimental Setup of Proposed System

As robots come closer to humans, an efficient human-robot-control interface is an utmost necessity. In this project, electromyographic (EMG) signals from muscles of the human upper limb are used as the control interface between the user and a robot arm. A mathematical model is trained to decode upper limb motion from EMG recordings, using a dimensionality-reduction technique that represents muscle synergies and motion primitives. The following figure shows the results of the experiment. Initially when the user arm is at rest position (i.e, when input is zero) the robotic arm is also in the rest position. When the user arm is at relax position then there is no electrical impulses is sensed by the EMG sensor.

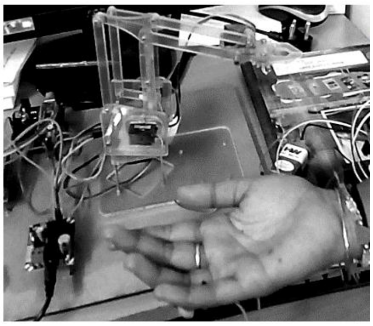

Fig- 15 Robotic arm at rest

When the user contracts the arm electrical impulses generated by the brain is captured the EMg sensor and as per the input given the robotic arm respnds. The following picture shows the result, when arm is contracted the robotic arm rotates.

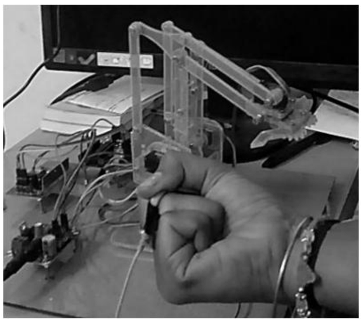

Fig-16 Robotic arm at motion

The EMG signal obtained from the sensor has lot of noise and distortion. These distorted signals are picked up and then amplified and filtered. Differential Amplifier is used in this operation (signal is rectified and averaged). The following figures shows the variation of EMG signals with the force given by the user.

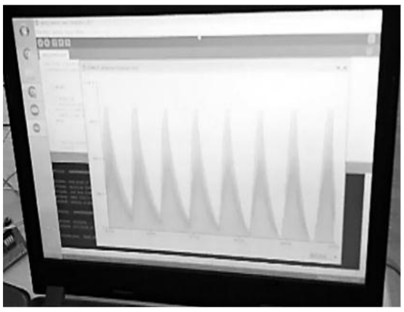

Fig-17 EMG Signal is high when input is higher

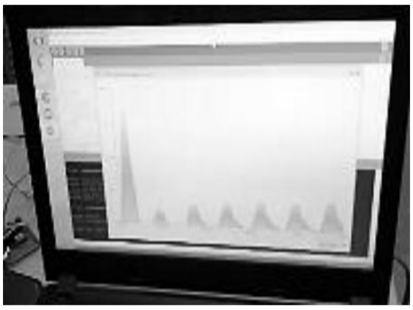

Fig-18 EMG signal is low when input is lower

The above figure shows that when the input is low the EMG graph is also low. These visuals of the EMG signals can be visualized using Arduino software. These visuals can be used to monitor the controlling of robotic arm. After connecting the sensor along with the Arduino to the laptop start giving input. This graphical representation of EMG signals can be seen in Serial plotter.

17. CONCLUSION

Industrial Automation uses the control systems or robots and information technologies for handling different processes and machineries in an industry to replace human being. In this project, the robotic arm was controlled using EMG signals. It can reduce the risk of human accidents. It can also reduce the cost associated with human operators. Since the robotic arm was controlled by EMG signals, it will be more flexible and accurate. It will reduce the operating errors and there is no need for technical operators. Since any authorized person can control this arm. The main advantage of using robotic arm includes lower operating cost, high productivity, high quality and highly secured. It has recently found more and more acceptance from various industries.

REFERENCES

[1] Kiwon Rhee and Hyun-Chool Shin" Electromyogram-based hand gesture recognition robust to various arm postures" International Journal of Distributed Sensor Networks 2018, Vol. 14(7).

[2] Junhong Liu, Wanzhong Chen* , Mingyang Li and Xiaotao Kang' Continuous Recognition of Multifunctional Finger and Wrist Movements in Amputee Subjects Based on sEMG and Accelerometry'Department of Communication Engineering, Jilin University, 130012 Changchun, China.

[3] Kyung-Jin You, Ki-Won Rhee and Hyun-Chool Shin' Finger Motion Decoding Using EMG Signals Corresponding Various Arm Postures' Department of Electronic Engineering, College of IT, Soongsil University, Seoul 156-743, Korea. Vol. 19, pages 54~61, June 2010.

[4] Zhen Ding 1 , Chifu Yang 1 , ZhihongTian 2 ID , Chunzhi Yi 1 , Yunsheng Fu 3 and Feng Jiang 4,*' sEMG-Based Gesture Recognition with Convolution Neural Networks'Received: 20 March 2018; Accepted: 28 May 2018; Published: 4 June 2018.

[5] srinivas k, manojkumarrajagopal*' study of hand over gesture recognition and classification'Received: 23 January 2017, Revised and Accepted: 03 March 2017.

[6] EMG-based teleoperation of a robot arm using low-dimensional representation Published in: 2007 IEEE/RSJ International Conference on Intelligent Robots and Systems Date of Conference: 29 Oct.-2 Nov. 2007

[7] IEEE Transactions on Robotics 26(2):393 - 398 · May 2010 *with* 400 Reads
'EMG-Based Control of a Robot Arm Using Low-Dimensional' Embeddingshttps://www.researchgate.net/publication/224109689_EMG

[8] DandamudinagaJayanth ; Emani Siva Sai ; Y. Sangeetha Surface EMG based intelligent signal processing for exoskeleton Published in: 2017 International Conference on Inventive Communication and Computational Technologies (ICICCT)Date of Conference: 10-11 March 2017.

[9] ShuheiIkemoto ; Yuya Kimoto ; KohHosoda' Surface EMG based posture control of shoulder complex linkage mechanism' Published in: 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
Date of Conference: 28 Sept.-2 Oct. 2015.

[10]Jose JairAlves Mendes Junior ; Marcelo BissiPires ; Sergio Okida ; Sergio LuizStevan' Robotic Arm Activation using Surface Electromyography with LABVIEW'IEEE Ltin American Transaction (Volume: 14 , Issue:8 , Aug. 2016)Published: 16 December 2016.

Authors

S. Jeniton, M.E.,
Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.

V. Uvaranjani, M.E.,
Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.

T. Thirumangai
Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.

M. Shakila
Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.

K. Thulasi
Department of Electronics and Communication Engineering, RAAK College of Engineering and Technology, Puducherry, India.