Analysis and Inference of E.M.G. Using F.F.T.

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Abstract - In recent years electromyography has become increasingly useful in clinical routine, occupational medicine and in research concerning nerve muscle function and movement control. In the proposed system analysis of EMG using Fast Fourier transform is developed. In this, first autocorrelation, power spectral density and cumulative power is found out on scan EMG images and analysis is done based on these parameters. The proposed system has tested on 20 images and it works satisfactorily. Earlier methods which was time consuming and expensive to use. Our proposed system is fast and with little modification can be work as real time system. This system may help even to junior doctors to diagnosis the diseases.

Keyword: E.M.G, FFT, Spectral Density

I. INTRODUCTION

MOVEMENTS and position of limbs are controlled by electrical signals traveling back and forth between the muscle and the peripheral and central nervous system. When pathological condition arise in the motor system, whether in spinal cord, the motor neurons, the muscle or the neuromuscular junctions, the characteristics of the electrical signals in the muscle changes. In electromyographic recordings [6]

i) Amplitude is determined by the presence of active fibers within the immediate vicinity of the electrode tip.

ii) Rise time is an increasing function of the distance between the electrode and the closest active muscle fibers.

iii) Duration is the time intervals between the first and the last occurrence of the waveform exceeding the predefined amplitude threshold.

iv) Area indicates the number of fiber adjacent to the electrode MUP area depends on MUP duration and is therefore influence by fibers in a larger region compared with that of MUP amplitude.

II. ACQUISITION MODULE

The Acquisition Module act as input module for the software and carries out task of reading in the bitmap in to memory and ask the user to select the area containing the actual signal to be used for EMG processing. From this user selected area the two dimensional image information is converted in to one dimensional array information by storing the amplitude in to array index representing the time equivalent.

i) Open the file

As the input BMP file has a specific scale along X and Y axis it is required to input the scale to the EMG software so that proper signal reconstruction is achieved

ii) Digitizing the image

In this stage, for every column of cropped bitmap area a scanning of positive and negative values of Y is carried out for signal detections until the end of the in upper or lower direction is not reached. In case of zero value of signal a miss at both boundaries occurs and in such cases average of previous and next is taken.

III. EXPLANATION AND CALCULATION OF DIFFERENT PARAMETERES

While developing the software following steps were carried out [1]

A. Bitmap image → Array representation of signal

B. Signal array → Array autocorrelation Information of the EMG signal

C. Autocorrelation → Power spectral density Function

D. Power spectral density function → Cumulative power function

E. Signal array → Fourier transform

F. Signal array → Fast Fourier transform

Analysis of the EMG autocorrelation function and power spectral density function is a reasonable starting point for an exploration of the properties of myoelectric signal .It has been suggested that the root mean square value of suitably filtered EMG is proportional to muscle tension. There is a useful EMG signals at very low frequencies reflecting the transition of muscle from one state another. However, it has been pointed out that their exist low frequency noise due to polarization potential and motion induced potential between the skin and electrodes.

The power spectral density function and cumulative power function are used to examine the change in the EMG frequency characteristics with varying subjects, muscles, tension levels and fatigues states. Sampling a continues record must be considered carefully so that the digital data is a true representation of the continues data. In order to avoid problems due to aliasing, the data must be sampled at a rate greater than twice the highest significant frequency found in the signal.

While implementing the software following expressions

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have been implemented.

i. Autocorrelation function [4]
The sample mean of an individual function computed by time averaging as given in equation 1.

$$\overline{U} = 1/N\sum_{n=1}^{N} Un \text{ ----------------------------- (1)}$$

The data is transform to zero mean to remove zero level of the data by using equation 2.

$$X_n = U_n - \overline{U} \text{ ----------------------------- (2)}$$

The estimated autocorrelation function is calculated by using equation 3 .

$$\hat{R}r = 1/(N-r)\sum_{n=1}^{N-r} Xn.Xn + r \text{ ---------- (3)}$$

r=0,1,2,--m

Where r is lag number, m is maximum lag number and h is sampling interval

ii. The power spectral density function
A finite Fourier transformation of autocorrelation function is used. At discrete frequencies the true power spectral density function is given by equation 4.

