Brain Computer Interface: Ethical & Social Implications Perspective

Ethical, Legal, and Social Issues in Information Technology

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Abstract

This paper investigates the ethical and social implications of Brain Computer Interface (BCI), how they function and the types of BCI applications. Research literature indicated that potential applications of BCIs include medical and non-medical uses. Ethical issues arising from the therapeutic and assistive capabilities of BCI are many but mainly include autonomy, identity, ownership, privacy, equality and liability. It is concluded that BCIs possess restorative and assistive capabilities but a number of ethical and social questions remain to be answered.

Introduction

Brain Computer Interface (BCI) is an exciting and cutting edge technology with a lot of therapeutic and non-medical applications. Due to the complex nature of BCIs' functions and applications, a number of various definitions currently exist. Wolpaw et. al (2002) define BCIs as devices that process brain electrical signals via electrodes positioned around the brain and translate patterns of these signals into actions, successfully permitting users' thought-control of devices without muscle movement. BCIs are also defined as devices that obtain and convert neural signals into actions intended by the user (Kotchetkov, Hwang, Appelboom, P. Kellner, & Sander Connolly Jr, 2010).

Current advances from a number of fields such as electrical engineering, human computer interaction (HCI), artificial intelligence and computer algorithms have given rise to remarkable innovation in BCI research (Nijboer, Clausen, Allison, & Haselager, 2011). This has resulted in wide variety of BCI uses and applications in both medical and non-medical areas such as robotics, military use, gaming, computer peripheral devices, brainstem stroke, spinal cord injury and a number of neurodegenerative diseases. Given the increasing number of potential uses of BCIs and the wide spectrum of its potential applications, a number of questions concerning the ethical and social implications were raised.

In order to study and explore the potential uses and misuses of BCIs, this paper will investigate the factors affecting the potential applications of BCIs and their ethical and social implications by conducting research in the current uses of Brain Computer Interfaces and the technological underpinnings of it.

Background

The term “Brain-Computer Interface” can be traced back to Jacques Vidal of the University of California, Los Angeles who developed a BCI system in the 1970s based on visual evoked-potentials. His users viewed a diamond shape red checkerboard illuminated with a xenon flash. By attending to various corners of the flashing checkerboard, they could generate right, up, left, and down commands, allowing them to navigate through a maze presented on a graphics terminal (Mcfarland & Wolpaw, 2011).

Historically, many people have wondered the possibility of electroencephalographic activity or whether other electrophysiological measures of brain function could offer a new mechanism for transmitting messages and commands to the outside world without muscular involvement (Ghanbari1, et al., 2008). Since then the research on BCIs has been developing for more than 20 years, but beginning in the middle of 1990s there has been a rapid rise in functioning experimental implants.

Interfacing the human brain with computer devices is a recent technology, even though prosthetic devices such as cochlear implants and pacemakers are decades old (Wolpe, 2007). In the last 40 years, Brain Computer Interface (BCI) has experienced a rapid development from neuroscience theory into a basic yet a powerful, capable technology with a lot of potential applications. A number of recent trails conducted on non-human primates and humans alike have attained brain-derived control (Kotchetkov, Hwang, Appelboom, P. Kellner, & Sander Connolly Jr, 2010). Furthermore, a recent advancement of supportive technologies from the fields of biomaterial engineering, computational neuroscience, and computer processing have considerably contributed to the rapid progress of BCIs.

