Introduction:

Using the power of machine learning and Artificial Intelligence along with a very unique approach named Electromyography we have collected and worked on huge data of muscle signals by recording and analyzing those data for our prosthetic hand system. The most uniqueness of our system is we have got highest accuracy of 95.398% by using hybrid algorithm of k-nearest neighbors and Support vector machine algorithms for data classification using signal ﬁltration along with signal processing and various feature extraction. We have worked on four gestures mainly. A point to be noted that, if we look at the previous similar works on this which are mostly done with single algorithm then we can see our system has got improved outcome than most of the other conventional systems as we combined two algorithms together for better accuracy.

Motivations and objective:

One of the motivation behind building this system was increasing number of amputees because of alarming rise of road accidents daily. According to THE DAILY STAR 6,953 people injured in 4,702 road accidents across the Bangladesh in 2019. Additionally, in a developing country like our workers daily lose their limbs during construction failure and Industrial accidents such as Rana Plaza Massacre. Most of the general amputees cannot afford the cost of imported prosthesis as we don’t have any local companies for cheap prosthesis. So these reasons motivated us for building such a bionic hand which can make less poor amputees sufferings by let them work again like before so our objective for this work is Developing a Prosthetic System along with Minimum Production Cost and Precise Data Classiﬁcation Using Unique Hybrid Algorithm Approach.

System Architecture:

The Architecture of this system is divided into three-tier in which each tier performs a particular logical function. Here, all tiers which are “Tier 1”, “Tier 2” and “Tier 3” are interconnected. “Tier 1” is an interface tier operated by a hardware which captures possible signals of different gestures and ensures valid commands for terminal devices. “Tier 2” which is “Gesture processing and control” handles the signal filtering, processing as well as classifying gestures with the help of trained data. It also serves the terminal devices with proper command by executing proper code and instructions. After predicting the hand gesture, that corresponding gesture gets performed by the Tier 3 where terminal devices are located.

Workflow:

This diagram represents our workflow. Firstly, the system works by collecting real time data through emg sensor. After that, pre-processing and feature extraction gets done in order to implement algorithms and classification techniques. If the classification is done, then the result is implemented into simulation in order to test accuracies.

SVM:

SVM or Support Vector Machine” (SVM) is a supervised [machine learning algorithm](https://courses.analyticsvidhya.com/courses/introduction-to-data-science-2?utm_source=blog&utm_medium=understandingsupportvectormachinearticle) which has been used for classification challenges. The SVM classifier is a frontier which best segregates the two classes (hyper-plane/ line). In the SVM algorithm, each data item has been plotted as a point in n-dimensional space, with the value of each feature being the value of a particular coordinate. Here, n is number of features. The classification is done by finding the hyper-plane that differentiates the two classes (FIG ta). Maximizing the distances between nearest data point and hyper-plane, SVM decides the right hyper-plane. This distance is called as **Margin**. SVM selects the hyper-plane which classifies the classes accurately prior to maximizing margin. SVM also classifies the nonlinear data points by introducing additional features which is done by SVM kernel. The SVM kernel works as a function that takes low dimensional input space and transforms it to a higher dimensional space that means it converts not separable problem to separable problem. It is mostly useful in non-linear separation problem. It works really well with a clear margin of separation and effective in high dimensional spaces.

KNN:

K-Nearest Neighbor (KNN) plays a significant role in pattern recognition. This method identifies the homogeneous things that are close to each other. It has been used to solve regression and classification problems which need predictions. For ease of interpretation and low calculation time, the KNN method gives a very good assumption. KNN classification has been used to perform statistical analysis using a discriminant function when stable parametric estimation is quite unknown or determining is tough [9]. This algorithm uses the Euclidean distance between two information like two points in N- dimensional space. Steps of KNN are: Firstly the data and the value of k gets initialized. After that, the predicted class gets achieved by iterating total number of training points. Calculation of the distances between test data and row of training data gets done within that phase. Among other metrics, we have used Euclidean distance as our distance metric since it is most popular. After that, the calculated distances gets sorted to get the higher values of k (Nearest neighbor). Finally, the most frequent class of the k rows is selected and the predicted class gets returned.

FEATURE Extraction:  
  
Various feature extraction methods have been used in order to reduce the primary set of raw data for efficient management without any loss of information. Successful EMG pattern classification, to identify individual and combined motion commands depends on the correct feature extraction techniques. To separate the desired output classes a feature set (i.e. feature parameters) must be chosen wisely. One feature parameter cannot represent the EMG signals to a motion command perfectly. In this study, various features such as Variance, waveform length, integral of emg, zero crossings, slope sign changes etc. have been used to extract useful information.  
  