$$\overline{G_k} = 2h\left[\hat{R}_o + 2\sum_{r=1}^{m-1}\hat{R}_r \cos(\Pi rk/m) + (-1)^k R_m\right] \text{---(4)}$$

Where k is number of harmonic we are evaluating
In order to reduce in accuracies introduce by computational noise and distortion the Hamming window is used
This window is represented by equation 5 and 6.

$$\overline{G_o} = 0.46\overline{G_1} + 0.54\overline{G_o} \text{ -----------------------------------(5)}$$

$$\overline{G_k} = 0.23\,\overline{G_{k-1}} + 0.54\,\overline{G_k} + 0.23\,\overline{G_{k+1}} \text{ ---(6)}$$

iii. Frequency of mean power [1]
Considering power spectral density function, the frequency of mean power is computed by equation 7.

$$\bar{f} = \frac{\sum_{f=f_0}^{f_c} fp(f)}{\sum_{f=f_0}^{f_c} p(f)} \text{ --- (7)}$$

iv. Frequency variance [1]
The frequency variance about f is calculated by equation 8.

$$\text{var} = \frac{\sum^{f_c}(f-\bar{f})^2 p(f)}{\sum_{f=f_0}^{f_c} p(f)} \text{ -------------------------------(8)}$$

IV. RESULT AND DISCUSSION

The available EMG signals are process and cropped signal is made available for the calculation of power spectral density, cumulative power, autocorrelation function. Also Fourier transform and fast Fourier transform made available in image view. It is found that nature of Fourier transform and fast Fourier transform is same so fast Fourier transform is used to calculate power spectral density function.

Broadly fatigue is detected using following observations

i) Fatigue is characterized by more power in lower half of the spectrum while signal produce before fatigue has greater power in the upper one half of the spectrum.
ii) The mean frequency by averaging all cases of fatigue is some what lower than the mean frequency of the spectrum representing before fatigue.
iii) During fatigue EMG appears slower.
iv) The time to the first axis crossing of the autocorrelation function increases with fatigue.

In figure 1A,1B, 2A,2B, 3A,3B, 4A and 4B cropped signal from available EMG signal is taken for processing and image view of their power spectral density, autocorrelation, cumulative power, Fourier transform and Fast Fourier transform is shown. This result is used to diagnosis the patient.

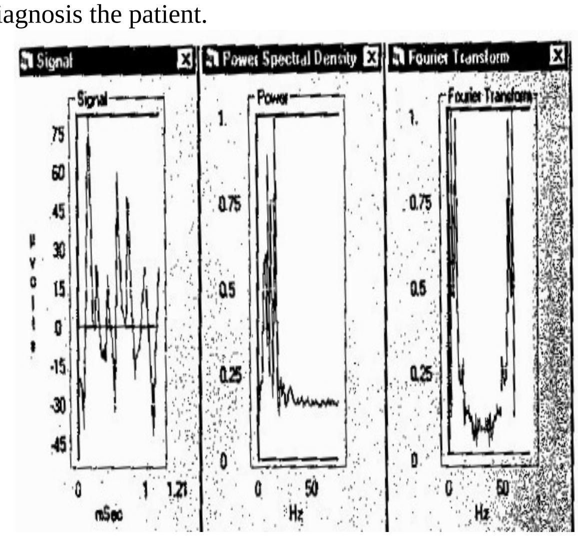

Figure: 1A, Cropped EMG signal 1,
Its power spectral density and Fourier transform.

