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MODERN SIGNAL PROCESSING TECHNIQUES FOR EEG SIGNALS TO DETECT SLEEP STAGES

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Abstract— *In human beings, sleep is a universal recurring dynamical and physiological activity, and the quality of sleep influences our daily lives in diverse ways. In this project we are proposing modern adaptive signal processing techniques, empirical intrinsic geometry and synchro squeezing transform, are applied to quantify different dynamical features of the respiratory and electroencephalographic signals. We will show that the proposed features will theoretically rigorously support, as well as capture the sleep information hidden inside the signals. The features can be used as input to multiclass support vector machines with the radial basis function to automatically classify sleep stages.*

Keywords— Sleep Stage, Synchrosqueezing Transform (ST), SVM Classifier, EEG Signal

1. INTRODUCTION

Sleep is a very important need for human life. Quality of sleep will be responsible for making day-to-day activities in right way. For sleep detection image processing based approach and signal processing approach can be used. Out of these two approaches signal processing through EEG signals is the best approach to achieve desired results towards sleep detection. Time frequency Analysis, Spectral Analysis is used and then statistical features like Mean, Standard Deviation, PSNR, Smoothness and Variance will be extracted. Various works was done in this area. But it was done on recorded EEG signals not the real time. I am implementing the real time system using EEG sensor. This will be helpful for avoiding accidents while driving or while working on any machine.

2. PROPOSED SYSTEM

Following fig shows the complete block diagram of proposed system

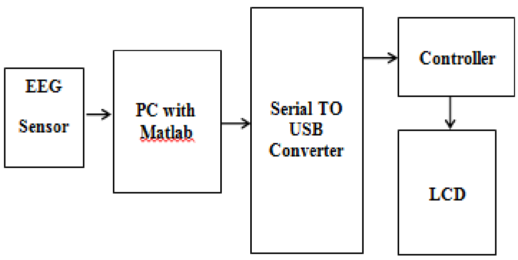

Fig. 1. System Block Diagram

EEG sensor output is given to signal conditioning device. This device is used to convert the electronic signal into the signal which is compatible to hardware. Serial to USB converter is used for converting USB signals to other communication standards. SVM Classifier is responsible for Sleep stage detection by which statistical features can be extracted.

A significant number of accidents still occur all over the world. Those are mostly caused by human mistakes, such as typing a text messages, speaking someone on phone, eating and drinking etc. while driving. In addition to these drowsiness, sleepiness or distraction could also result in critical and harsh accidents. Therefore to work on designing driver attention system is important.

A. EEG Sensor

An EEG sensor is used to detect the mental states. Hence this will be helpful in detecting the sleep stages. Various parameters of EEG signal needs to extract and depending on the parameter values sleep stage will be determined.

B. Signal Conditioning and ADC

Signal conditioning is the manipulation of a signal in such way that prepares it for the next stage of processing. A signal conditioner is a device that converts and electronic signal into another type of signal which is compatible with the hardware.

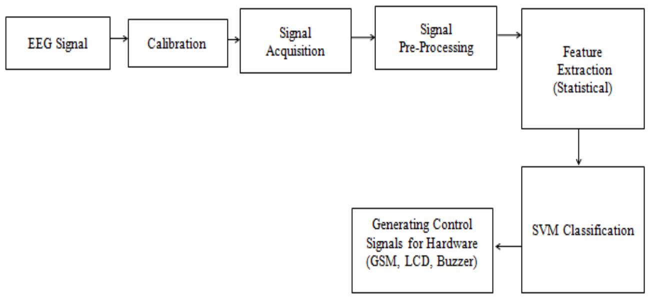

Fig 2. System Block Diagram

C. Serial to USB Converter

A USB adapter is a type of protocol converter which is used for converting USB data signals to and from other communication standards. Commonly, USB adapters are used to converts USB data to standard serial port data and vice versa.

