Ethical Issues of Brain-Computer Interface

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Abstract
This study is focusing on the overview of Brain Computer Interface (BCI), it describes functions, types, applications and its ethical issues. Furthermore, author has described the essence of BCI and possible enhancements to deal with ethical dilemmas related to BCI. This form of technology is on the verge of great advancement for its eminent benefits to the scientific world and medical paradigms. Basically this technology controls the signals between body part (any) and brain through a machine. It has shaped many therapies. Current discussion will be comprehensively dealing with the ethical boundaries which limit the use of this technology in such therapies. The main purpose of this report is to find the ethical boundaries of BCI and other issues and challenges which are being faced in its implementation and deployment. So that, these can be eliminated and this technology can give benefits to the mankind at its maximum level.

Key words:
Brain Computer Interface, Ethical Issues, neuro ethics.

1. Introduction

Humans have finally recognized themselves as the superior species that rule the top off the food chain and in the realm of speculation we have finally encountered new faces of evolution in our technology and that is BCI. The research on BCI based system started in mid 1960s, by the US Department of Defense to reduce the mental workload load of fighter pilots by interacting with their plane's computer. The project was terminated at that time because the technology was not sophisticated enough to support the cause. However, it laid the bases for other research programs and today researchers have designed many prototypes that record the brain activity of the user like NeuroSky, EPOC, P300, etc.[2].

The most interesting application of this technology is the rehabilitation of those people that suffers from severe motor impairments. This includes those patients that suffer from ALS (amyotrophic lateral sclerosis). In this disease the patient is unable to perform any muscular activity as it causes the nerve cells that carry information to the muscles to stop functioning and eventually die off. The purpose BCI based system in this regards is to enable the patients to perform daily life activities like operating a wheel chair or household appliances, etc. This technology has been the center of attention for the past few decades. The reason that very less work has done up to till now is because of the fact that human brain is a very complex organ. Therefore it is quite a challenge to design a reliable electronic device in order to establish a link with human brain.

In this study first we have briefly introduce that what actually BCI is and how it works then we have highlighted the major issues and challenges which are currently faced during the implementation of BCI technology.

2. Brain Computer Interface (BCI)

A BCI is a divulgation between the human brain and a digital computer. The aim of BCI is the restoration of movements, divulgation and environmental control. During the past few decades, the focus of the developers and researcher has been on BCI based systems.

Such systems can be classified into two types; 1-Invasive, 2-Non-Invasive. In invasive BCI systems, a chip is installed inside the brain which records the brain activity. This is not practical in our case because this requires a brain surgery. While in non-invasive technique a device (headset) is attached to the scalp (externally) which measures the brain signals. The later system can be operated using EEG (electroencephalography), MEG (magneto encephalography) or FMRI (function near infra-red imaging). EEG proves to be more cost effective and sensible recording technique for real time control systems. BCI systems are further categorized into synchronous or asynchronous systems. Asynchronous system is more desirable solution in our case as it allows for a non-control resting state for the user. The inspiration of this project also came from the team of researchers that worked on MIG31 FIREFOX, a highly advanced fighter aircraft developed by Russians back in 1970s, the most desirable feature of this aircraft was its thought controlled combat computer.

2.1 Process of BCI

A question is most commonly raised that how the activities which are not physically seen but only recorded are used to drive an external source, the answer lies in the process of this BCI. The neural activity is detected as first and then recorded as Data, this data is then further channelized towards the external source and thus the computer device is driven. BCI operations is a biggest achievement for the human evolution process.

Every activity however requires innovation so that it can further grow, BCI has also tamed this innovation by using Electroencelography EEG methods which describes the process of scraping neural signals from the human scalp and then transmitting them further. These types has been discussed above in background.BCI system not directly control the brain, first it measure the activities of the brain then translate it into commands. This translation consist of signal processing and pattern recongnization techniques that is performed in computer. Four basic steps of BCI system:

