Brain Computer Interfacing

Brain computer interfacing is one of the most revolutionary advancements in both medical and computer sciences. The simple description of it is; it is the control of computer systems using your brain. This is a concept which has been featured in a lot of sci-fi shows but up until now has not been possible. Thanks to researches run by some of the top computer and neurological scientists in the world, a lot of progress has been made in this field. In this essay I will explain the fundamentals of the field and elaborate on how it is achieved, as well as the multitude of uses for this technology in all areas of life such as the medical applications and also the effect it has had in understanding the complexities of the human brain.

Brain computer interfacing (BCI) can be broken down into three main categories: Active BCI, reactive BCI and passive BCI. Active BCI is one of the most common forms of BCI as it uses conscious thoughts from the user to control various computer systems. This has a lot of difficulties involved such as false signals often occurring from sub-conscious thoughts which can obscure the signal and give incorrect readings, resulting in the wrong action or output being recorded. It is one of the more useful of the three as it allows conscious control of a system. This can play a huge part in treating a variety of medical problems such as allowing disabled people who may not have the use of part of there body to communicate or control systems without the need for physical movement. Active BCI also has many applications in entertainment as with the rise of virtual reality and immersive gaming, it adds a new level as actions in the game can now be controlled through brain signals. (Paraphrasing Brain Computer Interfaces, 2010)

The main process for active BCI is electroencephalogram (EEG). This measures the electrical signals which are outputted by the brain. Although in the past there has been many invasive methods of doing this, in recent times the most common method is using electrodes which are placed in specific places around the subject’s head in order to record these signals and output them. This is an example of a passive method which is a lot safer and easier to set up than more dated methods. Although this process has advanced a lot, there are still many flaws included. The most serious one of which is the inaccuracy that is involved, this is due mainly to the number of variables implicated between tests. The best example of this is the fact that it is extremely difficult to place the electrodes back in precisely the same location between tests, this can lead to variance in test results and often completely different results as the electrodes pick up a different signal in the brain. Another problem associated with this method is the seemingly random patterns of the brain itself. We currently do not know much about the brain and how it works, so in most cases this leads to guessing whether the signal is the one needed or whether the signal will be strong enough to be picked up by the electrodes.

Reactive BCI is the process of measuring the brains reaction to a stimulus, it uses this reaction to generate a signal which can be outputted for a variety of uses. Passive BCI has a multitude of uses, much of which are very similar to those of active BCI. Because this method measures the brains reaction to stimuli, it allows a rudimentary form of emotion to be displayed. This is again very useful to those with disabilities as it allows them to express these emotions in a non-physical manner. It is also very useful for virtual reality gaming as a player can control a character’s emotions in a much more organic and intuitive way, as it records the emotions the player is feeling using the game as the stimulus.

Much like active BCI, this process is again done using EEG to measure the electronic activity the stimulus causes in the brain, creating recognisable patterns and signals which can be assigned to emotions. Although as with active BCI, this is a very unreliable and inaccurate method as I discussed earlier. Another method which can be used to measure reactive BCI is Functional Near-Infrared Spectroscopy (FNIRS), this method involves measuring the blood oxygen levels in the brain using an infrared light. This again allows us to see which parts of the brain are active by the amount of oxygen in that area. This is very useful for measuring brain activity and can be used for a variety of applications such as communication.

The final type of BCI is passive BCI which uses sub-conscious brain signals in order to create an output. As you can imagine, this is a lot more difficult to monitor and to control as the subject has very little control over there sub-conscious brain activity. Again, passive BCI uses the same methods to collect the data as active and reactive BCI, but they need to be implemented on a much larger scale to create a clear image from the weak sub-conscious brain signals. Magnetoencephalography (MEG) is a process which uses large scale EEG technology to measure brain waves which a much higher accuracy, although it is impractical for most uses as the technology needed is expensive and very large. Another method used for passive BCI is Magnetic Resonance Imaging (FMRI) which is a large-scale version of FNIRS technology which again is more accurate but is impractical due to the size of the equipment needed. With these methods it is possible to measure the sub-conscious brain signals and turn those signals into useful outputs. One of the primary uses for this technology is in a medical capacity as it allows patients who may have brain damage to communicate and control certain applications. Another popular use is in adaptive automation, more specifically safety features in vehicles. The subjects brain signals can be used to predict when an emergency brake is needed, allowing the car to brake sooner than if left to the user. This can be vital in preventing car accidents and making vehicular travel safer.

O Zander, T., Kothe, C., Jatzev, S. and Gaertner, M., 2010. *Brain Computer Interfaces*. London: Springer, pp.181-199.