



APPLICATION OF CYBORGS AND ENHANCEMENT TECHNOLOGY IN BIOMEDICAL ENGINEERING

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ABSTRACT

As we go deeper into the twenty-first century, there is a major trend to improve the body with "cyborg technology." In fact, due to medical necessity, millions of people around the world are now equipped with prosthetic devices to restore lost function, and the DIY movement is growing to improve the body to create new senses or to improve current senses "beyond normal". From prosthetic limbs, artificial cardiac pacemakers and defibrillators, brain-computer implants, cochlear implants, retinal prostheses, magnets as implants, exoskeletons and many other improvements, the human body becomes more mechanical and computational, and therefore less biological. This trend will continue to accelerate once the body is transformed into information processing technology, which ultimately calls one's sense of identity and what it means to be human. This article evaluates "cyborg enhancement technologies" with an emphasis on technological brain enhancements and the creation of new senses - the benefits of which can allow direct implantation of information into the brain, editing memories, wireless brain connection - brain communication and a wide range of sensory information to explore and experience. The paper concludes with reflections on the future direction of cyborgs and the meaning and consequences of becoming a cyborg and less so in an age of rapid progress in the design and use of computer technology. with an emphasis on technological improvements in the brain and the creation of new senses - the benefits of which can allow direct implantation of information into the brain, editing memories, wireless brain-brain communication, and a wide range of sensory information, which need to be explored and experienced.

KEYWORDS, : artificial intelligence, human enhancement, cyborgs, human-machine, augmentation

INTRODUCTION

For many years, science fiction looks to a future where robots are intelligent and cyborgs - human/machine mixtures - are commonplace: Terminator, The Matrix, Blade Runner and Ben, Robot are good examples of this. However, until the last decade, any assessment of what this might mean in the real world in the future was not necessary because it was all science fiction and not a scientific reality. But now, science has not only given a catch-up exercise but while also revealing some of the ideas put forward by science fiction, it has brought practicalities that the original stories did not extend.

What we are thinking about here are several different experiments that connect biology and technology in a cybernetic fashion, essentially combining humans and machines into a relatively permanent union. The key to this is that it is the overall ultimate system that matters. In the case of a brain, which it certainly is, it should not be seen as an independent entity, but rather as part of a general system that adapts to the needs of the system: the general unified cybernetic creature is an important system.

Each experiment is described in its section. While there is an obvious overlap between the

episodes, each suggests individual considerations. After the explanation of each research, some relevant topics are therefore discussed. In the near term, points were raised on a view of future technological advances and what these could mean in a practical scenario. There has been no attempt to present a fully packaged final document here; Rather, the aim was to open up the scope of the research conducted, to see what was involved, and to look at some of its results.

REASONS FOR EXPERIMENTING

The primary question is: why should we want to expand human capabilities? Despite the success of people on Earth, this is something we have always strived for in general. It could be considered an important part of what it means to be human. We have obvious physical limitations, and especially in the last few centuries, we have used technology to dig tunnels, lift heavy loads, communicate instantly around the world, repeat ground tasks accurately and quickly, and perhaps all sorts of things have allowed us to fly.

However, with their limited brain size, humans also show little range of mental abilities. However, such a claim may be difficult for some people to accept, mainly due to their limited brain



size. By comparing the human brain with the machine's brain, different modes of operation and, in some respects, the advantages of the machine in terms of its performance can be seen.

In recent years, some of the "mental" benefits of machines have been well exploited. For example, the brain of a computer can perform millions of mathematical calculations, accurately, and at the same time, it takes a person to perform one calculation inaccurately. Also, the memory capabilities of a computer on a network are phenomenal compared to human memory. Surfing the web for a lot of information that the human brain cannot keep has become commonplace. Such mathematical and memory abilities of machines have led to a considerable redefinition of what "intelligence" is about and have led to an ongoing controversy over what machine intelligence is and what it could be capable of.

Technology has also been used to improve the limited range of the human senses and to provide information about aspects of the world around us that are not apparent in everyday life. So, technology can now provide us with information about X-rays, what is happening in the infrared or ultraviolet spectrum, and even ultrasound images of the world around us. In most cases, such signals are converted into visual images that people understand.

