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Surface Electromyography (SEMG) Based Fuzzy Logic Controller For Footballer Based Actions Classification

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Abstract - *In this investigation diverse modules were assemble which perceive distinctive arranged activities and utilize them to control any machine. This work proposed an arrangement of dorsal flexion, augmentation and no activity of foot utilizing fuzzy logic technique. Surface electromyography signals (SEMG) were separated utilizing equipment comprising of differential speaker, non inverting enhancer, band pass channel and interface module. SEMG signals were obtained from Gastrocnemius literalis muscle in charge of these activities. MATLAB softscope was utilized to import signals from equipment to framework. Fluffy Logic Controller was utilized to order foot activities. For better grouping, three parameters, root mean square, middle and standard deviation were chosen as contributions to fluffy rationale controller. Results demonstrated that out of every one of the three parameters, standard deviation was turned out to be the best parameter for segregating activities..*

Key Words: Semg ; Footballer Actions ; Fuzzy logic controller; Gastrocnemius literalis muscle

1.INTRODUCTION

Electromyography (EMG) is an exploratory method worried about the advancement, recording and examination of myoelectric signals. Myoelectric signals are framed by physiological varieties in the condition of muscle fiber layers.Other than essential physiological and biomechanical considers, kinesiological EMG is built up as an assessment device for connected research, physiotherapy/restoration, sports preparing and communications of the human body to mechanical items and work conditions.EMG has additionally its utilization in recovery of amputee patients and automated prosthesis. EMG has demonstrated its significant component as it faculties in an extremely common manner and order diverse activities of the body on a multi-level of opportunity mechanical instrument which can successfully copy the movement of the human appendage. With cutting edge examines in gadgets and microcontroller innovations new enhanced control alternatives for automated systems are accessible. A standout amongst the most favorable microchipinnovations if there should arise an occurrence of mechanical prosthetics is the propelled EMG sifting calculations. Today, a large portion of the control choices are accessible which is time based for consummate prosthesis administration. Creating EMG flag is insufficient for controlling any component, sifting and enhancement of such produced signals is must. Hunting down better intensification and separating circuit outline for catching the elements of surface. EMG flags precisely is as yet a test. Our inquiry concentrated on little size intensification and sifting circuit plan so little measured speakers and channels can be settled inside an automated hand with restricted space. This will procedure surface EMG signals from muscles and summon to control the robot hand activity. There are different sorts of terminals accessible in the market which can be utilized to gain EMG signals from human body.

1.1 Fuzzification

Fuzzy logic is a form of multi valued logic derived from fuzzy set theory to deal with reasoning that is robust and approximate rather than brittle and exact. In contrast with "crisp logic", where binary sets have two-valued logic, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions.Fuzzy approach involved the concept without clearly defined boundaries. Linguistic statements express subjective ideas which can be interpreted using individuals involving fuzzy prepositions. Most natural language is fuzzy. The truth value assigned to fuzzy approach can be any value on the interval (0, 1). The assignment of these values is actually a mapping from this specified interval to the universe of truth values.

1.2 Defuzzification

The resulting fuzzy set must be converted to a number that can be sent to the process as a control signal. This operation is defuzzification and resulting fuzzy set is then defuzzified into a crisp control signal. There are several defuzzification methods:

1. Mean of Maxima (MOM).
2. Centroid of Area (COA).

2. EXPERIMENTAL SETUP

The system used for acquiring SEMG signal is called SEMG signal acquisition system. The design and implementation of experimental setup is explained using Figure.1

