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Research Article

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Analyzing EMG and MMG signals for MMG driven bionic arm

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ABSTRACT

Artificial limbs that are used for amputees have mostly been body powered. This paper emphasizes on the development and analysis of MMG and EMG signals and designing a bionic arm that utilizes MMG signals that would reduce the stress level, the patient/user suffers with a body powered arm. The MMG-driven prosthesis is composed of specialized hardware and software modules that emulate a conventional 1-site electromyography sensing system. The objective of this work is to obtain the muscle signals using a suitable sensor and using the signal, driving the bionic arm.

Keywords: Bionic Arm, EMG, MMG, Sensors

INTRODUCTION

When a person loses his or her limb, the integrity of the body is compromised. The social adaptability also changes. The person needs to be fitted with an artificial prosthesis to enable him to go on with the daily activities. Prosthesis provides a substitute for the missing body part. Prosthesis and orthosis are a part of biomechatronics, the science where mechanical devices are linked with human muscle, skeleton, and nervous systems to assist or enhance motor control lost by trauma, disease, or defect. Depending upon the loss and extent of the loss of limbs, the appropriate prosthesis is selected.[1]

Surface electromyogram (sEMG), sonomyogram (SMG), tensiomyogram (TMG) and mechanomyogram (MMG) are various non-invasive methods used to examine muscles activities.

Surface EMG has few drawbacks even though it is majorly used for skeletal muscle studies. Few drawbacks are its sensitivity to external noise and interference, which limits its operating environment. These electrodes require a very stable signal component with low noise. It is not very cost effective also.

Nowadays, MMG has been proved to be an effective sensor to study muscle mechanical activity. In mechanomyography, specific transducers are used to detect the mechanical activity of muscles. These transducers record muscle surface oscillations which occur during various muscle activities. The transducers used to detect MMG signals are Piezoelectric contact sensors, microphones, accelerometers and laser distance sensors.

Few advantages of MMG over sEMG are- The placement of MMG sensors is not required to be precise due to its propagating property through the muscle tissue. Change in skin impedance due to sweating need not be considered, as MMG is a mechanical signal. [2]

Several research works on MMG signal processing for muscle characterization have already been reported. Few notable areas include the development of prosthesis and/or switch control, studying activity of motor unit, evaluating muscles during sports and exercises, monitoring neuromuscular blockages, and development of a suitable model for studying the motor unit activity. Hence we decided to use MMG signals and accelerometers to provide a valid output so as to help in prosthetic arm movements in the above elbow amputees.

MMG signals accurately predict fatigue during muscle contraction. MMG signals can be recorded at a distance away from the active muscle, but the amplitude will be less. Because of this advantage it is commonly used in prosthesis manufacture as wire breakage will be less. Also MMG sensors are significantly cheaper than the sEMGs. MMG signals can be used to open and close a free-standing prosthesis hand. [3]

Other mentionable characteristics of MMG signals are their propagation through soft and deep tissues, its linear correlation to strength of muscle contractions.[4]

EXPERIMENTAL SECTION

Materials

A. Piezoelectric Sensor

Generation of an electric charge when a mechanical stress is applied is called piezoelectric effect. Also an electric field causing mechanical stress in a material can also be termed as piezoelectric effect. A piezoelectric sensor is a device that makes use of this property to measure changes in pressure, acceleration, strain or force by converting them to an electrical charge. The reasons why we have used piezoelectric sensors are because of its ruggedness, high modulus of elasticity, high natural frequency and an excellent linearity over a wide amplitude range. Also they are insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions.

B. Gyroscope

Gyroscope is an angular velocity sensor which is commonly used for measurement of human posture and movement. It is generally based on the concept of measuring the Coriolis force of vibrating devices. Coriolis force is the apparent deflection of moving objects as viewed by the observer in a rotating reference frame. [5]. Here we use a 3 axis accelerometer to help to detect the changes in the position of the sensor module for their respective arm movements. The position change for each movement is noted and is coded with the microprocessor to enable the initiation of motion in a particular direction. This would help in the electrical assistance for motion and would reduce the stress factor that is observed with people who use body powered prosthetic limbs.