Today, computers are also used to process data, to "think," in many dimensions. One reason is that human brains have evolved to think of no more than three dimensions, perhaps expanding to four if time is included as a dimension. Of course, the space around us is not three-dimensional, as people categorize it, but it can simply be perceived in as many dimensions as one wishes. Machines therefore can understand the world in a much more complex and multidimensional way compared to humans. This multidimensionality is an extremely powerful advantage of machine intelligence.

When one person communicates with either a machine or another person, the relatively complex electrochemical signals of the human brain are converted into mechanical signals, sound waves in speech, or movement using the keyboard. Realistically, it is a terribly slow, limited and error-prone means of communication compared to direct electronic signaling. As a result, human languages are the ultimate coding systems that fail to properly portray our thoughts, desires, feelings, and emotions. Problems arise mainly due to the wide range of different languages and cultures and the indirect relationships that exist between them. By comparison, machine communication is extremely strong, not least because it usually involves parallel transmission, while human communication is by nature serial.

When we compare the physical and mental capabilities of machines with those of humans, physically, humans can benefit from the

technological capabilities of machines through external implementation. In other words, we sit in cars or planes; we do not have to connect with them. When it comes to the mental field, people can benefit, as we do in many cases, through external cooperation. For example, the phone helps us communicate or the computer provides us with an external source of memory. But a much more direct connection could offer us much more. For example, by connecting human and computer brains, is it possible for us to understand the world in many dimensions in this cyborg form? Is it also possible to directly use the mathematical and memory capabilities of a machine network? Why should the human brain remember anything when a machine brain can do it much better? What are the possibilities of the direct delivery of other sensory information? What would the human brain make of it? And perhaps most important of all, by connecting the human brain to a computer, it is possible to communicate directly, a man on machine and man on man, by purely electronic signals - a phenomenon that can be considered thought communication?

All these issues, each of which is valid in its way, provide a strong driving force for scientific research, especially since technology is now available to enable these studies. It is a challenge that may be asking human scientists the final question. Can we technologically develop people into a posthuman, cyborg state?

BIOLOGICAL BRAINS IN A ROBOT BODY

We begin by looking at an area that may not be immediately familiar to our readers. When people initially think about linking the brain to technology, it might be about the brain already functioning and settled inside of its own body - could there be another way? Well, there can be! Here, we look at the possibility of a new fusion in which the brain is developed first and then introduced into its own body to function.

When people first think of a robot, it could be a memorable small wheel device or maybe a metalhead that looks almost like a human. Regardless of their physical appearance, our thoughts tend to suggest that the robot can be operated remotely by humans, as in the case of the bomb-handling robot, or it can be controlled by a program. Simple computer or can even learn with a microprocessor like its technology brain. In all of these cases, we consider the robot as simple as a machine. But what if robots had biological brains made up of brain cells, possibly even human neurons?

Nerve cells grown/grown under laboratory conditions on a series of non-invasive electrodes provide an attractive alternative to realizing a new type of robotic controller. An experimental control platform, essentially a robotic body, can move around in a defined area entirely under the control of



such a network/brain and be able to witness effects of the brain, controlling the body. Of course, this is extremely interesting from a robot perspective, but it also opens up a new approach to studying the development of the brain itself for the sensory-motor embodiment. In this way, investigations can be performed in memory-building and reward/punishment scenarios - factors that underlie basic brain function.

In vitro network of brain cells usually begins by separating nerve cells obtained from the foetal rodent cortex tissue. They are then grown in a dedicated chamber in which they can be supplied with the right environmental conditions and nutrients. An array of electrodes embedded in the base of the chamber acts as a two-way electrical interface to / from the culture medium. This allows electrical signals to be supplied to excite the culture and also to the logs to be taken as the output from the culture. Nerve cells in such cultures connect, communicate, and develop spontaneously within weeks, giving useful responses usually three months currently. It's like a brain in a jar!

The brain is housed in a glass sample chamber lined with a flat '88' MEA that can be used for real-time recording. In this way, it is possible to separate the rays of small groups of nerve cells by monitoring the output signals on the electrodes. Thereby, it is possible to form a picture of the global operation of the entire network. It is also possible to electrically stimulate culture through any of the electrodes to induce nerve activity. Therefore, MEA forms a two-way interface with the cultured nerve cells.

