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# Design of Wireless Controlled Artificial Arm for Stroke Survivors Using MEMS Technology and Health Assist Systems

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**Abstract:** ***The main objective of this artificial arm is to replace, as close as possible, the functional capacity formerly held by limb deficient person. The art of life is to show your arm and Hand. Various existing designs are available based on mechanical, electrical and electro-mechanical. In all such existing designs remain the numerous drawbacks, such as complex mechanical setup, sensitive sensors and improper recognition of objects. Another factor that includes with it is cost which is basically on the higher side. In this paper, we design an artificial arm with lightweight materials with tilt function, which enable to do the basic operation such as lifting the arm and to monitor the blood flow movement. These operations are identified and controlled based on surface MEMS accelerometer which is fixed on another non affected arm. This will reduce the cost and complexity of the design. This can be improved further for more operations.***

**Keywords:** Mems controlled arm

## 1. Introduction

The Arm and hand are very most important part of human life. People who suffer from the stroke feels the pain of lost and face many difficulties in daily life. The loss of limb has great impression on the person's social status which affects worse, as well as the mental pressure they felt. Many options are available by today's technology which helps the person. The cost is one of the factor, that gives how well the arms and limbs perform and how cosmetically appealing with the looks and other factors includes the skills that the technicians have to make the arm and limbs, and the materials for fabrication.

These give the properly fit device which shows the result of a close working relationship between the prosthetist and the patient. Ultimately, the design and fit of the socket to fit that arm in body is what determines the patient's acceptance, comfort, suspension, and energy they spend.

Artificial arm development gives some of the advantages like,
1) Feeling of a new arm.
2) Added health assist system can help to view the patients' health information.
3) Provide good shape to the body.
4) Lightweight materials can reduce pain and stress.
5) Very light to handle.
6) Ease of use and controller over wireless.

## 2. Literature Review

In this paper, we are going to present a detailed study of artificialarms which are available in various designs. Some of the existing systems is the myoelectric arms1, VAEDA gloves. VEADA gloves are EMG controlled devices which are taken to cure the hand but the method is somewhat complex and costly.

This system provides a light weight and compact myoelectric Arm in which the myoelectric signals are read by the myo-electrodes. These myoelectric signals are amplified and processed to measure the muscles electricity. Using suitable sensors these EMG signals2 can be acquired. The processed Signals are designed to control the degree of freedom in artificial limb. EMG signals are usually of low amplitude (10Hz-500Hz) which contains user intention information. For different motions of user, multiple EMG channels are used to acquire each data using corresponding electrodes.

In some systems disc electrodes are used. It should be placed on the surface of the forearms by using a conductive paste. When there is a change in the forearm muscles there evokes an action potential due to the large fibers in the forearms. The EMG signal is allowed for amplification, filtering and rectification. The final processed signal is given to microcontroller and using ADC, the analog signal is converted to digital one. The output from the microcontroller is used to drive the servo motor for intended functions. The motors are controlled by the external driver circuits. The output of the motor makes the artificial arm to rotate with corresponding functions.

The drawbacks of this existing system are as follows.
1) The EMG sensors is unreliable due to the artifacts, where connectors and wiring breakage can often occur.
2) There is an inconvenience indoffing and donning of electrodes and the maintenance of skin should be difficult.
3) Manual operation is needed in order to provide proper functions.

Due to these drawbacks this system is not so popularized in the market.

The artificial arm based on this approach consists of the developed molded metalarm liftings which are designed to do the six functionalities. A DC gearmotor is embedded in the palm which forms the grasp modes by its inward and outward movement. The material used for the fabrication of skeletal structure is Nylon. When compared with Teflon, Steel and Aluminum nylon is the best suitable and cost effective than all materials.

This system has a very complicated design. It takes long time to mimic the natural arm. It is unable to implement the apduction and apduction functions. The mechanical set up is difficult to understand my common persons and need technical assistance. It also provides less comfort to the patients.

## 3. Related Theory

Artificialarm based on Biomimetic design is another existing system. In this system the artificialarm mimic the natural arm. This artificialarm is designed by comparing it with the functions and properties of the natural arm. This system is also based on the EMG signal for its function. It has 15 degrees of freedom. It is designed to give six grasping functionalities of arm such as to give power to hold an object, Palm-up, to act as hook, Oblique, Precision and to pinch.

