Brain Fingerprinting

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Abstract— Different technologies and methodologies have evolved with times for the effective deduction of crimes viz. Fingerprint testing, DNA testing , Polygraph testing (lie detectors). Brain fingerprinting is a new addition to this list and has proved beneficial. The basic idea is that the brain emits a unique brainwave pattern when confronted with a particular stimulus. This brainwave pattern is then studied with a well-devised algorithm and the necessary deductions are carried out to avoid any error. Brain Fingerprinting differs from the Polygraph Test in a way that it does not detect lies, stress, emotions. It simply determines if the information is 'present' or 'absent' and delivers a confidence based on computed statistics for each determination.Apart from criminology, this technique is useful in other applications too.

Index Terms— Brainwaves, Electroencephalography(EEG), Electrodes, Probes, P300, P300-MERMER, Target.

1 Introduction

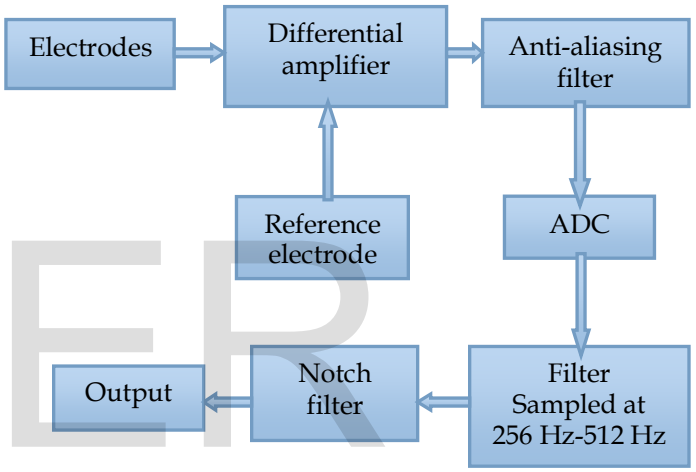
Brain fingerprinting is a scientific method developed on the theory that the brain detects, stores & responds to the worldly situations that it has witnessed. The basic principle used in Brain Fingerprinting technology is that when the brain is shown words, phrases or pictures of events it has already witnessed , it emits electrical pulses. These pulses can be measured to decide whether the concerned person was present at the crime scene or not. This phenomenon can find applications in crime detection, medical diagnosis (e.g. - Early detection of alzheimers), security, etc.

The event related pulse emitted by the brain is called P300. The P300 is recorded by electroencephalography (EEG) technique and it shows positive deflection in voltage with an extremely small delay in response to the stimuli (around 250ms to 500ms). In crime detection applications the Brain Fingerprinting technique uses the fact that perpetrator of the crime is the only one who has specific information of the event that has taken place at the crime scene.

The Brain Fingerprinting technique is more accurate and advanced than the existing polygraph procedure. Polygraph relies on measurement of physiological signals like heart rate, blood pressure and sweating whereas Brain Fingerprinting gauges electric pulses emitted by the brain using special sensors.

2 Electroencephalography (EEG)

EEG is a procedure to measure electrical activity along the scalp (especially the p300 and p300-MERMER). Electrodes are placed on the scalp with conductive gel. The locations and names of the electrodes are specified by the international 10-20 system. Each electrode is connected to one input of differential amplifier and a common system reference electrode is connected to the other input of each differential amplifier. The amplifiers amplify the voltage between active and reference electrode by 1000 to 10,000 times. These amplified signals are passed through a series of filters and amplifiers. The block diagram for the same is as follows:-



2.1 P300 & P300-MERMER

The P300 signal is a positive voltage which peaks 300ms after the occurrence of the event of consequence. The time domain plotting of this P300 signal is enough to corroborate the fact that the person in question has knowledge of that particular event. To further bolster the theory the P300-MERMER (Memory and Encoding Related Multifaceted Electroencephalographic response) signal is studied. The positive peak of the P300 is followed by a negative peak called late negative potential. The combination of these two potentials is called P300-MERMER. Though the P300 & P300 MERMER have other features apart from the simple time domain patterns they are not needed for defining response.