  
System Implementation

Data acquisition:

The dataset of the system has been acquired from online open source. Each dataset line has 8 consecutive readings of all 8 sensors. This provides us with EMG data of 64 columns. The last column is a resulting gesture that was made while recording the data(classes 0-3). So each line has the structure this fig no. ? The data has been recorded at 200 Hz. A classifier given 64 numbers would predict a gesture class from 0 to 3 where Rock is 0, Paper is 1, Spherical-grip is 2 and Alright is 3. Gesture Movements have been arbitrarily selected. They has been embedded via the EMG sensor and evaluated through the surface electrodes. Every gesture activity has been reported 6times for 20 seconds time period. During every held gesture, the tracking system was started. Although while still holding the movement, the tracking system was ceased. Every gesture is being held for a minimum of 120 seconds in a static position. They all emerged from the same right forearm within a short period. The document has been merged in a .csv format with a name of (0-3) in order to manage and use in the system.

Semg signal detection:

A single-threshold system has been used to expose muscle timing on and off, analyzing the mean value of the reformed signals to thresholds. The frequency range of the sEMG signal is (5-500) Hz. But the limitation up to 200hz has been used in this system for Myo Ware Muscle Sensor. Reliable as well as effective methods such as noise refining, rectification, normalization etc. is done to process as EMG data contains external and removable signals. Here in the picture, a part of raw emg signal has been shown where it shows the peak mega volts of a gesture with the respect of time in seconds. The portion of 0.5 sec to 2 secs means a gesture has been performed.

SVM-KNN hybrid approach:  
  
A new algorithm that combined Support Vector Machine (SVM) with K nearest neighbour (KNN) is presented and it comes into being an unique approach. It is the easy solution for deciding SVM kernel function parameter which reduces difficulty. The classifier selects only one representative point is selected for each class. In the class phase, the algorithm computes the distance from the test sample to the optimal super-plane of SVM in feature space. If the distance is greater than the given threshold, the test sample would be classified on SVM; otherwise, the KNN algorithm will be used. Moreover, the SVM can contribute to the KNN on the problems of smaller training samples size. In KNN algorithm, we have selected every support vector as representative point and compared the distance between the testing sample and every support vector. The testing sample can be classed by finding the k-nearest neighbor of testing sample. We propose a support vector nearest neighbor (abbreviated as SV-NN) hybrid classification approach which can simplify the parameter selection of SVM kernel while maintaining classification accuracy. The proposed approach is consist of two stages. In the first stage, the SVM is performed on the training samples to obtain the reduced support vectors for each of the sample categories. In the second stage, a nearest neighbor classifier (NNC) is used to classify a testing sample, that is, the average Euclidean distance between the testing data point to each set of support vectors from different categories is calculated and knn identifies the category with minimum distance.

RESULT AND ANALYSIS

**accuracy of Svm and knn:**

At first, the real live data has been acquired through signal of EMG. After that, pre-processing and feature extractions of signals have been executed by using different methods. Then, the data set has been classified in order to achieve the values for recognizing the motions as precisely as possible. In the end, those achieved values has been implemented into the simulation system and code instructions for acquiring the accuracy of each subject for each algorithm which has been presented through Table II and Table III.

**Accuracy table of Svm and knn:**

The classification rate of ten individual and combined finger movements is calculated ten times for each subject. Then the average classification rate is calculated for that subject. The process is repeated for the remaining subject’s. These tables shows the average classification rate for all five subjects.

**Accuracy rate of SVM-KNN hybrid:**

The Fig 7 describes the overall categorization score for all subjects that is 95.398% for using the hybrid algorithm which is the mixture of SVM and KNN. The accuracy is greater than using only SVM or using only KNN. Same method of implementing the user values to the simulation system and code instructions which was done in SVM and KNN has been used in acquiring accuracy related data for SVM-KNN hybrid algorithm.

**Bar Graph:**

Here the subjects are represented in x-axis and percentage of accuracy is represented in y-axis. The blue colored bars represent each subject’s classification accuracy where the orange colored bars represent the average classification rate of the whole system by measuring the accuracy of the subjects.

**Conclusions:**

To conclude, from the beginning of this research we have focused on the poor amputees of our country. For making their suffering less we have built a EMG Controlled Bionic Robotic Arm using a hybrid algorithm of Machine Learning. As a result, we have got accuracy of 95.398% which is comparative better outcome than others because we have not only focused on the preciseness but also on the cost efficiency. We have a future plan for our hand system to print it in 3D for prototyping so we can make the best use of our system by giving it to poor amputees for making their life better.