Design and Implementation of Artificial Upper Limbs Based on Arabic Speech Words

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Abstract

The human-like robot denotes a hopeful in the clinical, Handicapped and mechanical prosthetics application. The finger's control by verbally instruction is one of the significance of such applications. Here, we introduce the suggested structure of the hand controls circuit come from the voiced command. This structure depends on the controlling of electrical motors, for every finger by controller. From recognition process, an Arduino have gotten a coded sign (PWM) to give all motors signals by various' period to the servo motor to yield the necessary procedure which is matching to the verbally expressed words. Anywhere these codes are identified with statistical features, which are extorted from the verbally expressed signs. At that point, and by means of the Radial Basis Function (RBF) as a classifier, the recognition percentage are from 90% - 99.375% have been increased with independent talker, wherever these results are over-achieved the previous works, approximately with 2.045%. The simulation has been made by using Matlab 2017b.

Keyword: Neural Network, Radial Basis Function, Artificial Limbs and Pattern Recognition.

1. Introduction:

The requirements for robots have as of late been different from plant mechanization toward human-accommodating robot system [1, 2]. The Robots are utilized in the modern domain, anywhere, there are numerous undertakings and assignments are doing by fast and exactness. Likewise, with non- industrial areas, the robots are expected to help with individual requirements and expanded suitability [3].

One of the greatest encouraging utilizations of the robots is the human-like robot, which be able to walk bipedal and do handy errands with double arm hands. Wherever it has a capacity of helpful and concurrence with people, due to humanoid attribution, well-disposed structure, the relevance of headway, and conduct inside the human living environments [4].

In the writing, numerous examinations made with voice control framework, for example, in [5] robot arm control, was increased 88% classification in his 4-jointed robot limb plan by utilizing a double characterized client rate (TDuF) numerical system as voice classification calculation. While in [3] structure a prosthetic limb dependent on EMG, an objective of his strategy is to impersonate the genuine human arm limb. Additionally, a structure remained focused by the expense, although as his work considering the stage to the upcoming work for handling the exactness. With this unique situation, [6] give plan a control framework for arm dependent on speech classification to change an item starting with one spot then onto the next. Likewise, in [7] was planned 3-fingers hand for getting and discharging items dependent on the speech classification to explicit orders.

In this way, with our paper, the objective is to structure a circuit in the decoder framework that can translate a voice signs to control a prosthetic hand with 5-fingers. Wherever, this structure is utilized to accomplish the humankind-accommodating robot framework, which is utilized for some applications, such as, to connect an ordinary individuals with the hard of hearing. In this specific circumstance, numerous means were done to fulfill the structure working of this framework; they are; record the talking signs, pre-handling, features extraction, finally, the classification. At that point, gives the classification factors to the translator circuit, to control the limb fingers servo movement. At long last, the prosthetic hand will give the developments that antipodean the verbally expressed word.

The paper is structured as follows: In Section 2, we describe methodology of the work, including: speech recording, software part and hardware part, that cavers the electronics parts used in the work such as the microphone, the Arduino and the servo motors. In Section 3, we

describe proposed system design of robotics' hand. In Section 4, we perform experiments using the proposed system and present the results. Finally, in Section 5, we make conclusions

2. Methodology

The suggested methodology is came with two parts: firstly recognition of the features belong to the recorded words by NN and the microphone and the second part cavers the hardware operation: the microphone, the Arduino, servo motors and lastly the prosthetic hand.

2.1. Speech Recording

By using microphone, speech words are recorded with Mono sound with 16 bit coding and 1 channel, and 8000 Hz sampling frequency. That specification is chosen because, the size of each recorded word is very important, as the size is smaller, the process of all operations follows is faster and less memory used, the speech is meant the sign through the Microphone, at that point this sign go from the sound port toward the PC to finish the product pre-processing aspect by utilizing Matlab 2017b.

