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Surface EMG Signal Analysis Based on Empirical Mode Decomposition for Ruqyah Recitation

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ABSTRACT

A feature extraction techniques based on Empirical Mode Decomposition (EMD) for silent speech recognition from Electromyogram (EMG) signals is presented in this paper. Ten location between facial and neck muscles is recorded during the recitation of Ruqyah. This paper described the process for extracting features of EMG by using EMD. By extracting the features of EMG signals from audible and silent speech, the useful information can be use in classification process. The decomposed signals are separate to different feature space.

Key words: Electromyogram (EMG), Empirical Mode Decomposition (EMD), silent speech recognition.

1. INTRODUCTION

Surface electromyogram signals (SEMG) have been used to measure facial muscular activity, especially during speech. The movements of the lips, the jaws and the tongue, are among the activities of the facial muscles, which are often addressed [1]. These activities measures the electrical stimulation in the muscles in different muscle movements [2]. Speech and sound activities will be generated when the air passes through the vowels [3].

Feature extraction considered an important step to extract useful information from EMG signal to detect muscle movements during the speech activity [4]. Previous study, various techniques are used to extracts features from SEMG such as Fourier transform [5] and Wavelet transform [6]. These techniques have some weaknesses. Among them are Windowing effect, low time resolution and low frequency resolution [6].

This paper proposes to identify features of muscle trends, while reciting Ruqyah using SEMG. These signals are recorded using electrodes attached to specific muscles, either on the face and/or neck. Besides SEMG, the needle-electrode EMG is also often used to measure muscle activity. The difference is, the use of SEMG is much easier and less painful [8]. Ruqyah is defined as certain verses, taken from the Qur'an [7]. Ruqyah recitations generate sequential activities of the face and neck muscles, which produce unique EMG signals. The EMD method can decompose the EMG signal to some intrinsic mode functions. We proposed the use of Empirical Mode Decomposition (EMD) for the extraction features of EMG. Our results show that the information carried by the EMD extracted features can be used in the next stage of the classification process.

2. EMPIRICAL MODE DECOMPOSITION

In this paper, an input signal as an electromyogram (EMG) signal taken from the face and neck muscle [9]. The recorded signal will undergo pre-processing steps before the features were extracted using Empirical mode decomposition (EMD) as show in Figure 1. The data analysis by using EMD to extracting the features of EMG signals from audible and silent speech, the useful information can be use in classification process.

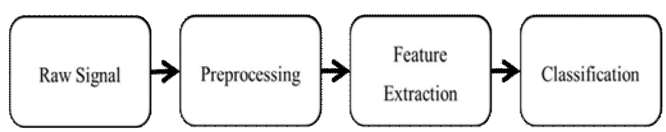

Figure 1: Block diagram of the process.

Empirical Mode Decomposition (EMD) is a technique for analyzing stationary signals from time domain to time-frequency domain using Intrinsic Mode Function (IMF) [10]. EMD decompose a signal into sum of the band-limited function of the IMF.

According to [11], this examination can be identifying into two ways, either using alternations of local maxima and minima or through zero crossing techniques. However, the adopt way by the time lapse between the successive extrema of the time scale because it only gives a much filter resolution of the oscillatory modes and can be applied to data with non-zero mean, either all positive or all negative values without zero crossings [11].

By IMF definition, the signal reconstruction process is given in (1), which involves combining the N IMFs formed from the EMD and the residual r[n].

$$x(t) = \sum_{j=1}^{N} IMF_j(t) + r(t) \quad (1)$$

Let $x(t)$ defined as an arbitrary signal as shown in Figure 2. The first steps in EMD's method is to identify all n extrema values (the maximum $x_{max}(n)$ and minimum $x_{min}(n)$ peaks) of $x(t)$. Next, all $x_{max}(n)$ and $x_{min}(n)$ are respectively connected generating upper $e_{max}(t)$ and lower $e_{min}(t)$ envelopes of $x(t)$. The local mean $m(t)$ is then calculated as shown in (1).

$$m(t) = \frac{e_{max}(t) + e_{min}(t)}{2} \quad (2)$$

Compute the difference signal $d(t)$ using:

$$d(t) = x(t) - m(t) \quad (3)$$

Replace *x[t]* with *d[t]* and iterate the previous steps until *d(t)* becomes zero mean. Then *d(t)* is IMF 1 and is named $IMF_1(t)$

$$r(t) = x(t) - IMF_1(t) \quad (4)$$

Calculate the residue signal and repeat the procedure as specified by all previous step with x(t) replaced by r(t) to obtain IMF 2. To obtain all IMFs, repeat all the step *N* times until the final residual signal is a monotonic function.