D. Signal Pre-processing

Preprocessing includes filtering of the original signal. Filters are used to reduce noise in the signal. Filtering can be easily done in the MATLAB using function.

E. Feature Extraction

Various features of EEG signal needs to be extracted for further operation. Mean, Variance, Standard Deviation, PSNR and MSC can be calculated. Sleep stage can be determined depending of the parameter values of extracted features.

F. SVM Classifier

Basically SVM classifier plays an important role in the proposed system as this is responsible for classification of sleep stage. Training algorithm will be provided to SVM. Depending of the parameter changes and training given, SVM classifier will classify the sleep stage and will perform further action. SVM classifier output is given to LCD.

G. Algorithm

1. Start
2. Interface EEG signal
3. Signal Calibration
4. Signal Acquisition
5. Signal Pre-processing
6. Noise Removal
7. Find statistical features
8. Provide training algorithm to SVM classifier
9. Recognize sleep stage
10. Generate control signals for hardware according to recognized sleep stage
11. Stop

3. SIMULATION RESULTS

Implementation is done in MATLAB software. In MATLAB I have created Graphical user interface. The GUI for implemented system is shown in figure.

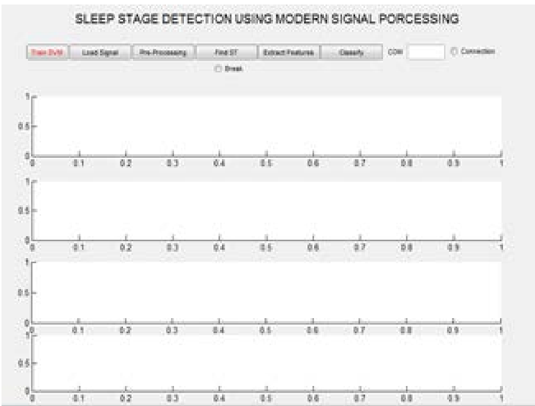

Fig 3. Graphical user interface in matlab

4. RESULTS

1. *LOW SEVERE STAGE SIGNAL*

First I load original signal corresponding to low severe sleep stage. Then pre-processing is done on original signal.

Pre-processing involves averaging of the samples to reduce fluctuations in the original signal. After that I have find synchro squeezing transform of the signal which is shown on axes3 and axes4. Dark lines indicates high variations in the original signal which means rapid eye movement and light lines indicates low variations in the original signal which means non-rapid eye movement.

Following figure shows output of Low severe stage of sleep.

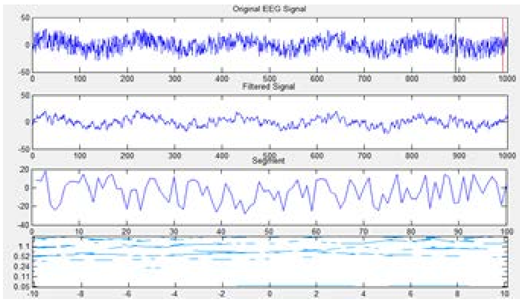

Fig 4. Original and Pre-processed signal of Low severe stage of sleep and corresponding SST

The classification output for Low severe stage signal is shown in below

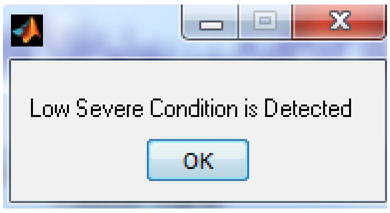

Fig 5. Classification of Low severe sleep stage signal

Below table shows the parameter values of the high severe sleep stage signal.

TABLE 1 PARAMETER VALUES OF THE LOW SEVERE SLEEP STAGE SIGNAL

Parameter/Stage	Mean	standard deviation	Variance	PSNR	MSE
Low severe stage signal	0.0128	0.0287	0.1691	28.61	89.4999

2. *HIGH SEVERE STAGE SIGNAL*

First I load original signal corresponding to High Severe sleep stage. Then pre-processing is done on original signal. Pre-processing involves averaging of the samples to reduce fluctuations in the original signal. After that I have find synchro squeezing transform of the signal which is shown on axes3 and axes4. Dark lines indicates high variations in the original signal which means rapid eye movement and light lines indicates low variations in the original signal which means non-rapid eye movement.