   I.   Recoding of signals from brain.
  II.   Classification of signals.
 III.   Generate command.
  IV.   Control the device.
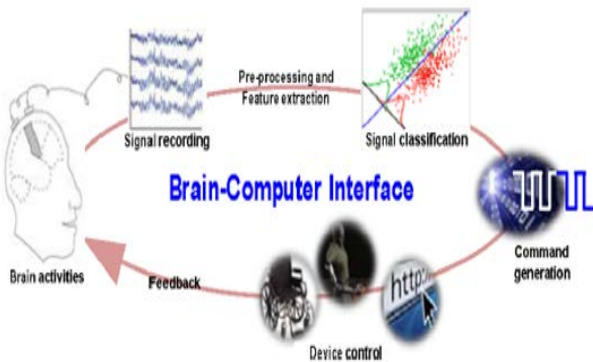

Fig. 1 A symbolic illustration of a BCI system [25]

3. Applications Of Bci Technology

3.1 Brain Speller

Last few years P300-base BCI'S become the main category of the BCI technology. P300 is a positive diversion with the latency of round about 250 to 300ms, which is obtained from oddball paradigm. Old version of P300 speller is laid out by 6x6 matrix. New design of P300

speller is like as hex-o-spell and center spell design. Both designs were developed by BBCI group for the patient of severe oculo-motor impairment [16].
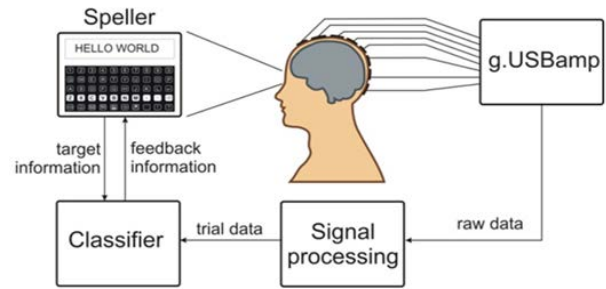

Fig. 2 Functionality of Brain Speller

3.2 Brain Activated

It can be very helpful for the paralyzed people who are not able to control their parts of body. Many groups are working on this application for giving the fitter life to the patient. A wheelchair which is use the P300 paradigm technology Develop by A *STAR group. Another group EPFL also design motor-imagery-based wheelchair. These groups merge the Brain control inteface with the computer vision system for the safety of the patient [4][5].
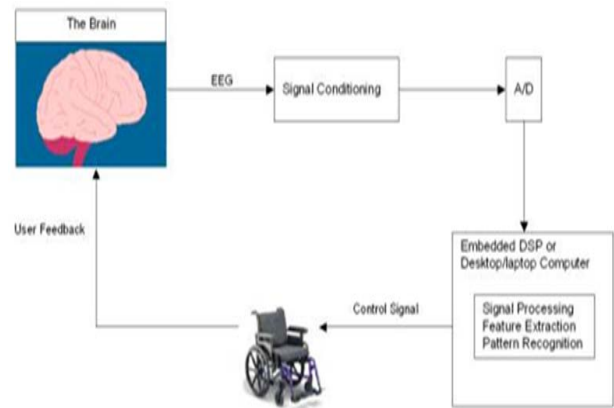

Fig. 3 Process of Brain Activated wheelchair

3.3 Monitor the user state of Mind

Next generation need to be able to understand and predict the user's state of mind and user's objectives by using BCI technology. For example, automobile will react to driver dopiness and virtual humans could convince the user to follow their diet [10].these future implementations are called user-system-symbiosis or affective computing [24] that is use to collect and elucidate information of user

mental state such as emotions, attentions, stress and mistakes.

3.4 Monitor the user state of Mind

Assessment applications can be used in constant monitoring by online and offline fashions. Two examples of assessment are neuromarketing and neuroergonomics. Neuroergonomics has a direct link to BCI, his current example is the use of cell phone while driving and the results of brain imaging shows that a hands- free and voice activated mobile phone [10].

3.5 Education and Training

For the education we need an efficient and effective automated tutoring system which have a good impact on society as well as on economic," especially for societies with a knowledge-based economy, facing an aging population and/or requiring a flexible workforce" [10].

Most of the features of the training are associated with brain and its flexibility. Measuring this flexibility and changes in the brain enhance the training methods for general and individual person. Beginner and experts are useful for this automated training system but this application area still in under procedure (conceptual phase) with limited experimental documentations.