2.2. Software part

In this part there are two phase: offline training and features extraction and the second is the online recognition as shown in figure (1). With each part, the words are feature extraction to decrease the preparing multifaceted nature as in past research [8]. At that point, when the classification was finished, a reasonable signal (code) is directing toward the translator circuit to set up a fitting voltage signal with various length (PWM) for sending it to the hand fingers servo for giving a last structure, which compares to word which is pronounced.
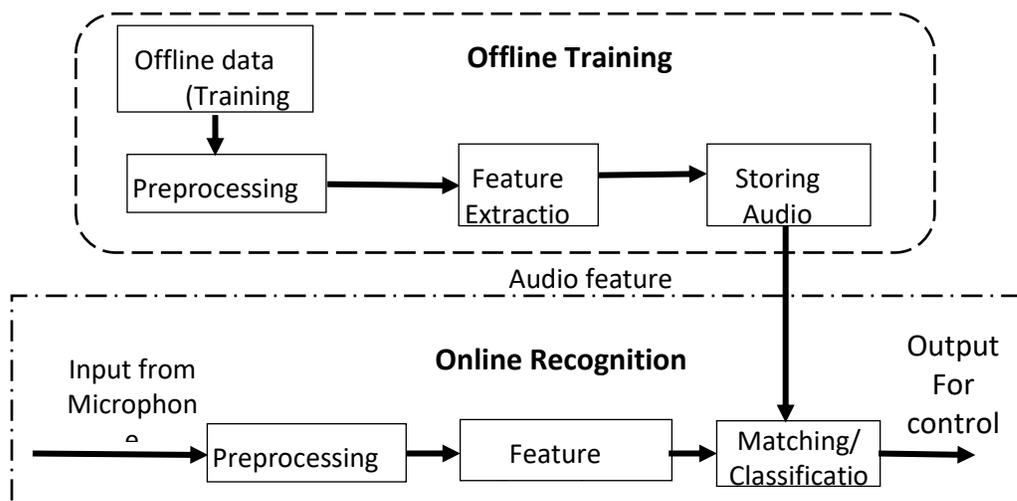

Figure (1) Block diagram of the Suggested Work

2.3. Hardware part

In this part there are the following items: the microphone, laptop, Arduino, servo motors and the prosthetic hand.

2.3.1 Microphone

The microphone used in the work is shown in figure (2), with its specifications in table (1).

Table 1: of Microphone Properties.

No	Property	Range
1	Sensitivity	-58db ± 3db
2	Impedance	< 10 kΩ
3	Frequency Restraint	20 Hz- 20 KHz
4	Mic. Plug	3.50 mm
5	Stereo Plug	
6	Cable Length	116.5 cm

Figure (2): Microphone used in the work.

2.3.2. Arduino

The control board used with this work was the UNO Arduino, simple cheap and active, where it generate the PWM signals to drive the servo motors and have the final movements, as shown in figure (2).

Figure (3) Uno Arduino.

2.3.3. Servo motors

With SG servo motor the prosthetic hand can Weight lifting to 2.5kg/cm. The motor received a PWM signals from Arduino and move the hand figure according to, as shown in figure (5). Figure (4) show the servo motor with the motor specification in table 2 [9].

Table 2: Servo motor specification

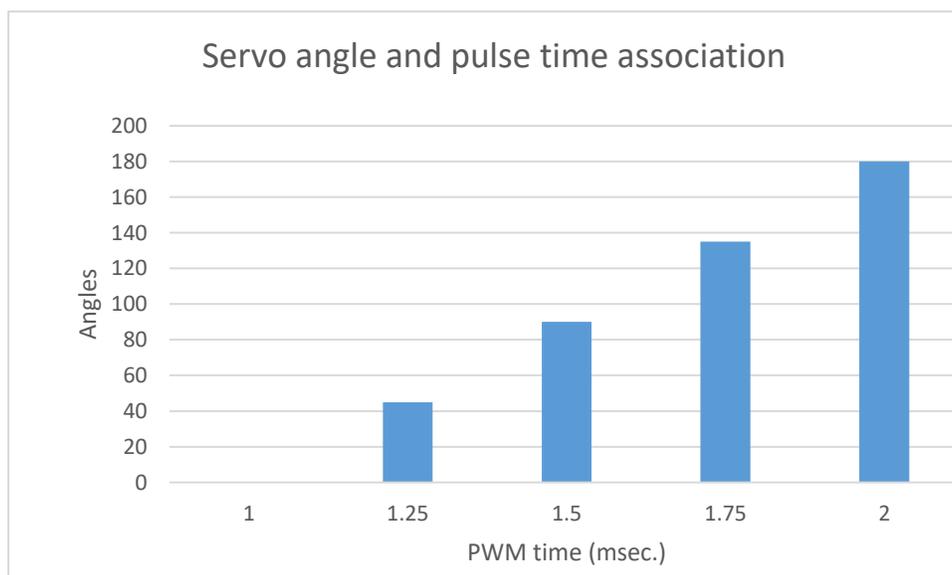| No.	Motro items	Spceifications
1	Speed	0.1
2	Torque	2.5(kg-cm)
3	Weight	14.7g
4	Voltage	4.8-6

Figure (4) Servo motor

Figure (5) showing angle and pulse time association.

