Original Article

# Digital Signal Processing Filter Techniques For Bio Potential Recording System Of Human Visual Optic Nerve Pathway Conduction Measurement Using Visual Evoked Potentials

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## Abstract

Basically Visual evoked potentials (VEP) are very low potential and it is very difficult to identify the original signal after many times of amplifications and filtering methods .Due to this problem we need to go for strong extraction tools to develop their originality reproducible morphology in the clinical laboratories. Normally the test carried out with conventional averaging method to avoid and cancellation of unwanted signals which is routinely used in hospitals. But there will be a little bit amount of information may lost to reproduce the original signal after averaging method. For this reason we need to go for adaptive noise cancellation filter techniques which will be helpful to eliminate the complete background noise and reproducible original signal without any loss of information.

**Keywords:** Electro diagnostic instrument, Human brain signals, VEP signals, Adaptive noise filter

## INTRODUCTION

The VEP is an electro diagnostic instrument which will be help to record optic nerve function of human eye between retinas to occipital lobes of conduction pathways. There are three latency mark identification namely N-75(N1), P-100(P1) and N-145(N2). The recording placement of surface disc electrodes were placed at reference point (FZ), active point (OZ) and ground point (FPZ). Basically the VEP potentials are low amplitude and cannot identify the original waveform morphology after so many times of amplifications and smoothing after the modified one from the original signal. Therefore we need to avoid the unwanted signals with the help of computerized averaging methods in the instrument itself to identify the original waveform morphology after several stages. The clean and pure VEP shows the exact result after the perfect recording placement and proper average methods followed by normal subject for collecting various sampling data values. Sometimes the study may possible to corrupted by noise due to technical problem and other atmospheric circumstances, the doctor asked to repeats the study once again and confirm it after averaging once, Sometimes the averaging method shows the amplitude distortions and the shape of waveform morphology when you average more number of times. Depending upon the method of doing averaging method shows a results considerable loss of information's. For this reason, effective filtering method is needed to avoid the loss of information, i.e., reduction of amplitude and jumping of latency in a particular method. In this chapter, adaptive filtering method is introduced for filtering the brain signal for determines the optic nerve from eye retina to occipital lobes. The adaptive noise method, the primary active potential and the reference signals which are helpful to record VEP sweeps.

## II. AVERAGING TECHNIQUE

For patient purpose, the potential can be used with average method. This is based on measuring the average values of multiple VEP single waveforms observed. It needs between 150 and 200 trails. The number of single waveforms to be averaged based on signal to noise ratio (SNR). Regarding this, the ISCEV study Standard recommends to fix the minimum number of sweeps per average to 60 and to produce two to three averages to confirm the waveform morphological of the recording study. The output produces in fatigue and discomfort of the subject and may or may not affect its concentration at the time of test. The accuracy of this method is doubtful considering that, theoretically, it provides an improvement of SNR directly based on the number of trails.

The tested study potential is producible clean repetitive and deterministic signal wave formations. Therefore this kind of potentials are type of stationary potentials and its statistical properties and not depends on the duration and also the noise of background may affect the study potential sweeps with an additional noise like additive white Gaussian noise.

## III. ADAPTIVE FILTERING METHOD

This type of filtering method before subtraction allows assigning two inputs that are deterministic or time variable. The improvement of Wiener solutions absorbs asymptotic adaptive filtering performances and result of output SNR for

stationary stochastic inputs, including one or more input references. From this reference input and certain other conditions is met noise in the primary input can be essentially eliminated without signal distortions.
The filter organization process of two basic signals $x(n)$ and $y(n)$ referred to as the primary potential and the further potential alternatively, as shown in Figure(6). Let us consider a clinical morphology contribution of $y(n)$ and from $x(n)$. This method gives a maximum estimation of that potential which is clinically and technically tolerated with $y(n)$.

The input potential gives the distortion potential in the final result can be subtracted of the suitable approximation from the basic input will organize the distortion signal as the final stage of this method and which will be helpful in need feedback to analysis of this method for filter tap weights, in the mathematical mean square value, then the morphological waveform coordination's is removed at the final stage completely.
The filter configuration process two basic signals $x(n)$ and $y(n)$ referred to as the primary potential and the reference potential respectively, as shown in Figure(1). Let us consider that a clinical correlation contribute between $y(n)$ and only a part of $x(n)$. This method gives the maximum estimate of that potential component which is clinically and technically correlated with $y(n)$.
The primary input potential gives the error potential in the output of the canceller can be subtracted of the best estimate from the primary input will produce the error signal as the output of the canceller and which is used in a feed back to adjust optimality of this method filter tap weights, in the mean square value, then the correlation is removed at the output completely.

