BRAIN - COMPUTER INTERFACES DEVELOPMENT TRENDS

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ABSTRACT: This paper seeks to present the Brain Computer Interfaces (BCI) current development stage and to analyze their progress trends in the near future. Special attention is paid to the BCIs role in improving the compatibility between humans and Artificial Intelligence (AI).
KEYWORDS: Brain Computer Interface, Artificial Intelligence.

1. GENERALITIES

The tools were, from the very beginning of Homo sapiens' evolution, an important asset in his attempt to amplify his strength and finally conquer the current dominant position on Earth. These utensils' main role was and still is to augment the man's capacity to modify the environment according to his needs.
In time, human's tools became more and more sophisticated. People handling such utensils need to have certain abilities gained during an apprentice stage. Therefore, the working instruments directly impact human's life and their advancement during technological revolutions does have a key role in changing society.
Hence, it is straightforward to consider that the nowadays evolution of computers technology leading to Artificial Intelligence (AI) will dramatically change our social environment and our whole civilization.
It is not only about computers more powerful than human brain, but a whole category of intelligent tools capable to understand their working environment and to take decisions accordingly.
Even if probably some people would like to stop progress, this is not possible as it never was during our history. The current economic competition is mainly about technological development. The modern man dependency on IT&C is growing continuously. The consumption society requirements for "more" and "better" do push production to intelligent robotics era.
Thus, above politics or marketing strategies the trend toward AI is the normal next stage of our civilizational advance.
No doubt, there will be many angry reactions about this development. For example, traditional production lines will be replaced by flexible automatization equipment and people working there will lose their jobs. Truck & taxi drivers will soon be replaced because autonomous trucks & cars will become available. Shop sellers, office clerks, public relations people, nurses, direct combat soldiers, actors, teachers, guardians, doctors, news anchors etc. will also become jobless or will have to adapt to a dramatically changed professional environment. Affecting a large number of people in a relatively short period of time will probably trigger social unrests and high instability.
More than that, the life quality gap between the members of the developed nations and those of the non-modernized ones could become unbearable for the last. Such an evolution could lead to profound aggravation of migration crisis or terrorism [Har17].
The authors of this paper do strongly believe that, even these problems will trouble the human society in the next few decades, the majority of the people will succeed in doing, as always during history, the transition from old to new and will adapt to the changed environment governed by the AI.
Nevertheless, this AI revolution is different from others technological revolutions in the past. This time, the tools will become more intelligent than humans and this could generate a dangerous evolution, even questioning the dominant role of Homo sapiens on Earth.

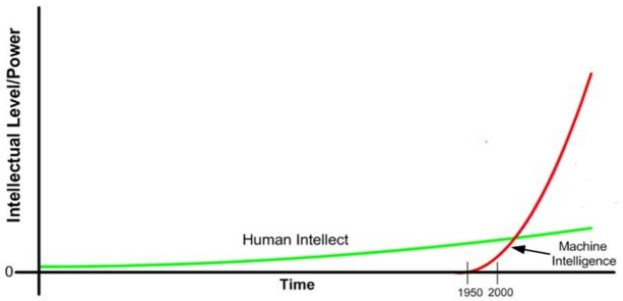


Figure 1. Human vs. Machine Intelligence [Urb17]

The AI will be more than a simple tool; it will control a great part of our life and of our environment. It will have the ability to decide on

almost everything with no human interference and this is a risk.

The visionary businessman Elon Musk said once: "Maybe one day the omnipotent AI will decide to get rid of the spam mails and will decide the best solution for that is to exterminate the spam producers, all humans". Similar thoughts were made public by many of today influential people. They all agree that; uncontrolled AI could be the end of Homo sapiens.

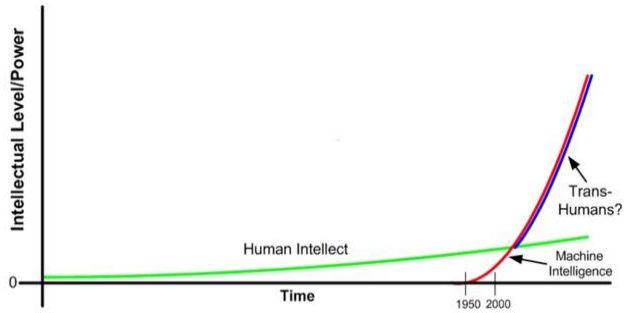


Figure 2. Trans Human vs. Machine Intelligence [Urb17]

The most debated solution to this danger is to find means to integrate humans into the AI in order to retain their command role and exercise a censorship over its actions.

