

Z. Hossain, M. M. H. Shuvo and P. Sarker, "Hardware and software implementation of real time electrooculogram (EOG) acquisition system to control computer cursor with eyeball movement," *2017 4th International Conference on Advances in Electrical Engineering (ICAEE)*, Dhaka, 2017, pp. 132-137.

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Abstract: Human computer interface (HCI) is an emerging technology of neuroscience and artificial intelligence. Development of HCI system using bio signal e.g. Electrooculogram (EOG), Electromyogram (EMG), Electroencephalogram (EEG), Functional near-infrared spectroscopy (fNIRS) etc. are attracted more and more attention of researchers all over the world in recent years because through this it is possible to get acquainted with advanced technologies of artificial intelligence. This paper presents the design and implementation of a fully functional Electrooculogram (EOG) based human computer interface. In this work we have designed and implemented necessary hardware and software for EOG signal acquisition along with controlling hardware such as wheelchair, robotic arm, mobile robot etc., and move computer mouse cursor simultaneously using EOG signal. This interface has three portion: EOG signal acquisition and amplification, analog to digital conversion, and real time hardware and mouse cursor movement. Eye movement is detected by measuring potential difference between cornea and retina using five Ag-AgCl disposable electrodes. Frequency range of EOG signal is considered as 0.3 to 15Hz, so this frequency range is taken using an active high and low pass filter so that accurate EOG signal can be achieved. The analog output of the EOG signal from filter is converted into digital signal by using an Arduino. Arduino serialize the EOG data for calibration and provides a threshold reference point which is used for controlling Hardware. The Classification module e.g. Support Vector machine (SVM) and Linear Discriminant Analysis (LDA) classify live data with respect to the horizontal and vertical data. This works as a binary classifier and choose optimal hyper-plane between two variables. According to each update on the eye position, cursor automatically accelerated in particular direction. PyMouse module in python is used for this task. Eye gesture based Hardware like robot, wheelcha- r etc. control and mouse cursor movement are the principle outcome of this research work.

keywords: {electro-oculography;electroencephalography;electromyography;eye;gesture recognition;handicapped aids;human computer interaction;low-pass filters;medical signal processing;support vector machines;wheelchairs;Ag;EOG data;EOG signal acquisition;Functional near-infrared spectroscopy;HCI system;accurate EOG signal;artificial intelligence;computer cursor;computer mouse cursor;controlling hardware;digital signal;frequency 0.3 Hz to 15.0 Hz;frequency range;fully functional Electrooculogram;human computer interface;mouse cursor movement;software implementation;time electrooculogram acquisition system;Calibration;Electrodes;Electrooculography;Hardware;Mice;Support vector machines;Cursor Movement;Electrooculogram (EOG);Human Computer Interface (HCI);Support Vector Machine(SVM)},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8255341&isnumber=8255315>

S. Mohammad and G. V. Kumar, "Development of sEMG based human machine interface control system for robotic watch," *2016 International Conference on Research Advances in Integrated Navigation Systems (RAINS)*, Bangalore, 2016, pp. 1-5.

doi: 10.1109/RAINS.2016.7764384

Abstract: In this paper, we introduced a novel and simple methods of extracting the general features of the EMG signal hand gestures segmentation for Human Machine Interface (HMI) for Spinal Cord Injury (SCI), recorded Electrode signals from the Abductor pollicies longus above the elbow are noise filtered and features sets were extracted. These feature set's are used to control wheelchair motion and control of Automated Instrument. Finally the results for HMI using SEMG signals of SCI proves that a subject can move the wheel chair in the desired direction and control of cursor; thus, a more intuitive human interface is implemented.

keywords: {electromyography;feature extraction;gesture recognition;handicapped aids;medical robotics;user interfaces;SCI;SEMG signals;abductor pollicies;automated instrument control;electrode signals;gestures segmentation;human machine interface control system;noise feature sets;noise filtered sets;robotic watch;spinal cord injury;wheelchair motion control;Electrodes;Electromyography;Feature extraction;Instruments;Muscles;Navigation;Rain;Microcontroller;Microcontroller DAQ Card;Surface electromyography (EMG) signalprocessing},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7764384&isnumber=7764359>

F. Wong *et al.*, "Model cart control using EMG signal," *2015 10th Asian Control Conference (ASCC)*, Kota Kinabalu, 2015, pp. 1-4.

