Assistive Limbs: Using MYO Armband

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ABSTRACT

The Assistive Limbs for amputees are becoming an important issue in the last few years.
This Paper intends to provide a solution for people who lost their arm to make them interact in real-time with their surrounding environment.
The Proposed system uses MYO armband to retrieve the (EMG) signals, location and acceleration of the arm movements for amputees. The Signals go through different phases. They are filtered from noise then extract Features from them with RMS algorithm. The next step is for classification the system uses CNN & SVM. The system starts by 10 movements and will increase. The main aim of proposed system is to add any new movements to the system and increase the accuracy more than 80%.

Author Keywords

MYO armband device
Electro myograph signals (EMG).
Convolutional neural network (CNN), support vector machine (SVM),
feature extraction by root mean square (RMS).
LinearDiscriminantAnalysis (LDA).

INTRODUCTION

Millions of people lost their limbs yearly in whole world in cause of accidents and diseases like diabetes, cancer …etc.
According to a newspaper in Indonesia, one of biggest public hospitals in Jakarta named Rumah Sakit Cipto Mangunkusumo (RSCM) has statistical data about 35 percent of diabetics that end with amputation. There are nearly 2 million people living with limb loss in the United States [1]. Approximately 185,000 amputations occur in the United States each year [2]. In 2009, hospital costs associated with amputation totaled more than 8.3 billion dollars [3]. Cyberdyne is a Japanese robotics and technology company most noted for the marketing and distribution of the HAL 5 robotic exoskeleton suit [6]. So, we decided to take challenge to help this people to feel normal again with an assistive limb. There are a lot of people will get benefit from arm so they won't feel that they are useless. We trying make their life more easy and smooth. Some of them got damaged EMG signals and it will be challenge to help them control the hand, but others can be detecting EMG signals. The system will recognize EMG Signals and analyses the signals with machine learning and make classification on it. Then it will use MYO device to send signals to the robotic arm. The Advantages of MYO: it's portable device, have 8 sensors, it helps a lot in real time.
The Disadvantages: the battery time.
But there is a challenge in that like the accuracy of the hand posture and detection to move in the real time.

RELATED WORK

Bebionic arm its programmable arm can perform 14 movements get accuracy up to 85% founded by Otto bock [4].It has individual motors for each finger and microprocessors to control each finger. It achieves 14 Movements. The cost of this arm about 11,000$.

Toward improved control of prosthetic fingers using surface electromyogram. Data is collected from 10 subjects
8 for training and 2 for testing. Classified by (KNN) and Extract features by (RMS). We use EMG signals like related works to detect the movement of arm. We aiming to improve the accuracy. [5]

Classification of hand opening/closing and fingers by using two channel surface EMG signals. In this paper they use only two channels of (sEMG) and apply it on hand open and close with fingers. They make experiments on 17 subject and get average of 94% classified fingers. [9]

A classification method of hand EMG signals based on principal component analysis and artificial neural network. In this paper, they use ANN algorithm to classify 8 hand movements. The paper result was 85.78% for training and 81.2% for testing. [10]

Hand and finger control of myo-prosthesis based on motion discriminator and voluntary control. In this paper, they use MYO Armband get extension and flexion movement on fingers. The paper works on 5 movements and the result of identification rate was 80%. [11]

Fully embedded myoelectric control for a wearable robotic hand orthosis. In this paper, they made combination between hardware and software using MYO. The system can classify only 5 gestures with accuracy 98%, but the online system can classify 3 gesture with 94%. The testing result was 78.8%. [12]

Electromygraphy (EMG) signal based hand gesture recognition using artificial neural network (ANN). In this paper, they use ANN for classification and use MAV, RMS and VAR for feature extraction. [13].

