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SLEEP QUALITY MONITOR USING STRESS ANALYSIS AND REM SLEEP DETECTION

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ABSTRACT

This paper discusses a method for estimating sleep quality. It expresses the sleep quality as percentage. It is based on National Instruments LabVIEW. Two approaches are used to arrive at the sleep quality. Approach one involves quantifying the stress level that the subject is under. It is done by measuring the change in skin resistance which changes with stress. Stress levels have shown to have significant impact on sleep quality. Approach two involves design of an electrooculograph system. The EOG helps in detection of eyeball movement, hence helps in detection of Rapid Eye Movement (REM sleep) during sleep. REM sleep is generally associated with quality of sleep. Hence, the frequency of eyeball movements during sleep and the cycles in which they occur are used as an indication of sleep quality. The results from above mentioned approaches are integrated in program in LabVIEW using a suitable algorithm to give an indication of sleep quality. This project can be used for early detection and treatment of sleep disorders.

Keywords: *Sleep quality, Stress Analysis, Electrooculograph, Rapid-eye movements (REM), National Instruments-Data Acquisition (NI-DAQ), LabVIEW.*

1. INTRODUCTION

Sleep is a vital life process, which is just as important as breathing or eating. A person generally spends one-third of his life in sleep. Many people suffer from sleeping disorders. The most common disorder observed sleep deprivation. This affects alertness, reduces judgment and affects mood. Sleep is a dynamic process, which involves physiological changes in many body organs. Electrophysiological measurements such as Electroencephalograpy (EEG), Electrooculograpgy (EOG) and Electromyography (EMG) help in understanding the changes that the body undergoes during sleep [4].

Using these techniques, sleep has been classified into two basic stages non–rapid eye movement (NREM) and rapid eye movement (REM) [1][3]. These stages of sleep occur in regular cyclic pattern during a sleeping period. The NREM stage is divided into 4 stages. Each stages presents with different physiological changes in the body, The later stages in NREM sleep the body repairs and regenerates tissues, builds bone and muscle, and appears to strengthen the immune system.[4]

During REM sleep, rapid eye movements occur, breathing becomes irregular, blood pressure rises, and there is loss of muscle tone (paralysis).However, the brain is highly active, and the electrical activity recorded in the brain by EEG during REM sleep is similar to that recorded during wakefulness. REM sleep is usually associated with dreaming. REM sleep accounts for $1/4^{th}$ of the sleep period.[4] To estimate the quality of sleep it's very important to detect the REM sleep stage. REMs can be recorded by standard EOG setup alone [3].

EOG are based on the natural potential difference that lies between the cornea and retina of the eye. The cornea is positively charged while the retina is negatively charged [1]. This happens due to different rate of metabolism at the two different sites. Thus the eye behaves a dipole. The movement of the eyeball can be detected by placing electrodes around the eyes as shown in Fig.3. This configuration of electrode is used to detect horizontal movements. Thus it can be used to detect REMs during sleep.

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The Sleep studies frequently use REMs to classify the stages of sleep. It has been verified that abnormalities in REM count, duration and frequency are associated with different sleeping disorders[1]. Sleeping disorders such as sleep apnea, narcolepsy, REM sleep disorders can all be detected by the analysis of the REM stage in sleep.

The other very important factor that affects the quality of sleep is the stress level a person is under. If a person is stress free he/she sleeps better. Stress causes various ill effects like memory problems, mood swings, aches and pain. Sleep quality is also greatly affected by level of stress. There is a need for a cheap and accessible sleep quality monitor which can help early diagnosis and treatment if such disorders. In this paper we describe a method towards estimation of sleep quality by combining two approaches, REM sleep detection and Stress analysis, which yields reliable results.