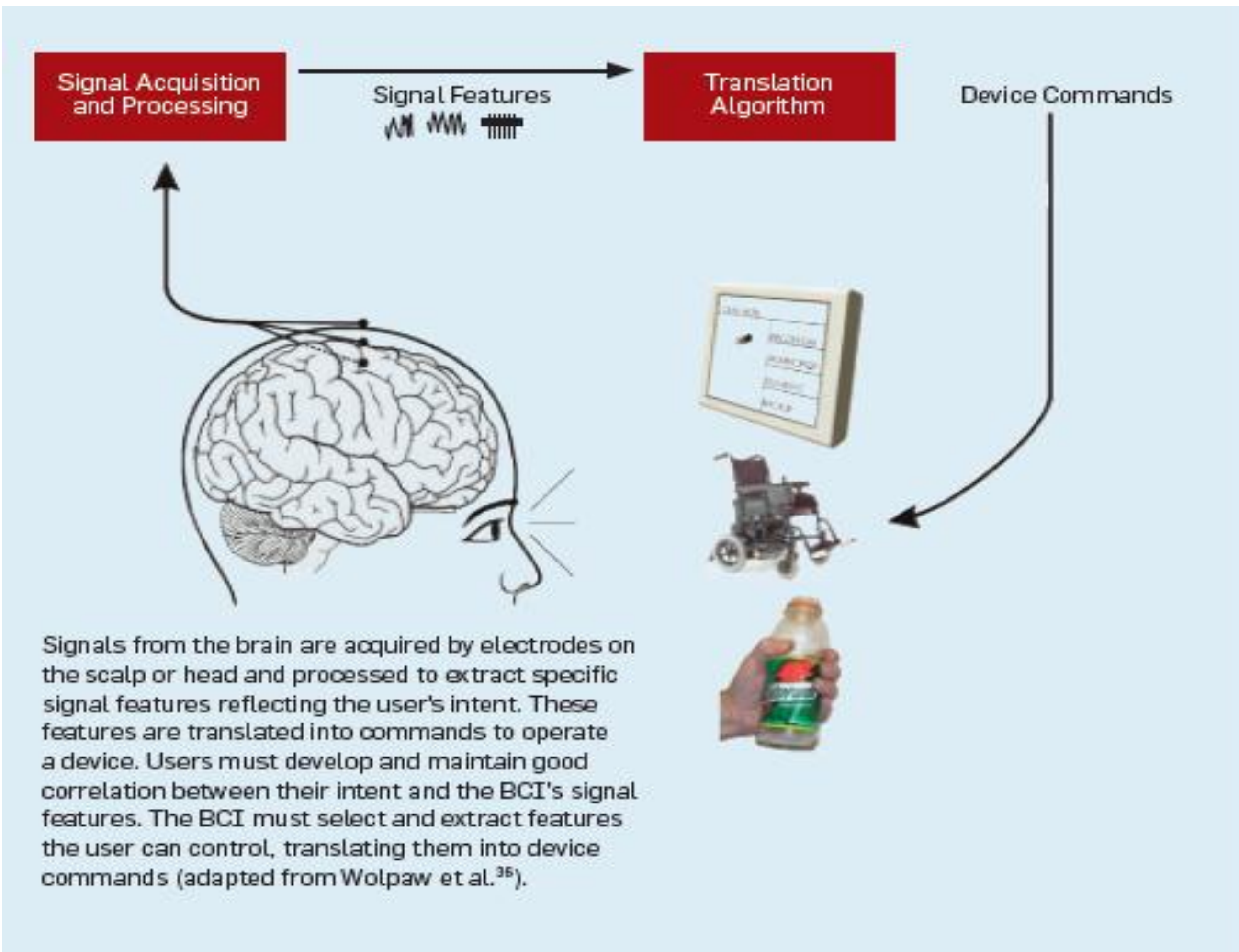
Although there are various uses of BCIs, nonetheless much of the past and present BCI research is concentrated on neuro-prosthetics, which enable the brain to make up for the motor functions lost due to injury or illness (Hammock, 2009). Additionally, BCIs can offer solutions to a numerous existing challenges in different domains such as robotics, military, education, and scientific experiments. Given the extensive potential power that BCIs possess to resolve complex neurological diseases and aid in the control of sophisticated devices, many organizations are turning to it for solutions.

How Do BCIs Work

Brain Computer Interface (BCI) transforms electrophysiological signals from simple reflections of human nervous system activity into the envisioned products of that activity by encoding them as messages and commands that act on the real world. It converts a signal such as an electroencephalography (EEG) rhythm or a neuronal firing rate from a mere image of brain function into a visible action such as the one achieved through normal neuromuscular channels (Ghanbari1, et al., 2008). BCI substitutes nerves and muscles and the activities they yield with EEG signals and the hardware and software that translate those signals into actions.

Almost every BCI system is composed of four components: signal acquisition, which obtains and records bioelectric signals from neurons firing within a user's brain; signal processing, translating information to messages or commands which is basically a device that can decipher and interpret the arriving signals from the recording device; devices and applications, such as a speller or robotic device which, in the end, translates the secret intentions into an action sequence, and executes the sequence to its capabilities; and an application interface that determines how these components interact with each other and the user (Allison, 2011). See Fig 1.

Fig 1. Basic design and operation of BCI system



Source: (Communications of the ACM May 2011)

Types of BCI

BCIs come in two main different groups (Invasive & Non-Invasive). Invasive BCIs are performed through surgery by implanting the essential sensors into the brain. These devices deliver the finest signals, but put users under the major risk in terms of its potential for brain damage (Das, 2010). Invasive BCIs raise many risks such as stability, reversibility, and body integrity concerns. These issues hinder one from making an extensive use of invasive BCI devices for rehabilitation and prosthetic uses, according to a recent assessment (Tamburrini, 2009).

