EMG SIGNAL BASED INTELLIGENT WHEEL CHAIR

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***Abstract*— The electric wheelchair is becoming increasingly critical in assistive technological and rehabilitation devices. The wheelchair is usually controlled by the joystick. Nevertheless, it's not always well suited for impaired people who lack control of the upper or lower-limbs. Latest advances of Electric Power Wheelchair (EPWs) based on electromyography (EMG) signals easily meet the needs of users having minimal arm or leg activity and offer powerful control. Consequently, EPWs controlled through EMG signs are usually extremely appropriate for elderly and disabled users. The aim of this article is to assess the state-of-the-art technology regarding EMG controlled EPWs in order to document the accomplishments of this technology to date. A report of the various styles of strategies for myogram-based management in literature is reviewed; the most purpose of this paper is to review all methods of EMG controlled chairs to assist the senior and disabled folks in dominant a wheelchair supported EMG signals.**

***Keywords*— EMG for control wheelchair navigation, Electromyogram signal, Electric power wheelchair, myoelectric control.**

I. INTRODUCTION

Early literature review indicates that paralyzed people have many difficulties moving around. One survey shows that 1.2 million people have a spinal cord injury and over 5.6 million people live with some form of paralysis leading to difficulty or inability to move the upper or lower limbs; these people require methods to enable them to move. The wheelchair is a good method to help these people move. It enables them to ambulate independently, but it must necessarily have a control mechanism to control it. One survey shows that wheelchairs that be controlled by leads comprise 81% of all types of electric power wheelchair, but this method of control has limited use for the elderly and people who limited ability to control their upper and lower limbs. Nearly half of the people in the survey could not control or move a wheelchair by using conventional controller interfaces. For this reason the authors suggest the development of control methods of a wheelchair to help all disabled people lacking control of upper or lower limbs. There are many types of controlling system proposed such as: vision based, hand gesture, head or chin control, voice recognition. Furthermore, the movement of a wheelchair can be controlled by electrical signals that result from the contraction of the muscles, the electrical signals of the EMG recording varies during movement of the different types of muscles such as those in the lower limbs, shoulder, upper limbs, head muscles, neck muscles. The EMG signals are more advanced and widely used in controlling of wheelchair movement.

The electrodes of electromyograms (EMG) collect signals from the surface of muscles and use them as a control signal. The EMG signals amplitude is very small (50µv to 1mv) with the frequency varying between 10Hz to 3000Hz. Also, the electronics circuit and processing programs become easier using the electrical signals of the muscle as a control signal on the movement of a wheelchair.

II. EMG DATA ACQUISITIONS

The electrodes are used to collect the electrical signal from the muscles, and differently types of muscles are selected according to level disability of the patient. The range of EMG potential is possibly a lot less than 50 µV around 20 for to 25 mV according to the target muscles, and this range may make limitation in the system, therefore it must amplify the recorded signal to eliminate the faint. Also, the EMG signal acquired has some noise from the surrounding muscles and it needs to filter it to remove any form of noise that be acquired. The analog signal must be converted to digital signal.

III. HARDWARE IMPLEMANTATION

EMG signal is achieved by using differential amplification where, the differential amplifier requires impedance. Essentially, it is achieved with an instrumentation amplifier. Three instrumentation amplifiers are shown in Fig 1. The particular instrumentation amplifier will subtract the voltage1 and voltage2. In this manner the disturbance is going to be common with the V1 and also V2 (electrode input). The actual propensity of the differential amplification to help avoid a common signal to each input is dependent upon common mode rejection retia (CMRR). A CMRR of 90 dB is very important to avoid the common signal of instrumentation amplifiers, where the most advanced technology despite, gives us together with CMRR concerning 120 dB. However, there are advantages for not pushing the CMRR to the limit, because the electric powered noise from the electrodes most likely is not in phase. The specific gain from the instrumentation amplifier can be established as a solitary resistor.