4. Ethical and Social Issues of Bci

The Invasive BCI can be dangerous due to its surgical procedure for implanting the device in to the brain of the patient and the main ethical issue is to reduce the perilous due to inserting a BCI device into the patient brain. Engineers of the medical profession said that the noninvasive BCI useful for the patient when other noninvasive procedures are rolled out. Because Brain surgery is always dangerous and poses many complexities. The existing and costly system that is being used shows a long term success but due to its high cost its availability for a common person is become difficult. For This purpose bioengineers working on this project trying to increase the availability of this product with low cost so the most people can afford it .the ethical concern arises with this new and cheaper product. Because it is more important that the bioengineer make sure the safety of this cheaper product before launching it to the market [11].

According the Biomedical engineering society Code of ethics "Consider the large consequences of their work in regards to cost, availability and delivery of the health care" [21]. Clausen observed that brain computer interface

"pause ethical challenges, but these are conceptually similar to those that bioethicists have addressed for other realms of therapy" [11].

4.1 Privacy

When a Brain Computer Interface is used to take record of brain movements and before translating these signals in to predefined control commands, it measures the brain singnals.it obtains neuronal data through either invasive or non-invasive methods. For the high accuracy get the patient personalized data, no doubt these data must be encrypted for the privacy of the patient but on the other hand this issue runs parallel to the neuro-ethical arguments in the surrounding of the neuro- imaging and Mind Reading [25].

4.2 Responsibility

The main ethical issue is liability in neuroethics, especially in drug research and brain computer interface research because signal accuracy and processing is very important in the BCI system. When an error occur during the scanning process, the BCI system interprets a command that is not deliberate by the user.in this situation a discrepancy occur between intension of the user and the command generated and we are confronted with the problem of resposibility[13]. Such as a BCI robot "accidently" break something or harms a human being, "who" or "what" take the responsibility for this damage? [25].

4.3 Personal Identity

Being a human being the change of her own personality may lead to controvert that weather the this change is acceptable or not for her own personality[13].When the technology is supposed to upgrade the user's potential to move and communicate in anyway in spite of aptitude risks and side effects, Brain computer interface recommend a similar debatable matter in neuroethics with reference to the intensification of human ability through medical measure such as drug or BCI [25].

4.4 Team Liability

An interdisciplinary research program of BCI demand experties from different fields like neuroetics, engineering,medical and computer industry, it is compulsory that there must be a fixed rules on team liability between researchers group, work should be divided reasonably and fairly and the regards should goes as well [15].

4.5 Availability of Technology

The information about the BCI technology between the public should be distributed fairly . This is very harmful in the medical field as well [25].this is a big challenge the equal availability of the BCI technology for a general public. Still, Scientists and researchers must try to educate the society about the BCI technology through a proper publications of articles in the society.

4.6 Another Ethical Dilemmas Regarding BCI Therapies

Ethics is a very wide range of study and the basic etymology of the word defines an action according to the ambit of good or bad. Whenever people require to break different ethics and their moral values, it results in various and drastic waveforms that are known as consequences. Different unethical situations result in different outbreaks from different people. The main consideration of ethics in this report arises when we consider different situations where patients who have locked in syndrome are involved.

4.6.1 Absence of care taker

It was discussed that these people are suffer from disparity of communication there is however another side of the story. Each patient has been blessed with a family member and they are the legal caretakers of these people and hence whenever a question arises about their treatment than these family members are involved for decisions. If a person is completely shut due to his paralyses than a legal and ethical contract is made by the family member with the doctor which allows the concerned doctor to use BCI as a treatment by penetrating the human body and inserting foreign technology. But what happens if that person is completely alone in the world and is on the midst of treatment. This situation is a real head cracker because this is where legal constraints fall back and moral, ethical issue take the charge. The doctor is in a handicapped situation and is tied between several ambiguities. Either it becomes ethical to actually implant devices in a person just because of the objective to restore his health or the other part of the moral constraint is that is it really unethical to use BCI just because doctors have this wish to be called life savers?

4.6.2 Solution to this Ethical Dilemma

These issues and the ambiguities can be easily solved by using certain theories that result because of such problems which exist in the society. The theory of Utilitarian suggests that in order to achieve the greater good one can easily neglect and put aside small bad effects and hence it automatically makes that action moral and ethically correct.