Self-Recalibrating Surface EMG Pattern Recognition for Neuroprosthesis Control Based on Convolutional Neural Network. In this paper, the system uses CNN Algorithm for classification and has 50 movements as Dataset. the Result was 78.71%.[14]

METHODOLOGY

The MYO armband got 8 channels can detect signals throw each channel for acceleration and orientation. After reading signals it will be filtered from noise and preprocessed to send it to firebase cloud. Firebase cloud sends the readings to processing unit to detect the movement and be classified and send the output generated to the cloud.
The classification system should mainly aim to provide accurate movements to help amputees achieving their daily life tasks easily. Cloud sends detailed signals and action for arm to render the movements by Unity3d.
If misclassification occurred the user sends feedback to the cloud. This Paper proposes Assistive Limbs: Using MYO Armband which is a system that performs detection and identification of users EMG signals using MYO armband device, the user will get an account when he/she downloads the application account to allow him uploading his dataset files which are CSV files to make it customizable, the user will be able to send feedback if the movements where wrong through log Files and he/she must also send his intent of the movement, the user can add new movements, then an alarm will be sent to the admin to check if the movement can be added so he will add it in the next update, if a new movement is add a notification will be sent to all users to make them update their application to the latest version as shown in Figure 1.

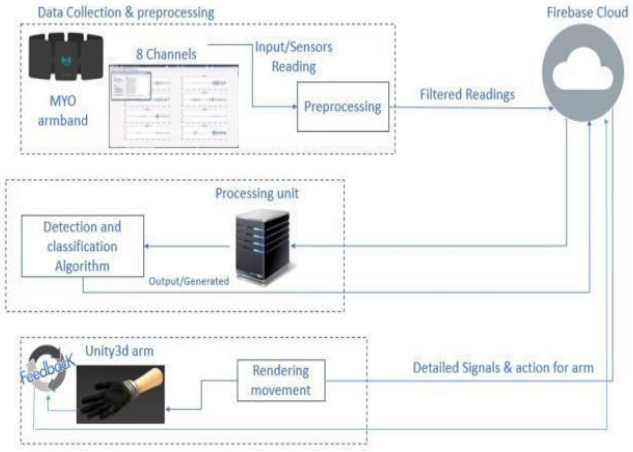

Figure 1: System Overview

PRE-PROCESSING

In this phase, In preprocessing, read the data and plot it then make noise

Removing on the raw data and plot it. Take the filtered data and detect onsets on it to can make segmentation by onsets. Take the filter data and segment

it by time windowing and make overlapping 50% then put segments on RMSE

Feature extraction to pass it to classifier.

Biosspy:

Biosspy is a library handles many kinds of bio-signals. The system uses this library to remove noise and detecting onsets of the filtered data. This

Library makes noise removing by skipping all the corrupted signals and normalizes it to represent it in straight line. Also, this library detects the onsets by make

Threshold (0.5) and (- 0.5) and the library also show the data after making all this functions by plotting.

FEATURE EXTRACTION

RMS : Root Mean Square

RMS is a Feature extraction algorithm. RMS used to get the main features

From our dataset to start working on it in the next phase.

In the case of a set of n values$\{X_1,X_2,X_3,\ldots\ldots,X_n\}$

$$\text{Xrms} = \sqrt{\frac{1}{n}(x1^2 + x2^2 + \cdots + xn^2}$$

$$f\text{rms} = \sqrt{\frac{1}{T2 - T1}\int_{T_1}^{T2}[f(t)]^2 dt}$$

$$f\text{rms} = \lim_{T\to\infty}\sqrt{\frac{1}{T}\int_{0}^{T}[f(t)]^2 dt}$$

RTM: REAL TIME MOINTERING

In This Phase, myo-python, in real-time processing the system first checks the connection between the MYO and the processing unit with the on connect port which connected to the CPU using blue-tooth device then the system collect the row EMG data from the MYO APIs which return the current reading of each sensor.

The listener class takes two parameters the first one is the port and the second one is the deviceListenerClass which contain on connect which returns true if the MYO is connected, on pair this method checks if the MYO device is warmed up and working probably, on unpair this method checks is the device is disconnected.

On EMG data this function returns the EMG. These are the methods used to connect with MYO for real-time processing the system read 50 array each array Contains 8 sensor values from each reading and waits for 2 seconds between each read, after the system collects data.