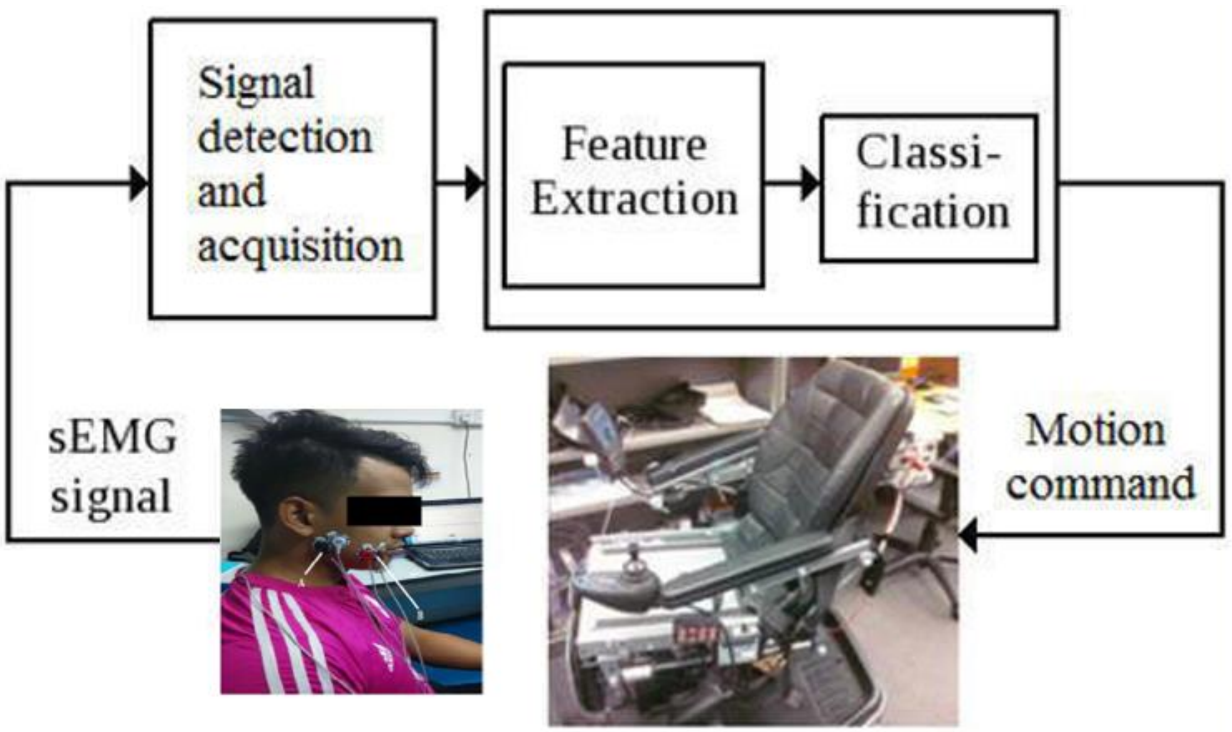


Fig 1 : Block Diagram of the Whole Process

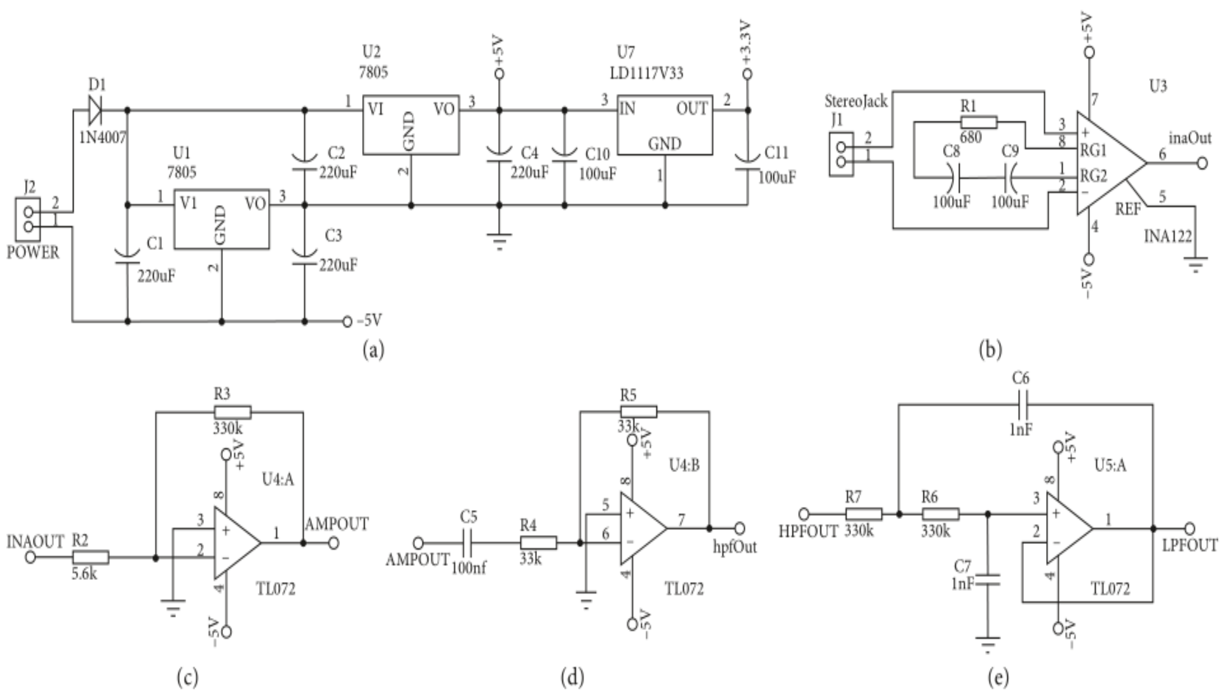


Fig 2: Circuit Diagram of the Proposed Wheel Chair.

IV. EMG SIGNAL PROCESSING

As mentioned previously, there are some concerns regarding the detection of the EMG transmission. Once the electrode is placed in a proper manner that extracts the signal with some noise, the noise has a role in the hampering of the recording signals. For this reason, the EMG signal must be filtering in a proper manner to remove any noise. The frequency of noise contaminating the EMG signal may be low or high. Low frequency noises are usually from amplifier DC offsets; this can be avoided with a high pass filter. High frequency noises come from nerve conduction. Also, the interference of high frequency comes from computers, radio broadcasts etc. and can be removed by using a low pass filter.