2. STRESS ANALYSIS

A circuit is designed which can quantify the amount of stress a person is under, called stress meter. This Stress meter allows assessing the emotional pain. If the stress is very high, it gives visual indication on a LED display. It gives different level of indication for different levels of stress. Stress meter is based on the principle that the resistance of the skin varies in accordance with your emotional states. Resistance varies inversely proportional to the stress. If the stress level is high the skin offers less resistance, and if relaxed resistance is high. The low resistance of the skin during high stress is due to an increase in the blood supply to the skin. This increases the permeability of the skin and hence the conductivity for electric current. This property of the skin is used here to measure the stress level.

Using suitable circuitry we can convert the amount of stress a human being feels to a varying analog voltage. The LM3915 is a monolithic integrated circuit that senses analog voltage levels and drives ten LED's, providing a logarithmic 3dB/step analog display. The touch pads of the stress meter sense the voltage variations across the touch pads and convey the same to the circuit. Fig.1 shows the positioning of the finger on the touch pad. The circuit is very sensitive and detects even a minute voltage variation across the touch pad.

A DC supply is used to give a regulated power supply to the circuit .The input touch pads are used

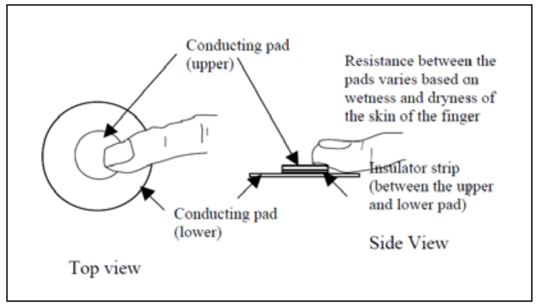

Fig.1 Positioning Of Fingers On Touchpad

to sense the resistance of our skin and this input is fed to the dot/bar display driver. The dot/bar display driver accepts the input through the touch pads which sense the small change in resistance the dot/bar driver gives the output stress level indication according the input. The output is indicated on a led display .The ten led's act like the stress level indicators form zero stress level to high stress level on a scale of ten. The complete circuit is shown in Fig.2.

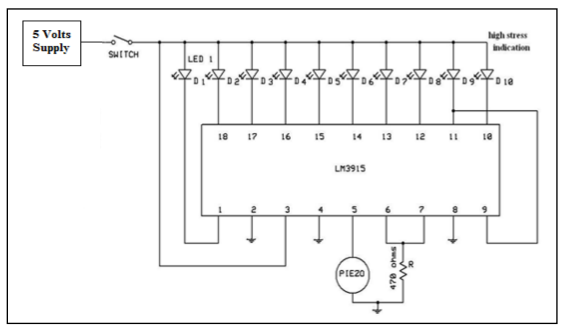

Fig.2 Circuit Of The Stress Meter

3. ELECTROOCULOGRAPHY

The movement of the eyeball causes the relative position of cornea and retina to change positions and electrodes are used to record the change in potential difference. Normal Ag/AgCl ECG electrodes are used.[2] Three electrodes configuration is used only to detect the horizontal eye movements. Shown in Fig.3 is the positioning of electrodes, the reference electrode is placed on the forehead, and the remaining two are placed on the left and right cantus.

The bio-potential amplifier used to in the electrooculogram is designed in 2 stages. The first

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stage is the preamp; it's a differential amplifier which takes input from the electrodes places on the

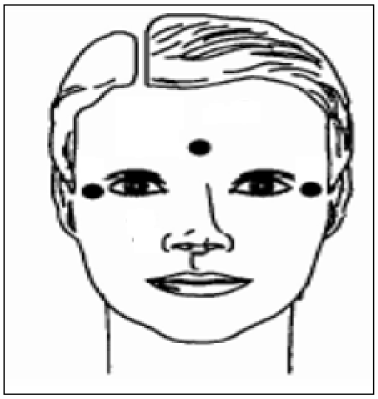

Fig.3 Positioning Of Electrodes

left and right canthus. The electrode placed in the forehead is grounded. The preamplifier must have high input impedance and low input bias current [5]. Then, a band pass filter is designed to filter out EOG signals which are in the range of 0.1 to 10Hz [2]. Instead of traditional IC741 op-amp LF356 was used because it has wide bandwidth and excellent low noise performance. Fig.4 shows the actual EOG amplifier circuit.