doi: 10.1109/ASCC.2015.7244693

Abstract: This paper describes the development of EMG signal acquisition system application for model cart control. The main application of this type of control is to assist disabled people or frail people to control a cart or device via their healthy muscle. In this project, the circuit was simulated, developed and troubleshoots. The aim of model cart control was to control four basic directions which is forward, backward, turn left and turn right. Threshold voltage level comparison method is used in this project for model cart control. By considering the user friendly issue for the application system, EMG signal acquisition method was decided to be used and obtained with surface electrode. There are two stages to be done for this system, in which the first stage is the signal acquisition system and the second stage is to control the action of model cart. First stage included pre-amplifier, rectification and filtering, which were done with instrumentation amplifier, active low pass and high pass filter and precision full wave rectifier. Second stage included the microcontroller and motor driver in which the microcontroller functions to read the two channel EMG signal and give signal for the motor driver to control the DC geared motor. The result of the hardware testing is compared with the software simulation where the same output is obtained. There were also some limitation and problem which have not been solved. There was wire connected to the model cart where it is not very convenient for the model cart to move around or further.

keywords: {electromyography;handicapped aids;high-pass filters;low-pass filters;medical signal detection;microcontrollers;position control;rectification;DC geared motor;EMG signal acquisition system;disabled peoples assistance;electromyography;frail peoples assistance;high pass filter;instrumentation amplifier;low pass filter;microcontroller;model cart action control;model cart control;motor driver;pre-amplifier;precision full wave rectifier;rectification;surface electrode;threshold voltage level comparison method;user friendliness;DC motors;Electrodes;Electromyography;Integrated circuit modeling;Microcontrollers;Muscles;Threshold voltage;EMG;Model Cart;Movement Recognition},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7244693&isnumber=7244373>

E. A. Clancy and N. Hogan, "Multiple site electromyograph amplitude estimation," in *IEEE Transactions on Biomedical Engineering*, vol. 42, no. 2, pp. 203-211, Feb. 1995.

doi: 10.1109/10.341833

Abstract: Temporal whitening of individual surface electromyograph (EMG) waveforms and spatial combination of multiple recording sites have separately been demonstrated to improve the performance of EMG amplitude estimation. This investigation combined these two techniques by first whitening, then combining the data from multiple EMG recording sites to form an EMG amplitude estimate. A

phenomenological mathematical model of multiple sites of the surface EMG waveform, with analytic solution for an optimal amplitude estimate, is presented. Experimental surface EMG waveforms were then sampled from multiple sites during nonfatiguing, constant-force, isometric contractions of the biceps or triceps muscles, over the range of 10-75% maximum voluntary contraction. A signal-to-noise ratio (SNR) was computed from each amplitude estimate (deviations about the mean value of the estimate were considered as noise). Results showed that SNR performance: 1) increased with the number of EMG sites, 2) was a function of the sampling frequency, 3) was predominantly invariant to various methods of determining spatial uncorrelation filters, 4) was not sensitive to the intersite correlations of the electrode configuration investigated, and 5) was best at lower levels of contraction. A moving average root mean square estimator (245-ms window) provided an average /spl plusmn/ standard deviation (A/spl plusmn/SD) SNR of 10.7/spl plusmn/3.3 for single site unwhitened recordings. Temporal whitening and four combined sites improved the A/spl plusmn/SD SNR to 24.6/spl plusmn/10.4. On one subject, eight whitened combined sites were achieved, providing an A/spl plusmn/SD SNR of 35.0/spl plusmn/13.4. <> keywords: {electromyography;medical signal processing;physiological models;245 ms;analytic solution;biceps muscle;individual surface electromyograph waveforms;moving average root mean square estimator;multiple site electromyograph amplitude estimation;nonfatiguing constant-force isometric contractions;phenomenological mathematical model;sampling frequency;signal-to-noise ratio;spatial uncorrelation filters;temporal whitening;triceps muscle;Amplitude estimation;Electromyography;Filters;Frequency;Mathematical model;Muscles;Noise level;Sampling methods;Signal to noise ratio;Surface waves;Adult;Arm;Calibration;Electrodes;Electromyography;Female;Humans;Isometric Contraction;Likelihood Functions;Male;Models, Biological;Muscle, Skeletal;Sensitivity and Specificity;Signal Processing, Computer-Assisted}, URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=341833&isnumber=7995>

R. Hardiansyah, A. Ainurrohman, Y. Aniroh and F. H. Tyas, "The electric wheelchair control using electromyography sensor of arm muscle," *2016 International Conference on Information & Communication Technology and Systems (ICTS)*, Surabaya, 2016, pp. 129-134.