There is another widespread theory which suggests that a person can actually perform actions which results in good outcomes and avoid the adverse effects and this is the phenomenon of consequences. The American Computing Mechanics code of conduct also deals with such things and its chapter can be used to apply and answer these questions which clearly states that the client should be duly notified of all possible risks and when the doctor actually informs the patient about all risks and finally obtains that consent than that action is ethically stable and absolutely correct.

4.7 More Discussion on Ethical Issues

It can be contentious between researchers of the BCI technology whether a prospective consequence of BCI is ethical or not. There are certain basic steps that must be applied during the decision-making process to stop these ethical or social issues. Three main values that should be applied in the medical field remain valid for the developing field of BCI technology [25].

BCI face a large no of ethical and social issues that arises from the uses of this technology. [15] has states the 17 questions regarding the ethical and social issues of BCI. The 17 questions are:

"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" [15].

These Ethical Questions have a wide of Social and ethical issues that faced by user's .A detail essay can be written on these topics but the limitation of this report, I will touch only current issues that is implemented on the BCIS technology. Note that Question (1-7) define the current ethical issues of BCI technology.

5. Challenges and Technical Flaws When Bci Are Used as Therapeutic Devices

5.1 Technical Flaws

With every responsibility and every procedure there are certain factors that are needed to be kept in check so that the procedure does not come into different questions and specially in this report where we are discussing ethical boundaries it is important to consider the factor of consent, in this very case it is known as informed consent which is obtained by the doctor from the patient before he decided to perform any kind of implantation either its small or large. The informed consent however results in many different types of drags because there are different kinds of scenarios in which people are indulged in and one cannot always believe that consent is absolute, it is always relative and varies from person to person. Let's examine the case of people who suffer from locked in syndromes, these people are of two types the ones that have minute one and the one who have total syndrome, the ones with minute ones can communicate with their eyes and hence people often give sign of either they want an implant or not by moving their eyes from left to right.

Brain computer interface applications that provide users with physical and cognitive rehabilitation therapy (CRT) enhance the ethical and social issues. Different people give the different views about such application, it's acceptable or restricted. These debates will also effect the acceptance of BCI technology in the society [1].

5.2 Challenges to BCI Credibility

Like we discussed that there are many problems relating to technologies because in the end of the day they are still machinery and in the end of the day they can and would get rusty and possibly stop operating on optimal conditions. The BCI technology enhancement factor raises more questions than it should answer and there are some questions that need to be substantiated so that a person becomes quite clear about the scope and either it becomes a viable technology in the near future. The very common and inherited question from the previous paragraphs comes into play is that suppose in a situation where a soldier is in an ongoing battle and what if the device stops working because of its implant and since we know that implant cause weaker signals than this would not only be detrimental but could jeopardize the entire plan.

This is only one of the question which has been raised by skeptical people however there is another thought which comes into mind when you consider how and why the exoskeleton was made, the skeleton could have the probability of failing because the soldier might not be able to bare its weight which causes a domino effect as the first domino would be the loss of important supplies, another one would be the soldier to be in an exhausting condition. These question do pose a threat to the credibility of BCI but still ignorance of such things might be bliss.

6. Bci Enhancement to Deal with Ethical and Technical Issues

Humans always had the instinct to grow, to spread their wings far off and to make evolutions to the things. BCI can be used to improvise vision, it has already learnt that how blind people have been made to see but what happens, when people who can already see are given artificial vision systems? This vision system is very simple as they would manipulate our vision and here is where the enhancement comes into play, it would allow people to view different frequency lights such as ultraviolet and infrared rays. This is the very new high to enhancement ideas suggested and could actually eliminate the benefit of doubt by causing people to neglect the harmful effects and increase the tangible benefits.

The study of robotics is a very widespread belief and people all around the world are extensively researching on them. But here's the idea of how BCI could inculcate these robotic traits by using the Brain gate idea and simply by just replacing the human limb by a supersized bionic arm than it would surely be a new revolution when that arm can life heaviest of the objects without severing the fingers dexterity and would be able to cause a chaos in the world. Another perspective of such enhancement is a little bit off the practice for many people and some would find it practically not preamble and inhuman but the concept of cyborg animals could be used culturally growing neurons and then implanting them with these chips hence changing the way we think and we see our world. It is without a doubt that this enhancement is the new light way to the darkness and old ages that has been prevailing us and our society [9].