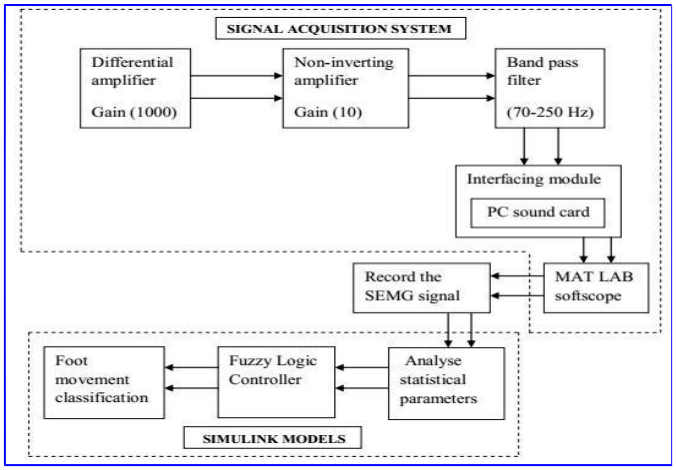

Figure -1: Experimental Setup Block Diagram

Point of this present work is to arrange of foot activities which can generally be utilized as a part of human-PC communication based applications. This set up comprises of enhancers, channels, interface module lastly fluffy rationale usage. Three Ag-Ag-Cl sort anodes were masterminded in an equilateral triangle way to decrease the odds of shortcircuiting among electrodes. Electrodes were stuck on a bit of little PCB having 1 inch remove among every cathode. To evacuate the intrinsic precariousness of EMG flag, terminals are put solidly utilizing a strap around the Gastrocnemius literalis muscle of lower appendage as appeared in Figure 2.

Figure -2 : Firm Placement Placement On leg

The plentifulness of EMG flag was little around about in the scope of smaller scale volt to milli volt (0-6 mv crest to crest or 0-1.5 Vrms). The nature of flag relies on the sort of speakers used to get the flag. Because of the feeble sufficiency of flag, the pick up of speakers should be in the scope of 1000-10000. In this investigation, differential intensifier was outlined with a legitimate pick up of 1000 and non altering speaker was composed with pick up of 10. Both were consolidated in a solitary enhancer circuit . EMG flag was all around acknowledged to be in the scope of 20Hz-300Hz. Along these lines, there was a need of band pass channel to build the flag to-commotion proportion. Moreover, sifting area was planned utilizing a band pass crest channel utilizing the same LM124. Band pass channel permit the signs of a particular scope of recurrence to pass and square alternate signs. Band pass was composed with a predetermined scope of 70Hz- 250Hz. It implies band pass channel would pass SEMG signs of this predetermined range as it were. Besides, outlining of pre enhancement and separating circuit was finished utilizing a solitary chip of fourfold operational intensifier LM124. Fourfold operational intensifier LM124 has four Op-Amps inbuilt.The next step was to record SEMG signal on MATLAB-Softscope. This can be explained using flow chart shown in Figure 3.

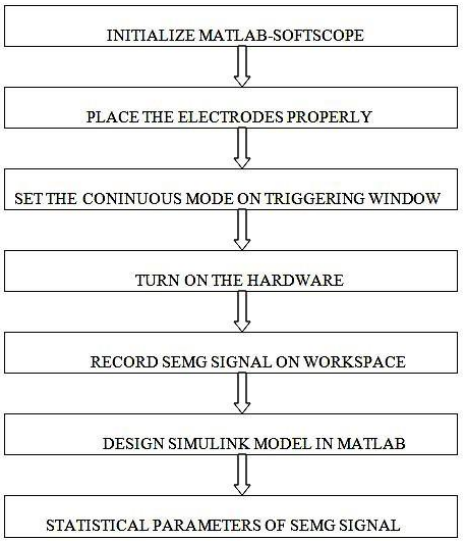

Figure -3 : Flow chart of parameter calculation

Three healthy males were selected as subjects to record SEMG signal with a sampling rate of 8000 Hz. The softscope was initialized with continuous mode on triggering window. Turning on the complete hardware circuit and triggering, SEMG signal was recorded on workspace using export function and stored under a specific name. By designing Simulink model, three statistical parameters i.e. root mean square (Rms); median (Median) and standard deviation (Std. Dev.) were calculated for specified three actions of foot . For designing

Simulink model, MAT LAB defined functions for Rms, Median and Std. Dev. were used.