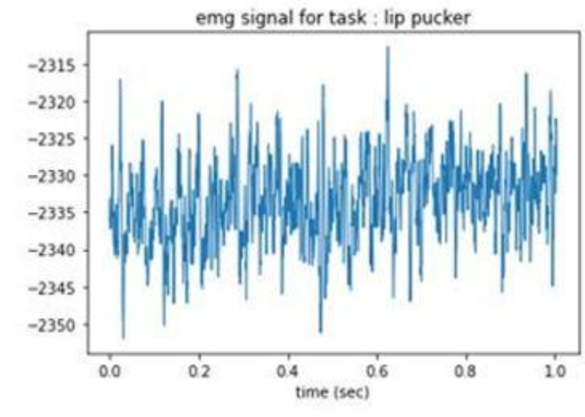


Fig 3: Raw EMG Data

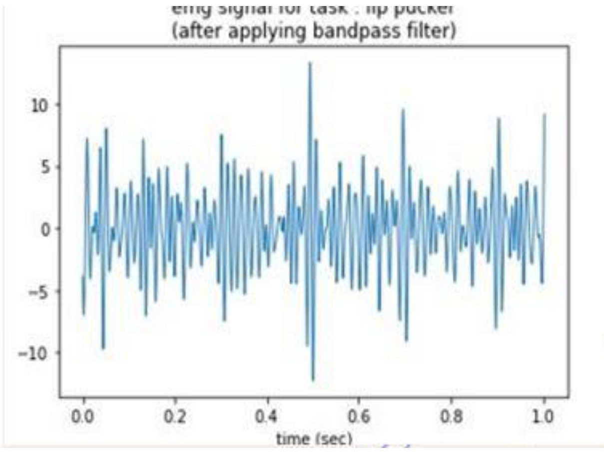


Fig 4: Output at Bandpass Filter

V. FEATURE EXTRACTION

The EMG signals are very important in the method of controlling. There are also many features of the EMG signals in time domain, frequency domain, and time-frequency domain. The stage of feature extraction is very important for the pattern recognition system. The feature of the EMG signals extracted from the AR model four-order in time-frequency domain, the reason of choosing the AR model four-order in this research work is because the experimental result shows the accuracy of classification is very high with AR four-order compared with the other result with using another order of AR model, where the algorithm of an autoregressive model is used to extract the feature of signals, also the fourth-order of AR model is used to analyze the EMG signals, by using the mathematical expression as shows in Equation 1 :

$$x(n) = -\sum_{k=1}^{p} akx(n-k) + w(n) \qquad (1)$$

Where x(n) represents the current sampling value of the EMG signals. w(n) is the current incentive value, i.e., the residual of the white noise. p is the order of the model. ak is the kth coefficient of the AR model. The meaning of the Equation is that x(n) is generated by the linear combination of several past values x(n − k) and the current incentive value w(n). The chosen of p is very critical, where if the order be very low, the result will be smooth, while if the order be high, the result will contain a dramatic and vibration.

