Calculation of Rejection Ratio for EMG Signal for a Paralytic Patients Using Windowing Method

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Abstract: In this paper the noisy EMG signal is processed for filtering through windowing method. When the windowing method is used for filtering purpose then some part of the original EMG signal may be filtered with the noise. Since EMG is a low frequency and small amplitude signal so low frequency components may be filter out in filtering process. So, in this paper a parameter is introduced called EMG rejection ratio. It can be defined as a parameter which shows how much original EMG signal has been filter out with the noise in EMG signal processing.

Keywords: sEMG, Window, Paralytic, filtering, Rejection ratio.

I. INTRODUCTION

For simple detection of muscle contraction, it is usually sufficient to measure the electromyogram non-invasively, using surface electrodes. The standard measurement technique for surface electromyography uses three electrodes. A ground electrode is used to reduce extraneous noise and interference, and is placed on a neutral part of the body such as the bony part of the wrist. The two other electrodes are placed over the muscle. These two electrodes are often termed the pick-up or recording electrode (the negative electrode) and the reference electrode (the positive electrode). The signal from these two electrodes is differentially amplified to cancel the noise, as shown in Figure 1.

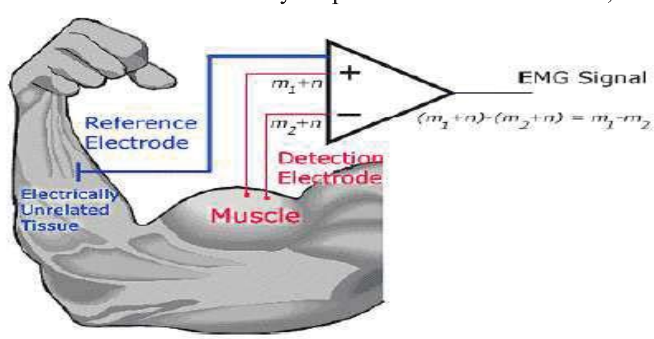


Figure 1: EMG differential amplifier configuration. The EMG is represented by m and the noise signal by n.

In this paper we propose a method of Improving EMG rejection ratio to eliminate the noise with the help of windowing functions while we are processing the EMG signal of paralytic patients during different activities of finger movement.

II. DATA COLLECTION

Ten subjects, eight male and two female, age between 40 and 65 years were enrolled to carry out the required finger movements. The individuals were all paralytic Sufferers with one side nerve or muscle problems. Subjects were relaxing on bed, with their arm reinforced and glued at one position to avoid the effect of different limb positions on the produced EMG signals [19]. The EMG information was gathered using one EMG programs (Delsys DE 2.x sequence EMG sensors) and prepared by the Bagnoli computer EMG Techniques from Delsys Inc. A 2-slot sticky skin interface was put on each of the sensors to strongly keep the sensors to the skin. A conductive sticky reference electrode has been used on the hand of each patient. The position of these electrodes are shown in Fig. 2. The EMG signal collected from the electrodes has been amplified using a Delsys Bagnoli-8 amplifier to a gain of 1000. A 12-bit analog-to-digital converter BNC-2090 has been used to sample the signal at sampling frequency 4000 Hz. The signal data has been acquired using Delsys EMG Works acquisition software. The EMG signal has been filtered by band pass filter having cut off frequency between 20 and 450 Hz with a notch filter used to remove the 50 Hz range disturbance.

Figure 2a Position of First Electrode

Figure 2b Position of Second Electrode

Ten classes of individual and combined fingers movements were implemented including: the flexion of of the individual fingers, i.e., Thumb (T), Index (I), Middle (M), Ring (R), Little (L) and the pinching of combined Thumb–Index (T–I), Thumb–Middle (T– M), Thumb–Ring (T–R), Thumb–Little (T–L), and finally the hand close (HC) as shown in Fig. 3.