3. RESULTS

In order to classify single channel SEMG for up, down and no actions, the acquired SEMG signal was stored in the MATLAB workspace under the names up l, up 2, up 3 for up actions and similarly dw 1, dw 2, dw 3 for down action and no1, no2, no3 for no actions as shown in Figure 6.1 and 6.2. Three selected statistical measures root mean square (Rms), standard deviation (Std. Dev.) and Median were used for analysis and classification of acquired SEMG signal.

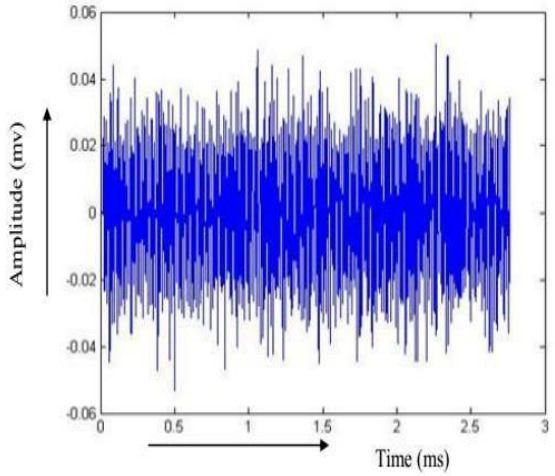

Figure -4: Acquired Signal for High Kick Signal

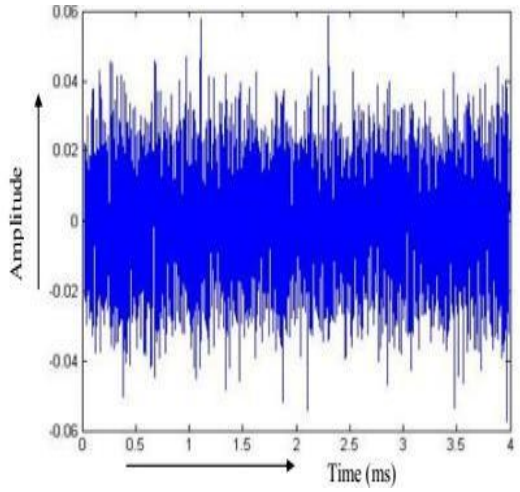

Figure -5 : Acquired Signal for Low Kick Signal

Table -1: Formulas Used

Sr. No.	Name of the parameter used	Formula	Unit
1	Root mean square (Rms)	$x_{rms} = \sqrt{\frac{x_1^2+x_2^2+....+x_n^2}{n}}$	Same as data set x_n
2	Standard deviation (Std. Dev.)	$\sigma = \sqrt{(x-\mu)^2/n}$	Same as data set
3	Median	$N+1/2$	Same as data set N

Three healthy subjects were used for acquiring SEMG signal .After that signal was filtered using band pass filter. Then all the three selected statistical measures were calculated by using mathematical formula for each parameter by using simulink model as shown in Figure 6.3. In this model first block was used to acquire SEMG signal stored in workspace and then this signal was filtered by using a filter.

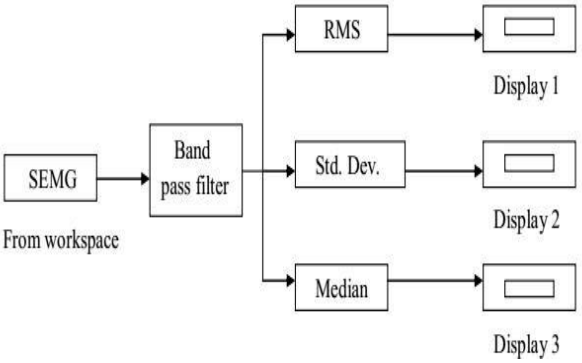

Figure -6: Simulink model for calculating statistical parameters.