3. Proposed System Design of Robotics' Hand

The suggested plan of the relate robot's limb framework has been completed with many points, they are;

3.1. Robot Hand model

The expected necessary structure of the fingers and hand to reach the last 3D point with acceptable error and with forward law was completed in [10], 1.461x10-4sec., was the time for the hand to reach an ideal location, and 0.00019sec., for the finger to have its position. Likewise, location error has been calculated with various NSPR (from 0.1 to 1) sum of error was about (0-12mm). The hand with five fingers used in the work is shown in figure (6).

In this manner, for the plan thought, two guidelines for hand and fingers to be moving; forward and reverse kinematics law. With this work, forward law [10] was taken on the grounds that it is less multifaceted nature, give direct outcomes as it requirements for finger measurements with a few angles to deliver the last location.
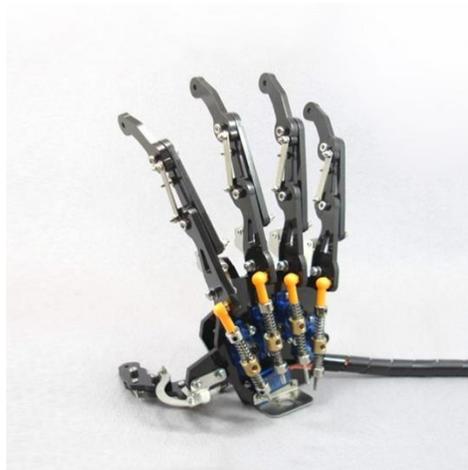
Figure (6) Robotic hand

3.2. Voice to voltage signals Translation for Servo

The activity comprises numerous phases, they are;

I. Pre-handling aimed at setting up to extract the voice sign to their factual component as in [8].

II. Eight features has been measured for the classification, they are; Zero intersection, signal and Energy, RMS, spectral flux, Spectral energy, energy entropy (EE), temporal centroid and mfcc, also, the eight features reduced fistly to three (Zero intersection, signal and Energy and RMS)

then to one feature (Energy), witjh good resluts. Reducing featres will give fast processing time and less memory space.

III. Classification of the word of speech signal for each measurable features, wherever, many neural network procedures were utilized to fulfill ideal recognition [11]. In this specific situation, the classification which relies on a mix of the measurable traits by Radial Basis Function (RBF) just as a classification system calculation were increased. This improvements of that mix is brought about by utilizing RBF, wherever with this calculation the masked work is a Gaussian, where the Euclidean separation was registered from the check point toward the mean focal point of every network neuron. Thusly, a normal classification percentage which is an increase of the mix is 99.175%.

4. Test Case

Experiment operated as in figure (7) which has been finished by the following points;

1. By utilizing the Microphone, and the Arabic word is spoken, an interpretation of it to the electrical sign, at that point, through the sound port to the PC.

2. By Normalization, Pre-emphasis, Windowing and Framing, digitized sound sign and pre-processing activity are done.

3. As in [8] Features extraction was done.

4. Relating to the words were it pronounced, Arduino controller were utilized to generate a code (PWM) to every finger's servo for give the hand shape.

For each finger's servo, a pulse length is changed about (1-2 msec.), which compares with the necessary outspread angle of engine movements, a duty cycle from (2-4%) with 50 Hz frequency.