Both the outputs of the Piezoelectric crystal film as well as the Gyroscopes are taken as inputs and the movement is coded. Thereby releasing both the stress factor as well as reducing the complexity of the setup. Such a design is expected to be both practical as well as a cheaper alternative to the bionic arms in the market today.

C. Arduino

Arduino is a single-board microcontroller, which is used in our research. The hardware basically consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. It is provided with a boot loader that helps in uploading programs into the microcontroller memory without needing a chip programmer. the CPU board can be connected to the Arduino using interchangeable add-on modules known as shields.

Methodology

The piezoelectric crystal film sensor used in our work was taken from the normal alarm buzzer that is obtained from the stores. The piezoelectric crystal converts the sound vibrations into electric signals. The piezoelectric crystal film sensor circuit was designed which included a basic conditioning circuit. (Figure 1)

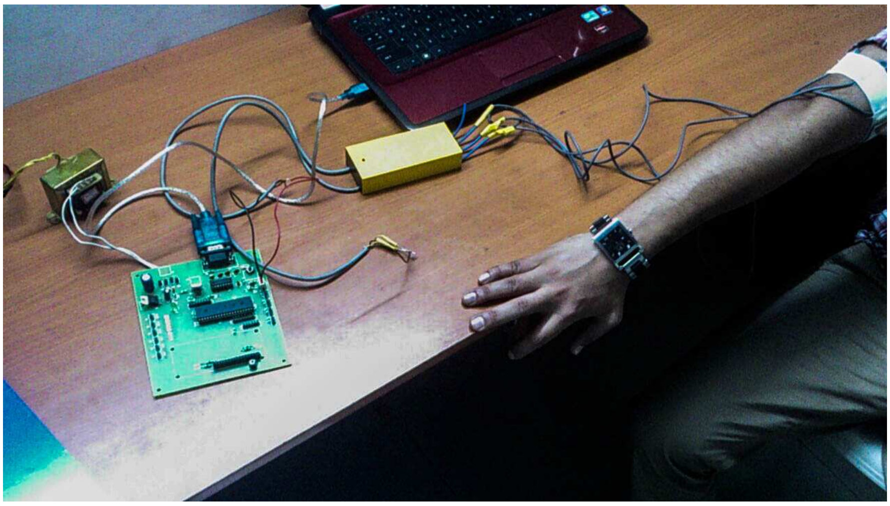

Figure 1 : MMG analysis using condenser microphones

The output was fed directly to a digital storage oscilloscope (DSO) in order to compare the outputs. The signals obtained from the piezoelectric film sensor was precise as well had lesser amount of noise than the previous sensor outputs. Hence the basic comparison of the signals from MMG signals with the EMG signals were done and the MMG signals were found to be apt for our needs as there was a lot of lesser noise when compared to the outputs that were obtained from the EMG signals.

A basic prototype of a bionic arm that could be able to show the basic movements was designed and assembled. The various MMG signals associated with their respective movements were already coded using the basic sensor circuit. The MMG signals were fed into the ARDUINO processor which then drove the robotic prototype. (Figure 2)

Figure 2: Block diagram

An LCD is also used to show the analysis of the various movements and the values associated with the various movements. This would also help in the verifying the various voltage fluctuations that were associated with the sensing element.

RESULTS AND DICUSSION

A comparative study of the MMG signals that are acquired and the readily obtained EMG signals were done. The MMG signals were observed to provide better output than the EMG signals .It is observed that for amputees the EMG signals could not obtained in certain cases, whereas the muscle sounds could be easily observed and analyzed. Hence we concluded to use MMG signals instead of the EMG signals that were being used in the past.

The EMG sensors were observed to give outputs that were having high noise within them and could be replaced with the MMG signals that were observed to provide lesser amount of noise.

