International Journal of Scientific & Engineering Research Volume 9, Issue 3, March-2018 103
ISSN 2229-5518

Electromyography

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Abstract— The idea is to change the perception of remote controls for actuating manually operated Robotic-Arm. Well, this paper presents a thought and a way to eradicate the buttons, joysticks and replace them with some other more intuitive technique, that is, controlling the complete Robotic Arm by the operator's hand movement or motion or gesture. In this paper the completely electronic (i.e. without mechanical sensors) way of achieving the above stated goal is discussed. This is achieved by using electromyography sensing, showing the diversity of the application of the same technology.

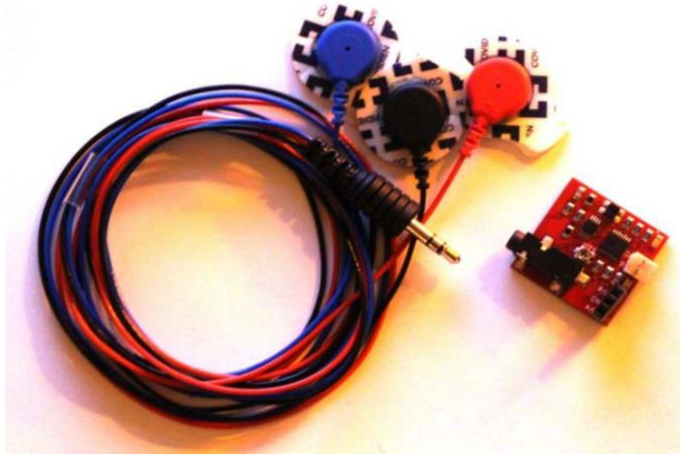
Index Terms— Actuation, DOF – Degree of Freedom, Electromyography, Sensor.

1 Introduction

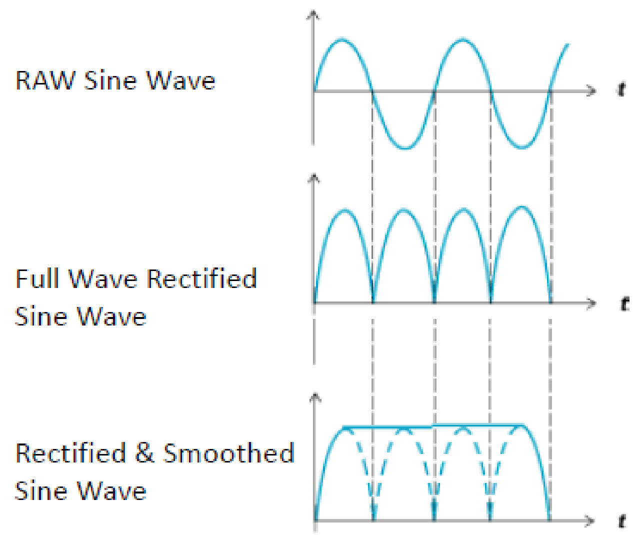
The breakthrough technological revolutions that changed the dimensions of the perception of manufacturing in the industry took place due to ROBOTIC-ARM. Traditionally and currently these Arms or machines are controlled either by preloaded code (i.e. automatic) or via Joystick (i.e. Manual). Now in industries or anywhere else minimum the Robotic Arm with 5DOF and a Gripper is required. So in all 6motors or actuators are required to drive it. And hence this calls for the need of (in case of manually operated) joystick or remote control that has 5 to 6 keys to control and actuate the individual motions/ motors of robotic arm respectively. Practically thinking simultaneously using 6keys and using them by analyzing the motion of robotic arm in 3D requires rigorous practice and judgment. That is the system is very less intuitive and this is the knack of the article, that is, to develop the system that would make the existing system more intuitive and user friendly. Rather than hunting for some other kind of 'Soft-keys' etc I just thought of utilizing the super-natural power of human i.e. to 'move our hands'. So the system discussed in the paper is to control the motion of Robotic-Arm by mere movements of human arm eradicating the species of keys and joysticks. So the aim of the paper can be briefed as "designing the system, the sensory part, which can be mounted on the human (rather operators) arm, synthesize the signals and ultimately generate the signals to actuate the Robotic Arm" and hence to Replicate the motion of the human arm.

2 Electromyography Sensors

Easy to use single channel EMG sensor boards have been used



to sense and measure muscle activity. This kit contains a small PCB and three surface electrodes. Two of these electrodes measure the voltage potential across a muscle and the third is a ground reference point placed on a boney feature. The muscle sensor kit is designed to be used directly with a microcontroller. As a user flexes, an internal amplification system converts minute electrical pulses into a rectified and smoothed signal that can be used as an input to a microcontroller's analogue to digital converter.