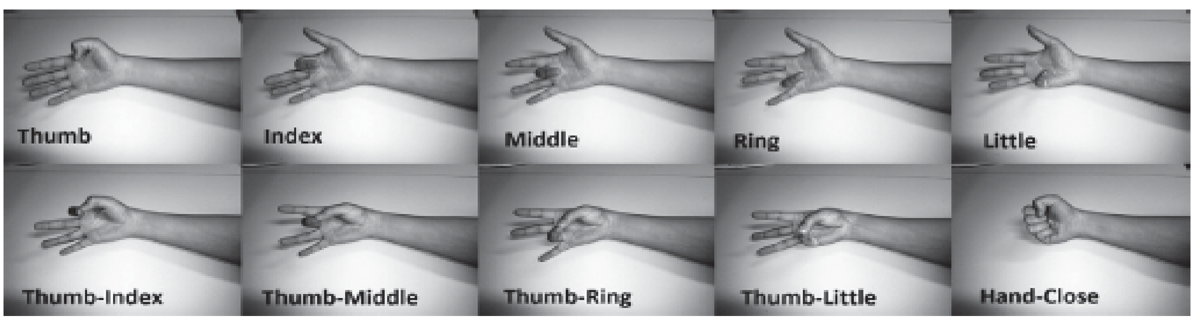


Figure.3 Different Movement Classes

III. SYSTEM MODEL

Algorithm 1

A. Add additive white Gaussian noise AWGN to clean EMG.
B. Remove DC offset and rectify the signal.
C. Use 3^{rd} order FIR low pass Butterworth filter.
D. Apply FFT technique to find the Fourier transform of noisy EMG signal.
E. Calculate average power of noisy Filtered EMG signal.
F. Calculate Signal to noise ratio by mean (noisyEMG.^2)/ mean (noise.^2).
G. Calculate EMG rejection ratio by sum (cleanEMG.^2)/sum (noisyEMG.^2).

Flow Chart

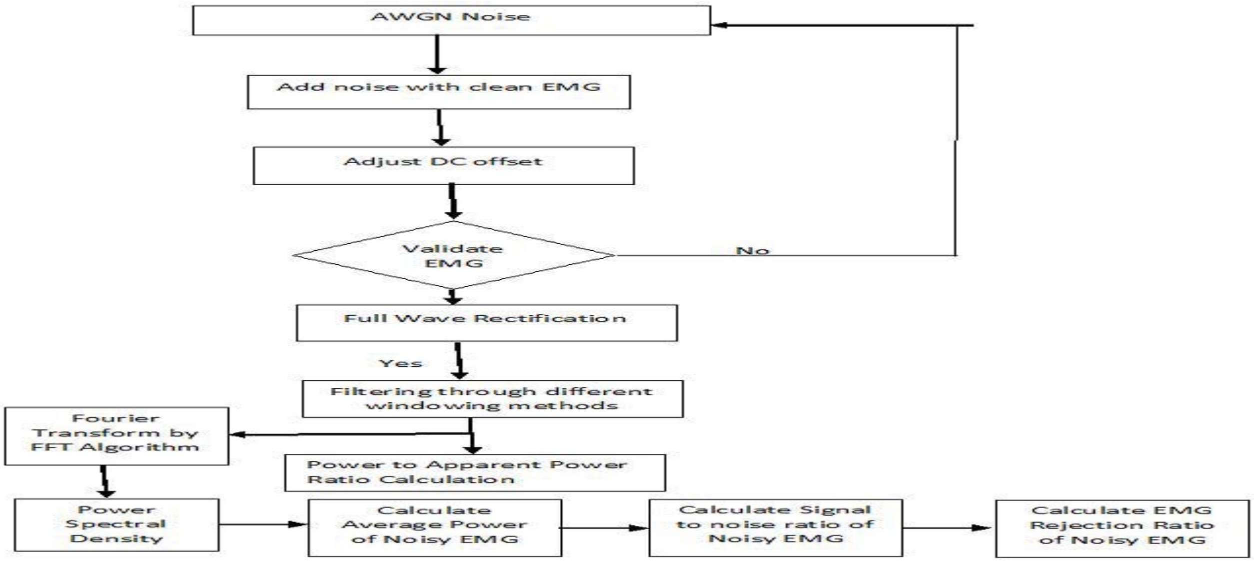


Fig. 4 Flow chart representation of algorithm 1

Algorithm 2

A. Apply different windowing methods like hamming window, hanning window and rectangular window on noisy EMG signal for filtering.
B. Apply FFT method for power spectral density of windowing EMG signal.
C. Calculate average power and signal to noise ratio and EMG rejection ratio for windowing EMG signal.
D. Compare the parameters for different windowing EMG signals and find the best suitable window for processing of EMG signal.