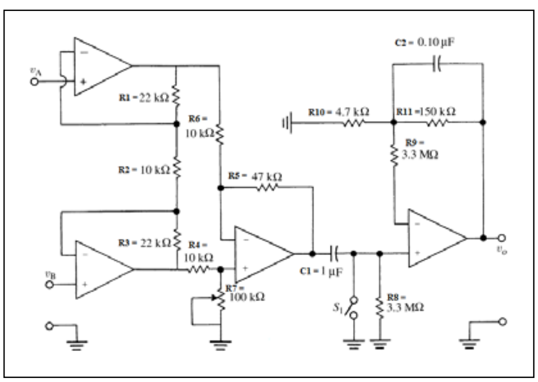

Fig.4 Circuit Of EOG Amplifier [5]

4. DATA ACQUISITION

The output from both the hardware circuits is then acquired into NI LabVIEW through NI DAQ board. The hardware is interfaced with the software so that we can program it to get desired results. The output of the Stress meter circuit is given to the NI DAQ. Instead of the 10 indicators LED's we have used only each alternate LEDs making it a total of 5 LEDs. So, we utilize 5 channels of the DAQ. It also makes the hardware less complicated as individually interfacing 10 LEDs, which would create a problem of too many wires. As alternate LEDs are interfaced, the sensitivity of the apparatus reduced slightly but overall it doesn't affect the working of the system.

The 5 LEDs interfaced through the 5 channels of the NI DAQ are acquired by the NI DAQ Assistant. The 5 different channels are converted into a Double data type array. This array is then compared to another double type array to determine when the voltage exceeds the threshold potential of the LEDs and they glow. We used a Boolean Array Indicator in form of LEDs to indicate, the stress level on the PC. Fig. 5 shows the snapshot of the LabVIEW program from data acquisition from Stress meter.

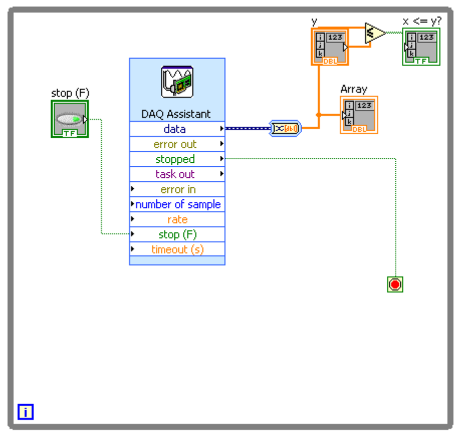

Fig.5 Labview Program For Interfacing Of Stress Meter

Similarly, The EOG circuit is also interfaced with LabVIEW. Here, we single channel since we have only one output. DAQ Assistant acquires the signal from the NI-DAQ. Another Low pass filter is designed in LabVIEW of cut-off frequency 10Hz to eliminate high frequency noise generated by the resistor and capacitor and to make sure that no other signals are mixed with the EOG signal. We get a constant noise due to the resistor and capacitors used in the circuit. To eliminate the noise, we took the average of the acquired signal. This gave an almost constant signal when no input was given to the circuit. The average block has option between two averages DC Average and RMS Average. Both gave satisfactory results in the experiment. The signal is acquired in real time through the Waveform Chart. Fig. 6 shows the LabVIEW program for acquisition of the EOG signal.