In real-time the system passes it for pre-processing the system apply root mean Square algorithm (RMS) after the value is returned the system then takes segments on for the RMS values returned then it_s sent to the classifier we have tried many of them CNN, SVM, KNN, FNN, we have found that SVM accuracy is acceptable and it has some convenient speed at run-time it has accuracy of 95 % after the classifier finishes the extracted model is sent to the unity3d render to render the arm with the intended Movement while the CNN has accuracy up to 98% but it takes much more time to calculate the movement which is not accepted.

CLASSIFICATION

SVM : Support vector machine

Support vector machine is a classification algorithm where a set of examples is collected and each one has a known class. As Shown in Figure [5], the algorithm divides the classes by line and put each value to his class. as for instance, it does not suffer Limitations of data dimensionality and limited samples[7][8].

The disadvantages of SVM are it is less effective on noisier datasets with overlapping classes.
Multi SVM is Multi-class algorithm where the labels are drawn from a finite set of several elements. The system uses Multi SVM to classify our 10 Movements on our system.
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CNN Algorithm

Convolutional neural network is a deep-learning algorithm. CNN is used for images and signals classification. In this project use CNN for classifying the signals make the system can predict the user's signals belong to which class and this classifier can give accuracy reach the 90%. We used keras frame work to implement CNN because it has many benefits than implementing the CNN code or with another framework
CNN is used for images and signals classification.
the design of CNN as following.
Convolutional
Fully connected.
Weights.

Experimental

This work aims to control prosthetic arm gestures to make different moves and the user can add new customized movements on robotic arm using classification algorithm to classify the movements.

Experimental setup:

in this paper we have made experiments on 10 adult health people however from the 10 we had 3 women and 7 men the dataset gathered from this people is used for training all of it since we are trying to increase accuracy in real-time, we had to make the testing in real-time also to make our experiment as real as possible, each movement of the ten movements collected from each user on his/her own in the same place with the same room temperature, also sitting on the same chair maintaining the same position, each user had to repeat the same movement for 10 times with break about 2-3 seconds between each reading and the other the MYO armband sends then the signals to the pc to save it for late processing,
After each user entered and saved his/her movements he/she selected to try gesture detection with their movements only and with all of the movements saved on the system, the accuracy increased a lot when the system is user independent each user has to enter his/her movements and to train the system for the maximum accuracy results as mentioned in table 2. This accuracy is user independent as all of users asked us to make it like this.

Subject:

Ten able-bodied grown-up 3 women and 7 men volunteers performed the preparing sessions with ages of 19 – 70. Each subject performed five rehashed recordings for each hand motion as one shot. All test strategies were conducted in agreement with the rules of the neighborhood regulation morals committee.

System composition:

The arm band takes the signals through its eight sensors in eight different channels and sends it to pc by Bluetooth by sampling rate 200Hz to make processing on it and classification

Experiment protocol:

In this work take all the samples as a training data where the user choose to add new movement. User must wear the armband in the right hand in the lower arm and make the movement serval times and take rest between them 10 sec.

RESULT AND DISCUSSION

Before the user takes the action, it goes through the initialization process. Then, the user takes an arbitrary motion proposed in this paper.in the following figure [7], the proposed movements.

Figure 1: the proposed Movements

The system tries many Algorithms for classification and there is the result in following table:

Algorithms	Result
SVM	80%
LCM	80%
ANN	80%
CNN	70%
LDA	90%

Finally, the motion estimated by the EMG and IMU sensor is presented through simulation as shown in the following table:

	User1	User2	User3	User4	User5	User6	User7	User8	User9	User10
HC	90%	90%	80%	90%	80%	90%	90%	80%	90%	90%
I	40%	30%	30%	40%	40%	20%	30%	10%	20%	0%
MF	80%	70%	80%	90%	70%	80%	90%	70%	80%	90%
RF	20%	30%	20%	40%	0%	10%	20%	10%	20%	20%
LF	80%	70%	90%	80%	70%	90%	70%	80%	90%	80%
S	80%	90%	70%	60%	70%	70%	90%	80%	80%	70%
LT	80%	90%	80%	90%	80%	80%	90%	90%	80%	90%
IL	20%	30%	20%	40%	40%	30%	50%	20%	10%	0%
OK	60%	60%	70%	50%	80%	70%	50%	50%	40%	30%
TR	50%	40%	50%	60%	50%	40%	40%	50%	60%	70%