This Biomimetic approach is used to overcome the poor functionality and low controllability of the previous systems. Based on this approach an upper limb artificial arm controlled by EMG signal is designed. Some systems provide an exoskeleton format which is like shown in figure 1below.

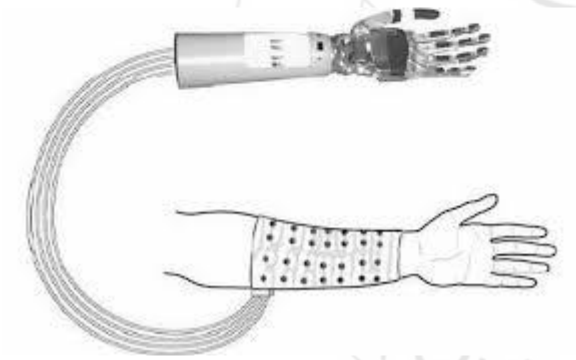

**Figure 1**

The above stated designs hold drawbacks and also, lot of the models are considered and designed only for the lower limb and arm control only which is a major draw. Also no other simple systems exist to provide easy way of physiotherapy treatment, which is still a hazard to the patients, in the mean of amputation. To relieve them from all these, we propose this design of MEMS controlled artificial arm.

In addition to that there is no wireless technology implemented in these type of arm so that it can be implemented for near functions and distance care etc..

## 4. Methodology

The main problems for artificial limb in most of the countries are having lack of skilled persons to update, no proper construction for fitting, and aligning, and for wearing it up and removing without hurting which needs more training. Though there are more demand for this, there is a very few training mobilized. The other factors to be kept in mind are the cost factor, this is important to be analyzed for the society. And for individual satisfaction, cosmetic issue will also lay its arm. The wired controllers are somewhat risky and careful for shock attacks.

To overcome all the difficulties in the existing method, in this paper we have implemented a new design of artificialarm with two arm liftings, which implements fundamental motions, such as arm lifting and self-controlled movement which requires no assistance, which is required. In order to control the lifting of the developed Artificialarmin dependently, an identifier which recognizes the arm lifting motions based on the surface MEMS accelerometer, and recognition rate of the arm lifting motions was examined. And an adaptive sensor is used to recognize the object.

An accelerometer is a device that measures the vibration or Acceleration of motion of a structure that measures the changes in speed of anything that is mounted on it. It is an Electro-mechanical device that measures acceleration forces which may be static like the constant force of gravity pulling at our feet, or they be dynamic could be caused by moving or vibrating the accelerometer. The MEMS sensor used in this is accelerometer whose axis is used for doing the fundamental action. The Accelerometers are available in one, two or three axes. Here we are using with two axes. When the axis is X then it does the action of grasping and if the axis is Y then it does the action of holding. To identify the object, that is, to recognize the object we implement an adaptive sensor for the identification operation. The microcontroller used here is PIC, which has the inbuilt analog to digital converter and helps for the UART interface.

This proposed method can be further improved for many more operations. This method is an advanced vision of the existing Systems that has a drawback in sensitive sensors such asmyoelectric sensor and complex training procedures with non-recognition problems. The person with both arm amputations can use this low cost device for their fundamental operation, Grasping and Lifting. This will replace their natural arm loss80 percent. Thus it will be one of the best designs of the artificial arm so far implemented.

**MEMS accelerometer**

Most accelerometers are Micro Electro Mechanical Sensors (MEMS). The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams. Consistent with Newton's second law of motion ($F = ma$), as an acceleration is applied to the device, a force develops which displaces the mass. The support beams act as a spring, and the fluid (usually air) trapped inside the IC acts as a damper. Under the influence of external accelerations the proof mass deflects from its neutral position. This deflection is measured in an analog or digital manner. Most commonly, the capacitance between a set of fixed beams and a set of beams attached to the proof mass is measured.

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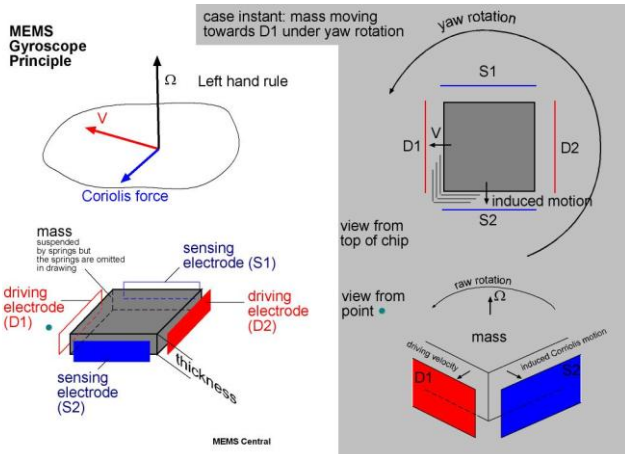