7. Conclusions

Overall in this study we have comprehensively explained at well-orchestrated order that how BCE is being used in two very versatile and diverse fields, we see that BCE is not just a growing innovation but rather that catalyst which brings under all the futuristic approaches of mankind under its ambit, by providing missing limbs to supersized arms which can lift heavy weights. Now considering the therapeutic approach, it is now fully recommended that

one should always seek the consent of the patient because every doctor first and civic duty is to work under the best possible interest of the patient, consent is important even if it means seeking the patient's eye movement and tracking it for a yes or no. The ACM code of conduct also advises that one should always tell the customer or in the case of doctors the patient about all the pros and cons and accept responsibility after and before the operations, these are the guide lines and recommendations towards using BCE as Therapeutic Technology.

Now considering the fact that we can use BCE as Enhancement should not be used because as we have clearly mentioned and explained in this highly comprehensive report that how it causes the sense of inferiority and superiority in a person and the social structure upon which the society has been built upon would be completely destroyed, this where people would start to loath their own species and except for creating harmony this would create chaos on a superseded level. Never the less if mankind successfully reaches to the point where it goes beyond such question than BCE would bring about remarkable changes and it is with great prejudice one could say that BCE is the near future of mankind.

References

[1] Biomedical Engineering Society. (2004). "Biomedical Engineering Society Code of Ethics." Biomedical Engineering Society. (Online resource).

[2] Jan B.F. Van Erp, Fabien Lotte, Michael Tangermann. Brain-Computer Interfaces: Beyond Medical Applications. Computer -IEEE Computer Society-, IEEE, 2012, 45 (4), pp.26-34.

[3] J.B.F. Van Erp, J.A. Veltman, M. Grootjen. Brain-Based Indices for User System Symbiosis. In: D.S. Tan & A. Nijholt (Eds.) Brain-Computer Interfaces, Human-Computer Interaction series, pp. 201-219. London: Springer-Verlag. 2010.

[4] B. Rebsamen, c. Guan, and H Zhang, "A Brain Controlled Wheelchair to Navigate in Familiar Environments," IEEE Trans. on Neural Systems and Rehabilitation Engineering, Vol. 18, No.6, 2010, pp. 590-598.

[5] T. Carlson and Y. Demiris, "Collaborative control for a robotic wheelchair: evaluation of performance, attention and workload," IEEE Trans. on Systems, Man, and Cybernetics - Part B: Cybernetics, Vol. 42, No.3, 2012, pp. 876-888.

[6] M. Velliste, S. Perel, M. C. Spalding, A. S. Whitford, and A. B. Schwartz, "Cortical Control of a Prosthetic Arm for Self-Feeding,"Nature Letter, Vol. 453, No. 7198, 2008, pp. 1098-1101.

[7] L. R. Hochberg, D. Bacher, B. Jarosiewicz, N. Y. Masse, 1. D. Simeral, 1. Vogel, S. Haddadin, 1. Liu, S. S. Cash, P. Smagt, and 1. P. Donoghue,"Reach and Grasp by People with Tetraplegia Using a Neurally Controlled Robotic Arm," Nature Letter, Vol. 485, No. 7398, 2011, pp. 372-375.

[8] Daly and 1. R. Wolpaw, "Brain-Computer Interfaces in Neurological Rehabilitation," Lancet Neurology, Vol. 7, 2008, pp. 10321043.

[9] C. Moreno, A. 1. Ama, A. Reyes-Guzman, A. Gil-Agudo, R. Ceres, and 1. L. Pons, "Neurorobotic and hybrid management of lower limb motor disorders: a review," Medical & Biological Engineering & Computing, Vol. 49, No. 10, 2011, pp. 1119-1130.

[10] Van Erp, F. Lotte, and M. Tangermann, "Brain-Computer Interfaces: Beyond Medical Applications," IEEE Computer Magazine, Vol. 45, No. 4, 2012, pp. 26-34.

[11] P. Haselager, R. Vlek, 1. Hill, and F. Nijboer, "A Note on Ethical Aspects ofBCI," Neural Networks, Vol. 22, No.9, 2009, pp. 1352-1357.