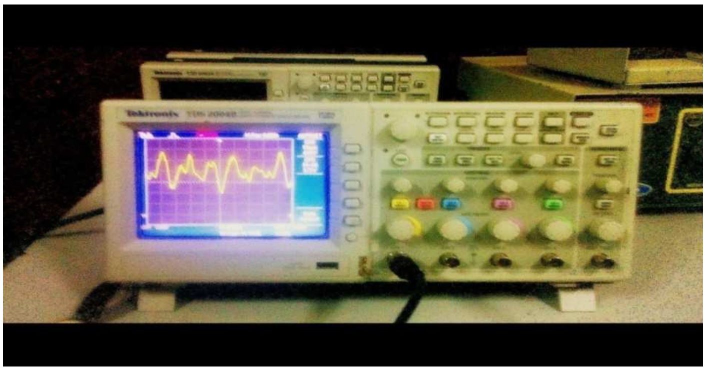

Figure 3: Detecting the upward movement of arm using EMG

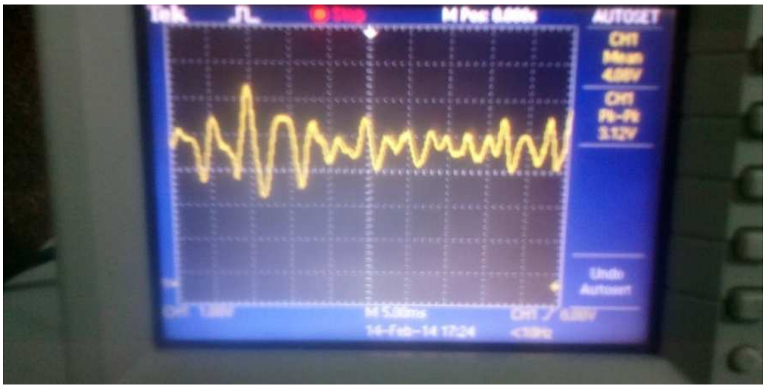

Figure 4: Detecting the downward movement of arm using EMG surface electrodes

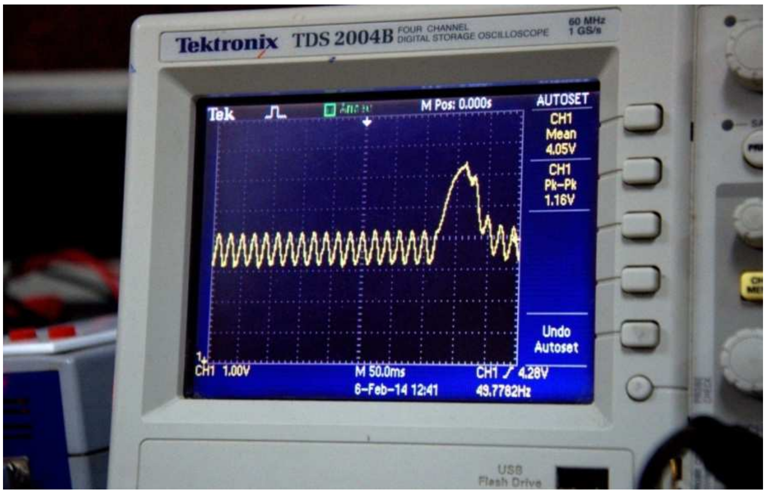

Figure 5: Detecting the upward movement of arm using MMG sensor

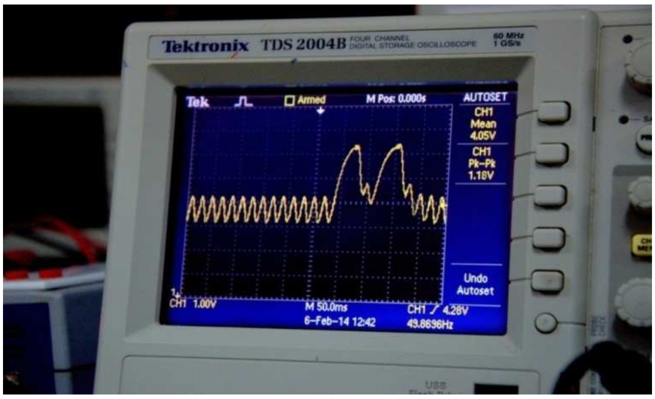

Figure 6: Detecting the downward movement of arm using MMG sensor

CONCLUSION

The work was done to improve the area of prosthesis and to design a bionic arm which is user friendly and available at a lower cost. Both EMG and Optical fibers are proven to be a much more expensive option when compared to the MMG signals.