Any word can be chosen to be considered for fingers as reference (zero) location, here all servo motors were with the (0°), and as per that assumption, and for each word that will have a particular location, as shown in figure (8) as example for the word (one). Besides, figure (5) gives the PWM comparing to the related angles. With the figure (7), it show the work setup, it consists from the hand with five fingers, an Arduino as control board, dc power supply for the hand servo motors and the laptop that holding the Matlab and Arduino software.
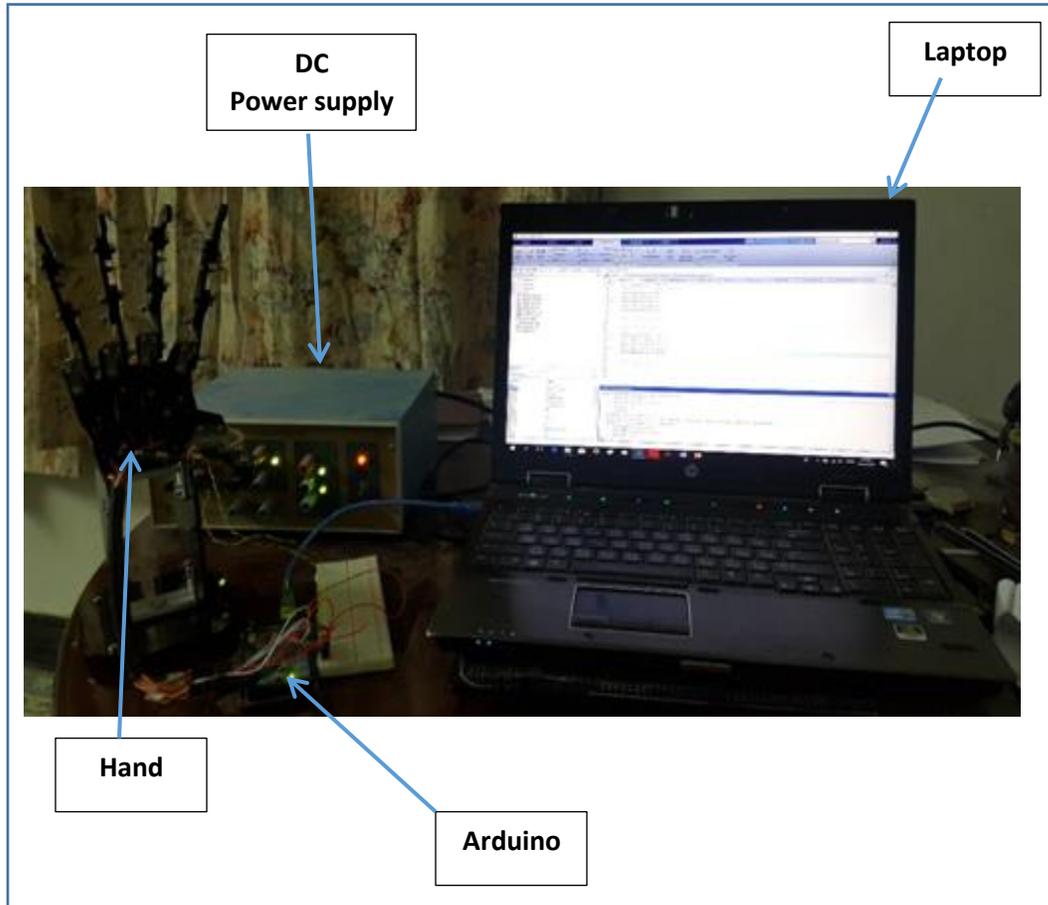
Figure (7) proposed trial system work

5. After the words that is pronounced, the exploratory recognition of the finger was completed. As in [11], the classification is made with a similar type, a 20 forms for each type (word), an aggregate about 50 forms for 5-words for teaching, while, ten type for checking where, the outcomes indicated worthy outcomes as appeared in figure (8) and table (3). The regular classification is 98.75%.
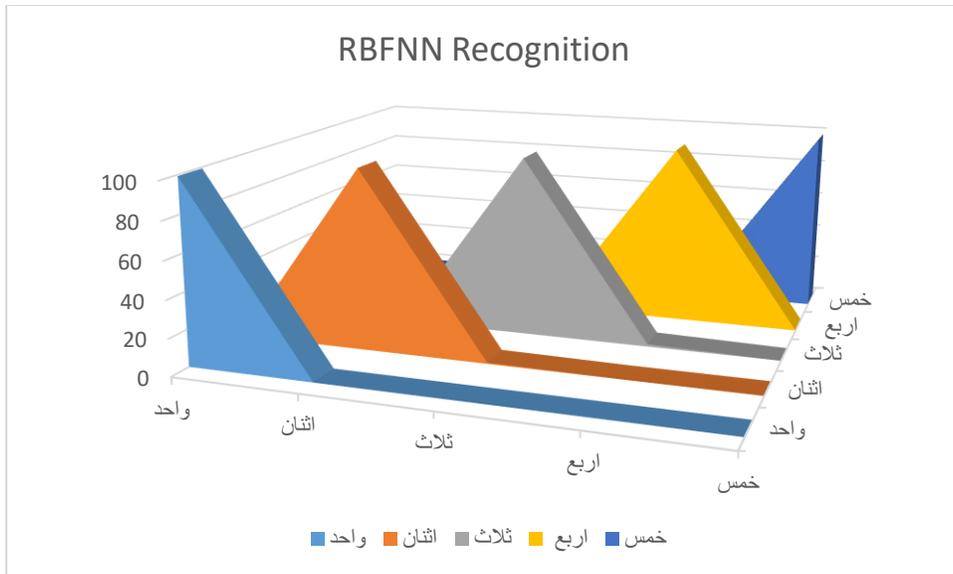
Figure (8) Show Temporal Radial Basis Function (TRBF) classification