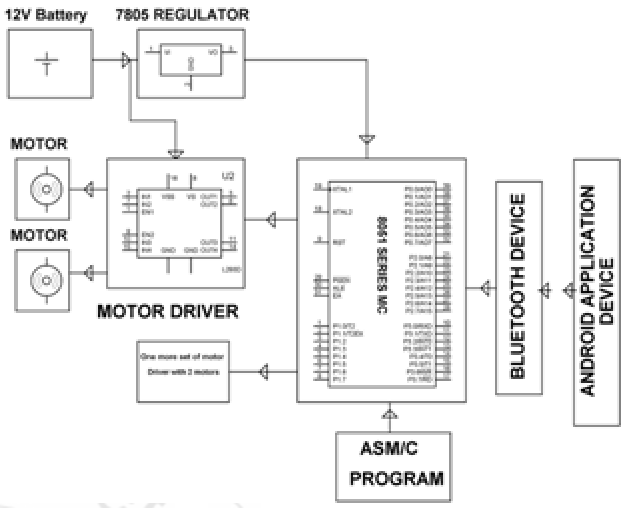

**Figure 2:** Accelerometer working operation

The 3 axis accelerometer is based on the principle of capacitive sensing. The figure-1shows basic principle of Accelerometer sensor.


The MEMS accelerometer sensor is shown above. The sensor is made of spring loaded, micro machined structure, mounted on silicon base. Force on the structure changes the position of seismic mass attached on the spring. This deflection is measured using fixed plate capacitor sensors. The change in acceleration unbalances capacitor plate distance, observedbymodulation/demodulation circuits and thus, resulted in output proportional to acceleration. The sensing can be static (gravity) or dynamic (forced acceleration).The MEMS accelerometer which is used in this is ADXL330 which are low cost, low power, complete 2axis accelerometers with a measurement range of either ±2 g/±10 g. The ADXL330 can measure both dynamic acceleration (e.g., vibration) and static acceleration (e.g., gravity). The outputs are digital signals whose duty cycles (ratio of pulse width to period) are proportional to the acceleration in each of the 2 sensitive axes.

## 5. Working Process

The objective of our work is to design anartificialarm that has two arm liftings which can do two fundamental motions, such as grasping and lifting operation. To accomplish our objective, we have designed using the MEMS accelerometer that acts as the identifier of the fundamental motions such as grasping and holding. Figure 2depicts the block diagram of the design. Here we are using two axes fashion, if the axis is X, then it does the grasping operation(half arm lift) and if the axis is Y, then it does the lifting (full arm lift) operation. The MEMS surface sensor identifies the angle and gives as an analog signal, which is converted into digital signals and given to the microcontroller. The Microcontroller used is PIC16F877A, initially we were using basic 8051 microcontroller, which lacked inbuilt A/D conversion, and for the analog to digital conversion and for UART operation, the PIC microcontroller is used. This was tested with the UART, MAX232 to find how reliable the motors are. And the input From the MEMS sensor can also be checked with the UART.




The block diagram for the Bluetooth wireless control which is connected to the pic microcontroller is shown in the figure.

The Motors used in this is the high torque servo motors. We are using seven motors for the correct flexibility of lifting operation. Three motors are placed along the upperarm lifting and three motors in lower arm lifting and other one between the two arm liftings. Since servo motor with stepper has an advantage of operation of step moment. This will be used for the exact holding posture of the object.

For the fabrication, we are using Surface Mount (SMT) Technology. This will give good cosmetic appearances.