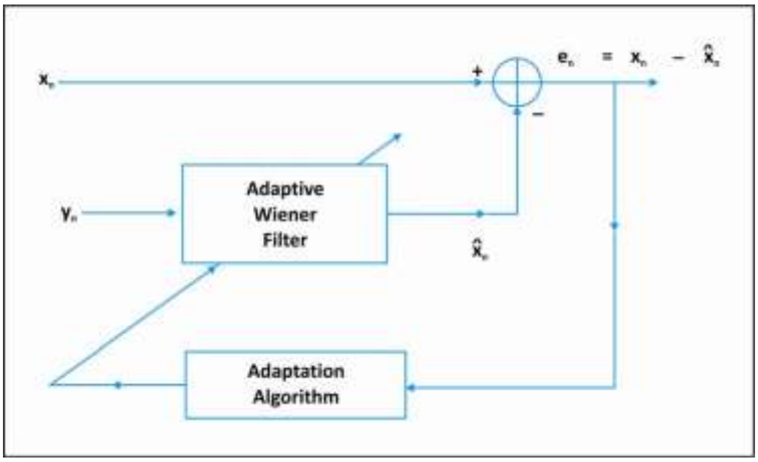


**Figure 1:** Adaptive noise Canceller method

The VEP noise signals in figure (2) are applied to adaptive noise of the input signals. The measurement of latency and amplitude values are shown in Table (1)Let us consider active signal and reference signal are given by the original potential $s(n)$ and two deference additive noise potentials.
*K1* ($n$) and K*2* ($n$) as follows.

$A(\nu)=\rho(\nu)+K1(\nu)$ (1)

and

$2B(\nu)=\rho(\nu)+K2(\nu)$ (2)

The difference between the error potential of primary and estimated potentials are

$E(n) = x(n) - \hat{x}(n)$ (3)

The filter eliminates based on the adaptive noise filter
Let us define the tap weights vector potential and the reference vector potential at the *nth*
Sampling time by:

L [(0), (1),……..,(1)] (4)

and

L [(0), (1),…(1)]

Nnnnh = ynyn–yn-N (5)

Where N represents the filter order and L the vector transpose. The adaptation factor $\mu$ acts on the weights' fluctuation about their true values as they converge to the Wiener optimum solution. In addition, this factor controls the convergence and the rate of convergence as well. A too small value for $\mu$ will guarantee the convergence, thereby slowing the convergence rate. Figure (3) showed a clean VEP signal using adaptive noise filtering methods.

## IV. EXPERIMENTAL METHODS

There are four different normal healthy subjects were recorded individually and the original signal amplified and preprocessed after several stages. After amplification of these signals are modified into pure original signal with the help of averaging methods.

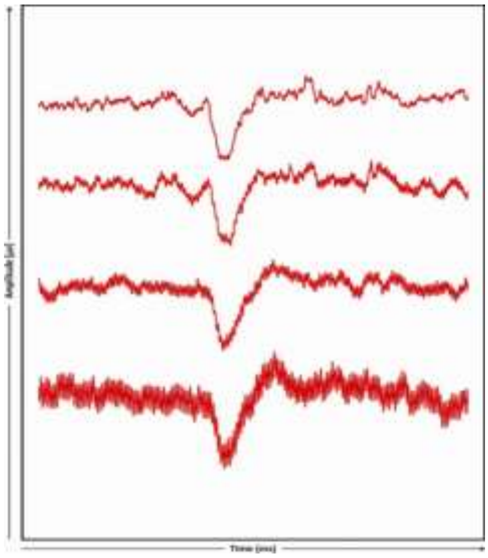

**Figure 2:** VEP Noisy signals after several amplification stages

In figure(2),there are four different brain signal taken for analyzing optic nerve such as subject-1,subject-2,subject-3 and subject-4 data samplings respectively. In subject–1 recording, the latency values are noted as 93.8 ms (N-75), 122.5ms (P-100), 151.3ms (N-145) and 4.1 micro volt amplitude value. From subject–2recording, the latency values are noted as 92.5ms (N-75), 123.9ms (P-100), 144.4 ms (N-145) and 4.3 micro volt amplitude value. In subject–3recording, the latency values are noted as 93.1ms (N-75), 126.9ms (P-100), 153.8ms (N-145) and4.7micro volt amplitude value. In subject–4recording, the latency values are noted as 94.4 ms (N-75), 123.1ms (P-100), 151.3ms (N-145) and4.9micro volt amplitude value. These values are shown in Table (1)