Table 3: RBFNN recognition

الكلمات	واحد	اثنان	ثلاث	اربع	خمس
واحد	99.3	0	0	0	0
اثنان	1.25	98.125	0.625	0	0
ثلاث	0	0.625	98.125	1.25	0
اربع	1.875	0	0.625	97.5	0
خمس	1.25	0	0	0	98.75

The development of the suggested procedure were demonstrated through the comparing among the outcomes (recognition), that has been picked up with other published work as introduced with the Table (4). Additionally, different works didn't actualize their work tentatively.

Table (4) suggested work with others Comparison

References . No.	Recognition Algorithm	Classification %	Test Recognition %
[12]	TMNN	90.7	Non
[13]	MLP	96	94
[5]	TDuF	88.3	88
Present work	RBFNN	99.175	94.8

As example, to have the movement shown in figure (9), a specific word (one) is spoken, with the hand shape as in figure (9), four fingers with angle (180^0) and one, the index, with (o^o) angle, then it converted to digital samples, feature extraction, recognized with the data base stored, a PWM code is transmitted from Arduino the hand servo motors to move and give the specific movement. Table (5) show the related angles for the word (one), while figure (11) give the steps of the work
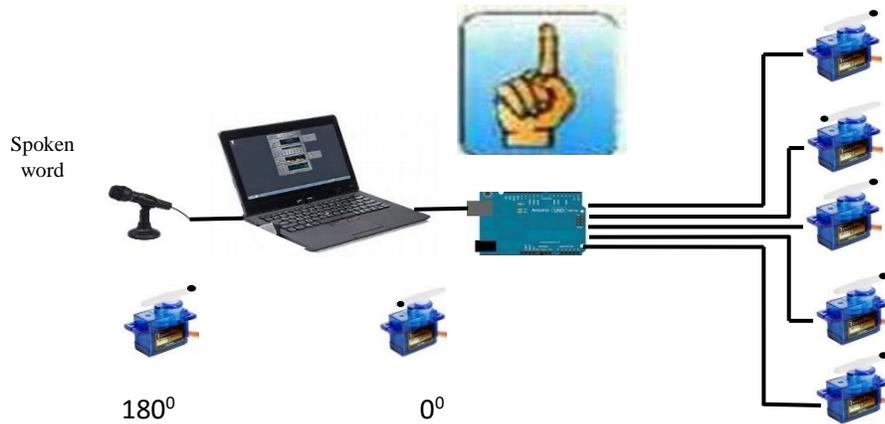
Figure (9) proposed trial system work

Table 5: Angles for the spoken word

word	M1	M2	M3	M4	M5
واحد	180^0	0_0	180^0	180^0	180^0

In this work, as example for calculating the recognition ratio, and as known, there are mu be thousands of words in the Arabic language, therefore, a five words (one, two, three, four and five) are taken, as shown in figure (10).