The brain can then be combined with its physical robotic body "robot to culture", which involves an input mapping process, from robot sensors to stimulation of culture.

The actual number of nerve cells in the brain depends on the natural density variations during the initial cultivation. The electrochemical activity of the culture is sampled, and it is used as the input to the robot's wheels. Meanwhile, the robot's sensor readings are converted into a stimulus signal received by the breeder, thereby closing the loop.

When the brain has developed for several days, involved in the formation of some basic nerve connections, an existing nerve cell pathway through the culture process is determined by looking for a tight affinity. close between pairs of electrodes. Such pairs are defined as electrode combinations in which nerve cells near one electrode react to stimuli from the other at which the stimulus is applied more than 60 percent of the time and react. No more than 20 percent of the time with excitation on any other electrode than the electrode.

Therefore, a raw input-output response map of the culture process can be produced by bypassing all electrodes in turn. In this way, a suitable input/output electrode pair can be selected to provide an initial decision-making pathway for the robot. This is then

used to control the robot's body - for example, if the ultrasonic sensor is working and we want the reaction that causes the robot to turn away from the object being positioned with ultrasonic waves to continue. move.

For simple experimental purposes at this point, the goal is for the robot to follow a path ahead until it reaches a wall, at which point the forward sonar value drops below the threshold, activating stimulating pulse. If the electrode responds / the output records activity, the robot will spin to avoid the wall. In the experiments, the robot automatically rotates whenever the activity is registered on the reaction electrode. The most relevant result is the occurrence of the sequence of events: wall detection - excitation - response. From a neural perspective, of course, it is also interesting to speculate why there is action on the reactive electrode when no stimulating pulses are applied.

As an overall control element for direction and wall avoidance, the brain is nurtured to act as a single decision-making entity in the overall feedback loop. An important aspect then involves a change in nerve pathways in the culture medium, which is time-related, between the stimulating electrode and the recording electrode.

In terms of research, the investigations of learning and memory, in general, are in the early stages. However, the robot can improve performance over time in terms of wall avoidance in the sense that the nerve pathways deliver a satisfactory action that tends to fully enhance through the routine performed habit: learning by habit.

However, the number of variables involved is significant and the plasticization process, which takes place over a fairly long time, depends on factors such as initial seeding and growth near electrodes as well as overgrowths. a process such as a temperature and humidity. Learning by reinforcement - rewarding good deeds and punishing bad behaviour - is investigative research at this point.

In many cases, culture meets expectations. In other cases, it does not, and in some cases, it delivers motor signals when it is not expected. But does it "intentionally" make a different decision than we expected? We cannot say but merely guess.

In terms of robots, this study has shown that a robot can have a biological brain to make its "decisions". Nerve cell sizes of 100 000–150 000 are merely due to the present limitations of the described experiments. Indeed, three-dimensional structures are being studied. Increasing complexity from two dimensions to three would produce approximately 30 million neurons for a three-dimensional case, not to reach 100 billion neurons for a perfect human brain, but suitable for the brain size of many other animals.

This field of research is expanding rapidly. Not only is the number of cultured neurons increasing, but the range of sensory inputs is being expanded to include both acoustic, infrared, and even



visual stimuli. Such a rich stimulus is sure to have a significant impact on cultural development. The potential of such systems, including the range of tasks they can deal with, also means that the physical body can take on different forms. For example, there is no reason the body cannot be a bipedal walking robot with a rotating head and the ability to walk in a building.

Certainly, the case of understanding nerve activity becomes more difficult as the culture size increases. With the three-dimensional structure, monitoring activity deep inside the central region, as well as with the human brain, becomes extremely complex, even with needle-like electrodes. The current 100 000–150 000 neuron cultures are too complex for us to have a holistic view. When they grew to the size of 30 million nerve cells and beyond, it became apparent that the problem was greatly exaggerated.