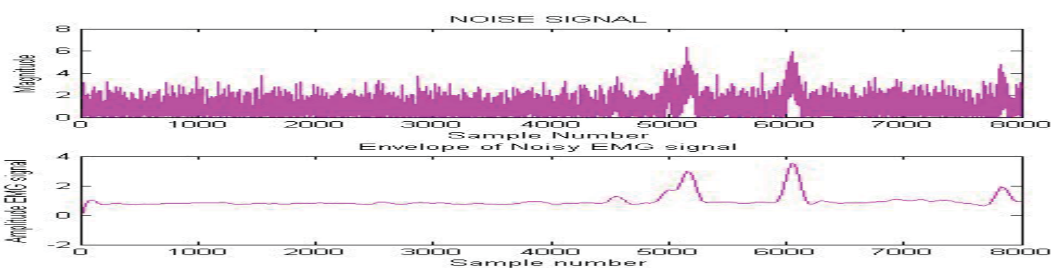
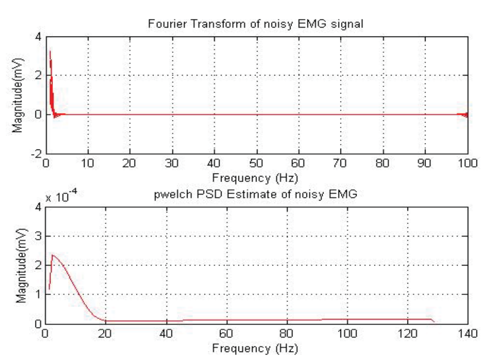


Fig. 5 Representation of noisy signal and its envelope



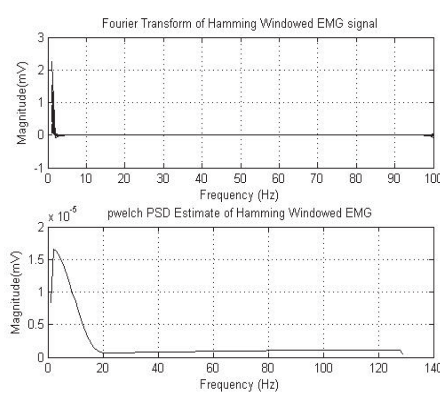


Fig.6 Fourier transform and power spectral density of noisy EMG

Fig.7 Fourier transform and power spectral density of hamming windowed EMG

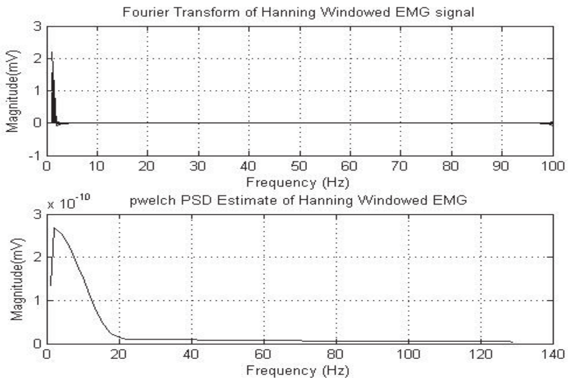


Fig.8 Fourier transform and power spectral density of hanning windowed EMG

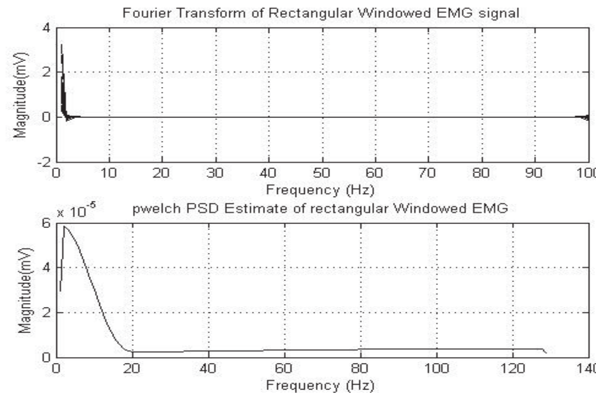


Fig.9 Fourier transform and power spectral density of rectangular windowed EMG

Real time result

Table 1 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing hand closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0753	-3.9737	-3.9675	-4.0504	-4.0452	-4.0842	-4.0303	-3.9716	-3.9517	-4.0056
EMG RR HANNIING WINDOW	-4.3333	-4.2245	-4.2174	-4.2998	-4.2989	-4.3405	-4.2835	-4.2218	-4.2008	-4.257
EMG RR RECTANGULAR WINDOW	-1.1312	-1.0701	-1.0674	-1.1282	-1.1127	-1.1453	-1.1181	-1.0934	-1.0854	-1.11