One   Two   Three   Four   Five

Figure (10) the five hand movements

```
                    ┌──────────┐
                    │  Start   │
                    └────┬─────┘
                         ▼
          ┌──────────────────────────────┐
          │ Data Collections (Audio Inputs) │
          └──────────────┬───────────────┘
                         ▼
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Preprocessing
Removing Silence, Sampling, Normalizing, Pre-emphasis and Framing & Windowing

Features Extraction (Energy entropy (EE))

Recognition
Neural Network (MLFFNN)

Decoder
Generate PWM Signals for Driving Motors
According to the Recognized word by Arduino to the DC servo

```
                    ┌──────────┐
                    │   End    │
                    └──────────┘
```
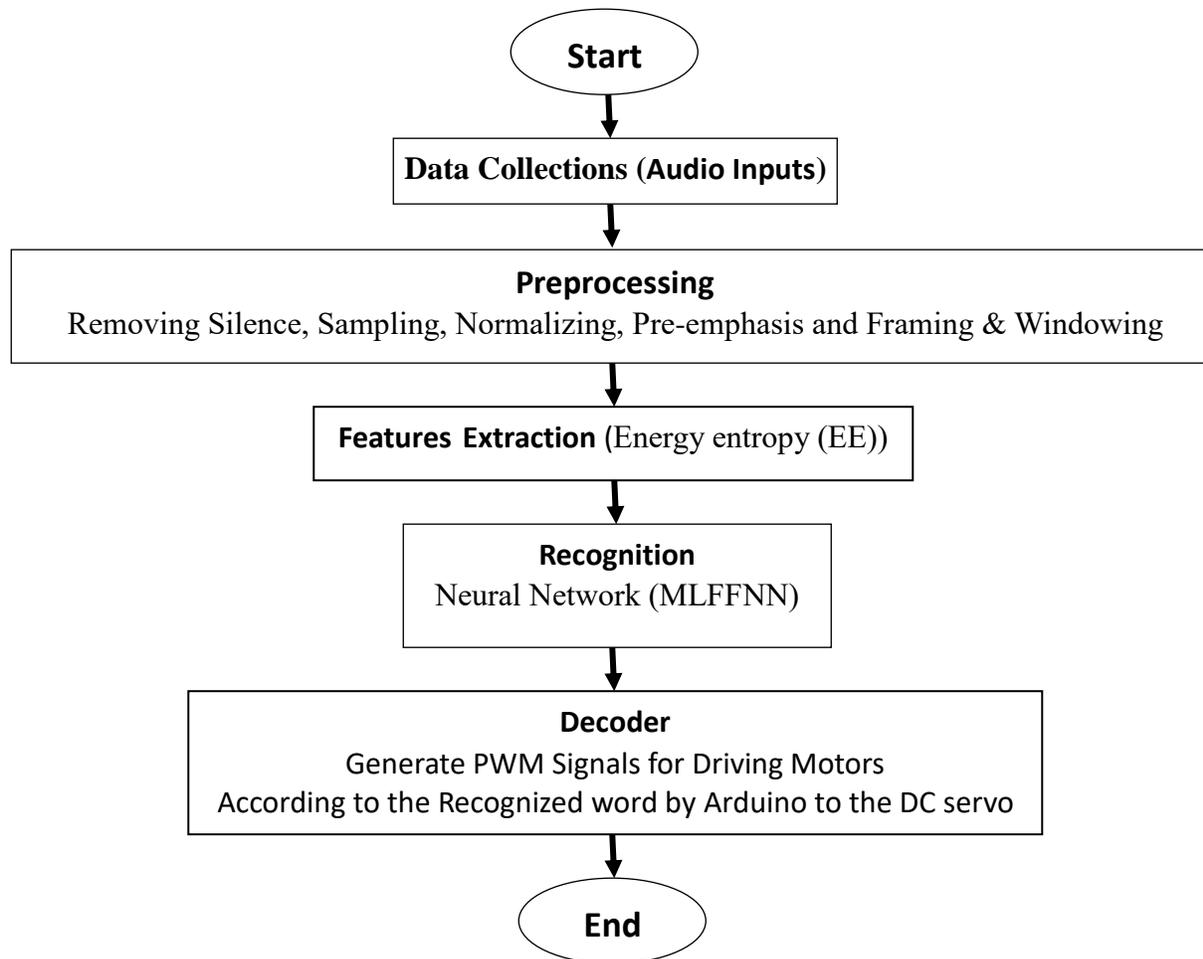
Figure (11) Work follow chart

5. Conclusions:

The outcomes have been demonstrated the capability of the suggested framework to regulator the fingers with the related servos. The control process of these servos gets by the Arduino as a controller, the work on the similarity of the separated features is done by the classification of forms related to words which are translated into codes (PWM), to move the motors to the necessary patterns relating to the pronounced words. And by utilizing of RBFNN as classifier, the average classification rate is a gain of that combination was 99.175%.

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