Following figure shows output of High severe stage of sleep.

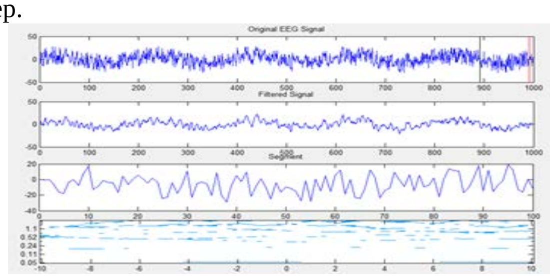

Fig 6. Original and Pre-processed signal of High severe stage of sleep and corresponding SST

The classification output for Low severe stage signal is shown in below

Fig 7. Classification of High severe sleep stage signal

Below table shows the parameter values of the high severe sleep stage signal.

TABLE 2 PARAMETER VALUES OF THE HIGH SEVERE SLEEP STAGE SIGNAL

Parameter/Stage	Mean	standard deviation	Variance	PSNR	MSE
High severe stage signal	0.0124	0.0284	0.1683	28.936	83.0760

3. *NORMAL SEVERE STAGE SIGNAL*

First I load original signal corresponding to normal sleep stage. Then pre-processing is done on original signal. Pre-processing involves averaging of the samples to reduce fluctuations in the original signal. After that I have find synchro squeezing transform of the signal which is shown on axes3 and axes4. Dark lines indicates high variations in the original signal which means rapid eye movement and light lines indicates low variations in the original signal which means non-rapid eye movement.

Following figure shows output of normal stage of sleep.

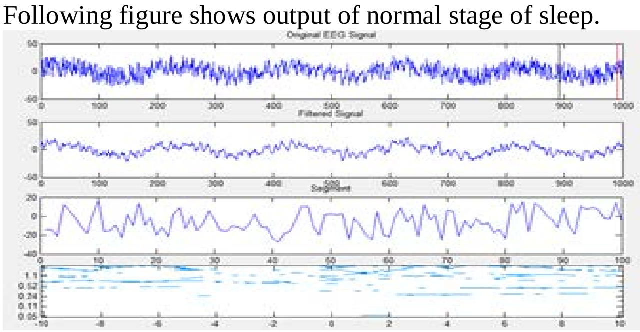

Fig 8. Original and Pre-processed signal of normal stage of sleep and corresponding SST

The classification output for Normal stage signal is shown in below

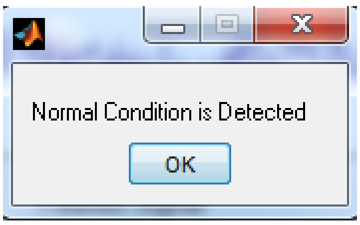

Fig 9. Classification of Normal sleep stage signal

Below table shows the parameter values of the normal sleep stage signal.

TABLE 3 PARAMETER VALUES OF THE NORMAL SLEEP STAGE SIGNAL

Parameter/Stage	Mean	standard deviation	Variance	PSNR	MSE
Normal stage signal	0.0123	0.0271	0.1643	29.214	77.9155

5. CONCLUSION

By applying modern signal processing techniques to respiratory and EEG signals, we find a set of suitable features, which allow us to predict the sleep stages accurately. The features we acquire from the EEG signals are actually finer and hidden deeply inside the signal, which may not be easily identified by human's naked eyes. The feature of the signal like Mean, Variance and Standard Deviation are extracted. Calculated the values of PSNR and MSE also which is used in training algorithm of SVM.

6. ACKNOWLEDGMENT

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