**Table-1:** Latency and amplitude measurement in VEP noise signal

| Data Samples | N75(ms) | P100(ms) | N145(ms) | Amplitude(μv) |
|---|---|---|---|---|
| subject-1 | 93.8 | 122.5 | 151.3 | 4.1 |
| subject2 | 92.5 | 123.9 | 144.4 | 4.3 |
| subject-3 | 93.1 | 126.9 | 153.8 | 4.7 |
| subject-4 | 94.4 | 123.1 | 151.3 | 4.9 |

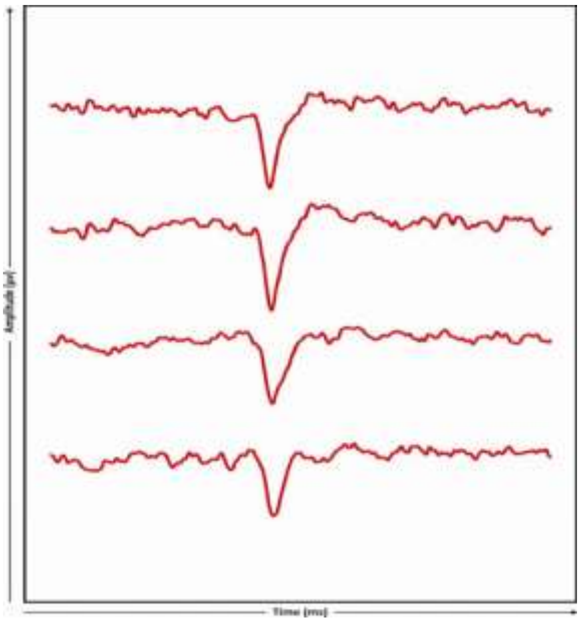

**Figure 3:** Conventional Averaging methods

From conventional averaging methods, the noises were removed and a clean VEP shown in figure (3).The amplitude greatly reduced and latencies are moved towards the value when compared to VEP noise signals, ie, before averaging the signals. After conventional averaging methods, the sample –1 recording latency values are noted as 93.8 ms (N-75), 122.5ms (P-100), 151.3ms (N-145) and 4.1 micro volt amplitude value. From sample–2recording, the latency values are noted as 92.5ms (N-75), 123.9ms (P-100), 144.4 ms (N-145) and 4.3 micro volt amplitude value. In sample –3 recording, the latency values are noted as 93.1 ms (N-75), 126.9ms (P-100), 153.8ms (N-145) and 4.7 micro volt amplitude value. In sample -4 recording, the latency values are noted as 94.4ms (N-75), 123.1ms (P-100), 151.3ms (N-145) and4.9 micro volt amplitude value. These values are shown in Table (2).

**Table 2:** Latency and amplitude values after conventional averaging methods.

| Data Samples | N75(ms) | P100(ms) | N145(ms) | Amplitude(µv) |
|---|---|---|---|---|
| **subject-1** | **94.7** | **123.1** | **151.9** | **3.5** |
| **subject-2** | **94.8** | **125.9** | **145.8** | **3.6** |
| **subject-3** | **94.9** | **126.9** | **155.9** | **4.0** |
| **subject-4** | **95.0** | **127.1** | **152.8** | **4.1** |

**Table 3:** Comparison between before and after averaging methods

| Data Samples | N75(ms) | P100(ms) | N145(ms) | Amplitude(µv) |
|---|---|---|---|---|
| **subject-1** | **93.8 (94.7)** | **122.5 (123.1)** | **151.3 (151.9)** | **4.1 (3.5)** |
| **subject-2** | **92.5 (94.8)** | **123.9 (125.9)** | **144.8 (145.8)** | **4.3 (3.6)** |
| **subject-3** | **93.1 (94.9)** | **126.9 (126.9)** | **153.9 (155.9)** | **4.7 (4.0)** |
| **subject-4** | **94.4 (95.0)** | **123.1 (127.1)** | **151.3 (152.8)** | **4.9 (4.1)** |

Table (3) showed, VEP, noise signal before and after conventional averaging signals. The bold numbers within the bracket terms are showed as conventional averaging values.

**Table 4:** Reduction of amplitude measurement values

| Data Samples | VEP Noise signal (µv) | Conventional Averaging (µv) | Reduction of Amplitude (µv) |
|---|---|---|---|
| **subject-1** | **4.1** | **3.5** | **0.6** |
| **subject-2** | **4.3** | **3.6** | **0.7** |
| **subject-3** | **4.7** | **4.0** | **0.7** |
| **subject-4** | **4.9** | **4.1** | **0.8** |

From Table (4), the reduction of amplitude noted after traditional averaging methods and the amplitude values are 0.6 µv, 0.7µv, 0.7µv and0.8µvin subject-1, subject-2, subject-3andsubject-4 recording respectively.