The MMG sensor that is being used incorporates a piezoelectric crystal that is cheaply available and would help in the reduction of the costs of the overall setup. The basic circuitry required is also much simpler when compared with the circuitry that is seen in the case of the bionic arms available in the market today. This would hence be an alternative to the existing prosthetic limbs. The gyroscope used in parallel so as to enhance the output of the muscle sounds that are to be obtained was also proven to be very useful .Hence, the sensor used is proven to be compatible and user friendly and is a better alternative to all the existing prosthetic arms available in the market.

In this work, a robotic arm as shown in Figure 7 has been made which is driven by MMG signals. As of now, the bionic arm is in the design process using CADD (Figure 8) and suitable materials to be used are being researched.

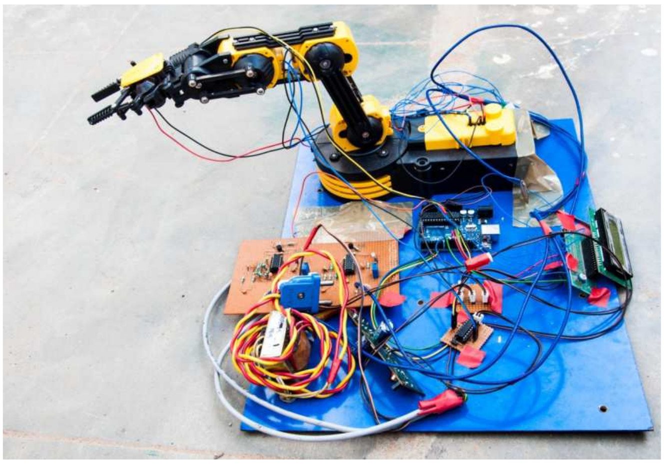

Figure 7: Robotic arm driven by gyroscope/ piezoelectric sensor

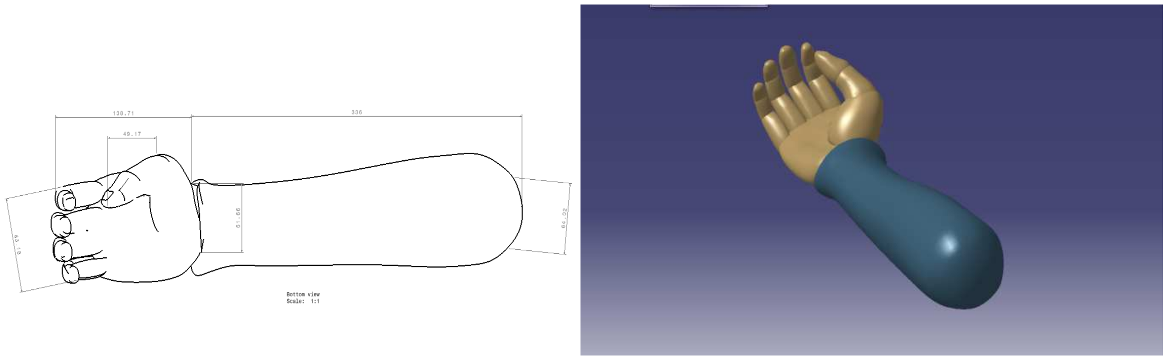

Figure 8: Bionic arm external design and CADD design

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REFERENCES

[1] Sri Balaji V, Samson Nivins S, Aravind A.R, *The International Journal Of Science & Technoledge*, March **2014**

[2] Islam Md Anamul, Kenneth Sundarraj, et al , *PLoS ONE*, Edited by William Phillips, vol. 8, issue 3, **2013** p. e58902

[3] Silva J, Heim W, Chau T. *Arch Phys Med Rehabil* **2005**;86:2066-70

[4] Natasha Alves and Tom Chau, “Towards Mechanomyographic Control of Multi-Articulated Upper-Limb Prosthesis: The Existence of a Functional Mapping Between Grip and Forearm Vibrations”, RESNA 28th Annual Conference - Atlanta, Georgia

[5] Giuliana Grimaldi and Mario Manto, *Sensors* (Basel). **2010**; 10(2): 1399–1422. Feb **2010**