3 EMG Control

Each muscle sensor board outputs an analogue signal (0–3V) into an analogue pin on the microcontroller. The microcontroller performs and analogue to digital conversion on this signal storing the result as a 10-bit binary value which is used to control the positioning of the servo motors.

Two electrode pairs provide two analogue signals which are used to control the actuators of the device. As the magnitude of the EMG signals pass above arbitrary thresholds specific commands are executed. The basic EMG control is as follows.

- One electrode set measures myoelectric signals from a muscle region such as the bicep. As a user flexes the EMG signal is used to switch between different grip pattern states of the Arm. A state could be a precision grip, power grip or wrist/elbow rotation configuration.
- The other EMG sensor monitors another muscle region such as the forearm. Flexing the this muscle region actuates the specific state the device is in – fingers close or joints rotate to pre-set positions.

Using this method it is possible to control the opening and closing of different grips as well as allowing for wrist and elbow rotation states. However, only a single command can be executed at a time and it naturally takes a user some time to cycle between states. This means it is not possible to close individual fingers and rotate the wrist at the same time using this basic control. Ideally we would like a system which allows the user to control the exact positions and force applied by each digit and also allow for control of several movements simultaneously. A basic form of proportional control was implemented and tested on this device. This allows the user to close the fingers more by flexing harder. The magnitudes of the EMG signals were used to linearly increase the pulse widths of the PWM servo signals – shown in the equation below.

$$WPWM(t) = a + k\,|emg\,(t)|$$

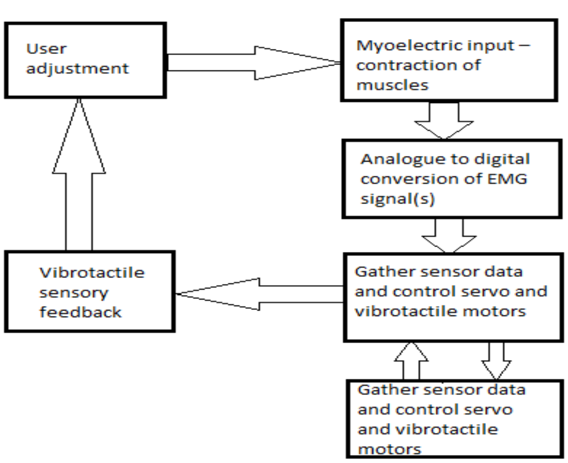
WPWM = servo signal pulse width
a = arbitrary offset (servo PWMs start at 1ms)
k = Scaling factor
emg = EMG signal magnitude

4 Sensor Feedback

Ideally we would like to include pressure sensors on each finger to provide some feedback. These sensors provide information to the microcontroller about how much force is being applied at each fingertip. This information can be used to control vibration motors housed in a flexible band than can be worn around the upper arm. This provides some basic sensory feedback to the user letting them know if they are grasping an object and how much force they are applying.

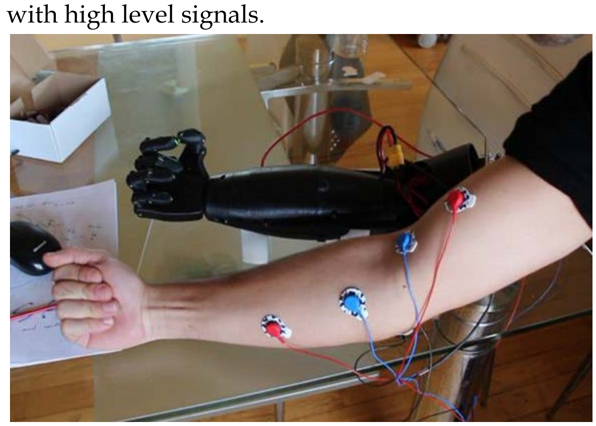
5 Program Flow

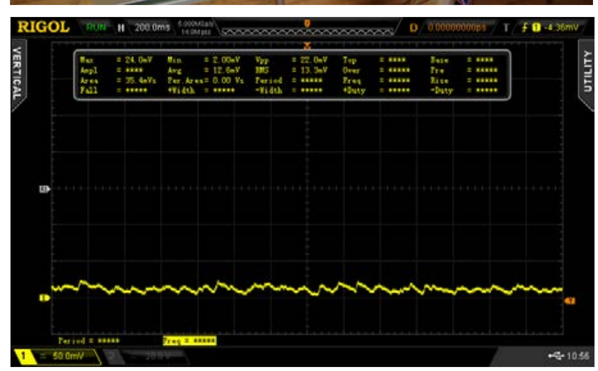
The basic structure of the current program is outlined below.