Human cerebellum is the most complex biological structure on Earth. It contains 10^{11} neurons and each of them is interconnected to around 10.000 other neighboring neurons. These means it can store large quantities of data and is capable to process these data using massive parallelism schemes. Still, computers already surpass us on certain activities because our brain has a limited available memory and especially a much lower speed of reaction. The best way to increase the human brain power is to link it to a computer through an interface able to provide direct communication between the biological structure and the artificial one.

This Brain Computer Interface (BCI) is not an easy task to fulfill, because its implementation raises both technical and ethical problems.

Realizing a trustworthy, non-health-risking, effective connection between the human cerebellum and an intelligent machine is not a common engineering work. Some progresses were made during last few years, but for the moment research results show that current technology can only manage a limited number connected of neurons.

On another hand, public reaction to BCIs on ethical, religious and political grounds is even more important than the technical issues. A massive negative response can delay researches progress for some decades. Hence the opinions of both leaders and commoners are an important fact to take into consideration.

2. THE PUBLIC ACCEPTANCE OF LINKING BRAIN TO MACHINE

Certainly large groups of people will be annoyed by the idea of creating a race of "upgraded Homo sapiens" with real "superpowers" similar to the heroes of the X Man movies. It is only logical to think that such Trans-humans can be as dangerous to our civilization as a robotic army of terminators.

Our historical experience prove that whenever a more advance human subspecies meet a less evolved one, mass extinction happens. During the last millions of years, Homo sapiens progressively occupied the whole land eliminating all his "cousins" (i.e. Homo Erectus, Homo Habilis etc.).

Even the confrontation among different human's civilizations leads to tragic effects. Firstly the Spanish conquistadors and later English, French, Dutch, Portuguese and American pioneers quickly destroyed the Amerindian, Australian and Oceania's societies. Then, they succeed to depopulate almost the whole western hemisphere in order to free the land for the white colonists and their black slaves.

Still, there is a different & better perspective to consider about enhancing human intelligence and power. Today medicine uses a wide range of prostheses to substitute different missing/non-functional parts of ill patients. Some of these evolved recently to intelligent apparatus able to link directly to human nervous system. Robotic arms and legs, automatic will chairs and some other medical devices tend to became more and more common.

Other promising research programs are oriented to prosthesis capable to compensate as much as possible the absence of sight or of hearing. It is not yet achieved, but soon blind and deaf people will be helped by specialized BCIs bringing images and sounds directly to the specialized neural centers in their cortex.

Degenerative brain diseases (e.g. Alzheimer, Parkinson etc.) are not efficiently treated nowadays. Some scientists believe that a link between the ill cerebellum and a computer will help compensate for a time the loss of brain's functionality.

On top of all these, the military research makes every day spectacular progresses in improving the combat abilities of fighter pilots and tank drivers. Night view, augmented reality, high speed reaction chains will be soon accompanied by new upgrades based on BCIs. It is here, where the great risk for human civilization stays. If this goes wrong a confrontation between man and an AI controlled army of combat robots could mean our civilization end.

Soon, these army technologies will be imported to computer games and many people will use them for fun and will become routine for them.

Therefore, the BCIs idea is not a horror SF, but a real fact entering step by step into our lives. It has light and dark sides, but it is our scientist & engineers task to choose the good from evil.
Hence, the public acceptance for direct linking brain to computer will come in time and many intelligent devices connected through BCIs to different nervous centers in our cortex will populate our environment. No one will walk on city streets without GPS & Augmented reality glasses able not only to indicate shops, cafeterias and restaurants in our neighborhood, but also recognizing people around and giving us hints about: name, phone number, common history etc.
Other popular BCIs could be a universal remote controller linked to one of our specially trained neural center for mastering everything in the house from lights to game box.

3. IMPLEMENTATION PROBLEMES

A Brain Computer Interface is an apparatus that translates neural commands into coherent information for controlling external software & hardware. Hence BCI is a bidirectional interface for human brain to computer interaction. Usually the computer is used to further control a mechanical device such as a robotic arm/leg, an automatic wheel chair etc. [Nai13].

