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EXPERIMENT: Electrooculogram (EOG)

AIM:
To analyze the EOG signal obtained from horizontal and vertical channels acquired from a subject viewing a pendulum motion.

OBJECTIVES:
i. To find the frequency of the pendulum from the acquired EOG signal.
ii. Analyze the differences in the horizontal and vertical components of eye motion observed from the signals acquired from the horizontal and vertical channels.

APPARATUS & SOFTWARE USED:
i. EOG Electrodes
ii. BIOPAC MP 36 system for EOG acquisition
iii. Toy Pendulum
iv. BIOPAC Student Lab MP 36 – Software for signal acquisition and filtering
v. MATLAB software for further analysis

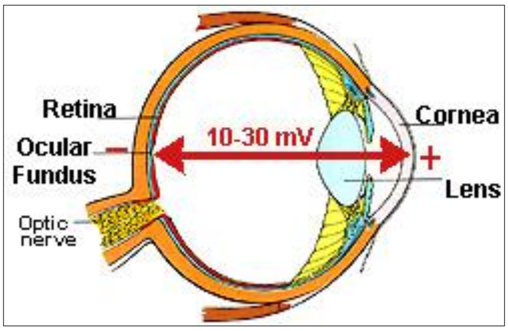

Fig1: EOG potential medicine.mcgill.ca

THEORY:

Electrooculography (EOG) is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye. The resulting signal is called the Electrooculogram. In the early 1900's, it was discovered that by placing electrodes on the skin in the region of the eyes, it was possible to record electrical activity which reflected the synchrony of eye movements. It was initially believed that these potentials originated from the action potentials in the muscles responsible for eye movements. However, it was later proved that these electrical potentials are generated by the permanent potential difference which exists between the cornea and the ocular fundus (cornea-retinal potential, 10-30mV: the cornea being positive). This potential difference sets up an electrical field in the tissues surrounding the eye. As the eye rotates, the field vector rotates correspondingly. Therefore, eye movements can be detected by placing electrodes on the skin in the area of the head around the eyes. Vertical movements of the eyes are best measured by placing the electrodes on the lids, while horizontal eye movements can be best measured by placing the electrodes on the external canthi (the bone on the side of the eye). [1]

Measurement of electric potential between electrodes placed at points close to eye used to investigate eye movements. The EOG ranges from 0.05 to 3.5 mV in humans and is linearly proportional to eye displacement. The human eye is an electrical dipole with a negative pole at the Fundus positive pole at the Cornea.

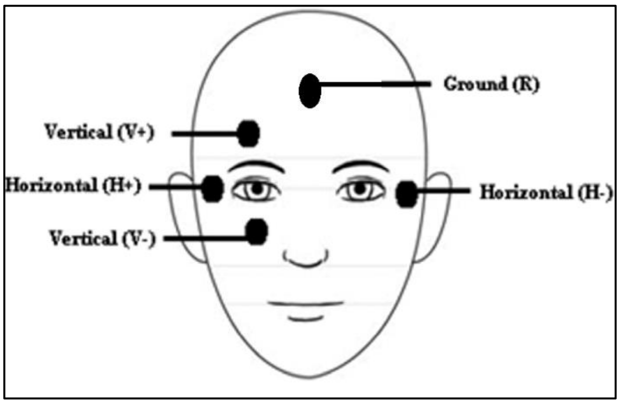

Fig2: Electrode placement

Conventionally, the EOG is recorded in two bipolar leads as illustrated in Fig2.
The horizontal channel records the voltage between electrodes positioned near the outer canthi of each eye, which changes when the eyes move horizontally.
The vertical channel records the voltage between electrodes positioned above and below one of the eyes, which changes when the eyes move vertically.
From the two recorded voltage signals, the movement of the eyes can be inferred approximately. It allows the detection of the same eye movements with an 8-electrode configuration but with less resolution. The electrodes are connected to a high-gain, low-noise, DC coupled biopotential amplifier. The output of the amplifier is digitized and recorded or processed in real-time.

For angular displacement of the eyeball within about 45 degrees either side of the central position, the EOG voltage varies linearly with angle. The magnitude of voltage variation is variable, but is of the order of 15uV per degree of rotation. Since EOG is a relatively simple technique, it is commonly used clinically for testing eye movements in patients.