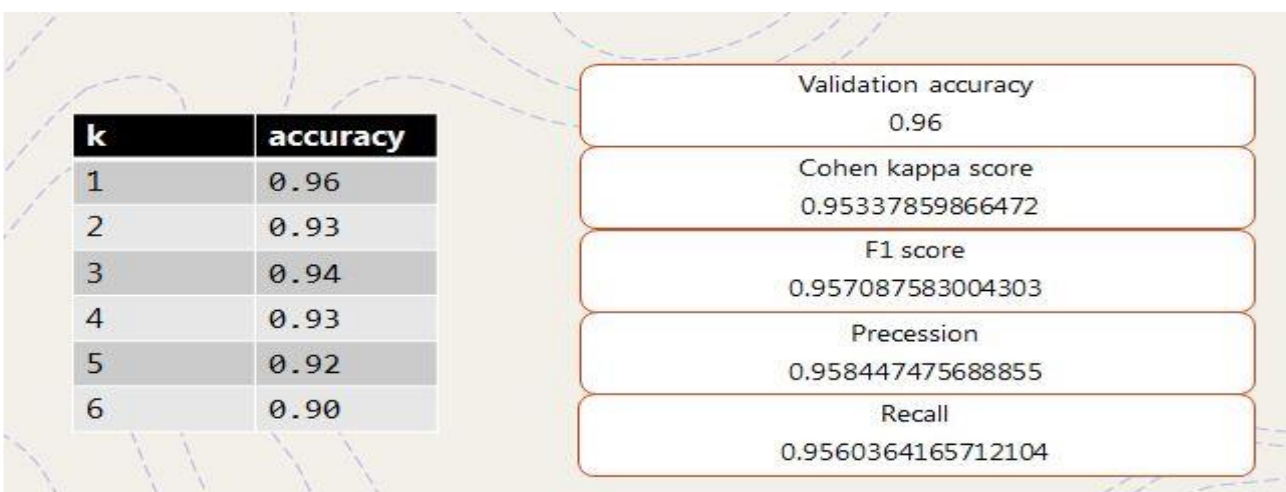
VI. ANALOG TO DIGITAL CONVERSION

The actual digitization means of the actual analog indication can be performed by using the analog to digital Converter. (ADC). This kind of ADC has changed into a frequent component of converter. Their use has grown to be hugely diverse in addition to wide-spread. Its specifications, benefits and limitations have to be examined so that can select the most suited one for the applications. Such as, significant concerns ought to become looked at although switching EMG signals in a digital format. A specific ADC carries a distinct choice of conversion. There is certainly optimum along with least degrees explained on an ADC over that it may well function. A good ADC may alter the exact analog sign on the specific variety of bits. The number of portions that ADC may enhance is referred to as the “quantization scheme”. The most amount of voltage a great ADC may well adjust into digital quantized bits will become the number in the ADC. The sampling rate signifies the volume of trials the ADC can transform in one minute. After the EMG sign have been increased up to an acceptable level, the product range of ADC should be determined so it can quickly comprehend a particular voltage level. The number of quantization pieces is essential, given that they determine the actual resolution from the ADC. The particular ADC testing rate can be considering as a vital consideration and should be as large as possible for keeping the data of EMG signal at least loses.

VII. MACHINE LEARNING APPROACH

1. KNN BASED MODEL FOR CLASS PREDICTION

The principal type of classifier used in EMG-based manage methods are art k-Nearest Neighbors (KNN). Several kinds of KNN are present in EMG control but the use of KNN classifiers in EPWs control started within the last years, possibly because of the poor performance compared with other classification methods. Here, AR Co-efficients and Variance of EMG signal were used as input features and taking k=1 we get 96% accuracy on validation data, k=3 gives 94%.



k	accuracy
1	0.96
2	0.93
3	0.94
4	0.93
5	0.92
6	0.90

Fig 5: Accuracy Vs K & Performance Parameters of KNN Model.

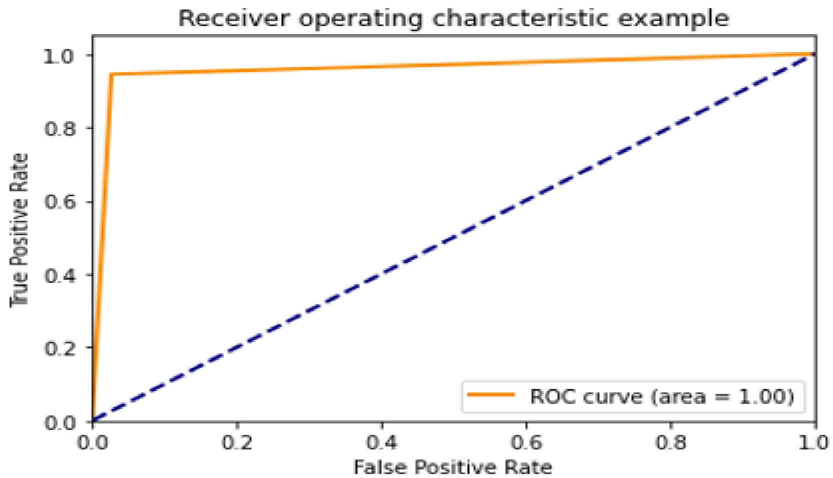


Fig 6: ROC Curve for the KNN Model

2. CNN MODEL

Another Model that has been used in this phase is Convolutional Neural Network, or CNN Model. Using the same features as KNN and using 3 1D Convolutional layers and 3 dense layers we got approximately 96.7% accuracy.