After filtration, statistical parameters were calculated and numeric output was displayed on the display scope. Then three tables were created after calculating the values of all three parameters i.e. root mean square (Rms), standard deviation (Std. Dev.) and Median of filtered SEMG signals for all three actions i.e. no action, Kick (Low) action and for Kick (High) action. Table 2 showed three calculated parameters i.e. root mean square (Rms), standard deviation (Std. Dev.) and Median for no foot action.

Table -2: Calculated parameters for no action

Parameters	Subjects		
	S1	S2	S3
Rms	0.021243	0.010618	0.024662
Median	0.101	0.1028	0.117
Std. Dev.	0.002	0.005570	0.0031632

Table 3 showed three calculated parameters i.e. root mean square (Rms), standard deviation (Std. Dev.) and Median for Kick (Low) action. And Table 4 showed three calculated parameters i.e. root mean square (Rms), Standard Deviation (Std. Dev.) and Median for Kick (High) action. After this calculation, another simulink model was designed in MATLAB with 3:1 MUX for providing these parametric values as inputs to Fuzzy Logic Controller.

Table -3: Calculated parameters for Kick (low) action

Parameters	Subjects		
	S1	S2	S3
Rms	0.09183	0.14881	0.26160
Median	0.511	0.512	0.513
Std. Dev.	0.3311	0.24351	0.4080

Table -4: Calculated parameters for Kick(low) action

Paramaters	Subjects		
	S1	S2	S3
Rms	0.096	0.16263	0.23341
Median	0.907	0.921	0.916
Std. Dev.	0.008123	0.76003	0.00710

3.2 Graphical results using parameters

After calculating parameters for all three subjects for each action, graphs were plotted as shown in Chart 1 , 2 and 3. Here Figure 6.4 shows graphical representation of no action for all three subjects.

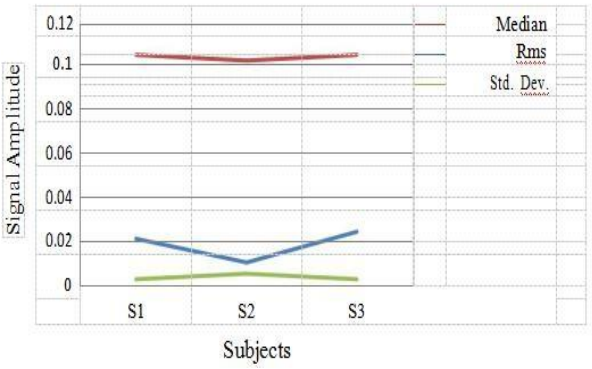

Chart -1: Graphical representations of parameters for no action.

This representation was showing discrimination among subjects for one particular action i.e. no action. It was clear from graph that for no action, Median i.e middle value of ordered set of SEMG signal was 0.101 for S1, 0.1028 for S2 and 0.117 for S3. The Rms parameter was varying from 0.02 for S1 to 0.01 for S2 and from 0.01 to 0.02 for S3 where as Std. Dev. was varying from 0.003 for S1 to 0.005 for S2 and from 0.005 to 0.003 for S3. Here Rms is showing maximum discrimination for S1 and S2 i.e. 0.08 and for S2 and S3, it is 0.014. But for S1 and S3, Median is showing best discrimination. So this representation showed that Rms parameter discriminating subjects better than all three for one particular action.

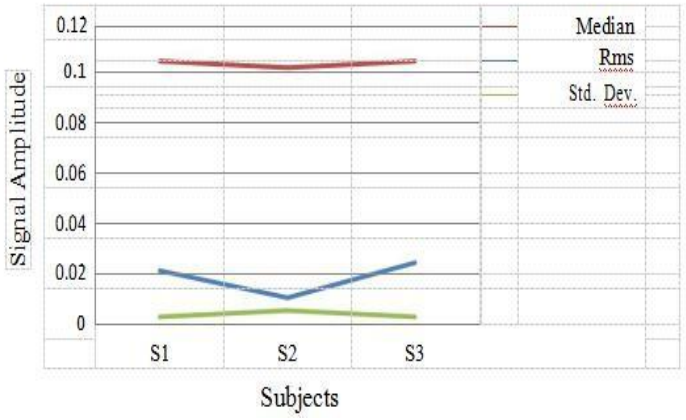

Chart -2 : Graphical representations of parameters for Kick (Low) action.