[12] K. Jebari, "Brain Machine Interface and Human Enhancement – An Ethical Review," Neuroethics, 2013 (In press).

[13] F. Lucivero and G. Tamburrini, "Ethical Monitoring of Brain-Machine Interfaces: A Note on Personal Identity and Autonomy," AI and Society, Vol. 22, No.3, 2008, pp. 449-460.

[14] G. Tamburrini, "Brain to Computer Communication: Ethical Perspectives on Interaction Models," Neuroethics, Vol. 2, No.3, 2009, pp. 137-149.

[15] R. 1. Vlek, D. Steines, D. Szibbo, A. Kubler, M.-1. Schneider, P. Haswelager, and F. Nijboer, "Ethical Issues in Brain-ComputerInterface Research, Development, and Dissemination," Journal of Neurologic Physical Therapy, Vol. 36, N. 2, 2012, pp. 94-99.

[16] M. S. Treder, N. M. Schmidt, and B. Blankertz, "Gaze-Independent Brain-Computer Interfaces Based on Covert Attention and Feature Attention," Journal of Neural Engineering, Vol. 8, No.6, 2011, pp. 066003.

[17] S.-K. Yeom, H.-I. Suk, and S.-W. Lee, "Person Authentication from Neural Activity of Face-Specific Visual Self-Representation," Pattern Recognition, Vol. 46, No.4, 2013, pp. 1159-1169.

[18] C. Devue, F. Collette, E. Balteau, C. Degueldre, A. Luxen, P. Maquet, and S. Bredart, "Here I am: the cortical correlates of visual selfrecognition," Brain Research, Vol. 1143, No.1, 2007 pp. 169-182.

[19] M. Sugiura, Y. Sassa, H. Jeong, K. Horie, S. Sato, and R. Kawashima, "Face-specific and domain-general characteristics of cortical responses during self-recognition," NeuroImage, Vol. 42, No.1, 2008, pp. 414422.

[20] S. K. Rosahl, "Neuroelectronic Interfaces with the Central Nervous Systems - Ethical Issues," Proc. ofWorld Congress on Medical Physics and Biomedical Engineering, Vol. 25, Munich, Germany, 2009, pp. 4851.

[21] A. Fenton and S. Alpert, "Extending Our View on Using BCl for Locked-in SYndrome,"Neuroethics, Vol. 1, No.2, 2008, pp. 119-132.

[22] "Dr. William H. Dobelle, Medical Device Innovator, Dies." Syosset Jericho Tribune. Oct. 22, 2004. Dec. 10, 2011. <http://www.antonnews.com/syossetjerichotribune/2004/10/22/obituaries/>.

[23] Jennings, Bob. "A bionic visionary for the blind." The Sydney Morning Herald. Feb. 20, 2003. Dec. 10, 2011. <http://www.smh.com.au/articles/2003/02/19/104533066202016.html>.

[24] Martin, Richard. "Mind Control." Wired.com. Mar., 2005. Dec. 10, 2011. <http://www.wired.com/wired/archive/13.03/brain.html>.

[25] McGee, Ellen M. and Maguire, Jr., G.Q. "Ethical Assessment of Implantable Brain Chips." Bioethics and Medical Ethics. Paideia Archive. Aug., 1998. Dec. 10, 2011. <http://www.bu.edu/wcp/Papers/Bioe/BioeMcGe.htm>.

[26] Shalhoup, Mara. "The father of cyborgs." Creative Loafing. Feb. 5, 2003. Dec. 10, 2011 <http://cltampa.com/gyrobase/the-father-of-cyborgs/Content?id=2014709&showFullText=true>.

[27] Wolpe, Paul R. "Ethical and Social Challenges of Brain–Computer Interfaces." Virtual Mentor. American Medical Association Journal of Ethics. Feb., 2007. Dec. 10, 2011. <http://virtualmentor.ama-assn.org/2007/02/msoc1-0702.html>.

[28] K. Y. Lee and D. Jang, "Ethical and social issues behind brain-computer interface," 2013 International Winter Workshop on Brain-Computer Interface (BCI), Gangwo,2013,pp.72-75. doi: 10.1109/IWW-BCI.2013.6506635