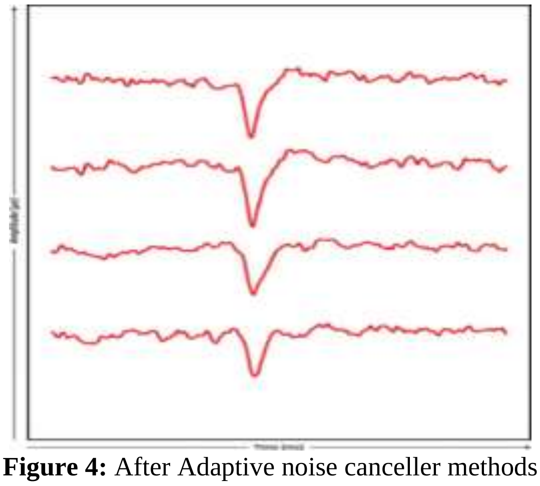

**Figure 4:** After Adaptive noise canceller methods

**Table 5:** Latency and amplitude values after adaptive noise canceller method

| Samples | N-75(ms) | P-100(ms) | N-145(ms) | Amplitude(µv) |
|---|---|---|---|---|
| **Sample-1** | **93.6** | **122.6** | **151.8** | **4.0** |
| **Sample-2** | **92.4** | **124.1** | **144.8** | **4.2** |
| **Sample-3** | **93.2** | **127.2** | **154.2** | **4.5** |
| **Sample-4** | **94.7** | **123.4** | **151.7** | **4.7** |

Table (6) showed VEP noise signal and adaptive noise signals. The bold numbers within the bracket terms are showed as adaptive noise filter values.

**Table 6:** Comparison between before and after adaptive noise filter technique

| Samples | N-75(ms) | P-100(ms) | N-145(ms) | Amplitude(μv) |
|---|---|---|---|---|
| Sample-1 | 93.8 **(93.6)** | 122.5 **(122.6)** | 151.3 **(151.8)** | 4.1 **(4.0)** |
| Sample-2 | 92.5 **(92.4)** | 123.9 **(124.1)** | 144.8 **(144.8)** | 4.3 **(4.2)** |
| Sample-3 | 93.1 **(93.2)** | 126.9 **(127.2)** | 153.9 **(153.9)** | 4.7 **(4.5)** |
| Sample-4 | 94.4 **(94.7)** | 123.1 **(123.4)** | 151.3 **(151.5)** | 4.9 **(4.8)** |

From Table (7), the reduction of amplitude showed 0.1 μv, 0.1μv, 0. 2μv and0.1μv in sample-1, sample-2, and sample-3andsample-4recording respectively. From this adaptive noise canceller method, the amplitudes are slightly reduced as shown in Table (7).

**Table 7:** Reduction of amplitude after adaptive noise filter techniques

| Samples | VEP Noise signal (μv) | Adaptive Noise filter (μv) | Reduction of amplitude (μv) |
|---|---|---|---|
| Sample-1 | 4.1 | 4.0 | 0.1 |
| Sample-2 | 4.3 | 4.2 | 0.1 |
| Sample-3 | 4.7 | 4.5 | 0.2 |
| Sample-4 | 4.9 | 4.8 | 0.1 |

**Table 8:** Comparisons between conventional averaging and adaptive noise filter methods

| Samples | VEP Noise Signal-μv) | Difference of amplitude (Conventional averaging-μv) | Difference of Amplitude (Adaptive filter-μv) |
|---|---|---|---|
| Sample-1 | 4.1 | 3.5**(0.6)** | 4.0**(0.1)** |
| Sample-2 | 4.3 | 3.6**(0.7)** | 4.2**(0.1)** |
| Sample-3 | 4.7 | 4.0**(0.7)** | 4.5**(0.2)** |
| Sample-4 | 4.9 | 4.1**(0.8)** | 4.8**(0.1)** |

From Table (8), the reduction of amplitude value comparatively less in adaptive noise canceller method when compared to conventional averaging method. The averaging method resides in the fact that the obtained signal's shape presents some amplitude distortion the number of the averaged recorded single VEP increases. This method of ensemble average results the reforming considerable loss of information.

## V. CONCLUSION

The clean visual potentials have been recorded and averaged from the standard normal subject. In clinical laboratories, the potentials are sometimes may corrupt by noise in certain circumstances, then the neurologists wants to record the study repeatedly and make it sure the natural one. Finally the adaptive noise canceller method which will be helpful to avoid the unwanted artifacts with original VEP signals. This study produces the best results for recording optic nerve potential from filtering cortical brain waves as compared with traditional averaging method used in the clinical practice.

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