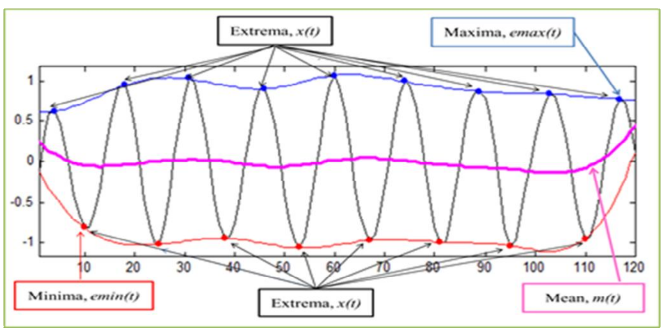

Figure 2: Empirical Mode Decomposition component.

3. SIMULATION SETUP

The EMG signals were recorded on the facial and neck muscle using 4-channel Bagnoli, Delsys. Grounding electrode is located at the wrist of the subject. To minimize skin impedance, the surface of the skin was clean before placing the EMG electrodes. During the recording session, participants will sit calmly and their recitations are being record.

The subjects are from UniKL MITEC student age between 18 to 30 years old. The selection of candidate based on the ability to read the verse of the Quran properly and smoothly, which assessed by the 'Ustaz'. Before starting the experiment, the candidate has fully understood what they were to do during the experiment session..

4. RESULTS AND DISCUSSION

In this paper, an example of clean signal and IMF by using EMD method is show in this section. The clean signals of EMG were separate verse by verse according to the recitation of the subject. After that, the signal will be decomposed using EMD also called as Intrinsic Mode Function (IMF). Figures 3(a), (b), (c) and (d) show the result of decomposition of the signal along with the first five IMFs for each verse from surah 'Al-Fatihah'. In the process of IMF, each verse has different value of iteration. As shown in those 4 figures, we can observe that the different in the all of the signal is not significantly changes. However, the value of the frequency and magnitude are significantly changes due to the process of IMF iteration. The result of the value is show in Table 1.

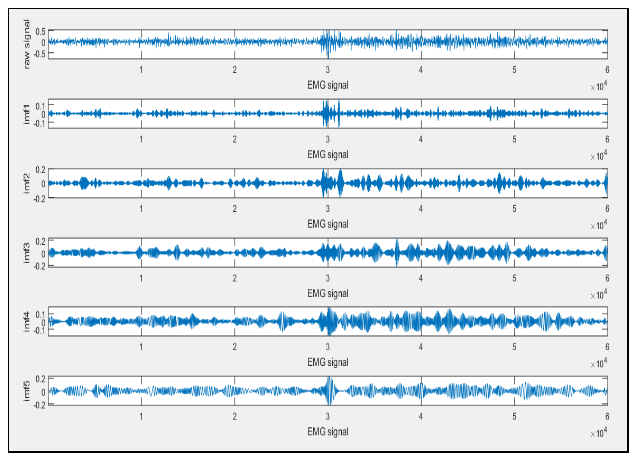

Figure 3(a): Imf signal for versus 1.

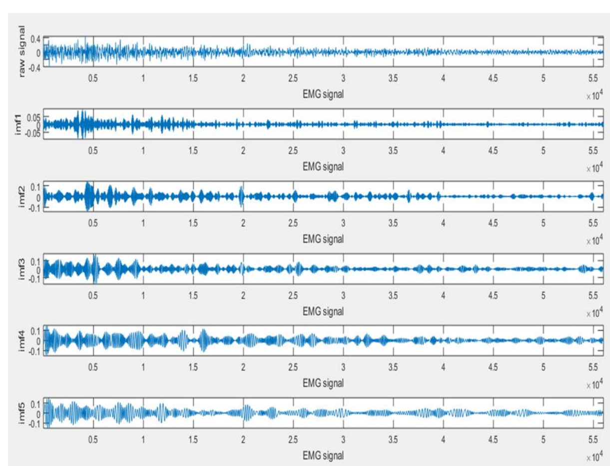

Figure 3(b): Imf signal for versus 2.