After signals from both the circuits have been acquired, they are manipulated in LabVIEW to yield Sleep quality. The LED glowing for the stress

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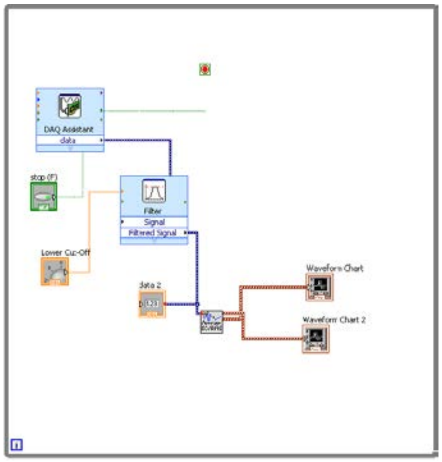

Fig.6 Labview Program For EOG Signal Acquisition

meter is converter to a number, it shows stress level on a scale of 1 to 10. Sleep quality deteriorates as stress level increases. Hence, sleep quality is .inversely proportional to the stress level obtained. Lower the stress level better sleep quality and vice versa. The acquired EOG is manipulated and its frequency is found out in LabVIEW. This frequency is near zero during NREM sleep or when the eyes are not moving, If frequency between DC to 10Hz is obtained it indicated REM[2]. During REM sleep the frequency varies. A direct relationship is obtained between REM frequency and Sleep quality. Higher the frequency, better the sleep and vice versa. The results obtained from the EOG are given 70% weightage and those from the Stress meter are given 30% weightage in final calculation of the Sleep quality. Both the circuits together give better and accurate estimation of sleep quality.

5. RESULTS

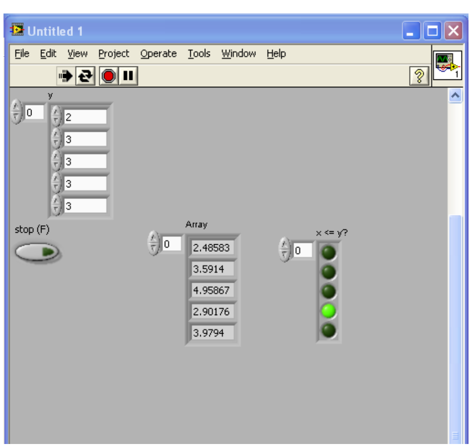

Fig 7 Output of the stress system

The above result was obtained by interfacing of the designed hardware with LabVIEW. Fig. 7 shows the 4th LED glowing, which implies a stress level of 4 on a scale of 5.

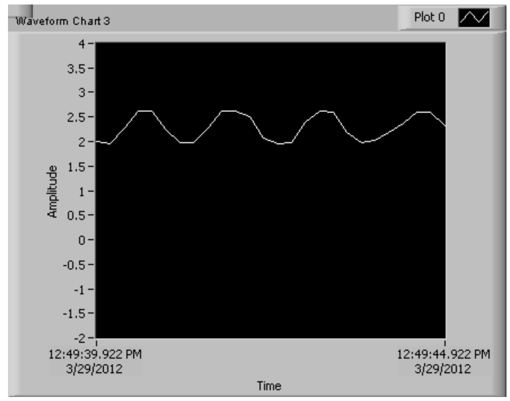

Fig. 8 The Acquired EOG Signal

Fig. 8 shows the EOG signal, the part of the signal shown indicates Rapid Eye Movements as we can see positive peak and negative peak clearly. It implies a horizontal eye movement from left to right continuously. The electrode position and environment can vary over time, it's necessary to recalibrate after each positioning of electrodes and also adjusting parameters overtime. The frequency of this signal is calculated and using results from stress meter output final sleep quality is evaluated using a suitable algorithm.(70% EOG results and 30% stress meter) The final outcome is sleep quality expressed as percentage and a graphical indicator indicating sleep quality from disturbed at the lowest to peaceful at highest.

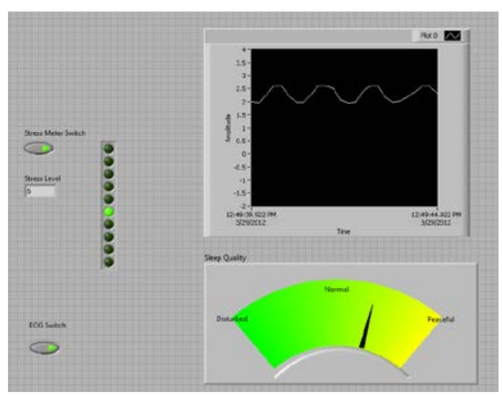

Fig. 9 Sleep Quality Monitor

The graphical display shows sleep quality 'disturbed; in green region and 'peaceful' in the yellow region. The results obtained were reliable, and with further research it can improve in accuracy and usability.