3 Techniques

Brain fingerprinting uses the fact that an individual's brain emits an electrical signal known as P300 when it confronts a stimulus of special significance. Since this signal gives a peak value at 300ms after the stimulus it is known as P300. The basic idea is to present three types of stimuli consisting of either words, phrases or pictures on a computer screen. These

stimuli contain information which may be relevant or irrelevant to the crime scene. The three different types of stimuli are :-

- Probe Stimuli
- Target Stimuli
- Irrelevant Stimuli

3.1 Probe Stimuli

The probe test is used to detect whether the subject has the knowledge or lack of knowledge regarding the or investigated situation. The probes are thus always related to the crime scene. The features of the probe are mentioned below.

1) 1st feature: It contains information about the crime learned by the perpetrator while committing the crime, or in course of gaining the knowledge from external sources.

2) 2nd feature: Information relevant to the crime scene but not known by the subject.

3) 3rd feature: Probes contain information that the subject refuses to have knowledge of.

3.2 Target Stimuli

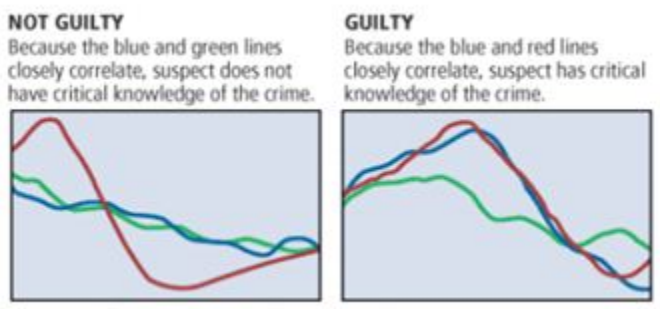
It provides the reference signal waveform for comparing with the probe stimuli. Target stimuli contains information relevant to the situation that is known to the subject. Target stimuli contains information that has been revealed to the subject after the crime or investigated situation.

3.3 Irrelevant Stimuli

This stimuli contains credible but incorrect information. It matches the probe information and checks if the subject lacks the relevant knowledge about the crime. Thus by comparing these two responses from irrelevant stimuli and probe stimuli it confirms the subject lacks the relevant knowledge or not.

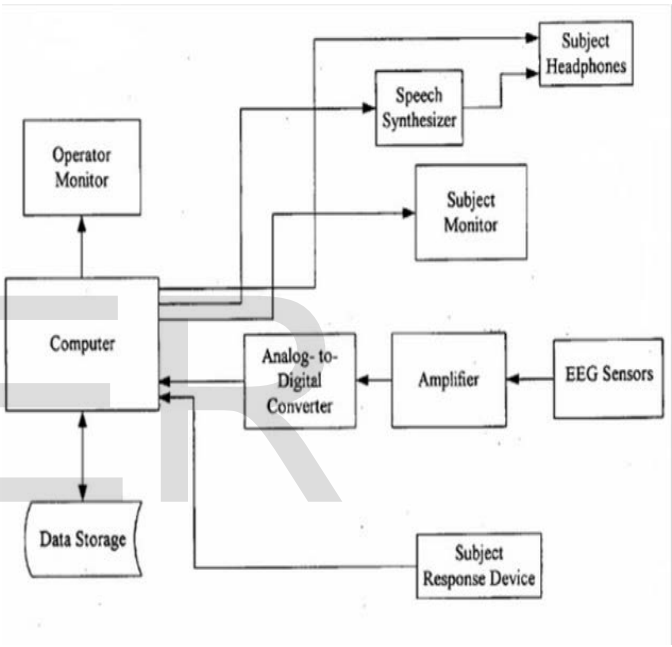
4 Scientific Procedure

Each stimulus is shown for a fraction of second. Generally a picture is shown for 1800ms and a simple stimuli like a word or a phrase is shown for a shorter period. Once the non invasive electrodes are connected to the subjects scalp a sequence of words or pictures is presented on a video monitor controlled by a computer. The subject is first shown the target and irrelevant stimuli to get the reference waveform. Probe stimuli is then presented to the subject which generates P300-MERMER response in the subject's brain. Thus multiple such stimuli are presented to the subject and then the accumulated data is processed. For each iteration the probe, target and irrelevant waveform are compared.