Fig.10 EMG rejection ratio comparison for different windows during hand closed

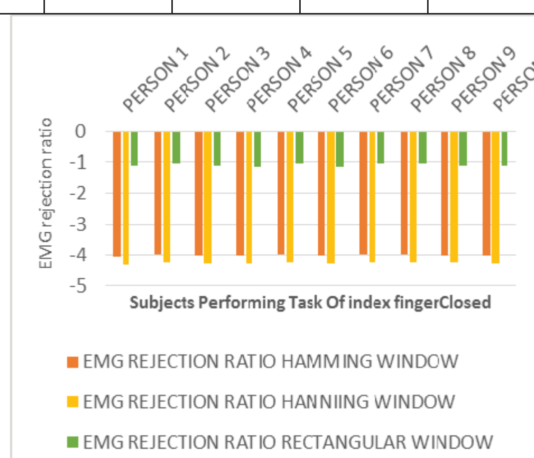


Fig. 11 EMG rejection ratio comparison for different windows during index finger closed

Table 2 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing index finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0452	-3.9737	-4.0218	-4.03	-3.9803	-4.0106	-3.9737	-3.9737	-4.0058	-4.0212
EMG RR HANNIING WINDOW	-4.2989	-4.2245	-4.2756	-4.2822	-4.2313	-4.2618	-4.2245	-4.2245	-4.2568	-4.2747
EMG RR RECTANGULAR WINDOW	-1.1127	-1.0701	-1.1019	-1.1272	-1.055	-1.1219	-1.0701	-1.0701	-1.0815	-1.0877

Table 3 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing little finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-3.999	-3.9675	-3.9761	-3.9761	-3.9308	-3.9308	-3.9675	-3.9675	-4.0419	-4.0488
EMG RR HANNIING WINDOW	-4.2498	-4.2174	-4.2258	-4.2258	-4.1753	-4.1753	-4.2174	-4.2174	-4.2987	-4.3011
EMG RR RECTANGULAR WINDOW	-1.1301	-1.0674	-1.0747	-1.0747	-1.1002	-1.1002	-1.0674	-1.0674	-1.0898	-1.1239

Fig. 12 EMG rejection ratio comparison for different windows during during little finger closed

Fig. 13 EMG rejection ratio comparison for different windows middle finger closed

Table 4 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing middle finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0303	-3.9802	-4.0452	-3.2526	-4.0504	-4.056	-4.0753	-3.9802	-3.9737	-4.0093
EMG RR HANNIING WINDOW	-4.2835	-4.2287	-4.2989	-4.2676	-4.2998	-4.3107	-4.3333	-4.2287	-4.2245	-4.2611
EMG RR RECTANGULAR WINDOW	-1.1181	-1.0811	-1.1127	-1.1099	-1.1282	-1.1323	-1.1312	-1.0811	-1.0701	-1.0934

Table 5 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing ring finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0902	-3.9716	-4.0842	-3.9491	-4.0902	-4.0483	-3.9737	-3.9716	-3.9675	-3.9849
EMG RR HANNIING WINDOW	-4.3475	-4.2218	-4.3405	-4.1944	-4.3475	-4.302	-4.2245	-4.2218	-4.2174	-4.234
EMG RR RECTANGULAR WINDOW	-1.1307	-1.0934	-1.1453	-1.0956	-1.1307	-1.1444	-1.0701	-1.0934	-1.0674	-1.1019

Fig.14 EMG rejection ratio comparison for different windows during ring finger closed