HC: making the hand close movement closing all of the five fingers of the hand.
I: stands for the Index finger by making the index with 90° and the 4 remaining finger are spread out.
MF: stands for the Middle Finger by also making 90° and the 4 remaining are spread out.
RF: stands for the Ring Finger by also making 90° and the 4 remaining are spread out.
LF: stands for the Little Finger by also making 90° and the 4 remaining are spread out.
S: the famous gesture as in the game rock, paper, scissors.
LT: Spreading the thumb and the little finger and the remaining for are closed.
OK: the ok sign for the divers which means the person is okay by spreading three fingers and the index making a circle with the thumb.
TR: matching the thumb and the ring finger and spreading the remaining fingers out.

Experiment analysis:

When the number of fingers increasing in one movement the gesture recognition decrease due to hardware limitation as documented on the MYO armband, also the MYO arm band predefined gesture has no complex finger movements.

CONCLUSION

This paper proposed a system for prosthetic arm using MYO armband attached to the upper arms. We estimate the motion of the arm by the EMG signals and its RMS, data was measured from the arm by 8 sensors of MYO .the user can add new movements and make training on it and the system can distinguish this movement by take this EMG signals that the user

input it and make classification using CNN and recognize this motion. Such an algorithm can be applied to robotic arm equipment by attaching to the upper arm for arm
Amputees, in addition we can make stimulation on arm we make it by unity3D.

REFERENCES

[1] ZieglerGraham K, MacKenzie EJ, Ephraim PL, Travison TG, Brookmeyer
R. Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050.
Archives of Physical Medicine
and
Rehabilitation2008;89(3):4229.

[2] Owings M, Kozak LJ, National Center for Health S. Ambulatory and
Inpatient Procedures in the United States, 1996. Hyattsville, Md.: U.S. Dept.
of Health and Human Services, Centers for Disease Control and Prevention,
National Center for Health Statistics; 1998.

[3] HCUP Nationwide Inpatient Sample (NIS). Healthcare Cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; 2009.

[4]http://bebionic.com

[5]Khushaba, R.N., Kodagoda, S., Takruri, M. and Dissanayake, G., 2012. Toward improved control of prosthetic fingers using
Surface electromyogram (EMG) signals. Expert Systems With Applications, 39(12), pp.10731-10738.

[6] https://www.cyberdyne.jp/english/

[7] Bernhard E Boser, Isabelle M Guyon, and Vladimir N Vapnik. A training algorithm for optimal margin Classifiers In: Proceedings of the fifth annual Workshop on Computational learning theory. ACM. 1992,pp. 144152.

[8] Vladimir Vapnik, The natural of statistical Learning Theory. Springer Science and business media,2013.

[9] Sezgin, Necmettin, et al. "Classification of hand opening/closing and fingers by using two channel surface EMG signal." *Artificial Intelligence and Data Processing Symposium (IDAP), 2017 International*. IEEE, 2017.

[10] Caesarendra, Wahyu, et al. "A classification method of hand EMG signals based on principal component analysis and artificial neural network." *Instrumentation, Control and Automation (ICA), 2016 International Conference on*. IEEE, 2016.

[11] Hiroki, Risako, and Masami Iwase. "Hand and finger control of myo-prosthesis based on motion discriminator and voluntary control." *Control Conference (ASCC), 2017 11th Asian*. IEEE, 2017.

[12] Ryser, Franziska, et al. "Fully embedded myoelectric control for a wearable robotic hand orthosis." *Rehabilitation Robotics (ICORR), 2017 International Conference on*. IEEE, 2017.

[13] Ahsan, Md Rezwanul, Muhammad Ibn Ibrahimy, and Othman O. Khalifa. "Electromygraphy (EMG) signal based hand gesture recognition using artificial neural network (ANN)." *Mechatronics (ICOM), 2011 4th International Conference On*. IEEE, 2011.

[14] Zhai, Xiaolong, et al. "Self-recalibrating surface EMG pattern recognition for neuroprosthesis control based on convolutional neural network." *Frontiers in neuroscience* 11 (2017): 379.