Chart 2 shows graphical representation of parameters for all three subjects for Kick (Low) action only. This representation was showing discrimination among subjects for one particular action i.e. Kick (Low) action. It was clear from graph that for Kick (Low) action, Median i.e middle value of ordered set of SEMG signal was 0.513 for S1, 0.511 for S2 and 0.512 for S3. The Rms parameter was varying from 0.091 for S1 to 0.16 for S2 and from 0.16 to 0.233 for S3 where as Std. Dev. was varying from 0.33 for S1 to 0.24 for S2 and from 0.24 to 0.040 for S3. As SEMG signal varies from person to person, the calculated parameter should also show discrimination among subjects for one particular action. Here in Rms parameter, discriminating factor between S1 and S2 was only 0.06 where as in Std. Dev., it was 0.09. Same was the case between S2 and S3. In Rms parameter, discriminating factor between S2 and S3 was only 0.12 where as in Std. Dev, it was 0.20. Same is the case for S1 and S3. So this representation cleared that Std. Dev. parameter showed maximum discrimination among subjects for one particular action.

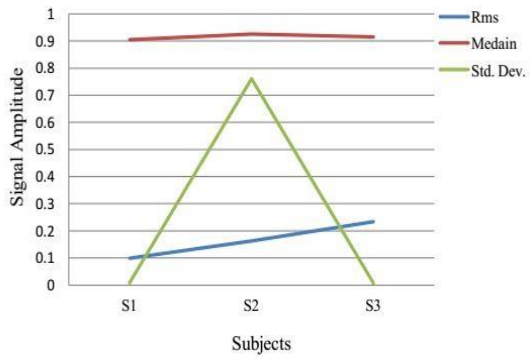

Chart -3: Graphical representations of parameters for Kick (High) action.

Chart 3 shows graphical representation of parameters for all three subjects for Kick (High) action only. This representation was showing discrimination among subjects for one particular action i.e. Kick (High) action. It was clear from graph that for Kick (High) action, Median i.e middle value of ordered set of SEMG signal was 0.907 for S1, 0.921 for S2 and 0.916 for S3. The Rms parameter was varying from 0.091 for S1 to 0.14 for S2 and from 0.14 to 0.26 for S3 where as Std. Dev. was varying from 0.008 for S1 to 0.76 for S2 and from 0.76 to 0.007 for S3. As SEMG signal varies from person to person, the calculated parameter should also show discrimination among subjects for one particular action. Here in Rms parameter, discriminating factor between S1 and S2 was only 0.07 where as in Std. Dev., it was 0.75. Same was the case between S2 and S3. In Rms parameter, discriminating factor between S2 and S3 was only 0.071 where as in Std. Dev, it was 0.75. Moreover, for S1 and S3, Rms showed maximum discrimination i.e. 0.13 as compare to other parameters. So overall, this representation showed Std. Dev. with maximum discrimination among subjects.But our objective is not to show discrimination among subjects based on parameters. Our main objective is to classify foot actions. So for that, all parameters need to be compared combinedly for all three actions to have best parameter for discrimination among actions this can be done by calculating parametric range for all three subjects combinedly for all three actions.

Table -5: Parametric ranges of all three parameters for all three actions.