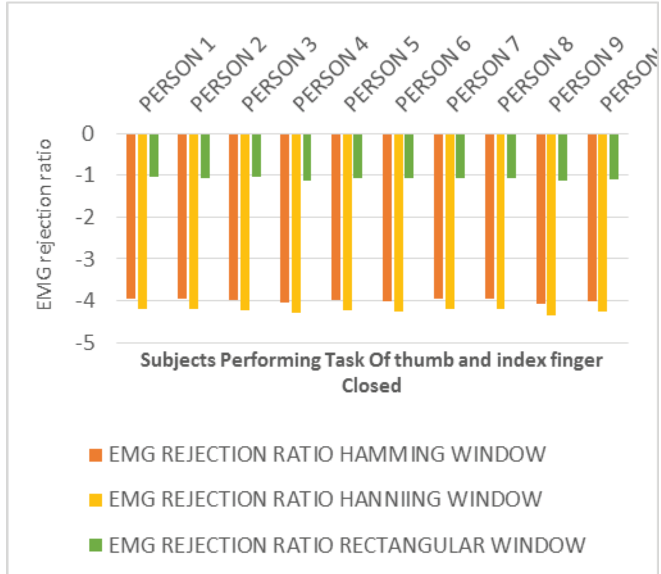


Fig.15 EMG rejection ratio comparison for different windows during thumb and index closed

Table 6 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing thumb and index finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-3.9556	-3.9517	-3.9803	-4.0389	-3.9675	-4.0058	-3.9517	-3.9517	-4.0753	-4.0049
EMG RR HANNIING WINDOW	-4.2043	-4.2008	-4.2313	-4.289	-4.2174	-4.2568	-4.2008	-4.2008	-4.3333	-4.2569
EMG RR RECTANGULAR WINDOW	-1.0551	-1.0854	-1.055	-1.1434	-1.0674	-1.0815	-1.0854	-1.0854	-1.1312	-1.104

Table 7 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing thumb and little finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-3.999	-4.0056	-3.9308	-4.0086	-3.9802	-4.0419	-4.0056	-4.0419	-3.9737	-4.0784
EMG RR HANNIING	-4.2498	-4.257	-4.1753	-4.2624	-4.2287	-4.2987	-4.257	-4.2364	-4.2245	-4.3352

WINDOW										
EMG RR RECTANGULAR WINDOW	-1.1301	-1.11	-1.1002	-1.1238	-1.0811	-1.0898	-1.11	-1.0898	-1.0701	-1.1221

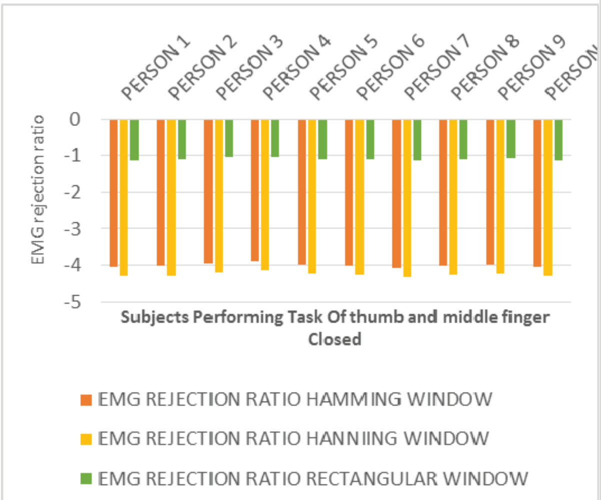


Fig.16 EMG rejection ratio comparison for different windows during thumb and little finger closed

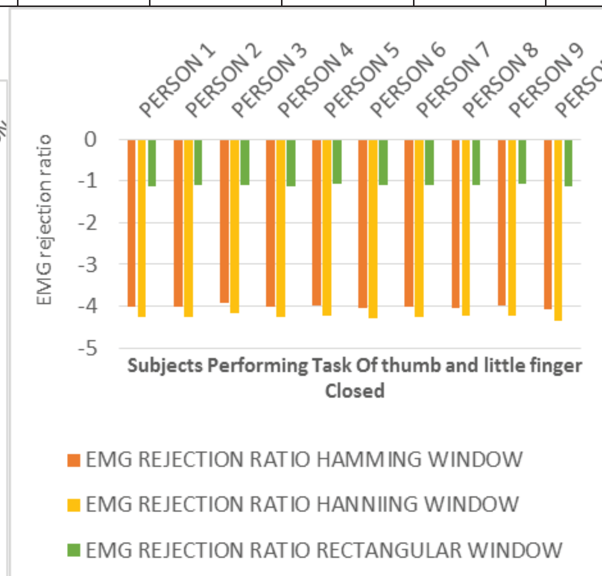


Fig.17 EMG rejection ratio comparison for different windows during thumb and middle finger closed