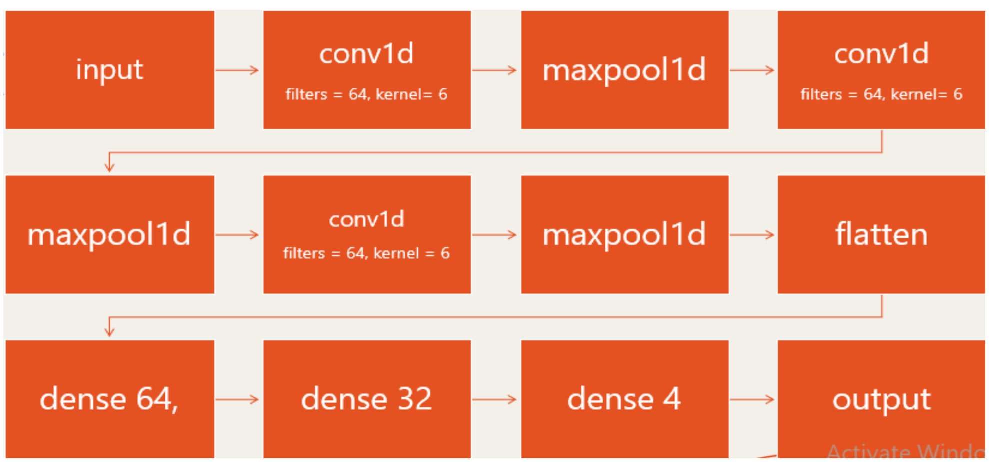


Fig 7: Block Diagram of CNN Model

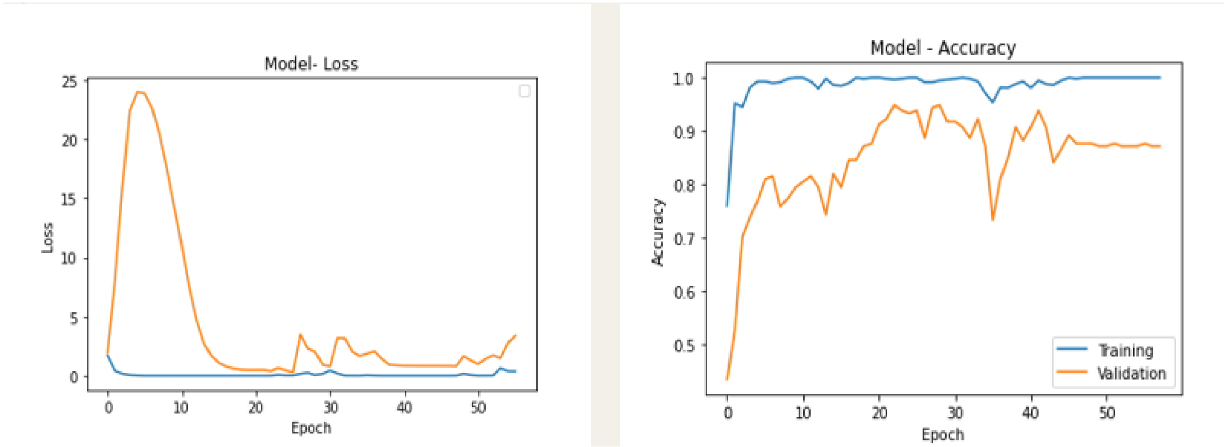


Fig 8: Plot of Validation Accuracy and Validation Loss

Different performance parameter of the model:

Validation accuracy = 0.967

Cohen kappa score: 0.9458

f1 score : 0.959

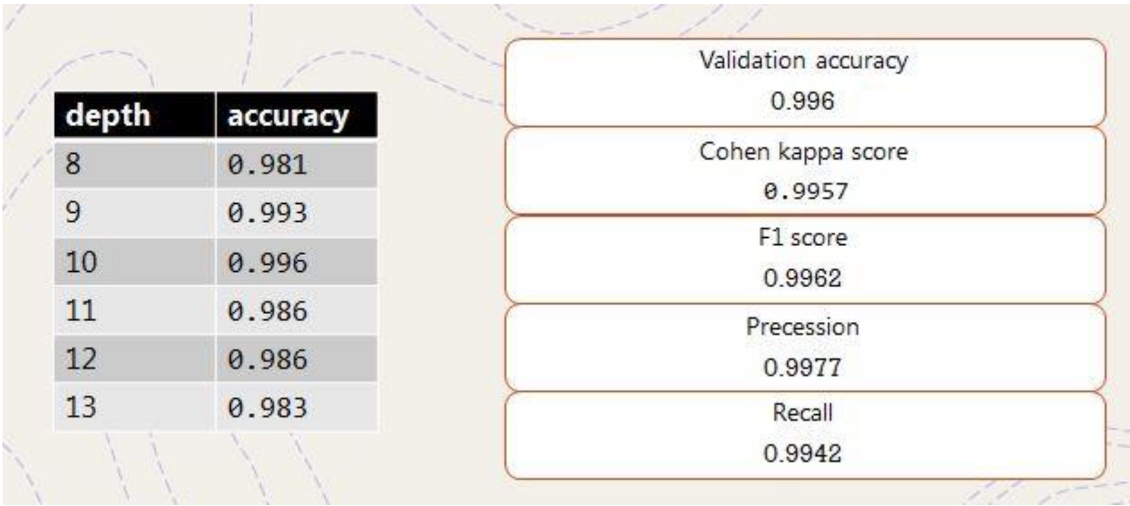
precession score : 0.951

recall score : 0.968797134

Fig 9: Different Performance Parameter of the CNN Model

3. RANDOM FOREST CLASSIFIER

Another type of classifier that has been used is Random Forest Classifier. AR Co-efficients and Variance of EMG signal were used as input features and using Depth = 10 we got best result that tends to 99.6%.



depth	accuracy
8	0.981
9	0.993
10	0.996
11	0.986
12	0.986
13	0.983

Fig 10: Accuracy Vs Depth & Performance Parameters of Random Forest Model.

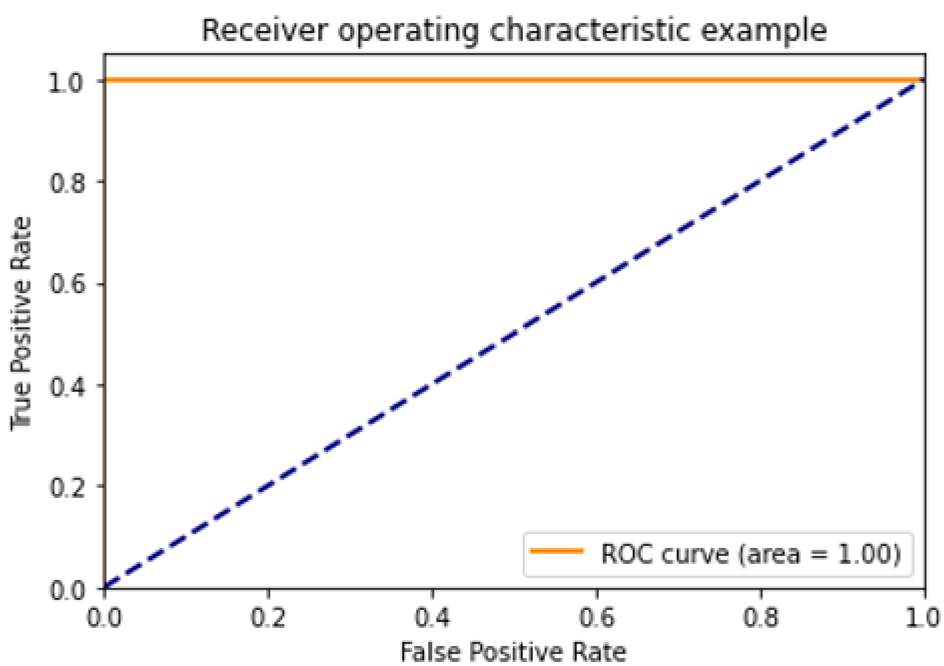


Fig 11: ROC Curve for the Random Forest Model

VIII. CONCLUSION:

This review describes the use of the EMG as a method of controlling wheelchairs. There are four control codes: pucker ,chew, frown and smile. An increase in the number of commands controlling the wheelchair is therefore the reduction of the number of EMG channels to be considered where possible. Only one muscle position with minimum five commands is recommended. Also, when used more channels EMG the feature classification will be improved and be more effectively. The development of wearable electrodes is another way to improve the control performance. According to the reviews, the SVM classifier based on the time domain with employing the pattern recognition method appears to be optimal.