PROCEDURE:

i. The subject was made seated in a comfortable position.
ii. First, the horizontal channel electrodes were secured on the subject as illustrated in Fig2.
iii. A toy pendulum was placed such that the resting position was always at eye level in between the eyes. The pendulum bob was taken ~30° on the side of the right eye and allowed to make 5 complete swings from the start position. The subject was asked to follow the bob closely while the EOG signal was recorded.
iv. Next, the vertical channel electrodes were secured as illustrated in Fig2.
v. Step iii. was repeated in this configuration and the EOG signal was recorded.
vi. The signal was acquired using the BIOPAC MP 36 system. The EOG signal was filtered with a bandpass filter of range (0.05 - 35 Hz). The sampling frequency was set to 10000Hz, the gain was set to 1000, and Q factor = 0.707.
vii. The EOG signals recorded from both the channels were analyzed using MATLAB.

RESULTS & OBSERVATIONS:

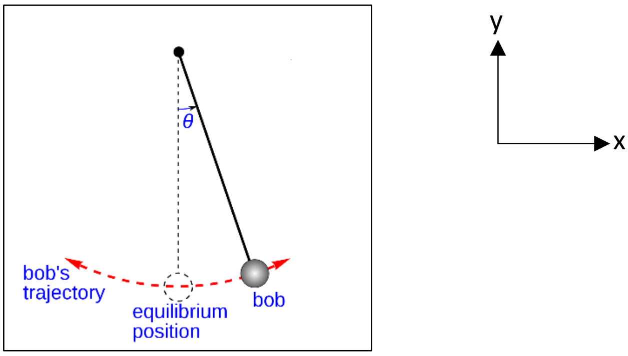

Fig3: Pendulum

Assuming SHM, and that the string is taut at all times, the pendulum bob traces an arc of the circle.

$x = A \sin \omega t \qquad y = A \cos \omega t$

Signal from Horizontal channel

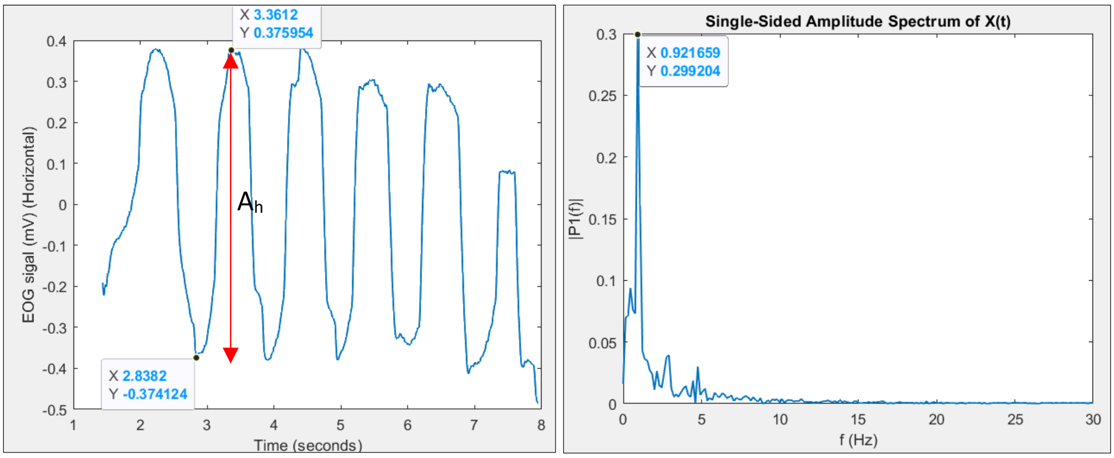

Fig4: Signal from horizontal channel

From Fig4, it can be observed that the horizontal channel is able to collect the signal corresponding to the horizontal movement of the eye. The slight vertical movement of the eye while viewing the pendulum does not show up. The peaks and troughs correspond to the maximal displacements of the bob on either side in the x-direction.

The amplitude of the signal,

A_h ~ 0.75 mv. This value can be assumed to be proportional to the x displacement of the pendulum bob.

The FFT of the signal shows a sharp peak at 0.92Hz. The time taken for the eye movement from right – left- right is the time period of the pendulum. Thus, the frequency obtained from the channel is the frequency of the pendulum= 0.92Hz.