Table 1 shows the extracted features from IMF. This study tends to study on the features of the magnitude value and maximum frequency value in each IMF. From Table 1, the highest magnitude for verse 1 is 281.65 and maximum frequency is 234.93 Hz. For verse 2, the highest magnitude is 161.45 and maximum frequency is 260 Hz. For verse 3, the highest magnitude is 335.71 and maximum frequency is 261.49 Hz. For verse 2, the highest magnitude is 456.23 and maximum frequency is 240.46 Hz.

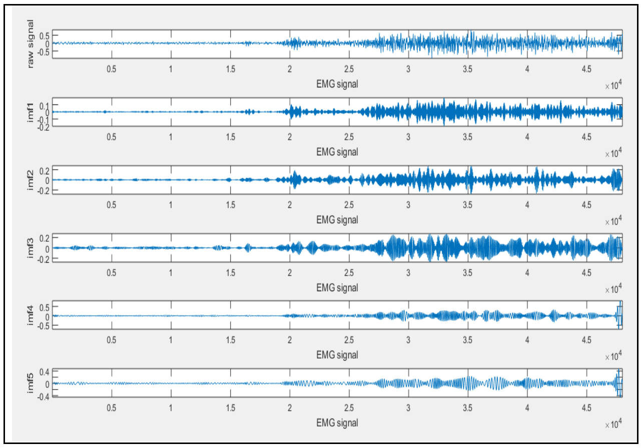

Figure 3(c): Imf signal for versus 3.

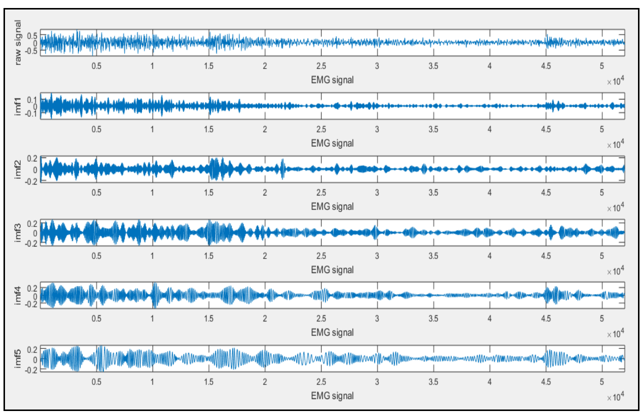

Figure 3(d): Imf signal for versus 4.

Furthermore, the result shows that if the magnitude is high, the frequency of the signal is low and vice versa. In some cases, at IMF_4_verse_3, the magnitude value is higher than IMF_5_verse_3 while the frequency IMF_ 5_verse_3 is smaller than frequency IMF _4_verse_3. This means that there is probability of variance in some cases that needs to be further research due to this case. Therefore, this technique can be use as one of the features for classification process.

Table 1: The magnitude and maximum frequency for verse 1, 2, 3 and 4.

	Magnitude	Maximum Frequency
Imf1_verse1	50.14	234.93 Hz
Imf2_verse1	99.14	91.73 Hz
Imf3_verse1	198.35	75.07 Hz
Imf4_verse1	271.58	64.93 Hz
Imf5_verse1	281.65	46.80 Hz
Imf1_verse2	28.02	260.00 Hz
Imf2_verse2	71.92	150.43 Hz
Imf3_verse2	132.05	80.57 Hz
Imf4_verse2	143.31	58.43 Hz
Imf5_verse2	161.45	37.14 Hz
Imf1_verse3	116.15	261.49 Hz
Imf2_verse3	152.97	114.50 Hz
Imf3_verse3	252.01	109.16 Hz
Imf4_verse3	335.71	65.33 Hz
Imf5_verse3	320.86	38.17 Hz
Imf1_verse4	94.22	240.46 Hz
Imf2_verse4	125.50	114.46 Hz
Imf3_verse4	240.96	74.46 Hz

5. CONCLUSION

In this paper, present a method for the extracting features of EMG signal by using EMD technique. Experimental result show, that the usage of EMD can acquire features of EMG signals. By using this method, it can obtain the value of highest magnitude and maximum frequency of each IMF. However, this study shows the basic features of EMG signal. Further development should take consideration of the instantaneous frequency spectra for improving the performance into classification stage.

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