Actions	Ranges		
	Rms	Median	Std. Dev.
No SEMG	0.01768	0.2	0.004365
Kick (Low)	0.040509	0.225	0.160105
Kick (High)	0.056619	0.35	0.433565

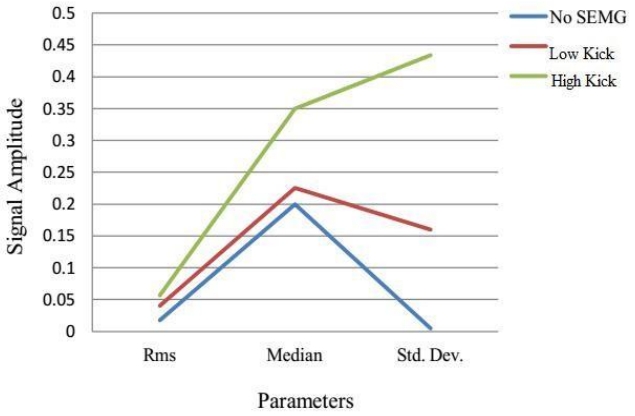

Chart -4: Graphical representations of parameters for low kick, high kick and no actions.

After calculating all three parameters for all subjects, these parameters were taken as input variables for Fuzzy Logic Controller. Figure 7 was showing simulink model with fuzzy logic technique. The SEMG based fuzzy logic controller was the main part of the thesis work. The first block will work as SEMG signal was taken from workspace. Then SEMG signal was filtered through band pass filter. After that statistical parameters were calculated. These inputs were multiplexed by using 3:1 MUX. Then after fuzzifying these paramaters in the Fuzzy

Logic Controller by implementing the rule set made for different foot actions, fuzzy outputs were displayed on display scope.

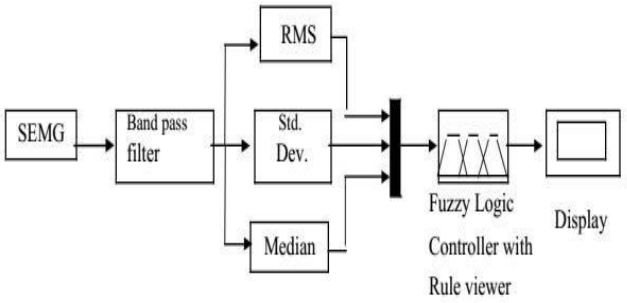

Figure -7 Simulink model with Fuzzy Logic Technique.

Table -6: Fuzzy controller outputs

Actions	Subjects		
	S1	S2	S3
No SEMG	0.03	0.015	0.03
Kick (Low)	0.08	0.19	0.27
Kick (High)	0.18	0.28	0.41

Table 6 was created to obtain fuzzy output values for different actions. The algorithm for fuzzification was developed for the analysis of precise foot actions using fuzzification technique.

Table -7: Percentage difference among all actions at each parameter

Parameters	Percentage difference		
	No SEMG and Kick (Low)	No SEMG and Kick (High)	Kick (Low) and Kick (High)
Rms	39%	52%	16%
Median	6%	27%	21%
Std. Dev.	94%	97%	46%

Now for more precise movement classification, these calculated statistical parameters were given to Fuzzy Logic Controller as inputs.

Table- 8: Average percentage difference among all actions

Actions	Average difference (mv)	Average percentage difference
No-SEMG and low kick	0.12	75%
No-SEMG andhigh kick	0.43	90%
Low & High Kick	0.31	53%

4. CONCLUSIONS

Out of Root mean square (Rms), Standard deviation (Std. Dev.) and Median; Standard deviation was proved to be the best parameter for classifying foot actions. Standard deviation discriminates no movement and Kick (Low) movement with 94% average difference between both actions. No movement and Kick (High)actions were discriminated with 97% average difference. Kick (Low) and Kick (High) were discriminated with only 46% average difference. Fuzzy Logic Controller discriminates all three actions with successful precision.Fuzzy Logic Controller discriminates no movement and Kick (Low) movement with 75% average difference. Fuzzy Logic Controller discriminates no movement and Kick (Low) movement with 75% average difference.No movement and Kick (High)actions were discriminated with 90% average difference.Kick (Low) and Kick (High) were discriminated with only 53% average difference.For maximum amplitude of signal, electrodes were placed one-third of the line joining innervation zone and tendinous insertion. 20.4 ± 5.1 % is the innervation zone position along the reference line

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