Table 8 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing thumb and middle finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.035	-4.02	-3.9556	-3.8878	-3.9716	-4.007	-4.063	-4.007	-3.9761	-4.0504
EMG RR HANNIING WINDOW	-4.2865	-4.2756	-4.2043	-4.131	-4.2218	-4.2554	-4.3198	-4.2554	-4.2258	-4.2998
EMG RR RECTANGULAR WINDOW	-1.1228	-1.1019	-1.0551	-1.0459	-1.0934	-1.1114	-1.1205	-1.1114	-1.0747	-1.1282

Table 9 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing thumb and ring finger closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0814	-4.03	-3.9361	-3.9999	-3.9517	-4.0212	-4.0902	-4.0212	-4.056	-3.9803
EMG RR HANNIING WINDOW	-4.3372	-4.2821	-4.1827	-4.252	-4.2008	-4.2747	-4.3475	-4.2747	-4.3107	-4.2313
EMG RR RECTANGULAR WINDOW	-1.138	-1.1272	-1.0794	-1.0978	-1.0854	-1.0877	-1.1307	-1.0877	-1.1323	-1.055

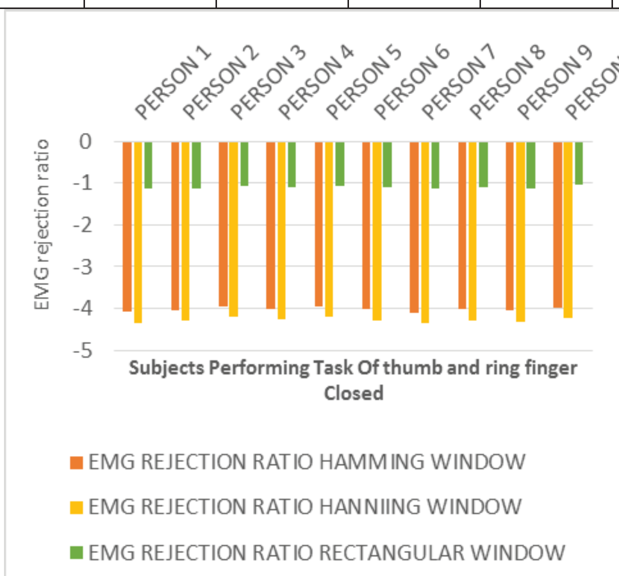


Fig.18 EMG rejection ratio comparison for different windows during thumb and ring finger closed

Fig.19 EMG rejection ratio comparison for different windows during thumb closed

Table 10 EMG rejection ratio for Hamming, Hanning and Rectangular Window during performing thumb closed activity

	PERSON 1	PERSON 2	PERSON 3	PERSON 4	PERSON 5	PERSON 6	PERSON 7	PERSON 8	PERSON 9	PERSON 10
EMG RR HAMMING WINDOW	-4.0338	-4.0389	-4.0006	-3.943	-4.0056	-4.0488	-4.0753	-4.0488	-4.0483	-3.9761
EMG RR HANNIING	-4.2858	-4.294	-4.2535	-4.1892	-4.257	-4.3011	-4.3333	-4.3011	-4.302	-4.2258

WINDOW										
EMG RR RECTANGULAR WINDOW	-1.1148	-1.1073	-1.1077	-1.0652	-1.11	-1.1239	-1.1312	-1.1239	-1.1444	-1.0747

IV. ANALYSIS

From the analysis of results it has been observed that the magnitude of EMGRR is very low when the noisy EMG signal has been processed by rectangular windowing function. The parameter EMGRR has value approximately unity in case of rectangular window, while for hamming and hanning window it goes up to 4.

So from the analysis it has been concluded that using rectangular window minimum EMG rejection ratio can be achieved.

V. CONCLUSION

In this paper, here a comparison of EMG rejection ratio in hamming, hanning and rectangular window has been shown during various finger movement activities by paralytic patients. From our result studies, we observe that the proposed method is highly effective & efficient.