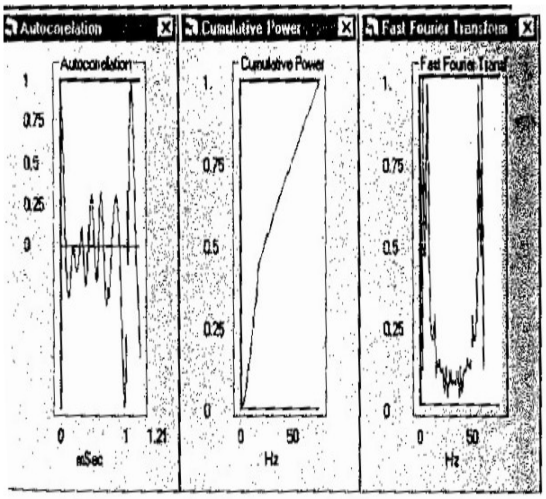

Figure: 1B, Autocorrelation, cumulative power and Fast Fourier transform of signal 1

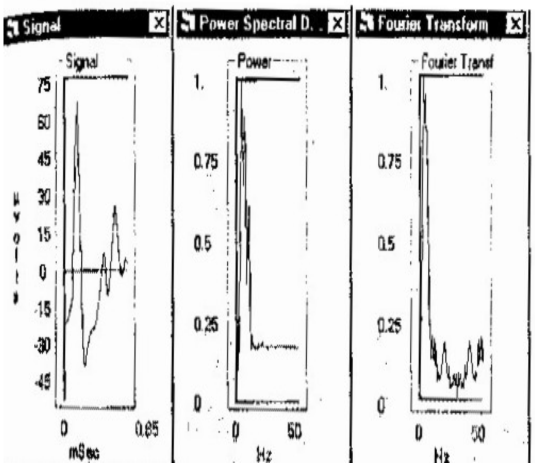

Figure: 2A, Cropped EMG signal 2, Its power spectral density and Fourier transform.

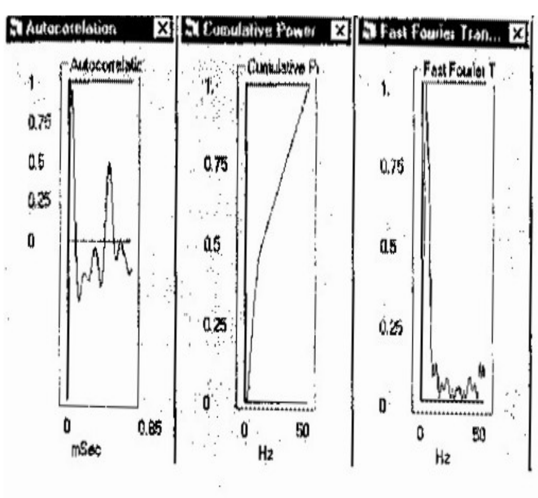

Figure: 2B, Autocorrelation, cumulative power and Fast Fourier transform of signal 2

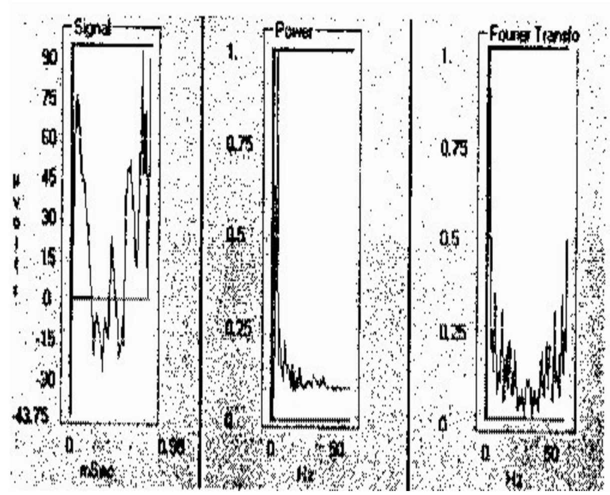

Figure: 3A, Cropped EMG signal 3, its power Spectral density and Fourier transform.