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Abstract: Conventional wheelchair is not effective for people with disabilities, because it requires a great power in pedaling wheelchair. To solve the problem, there is electric wheelchair with a joystick control. However it is also not effective, when users have limitations such as defects of the fingers. Given these circumstances, this research proposes an electric wheelchair with controlled by electromyography (EMG) which is placed on the arm muscles. The arm muscle signal which has an electric potential difference will be read by EMG sensors. Then the data will converted from analog to digital by Arduino. This Electric wheelchair use 4-channel electrodes for sampling muscle signal. Where, the wheelchair will move forward when the biceps muscle is active, moving backward when the teres major muscle active. The wheelchair will turn to the right when the muscles wrist flexor active and turn left when the muscles wrist extensor active. Then the wheelchair will stop when the four muscles are used active simultaneously.

keywords: {analogue-digital conversion;biomedical electrodes;brain-computer interfaces;electric vehicles;electromyography;handicapped aids;sensors;signal sampling;wheelchairs;4-channel electrodes;Arduino;EMG sensors;analog to digital conversion;arm muscle electromyography sensor;arm muscle signal;biceps muscle;electric potential difference;electric wheelchair control;joystick control;muscle signal sampling;muscle wrist extensor;muscle wrist flexor;people with disabilities;teres major muscle;wheelchair pedaling;Electrodes;Electromyography;Muscles;Notch filters;Rectifiers;Wheelchairs;Wrist;disability;electric wheelchair;electromyograph},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7910286&isnumber=7910258>

C. Zuo, X. Yang, Y. Wang, A. L. Li, Y. B. Peng and J. C. Chiao, "A wearable telemetric neural/EMG/ECOG activity acquisition platform for small freely moving animals," *2012 Asia Pacific Microwave Conference Proceedings*, Kaohsiung, 2012, pp. 43-45.

doi: 10.1109/APMC.2012.6421492

Abstract: The needs for in vivo wireless acquisition of bioelectric signals are emerging in various medical and research fields. Biopotentials span a wide range of amplitudes and frequencies making the system design requirement application-oriented. We have developed a versatile integrated wireless platform that can be used to record several types of bioelectrical signals such as electrocorticography (ECOG), electromyography (EMG) and neuronal spikes. This system can provide reliable communication in real time with sufficient data rates from objects to computers. The system has been successfully validated and demonstrated its functionality and performance in appropriate animal models.

keywords: {biomedical telemetry;electrocardiography;electromyography;medical signal detection;telecommunication network reliability;wearable computers;amplitude;bioelectric signal;biopotential;electrocorticography;electromyography;freely moving animal;medical field;neuronal spikes;reliable communication;research field;system design requirement;versatile integrated wireless platform;wearable telemetric neural/EMG/ECOG activity acquisition platform;wireless acquisition;Animals;Digital filters;Electric potential;Electrodes;Electromyography;In vivo;Wireless communication;Electromyography;electrocorticography action potential;wireless signal acquisition},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6421492&isnumber=6421477>

R. R. Harrison *et al.*, "Wireless Neural/EMG Telemetry Systems for Small Freely Moving Animals," in *IEEE Transactions on Biomedical Circuits and Systems*, vol. 5, no. 2, pp. 103-111, April 2011.

doi: 10.1109/TBCAS.2011.2131140

Abstract: We have developed miniature telemetry systems that capture neural, EMG, and acceleration signals from a freely moving insect or other small animal and transmit the data wirelessly to a remote digital receiver. The systems are based on custom low-power integrated circuits (ICs) that amplify, filter, and digitize four biopotential signals using low-noise circuits. One of the chips also digitizes three acceleration signals from an off-chip microelectromechanical-system accelerometer. All information is transmitted over a wireless ~ 900-MHz telemetry link. The first unit, using a custom chip fabricated in a 0.6- μ m BiCMOS process, weighs 0.79 g and runs for two hours on two small batteries. We have used this system to monitor neural and EMG signals in jumping and flying locusts as well as transdermal potentials in weakly swimming electric fish. The second unit, using a custom chip fabricated in a 0.35- μ m complementary metal-oxide semiconductor CMOS process, weighs 0.17 g and runs for five hours on a single 1.5-V battery. This system has been used to monitor neural potentials in untethered perching dragonflies.

keywords: {electromyography;low-power electronics;radio receivers;telemetry;BiCMOS process;EMG telemetry systems;biopotential signals;custom chip fabricated;frequency 900 MHz;low-noise circuits;low-power integrated circuits;miniature telemetry systems;off-chip microelectromechanical-system accelerometer;remote digital receiver;small freely moving animals;swimming electric fish;wireless neural;Batteries;Electrodes;Electromyography;Muscles;Neurons;Telemetry;Wireless communication;EMG amplifier;neural

amplifier;neuroscience;wireless telemetry},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5756673&isnumber=5765036>