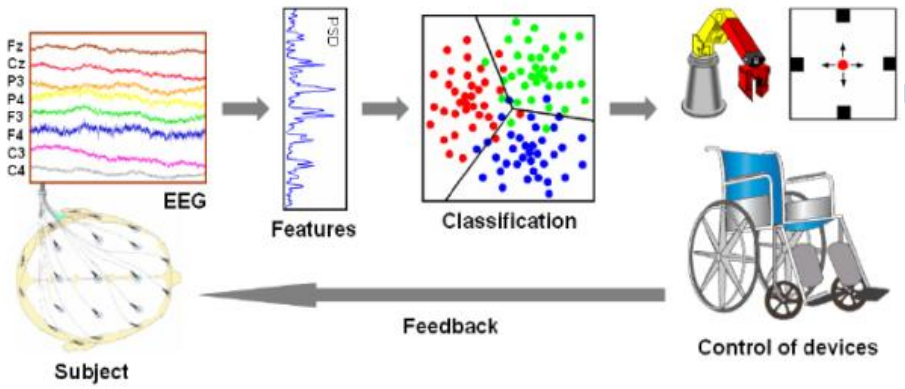


Figure 3. BMI for handicapped people [*16]**

These interfaces are still quite rare. The technology of robotic prostheses is young, thus it is expensive and not all details are perfected. The BCI is connected to the group of neurons previously controlling the replaced arm/leg. Difficult training is required to acquire the ability to command the artificial arm/leg and the functionality is just partially recovered.
A connection among BCI and multiple neural centers in the cortex area or even with the whole brain is not technically solved yet. Such wide range communication channel would be an extraordinary bidirectional way to convey information between us and our environment.
For realizing this, our knowledge on the human cerebellum should progress to more sophisticated models which could explain better the delicate process inside the neuron and the complex electric & chemic interaction between the axon's terminals and the dendrites.
Luckily many BCIs applications require just the access to a single neural center for commanding a certain precise element. The neural centers in the cortex are now mapped with good precision. Thus specially designed BCIs can link directly to the region directly responsible of a certain action [Nai13].
Hence, for commanding a BCI connected to a general remote house's controller, one available neural center in the cortex would be selected and trained. The interaction with a single BCI instead of different interfaces for each individual device would certainly be easier to learn. Furthermore, complex commands, involving more than one house device would be less difficult to perform.
Consequently our perception of the neighboring reality will adjust to a more complex scheme as our contact with the world will be both direct and through BCIs as in Figure 4.
The artificial entity (computer + BCI) existence as a third relevant part in the human environment interaction would fundamentally change our way of understanding and acting.
Things in our house will communicate to each other through the Internet of Things and the main computer would control everything to the finest detail. Thus our only job will be to control the main computer.

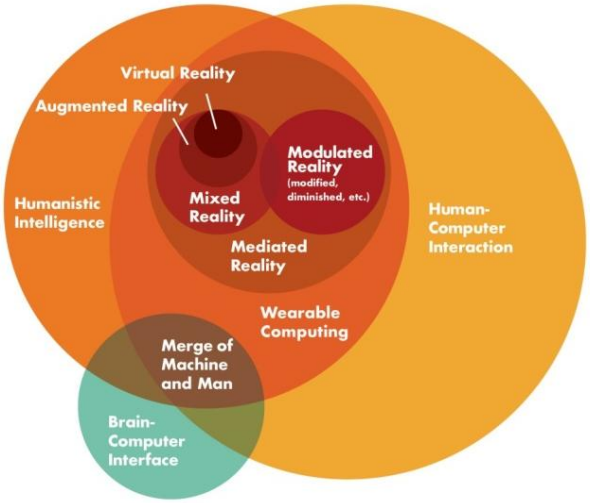


Figure 4. Human – Computer – Environment interaction [*18b]**

This perception shift would probably have a psychological impact on every person and its consequences must be investigated.
Anyhow, people will certainly become dependent on such BCIs more than they are now on mobile phones.

4. BRAIN – COMPUTER INTERFACES

Brain – Computer Interfaces are beneficial not just because we must control our intelligent utensils, but we also must diminish the speed difference among these AI equipment and our responses.
Todays, we relate with PCs and laptops through hand/voice/senses and the I/O peripherals.