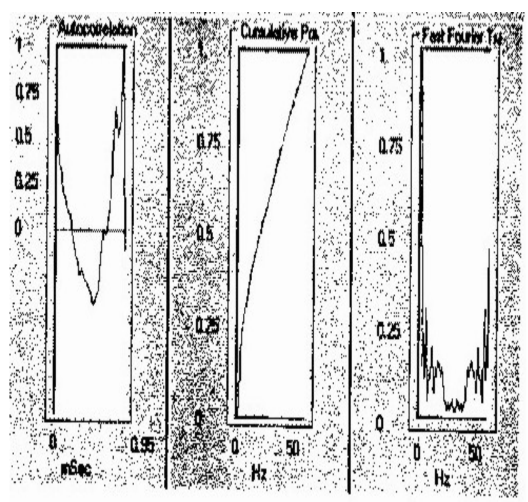

Figure: 3B, Autocorrelation, cumulative power and Fast Fourier transform of signal 3.

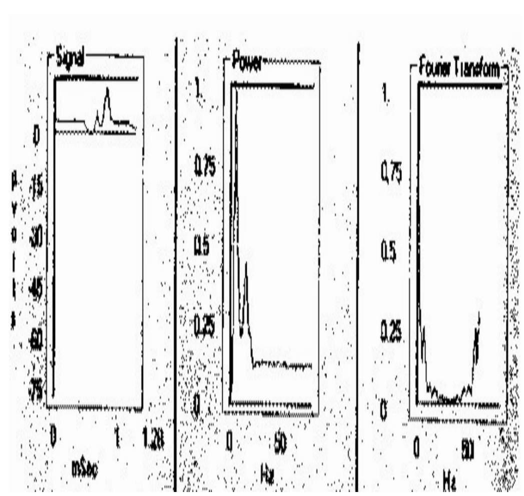

Figure: 4A, Cropped EMG signal 4, its power Spectral density and Fourier transform.

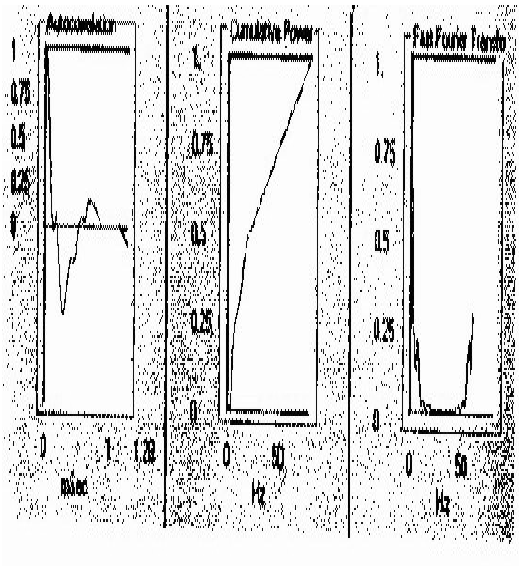

Figure: 4B, Autocorrelation, cumulative power and Fast Fourier transform of signal 4.

TABLE1
FIGURE NO. AND THEIR RESPECTIVE FREQUENCY OF MEAN POWER

Figure no.	Frequency of mean power
1	34Hz
2	21Hz
3	30Hz
4	31Hz

From above result we can conclude following points

i) Patient whose EMG signal is shown in fig.2 is suffering from more fatigue and patient whose EMG signal is shown in fig. 1 is normal one.

ii) It is observed that EMG signal for fig.2 appears slower among all and fig. 1 appears fasted among all selected signals.

iii) It is observed that more power in lower half of the spectrum in case of fig. 2

iv)The time to the first axis crossing of the autocorrelation function is highest in case of fig. 2 as compared to other selected signals.

V. CONCLUSION

This developed software is successfully implemented on more no. of available EMG signals and obtained results are perfectly matched reflecting comparative state of fatigue. Using the parameter like Autocorrelation, power spectral density, cumulative power and frequency of mean power the doctors can conclude the status of the diseases. This software may help even to junior doctors to diagnosis the diseases.

The proposed system has tested on twenty images and it works satisfactorily. Compare with earlier method which was time consuming and expensive, our proposed system is fast and with little modification can be works as real time system

VI. REFERENCES

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VII. BIOGRAPHIES

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