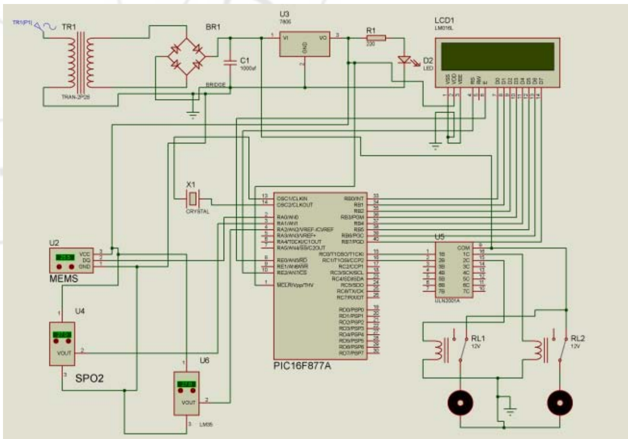



**Figure 3:** Circuit diagram of the design

## 6. Results and Discussion

With the implementation of MEMS Accelerometer, adaptive Sensor and seven motor systems will provide a best operation of the fundamental motion of arm - grasping and lifting. The above block diagram shows the proper idea of our developing hand so that we can modify and develop the artificial arm with effort. Some of the MEMS sensor values which are being identified using the embedded c programming and the PC so as the values helps to program the controller to give the operation when sensor gives such type of values.

The below block diagram shows the positive and negative values of the MEMS sensor which we have been tested to lift the arm and to work in slower manner when value reached. The flow of input signal from the sensor to the microcontroller is shown in the figure where the process shown in the figure 3, which will give a clean view of the signal process

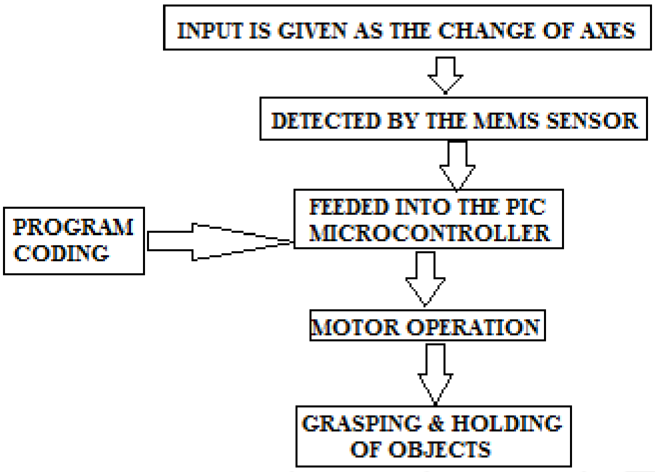
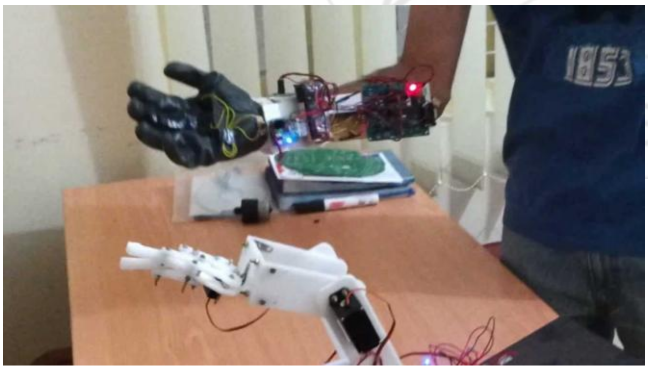



**Figure 4:** Flow of operation of signal

The Result may be similar to the natural arm operations.

Further this technique can be implemented to all the arm liftings with various operations. Hand and thumb lifting is also possible by this method which is shown in above figure 3.

The Real model of the arm which have been done as a project is shown in below figure 4.



Addition of health assists systems to the arm device by using the various sensors. The spo2 sensor which shows the oxygen amount in blood, PPG sensor is added to ensure the flow of blood inside the tissues. An external temperature sensor is added in order to maintain the body temperature levels. The information can be shown in the LCD display with the refreshing intervals of 1 minutes.

It is a predicted model for the reference (shown above image), but the actual model may be varies depending upon the development and its size which is it is modified. Thus this method not only will relieve the person from the loss of arm, it will also reduce the cost and training period. And this can also be implemented in the field of surgery as anartificialarm.

## 7. Conclusion

The design of artificialarm using EMG signal and electrodes to control has been historically unreliable of the surface EMG sensor because of artifacts, wire breakage, inconvenience of doffing and donning electrode, maintenance of the skin condition, and repeatability of electrode placing. But our method is different in approach.

It reduces the bulkiness and makes the control of arm easier and added wireless technology gives convenience. This not only can be used for the artificial replacement, it can also be used asrobotic arm in surgeries too. It can also incorporate many further operations. Thus it is the apt design of artificial arm which can also been improved. The health assists makes the patients peace of mind to know their body condition.

And yet other designs have pros and cons. Our design of artificial arm will be able to make a wide difference among the society.

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