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The above system was tested with a subject and the following results were obtained. The sleep quality index at different stages of sleep, obtained by the sleep quality monitor is tabulated in the Table 1

Table 1 Quality of sleep in different stages

Sleep Stage	Stress Level	Frequency of EOG	Sleep Quality
Awake	6	0 Hz	10%
NREM	3	1 Hz	30 %
REM	3	10 Hz	86 %

The sleep quality is found to be maximum in REM sleep stage 86%, hence the results are found to be reliable.

6. CONCLUSION

The primary objective of the estimation of sleep quality is to bring about improvements in monitoring and diagnosis of sleeping disorders. Sleep quality is directly related to many physiological changes, we chose REMs and Stress as sleep quality indicators. In order to diagnose Sleep Apnea and other sleep disorders, a patient must undergo a Polysomnography (PSG). This is typically done in a Sleep lab, requiring the patient to spend the night in the sleep lab, while the PSG equipment records patient's physiological data. However, the proposed method provides quick personal and cheap home sleep study. Thissysytem is aimed towards development of a usable low cost computer human interface for people with sleep ailments. It has yield promising results and can be used as a preliminary tool for early diagnosis and treatment of sleep disorders. But, it is advised final diagnosis may be only made after consulting a medical expert.

REFRENCES:

[1] Rajeev Agarwal, Member, IEEE, Tomoka Takeuchi, Suzie Laroche, and Jean Gotman, "Detection of Rapid-Eye Movements in Sleep Studies," *IEEE Trans. Biomed. Eng.*, vol. 52, pp. 1390-1396, Aug. 2005.

[2] S. Venkataramanan, Pranay Prabhat, Shubhodeep Roy Choudhury, Harshal B. Nemade and J.S. Sallanlbi, "Biomedical Instrumentation based on Electrooculogram (EOG) Signal Processing and Application to a Hospital Alarm System," *Proceedings of ICISP*, pp 536-540,2005.

[3] E Estrada, H Nazeran, J Barragan , J R Burk, E A Lucas, and K Behbehani, "EOG and EMG: Two Important Switches in Automatic Sleep Stage Classification," *Proceedings of the 28th IEEE EMBS Annual International Conference*, pp.2458-2462,2006.

[4] Nobuyuki Itsuki , Masashi Yamada, Masanori Kubo and Kayo Shinomiya, "Improved Method for Measuring Electrooculogram and its Evaluation", *8th International Conference on Control, Automation, Robotics and Vision Kunming, China*, pp. 947 – 952, 6-9th December 2004

[5] Dennis Majoe, Philipp Bonhof, Thomas Kaegi- Trachsel, Jurg Gutknecht and Lars Widmer, "Stress and Sleep Quality Estimation from a Smart Wearable Sensor", *5th International Conference on Pervasive Computing and Applications (ICPCA)*, pp. 14-19, 2010

[6] J. G. Minard and D. Krausman, ―Rapid eye movement definition and count: an on-line detector, *Electroencephalogr. Clin. Neurophysiol.*, vol. 31, pp. 99–102, 1971.

[7] R. J. McPartland, B. L. Weiss, and D. J. Kupfer, "An objective measure of REM activity", *Physiolog. Psychol.*, vol. 2, pp. 441–443, 1974.

[8] Ali Bulent, Usakli and Serkan Gurkan, ―Design of a Novel Efficient Human–Computer Interface: An Electrooculagram Based Virtual Keyboard, *IEEE Transactions on Instrumentation and Measurement*, vol. 59, no. 8, pp 2099-2109, August 2010.

[9] http://science.education.nih.gov/supplements/ni3 /sleep/guide/introduction.htm

[10] http://www.unc.edu/~finley/BME422/Webster/ c06.pdf