REFERENCES

[1] M. B. I. Reaz, M. S. Hussain, and F. Mohd-Yasin, "Techniques of EMG signal analysis: detection, processing, classification and applications," Biological procedures online, vol. 8, no. 1, pp. 11-35, 2006.

[2] Basmajian JV, De Luca CJ (1985) Muscles Alive. Their Function Revealed by Electromyography. Williams & Wilkens, Baltimore.

[3] Gerdle B, Karlsson S, Day S, Djupsjöbacka M (1999) Acquisition, Processing and Analysis of the Surface Electromyogram. Modern Techniques in Neuroscience. Chapter 26: 705-755. Eds: Windhorst U and Johansson H. Springer Verlag, Berlin.

[4] Freriks B and Hermens H (2000) European Recommendations for Surface Electromyography, Results of the SENIAM Project (CD-ROM). Roessingh Research and Development, the Netherlands

[5] Dario Farina, Corrado Cescon and Roberto Merletti. Influence of anatomical, physical, and detection-system parameters on surface EMG, Biol. Cybern., 86, pp.445-456. 2002.

[6] M.Solomonow, R.Baratta, M.Bernardi, B.Zhou, Y.Lu, M.Zhu and S.Acierno. Surface and wire EMG crosstalk in neighbouring muscles, Journal of Electromyography and Kinesiology, 4, pp.131-142. 1994.

[7] David H. Sutherland. The evolution of clinical gait analysis part l: kinesiological EMG, Gait & Posture, 14(1), pp. 61-70. 2001.

[8] G. Hefftner, W. Zucchini, G.G. Jaros. The electromyogram (EMG) as a control signal for functional neuromuscular stimulation - Autoregressive modeling as a means of EMG signature discrimination, IEEE Transactions on Biomedical Engineering, 35(4), pp. 230-237. 1988.

[9] Jacob Rosen, Moshe Brand, Moshe B.Fuchs and Mircea Arcan. A Myosignalbased powered exoskeleton system, IEEE Transact ions on systems, man and cybernetics-Part A: Systems and humans, 31(3), pp. 210-222. 2001.

[10] Cram JR, Kasman GS, Holtz J. Introduction to Surface Electromyography. Aspen Publishers Inc.; Gaithersburg, Maryland, 1998.

[11] Shahid S. Higher Order Statistics Techniques Applied to EMG Signal Analysis and Characterization. Ph.D. thesis, University of Limerick; Ireland, 2004.

[12] Nikias CL, Raghuveer MR. Bispectrum estimation: A digital signal processing framework. IEEE Proceedings on Communications and Radar 1987; 75(7):869-891.

[13] Kleissen RFM, Buurke JH, Harlaar J, Zilvold G. Electromyography in the biomechanical analysis of human movement and its clinical application. Gait Posture 1998; 8(2):143-158.

[14] Cram JR, Kasman GS, Holtz J. Introduction to Surface Electromyography. Aspen Publishers Inc.; Gaithersburg, Maryland, 1998.

[15] Reaz MB, Hussain MS, Mohd-Yasin F. Techniques of EMG signal analysis: detection, processing, classification and applications. Bio proceed Online. 2006; 8(1):11–35. doi: 10.1251/bpo115.

[16] W. H. Olson, "Basic concepts of medical instrumentation," in Medical Instrumentation Application and Design, J. G. Webster, Ed., 2nd ed. Boston, MA: Houghton Miffin, 1992. pp. 1–55.

[17] W. J. Tompkins, "Electrocardiography," in Biomedical Digital Signal Processing: C-Language Examples and Laboratory Experiments for the IBM PC, W. J. Tompkins, Ed., Englewood Cliffs, NJ: Prentice- Hall, 1993.

[18] V. Cherkassky and S. Kilts, "Myopotential de-noising of ECG signals using wavelet thresholding methods," Neural Networks, vol. 14, no. 8, pp. 1129–1137, 2001.
[19] Scheme, E., Founger, A., Stavdahl, O., Chan, A. D. C., & Englehart, K. (2010). Examining the adverse effect of limb position on pattern recognition based myoelectric control. In Proceedings of the 32nd annual international conference of the IEEE EMBS (pp. 6337–6340).