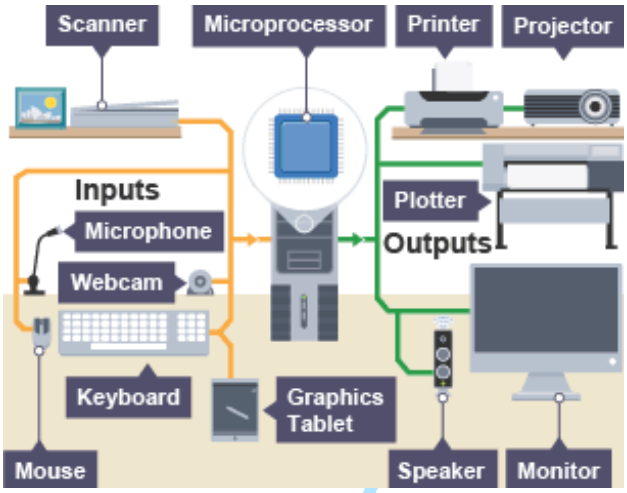


Figure 5. Today Human Computer Interaction [*15]**

Thus, there is an unavoidable delay coming from perceiving computer's output time (T_o) and from input execution needed time (T_i). If man has to reply to a computer action the total delay (T_T) is:

$$T_T = T_o + T_b + T_i \quad (1)$$

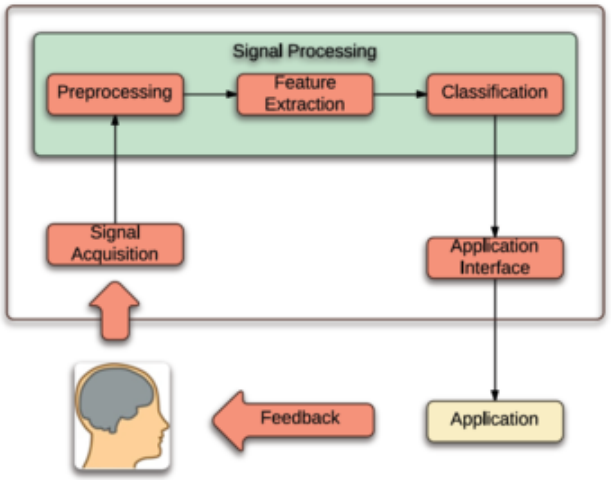
where T_b is the duration human brain need to decide its answer to the computer.
There are two methods to reduce this delay using BCIs:

A. The interface reads and interprets the brain input command. Hence the T_T became:

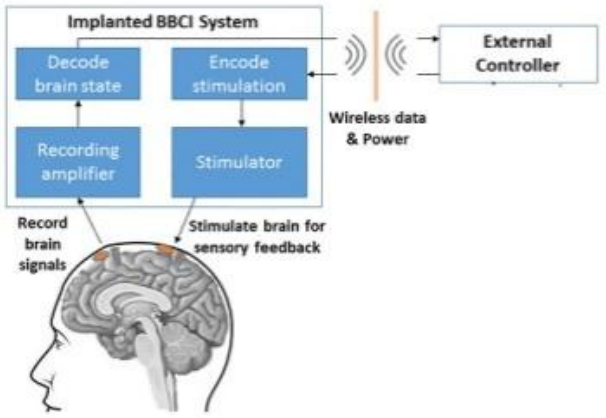
$$T_T = T_b + T_o \quad (2)$$

B. The interface is able to both interpret the input command and to produce a direct to brain output Therefore the T_T is minimized to:

$$T_T = T_b \quad (3)$$



a.



b.

Figure 6. Types of BCIs [*18a]**

The first strategy is feasible with a BCI linked to just one neural center in the brain. The second needs direct access to the entire cortex region responsible with our senses (touch, view, hear, etc.). Certainly B is the best, but building such a BCI is yet not technically achievable.

5. CONCLUSIONS

The computers development to super-human intelligence cannot be obstructed. The AI will soon be a reality in our world. Thus, the clever tools will action autonomously and will decide independently the course of their activities.

Our youth will have to deal with this new situation and they will need to live in a quite changed society. Their natural talents will probably be insufficient to adapt to such an environment. Hence, they need to integrate as part of the new technologies, as part of the AI world.

BCIs are a possible benefic answer for humans to evolve and stay in command of the Earth. BCIs are, even now, a reality in our life helping handicapped people to counterbalance their problems. Tomorrow BCIs will become customary to our work & life. Our whole interaction with our environment will be influenced by them.

Researchers would have to be careful to choose the good path for progress in order to circumvent the possible risks to human civilization.

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