Signal from Vertical channel

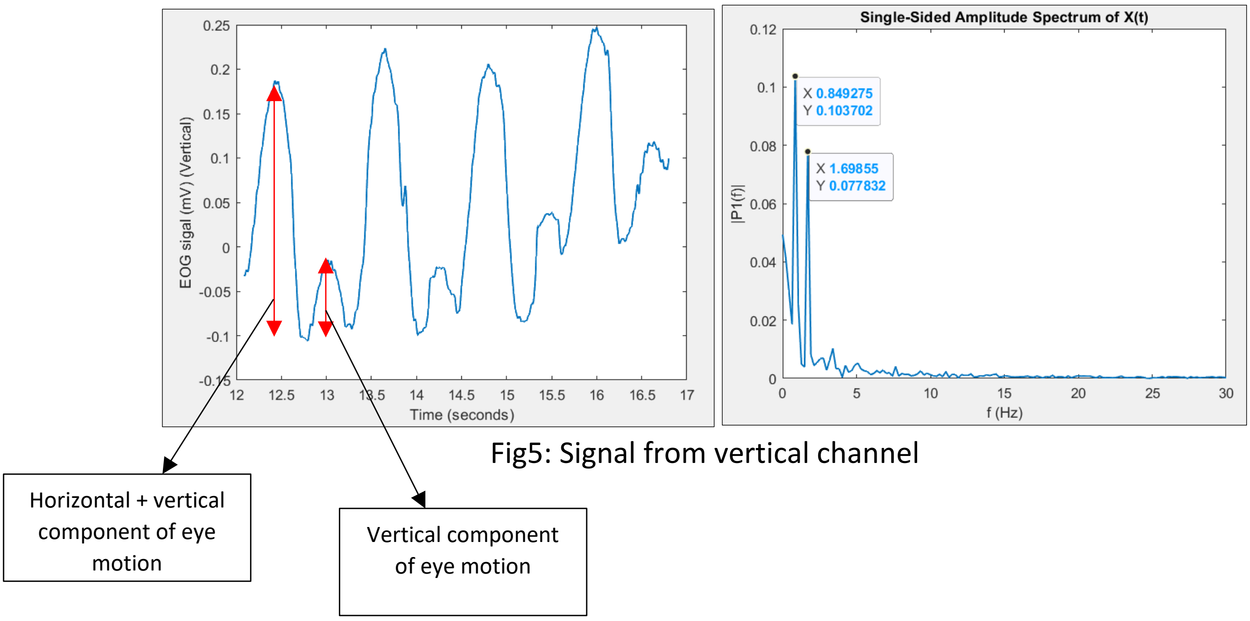

Fig5: Signal from vertical channel

The signal from the horizontal channel shows both horizontal and vertical components of eye motion. Results from other studies have also shown that the vertical EOG component is highly influenced by horizontal eye movements, whereas the horizontal EOG is rarely affected by vertical eye movements. It can be observed that two sharp peaks are obtained from the FFT of the signal. One at ~ 0.85Hz and another at twice this value ~1.7Hz.

During one period of the pendulum, the horizontal sweep of the eye (right- left-right) will be the period of the pendulum, but the vertical component of the eye peaks twice during this time period (up- down – up- down). Therefore, the vertical component of eye motion has twice the frequency of the horizontal eye motion.

Hence, horizontal motion of the eye has a frequency ~ 0.85 Hz (equal to pendulum frequency)

Vertical motion of the eye has a frequency ~ 1.7Hz.

A_v ~ 0.09mV

$A_v + A_h$ ~ 0.2878mV. A_h ~ 0.1978mV.

In addition, it can be observed that the horizontal amplitude is much greater than the vertical amplitude. This is consistent with the pendulum motion, since the x-direction has a larger displacement compared to the displacement in the y-direction.

CONCLUSIONS:

The EOG signal obtained from horizontal and vertical channels acquired from a subject viewing a pendulum motion has been analyzed.
The frequency of the pendulum during the two trials has been found.
The amplitude and frequency of the horizontal and vertical component of eye motion has been found.

CRITICAL REMARKS:

i. The electrode should be tightly secured on the region near the eye. Electrode movement during signal acquisition can result in noisy signals.
ii. The subject should try to maintain the same pace while performing the curls across all trials to make comparable distinctions between electrode distance.
iii. The EOG signal can be influenced by blinking of the eyes, the noise generated between the electrode contacts and the skin, the metabolic state of the tissues (pO_2, pCO_2, and temperature, visual stimulation and contraction of facial muscles. [1]

REFERENCES:

i. https://www.medicine.mcgill.ca/physio/vlab/Other_exps/EOG/eogintro_n.htm