Non-Invasive BCIs do not require electrodes to be implanted by surgery as is the case with the Invasive BCIs. They form 80% of all BCIs and include electroencephalogram (EEG) which is used to measure electrical activity associated with brain function and brain imaging system such as functional Magnetic Resonance Imaging (fMRI) (Allison, 2011). Non-Invasive EEG BCIs are normally favored due to portability and functionality. They tend to be quicker to set up and more convenient than functional Magnetic Resonance Imaging BCIs (Tamburrini, 2009).

Ethical Implications of BCIs

BCIs face a number of ethical and social issues that arise from their prospective uses. (Nijboer, Clausen, Allison, & Haselager, 2011) Outline 17 questions that describe the distinctive ethical and social implications of BCIs. The 17 questions are listed below:

> *"1) obtaining informed consent from people who have difficulty communicating, 2) risk/benefit analysis 3) shared responsibility of BCI teams (e.g. how to ensure that responsible group decisions can be made), 4) the consequences of BCI technology for the quality of life of patients and their families, 5) side-effects (e.g.neurofeedback of sensorimotor rhythm training is reported to affect sleep quality) 6) personal responsibility and its possible constraints (e.g. who is responsible for erroneous actions with a neuroprosthesis?), 7) issues concerning personality and personhood and its possible alteration, 8) therapeutic applications, including risks of excessive use, 9) questions of research ethics that arise when progressing from animal experimentation to application in human subjects, 10) mind-reading and privacy, 11) mindcontrol, 12) selective enhancement and social stratification, 13) human dignity, 14) mental integrity, 15) bodily integrity, 16) regulating safety, 17) communication to the media*" (Nijboer, Clausen, Allison, & Haselager, 2011)

These ethical questions form a wide-ranging list of the ethical and social implications faced by users of BCI technology. An extensive and detailed essay on every one of these topics can be written, but due the limitation of this paper, I will touch on these topics without delving deep into each one. It is also important to note that questions (1 and 7) represent current issues facing most of the BCIs as implemented today. The rest of the ethical issues encompass prospective uses of BCIs in the future.

Therefore, I will mainly focus on the present and the imminent ethical and social issues of specific domains of BCI.

Ethical Issues of Assistive and Restorative BCI

Assistive and Restorative BCIs include a wide variety of prosthetic and robotic devices that are controlled through thought. These devices include but are not limited to: wheelchairs, gaming joysticks, virtual keyboards, Prosthetic limps and a whole host of other devices that can be thought-controlled. The ethical issues that are related to assistive and restorative BCIs are numerous and cover areas such as privacy, social norms, ownership, bodily autonomy, liability, inequality and self-identity.

The use of BCIs could affect mental aspects of a person, including his or her self-perception, types of behavior typical of a person, the ability to recall, comprehend and decide upon information possibly raising questions regarding the mental continuity or even personal identity of the person. Since these abilities are related to the process of informed consent - impacting one's evaluation of a decision to proceed or stop the use of a BCI - this does not only raise an ethical issue but could also have legal implications (Nijboer, Clausen, Allison, & Haselager, 2011). Assistive BCIs use could also cause accidents. E.g., who is legally responsible if a BCI incorrectly interprets a wheelchair or prosthesis command and causes an operator to injure someone or inflict damages to properties or run through a red light?

As the BCIs advance, we can also expect a whole host of new ethical and social issues. For example, imagine your brain connected to a computer which, in turn, is connected to the internet. Then it is conceivable that a hacker with malicious intent can access your brain and control it or wreak havoc. This raises personal autonomy and privacy issues as experiments conducted on animal show that brain can be disrupted or conditioned with implanted electrodes (Wolpe, 2007). Similarly, risks to cognitive liberty and ownership would increase as our brains interface computer systems. The possibility of remote behavior control by criminals or governments through computer interface will also add to the BCI ethical debate. Furthermore, BCIs raise the ethical questions of inequality since rich people can buy expensive ear and eye implants where poor people can't as Professor Crutcher who teaches neuro-ethics at Emory University speculated (Hammock, 2009). Cruther continued to argue that BCIs raise safety and efficacy questions in addition to computer-enhanced elites it can create.

Defense Advanced Research Projects Agency (DARPA) is currently experimenting on an initiative called "Silent Talk," which would allow soldiers on clandestine missions to communicate with their thoughts alone (Hammock, 2009). This technology could be misused for evil means and opens up further ethical and social debates. You can perhaps imagine in the future communicating with friends through this technology. The raises another interesting ethical question. Do we want our friends or whomever we are communicating to know our thoughts?

Conclusion

The ethical and social implications of Brain Computer Interface (BCI) are many and I barely scratched the surface with my brief exploration of the challenges and the uses of BCIs. In this limited investigation, BCIs were found to be of great use to humanity in terms of their therapeutic and assistive capabilities but a number of ethical and social dilemmas remain. Issues such autonomy, identity, ownership, privacy, equality and liability will dominate present and future ethical debate of BCIs.

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