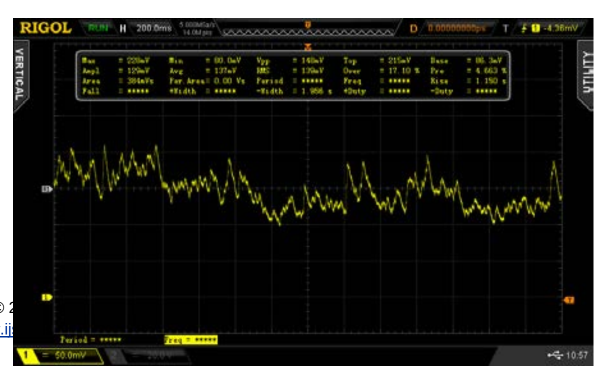


6 Control

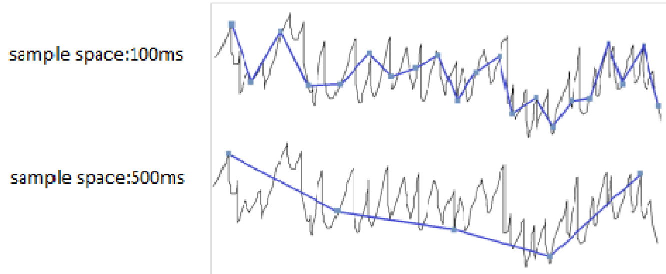
The basic Boolean EMG control allowed for different states to be cycled through and actuated . One state allowed for wrist rotation and another state allowed for finger actuation . It was possible to instruct the hand to close, rotate to a certain position, rotate back and then reopen. Such a movement could be used to grasp and pour a liquid from a bottle . However having to switch between the two states made the task slow and tedious using this basic EMG control. Proportional control of the fingers works fairly well – the harder the user flexed the more the fingers would close. However, this proportional control causes the fingers to start shaking when trying to close due to noisy signals being used to control servo positions. Initially the EMG signals were sampled every 100ms converting the magnitude of the signal to a decimal value. The servos were also updated every 100ms. As seen in the oscilloscope images on the next page the EMG signals are quite noisy. This means the signal voltage level can significantly jump or drop in 100ms which results in the servos being instructed to constantly move around to different positions. This is especially bad with high level signals.







As illustrated below the sampled points used for servo control are constantly shifting up and down. A smooth signal is desired which means some filtering should be done to these EMG outputs to improve control characteristics. Increasing the time between ADC samples and servo updates slows down the shaking of the fingers but does not fix the problem.



In order for proportional control to work we need an EMG signal that increases linearly with flex intensity. To generate the screen shot below the user focused on starting at rest and gradually increasing flex intensity to a maximum and then releasing. The magnitude of this signal seems to increase linearly with increasing flex intensity. This is required for accurate proportional control.

7 Conclusion

This article is an example of the completely diverse application of the electromyographic sensor in terms ofbrobotics and manufacturing sector. Here it is shown how with minimum simple hardware and intelligent software the gesture controlled technology shown in Sci-Fi movies can be implemented practically. Future works aimed is implementing the wireless protocol so that operator at one end can control the robotic arm wirelessly at the other end.

8 Reference

- Wong Guan Hao, Yap Yee Leck and Lim Chot Hun."6-DOF PC-Based robotic arm (PC-roboarm) with efficient trajectory planning and speed control" 2011 4th International Conference on Mechatronics (ICOM), 17-19 May 2011, Kuala Lumpur, Malaysia.
- ARM system developers guide (book) by Sloss & Symes & Wright.
- Application Note- AN3308
- International Journal of Scientific and Research Publications, Volume 2, Issue 12, December 2012 1 ISSN 2250-3153
- Dhillon GS, Horch KW. Direct neural sensory feedback and control of a prosthetic arm. IEEE Transactions on Neural Systems and Rehabilitation Engineering 13, 468-472.
- Hudgins, B Parker, P and Scott. A new strategy for multifunctional myoelectric control. 1993. IEEE Transactions on Biomedical Engineering.
- R. F. Weir, P. R. Troyk, G. DeMichele, T. Kuiken. Implantable Myoelectric Sensors (IMES) for Upper- Extremity Prosthesis Control - Preliminary Work. Proceedings of the 25' Annual lntemational Conference of the IEEE EMBS Cancun, Mexico * September 17-21.2003.