In fig. 3 red waveform is for Target stimuli, green waveform is for irrelevant stimuli and blue is for probe stimuli. As we can see in the figure when the suspect is not guilty or if he doesn't have required information the blue line and green line are closely correlated. That is probe and irrelevant stimuli are closely correlated and it shows that the suspect is innocent. When blue line and red line closely correlate it proves that probe and target stimuli are related and thus the suspect is guilty.

4.1 Instruments used in Brain Fingerprinting

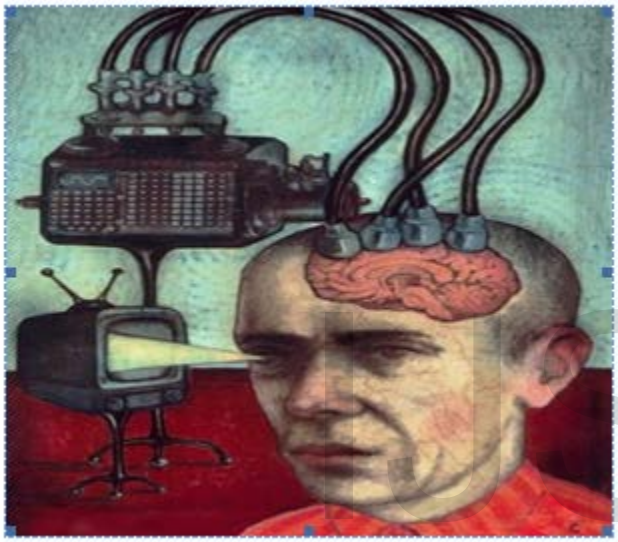


- Personal Computer.
- A data acquisition board.
- A graphics card for driving two monitors from one PC.
- A four channel EEG amplifier system.
- Software developed by the brain fingerprinting.

A Pentium 4, 1 GHz, IBM Personal Computer (CPU) is the important unit which is the brain of the whole setup for Brain Fingerprinting. It contains a graphic card which enables the CPU to drive two monitors from a single Processor. Among the two monitors, one is used by the tester while the other is used by the subject where different stimuli are projected. On confrontation, the brain of the subject emits the P300-MERMER pulse which is received by a special headband fitted with electrodes placed on the scalp. This headband

measures the electroencephalographic (EEG) response from several locations on the scalp. These electrodes range in number from tens to thousands. The EEG signal received is very small in millivolts and thus it needs to be amplified. An EEG amplifier system is used for this purpose. Further, a Data Acquisition Board (DAQ) is used for converting this signal into digital format i.e. digitization. A Brain Fingerprinting software developed for assistance is installed into the Personal Computer. This software is used for display of stimuli and analysis of EEG data collected according to a defined algorithm.

Apart from these instruments, other assistant devices like data storage device, synthesizer, headphones etc. are also used.



5 LIMITATIONS

Like all other technologies, Brain Fingerprinting too has some limitations. Since Brain Fingerprinting is all about the P300-MERMER pulse emitted by the brain, chances of the subject responding 'positively' to the probes are very high even if he has just been an eye-witness at the time of crime and not the actual perpetrator. Both the witness and the actual perpetrator would record the details of the crime in their brain since both of them were present at the time of crime ; the difference however lies in one being guilty and the other not.

It is possible for a subject selected for testing to possibly 'make up his mind' already, if he knows the questions beforehand. A subject, if he's the actual perpetrator, could train and control his own mind to be confident enough to answer and thus not let the machine detect it.

This technology would fail if by some measures, the executor loses his memory and thus the details of crime. Albeit a rare case, since the perpetrator is less likely to forget such details.

Brain fingerprinting won't work on people who are possibly the heavy drinkers, mentally unstable or who have many records of crime. The data collected in such cases may not be reliable.

5 CONCLUSION

Since it's inception, the technology of Brain Fingerprinting has proved quite useful in solving crimes and absolve the ones who are not guilty. The P300-MERMER technology has been 100% accurate in it's result as recorded at different agencies and in cases. It not only has a major hand in crime detection, but it also plays a role in different applications like detection of diseases like Alzheimer, researches on demographic study of advertising development, job recruitments for special secret services in military and intelligence sectors etc. The limitations of early Polygraph technology are clearly ruled out in this new technique, thus revolutionizing the process of crime detection.

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