Looking ahead a few years, it seems quite realistic to assume that such cultures will become larger, potentially growing into the size of billions of nerve cells. On top of that, the nature of nerve cells can be diversified. Currently, mouse neurons are commonly used in studies. However, human neurons are also being cultured even now, thus creating a robot with a human brain. If this brain were then composed of billions of neurons, many social and ethical questions would need to be asked.

For example, if the robotic brain has almost the same number of neurons as the human brain, could they / should have the same rights as the human? Also, what if such organisms had far more human neurons than the human brain - for example, more than a million times - would they give it all? decisions in the future rather than ordinary people? Certainly, that means that as we look to the near future, we'll soon see robots whose brains are not too different from humans.

GENERAL PURPOSE BRAIN IMPLANTS

Many human brain-computer interfaces are used for therapeutic purposes to tackle a medical/neurological problem - an example is deep brain stimulation electrodes used to overcome the effects of Parkinson's Disease.

The therapy/strengthening situation is more complex with more general brain-computer interfaces. In some cases, those who have had an amputation or spinal injury due to an accident can regain control of the devices through nerve signals. Meanwhile, stroke patients, such as those with motor neuron disease, may be given limited control over their environment.

In these cases, the situation is not simple as each individual is given abilities that a normal person does not - for example, the ability to move a cursor on a computer screen using nothing but nerve signals. The same dilemma exists for blind individuals who

are allowed non-sensory input such as sonar. This does not repair their blindness, but rather allows them to use an alternative meaning.

Some of the most impressive human studies ever have been conducted using the microelectrode array as shown in Figure 3. The individual electrodes are 1.5 mm long and taper to a tip diameter of fewer than 90 microns. Human testing is currently limited to two study groups, although there have been several trials using non-humans as the subject of testing. In the second of these, the series was used to record a single role, most notably as part of what has recently been called the "Brain Gate" system.

Essentially, electrical activity from several neurons monitored by array electrodes was resolved into a signal to direct the cursor movement. This allowed a person to position a cursor on a computer screen using nerve signals for control along with visual feedback. The same technique was later used to allow the paralysed individual receiver to operate a robot arm. However, the first use of the microelectrode array has significantly wider implications that increase the capabilities of the human receiver.

Deriving a reliable command signal from a collection of monitored nerve signals is not necessarily a straightforward task, partly due to the complexity of the recorded signals and partly to real-time constraints when dealing with data. However, in some cases, it can be relatively easy to search for certainly expected nerve signals and obtain a system response to them, especially when a person is

thoroughly trained with the system. The neural signal shape, magnitude, and waveform for time are significantly different from other visible signals, and this makes the problem a little easier.

The interface through which a user interacts with the technology provides a layer of separation between what the user wants the machine to do and what the machine does. This separation puts a cognitive load on the person concerned in proportion to the difficulties experienced. The main problem is to interface the human motor and sensory channels with technology in a reliable, durable, effective, and bi-directional way. One solution is to avoid this sensor-motor bottleneck altogether by interfacing directly with the human nervous system.

An individual connected in this way could potentially benefit from some of the advantages of machine / artificial intelligence, for example, fast and highly accurate mathematical skills, high speed, almost infinite, internet knowledge base, and accurate long-term memory. Additionally, while it is widely accepted that humans only have five senses we know of, machines offer a worldview that includes infrared, ultraviolet, and ultrasonic signals, to name just a few.

Humans are also limited in their ability to visualize and understand the world around them only in terms of three-dimensional perception, whereas computers can quite cope with hundreds of



dimensions. Perhaps most importantly, human communication tools, which transmit a complex electrochemical signal from one brain to another, often through a mechanically slow and error-prone medium, are extremely weak, especially in terms of speed, power, and precision. Connecting a human brain to a computer network using an implant can open up the obvious advantages of machine intelligence, communication, and perception capabilities to the implanted person in the long term.

As a step towards a broader concept of brain-computer interaction, the microelectrode array was implanted into the median nerve fibres of a healthy person during two hours of neurosurgery to test bidirectional functionality in a series of experiments. A stimulation current applied directly to the nervous system allowed information to be sent to the user, while control signals were decoded from neural activity in the area of the electrodes. In this way, several trials, in particular, have been successful:

- Feedback from robotic fingertips is sent back as neural stimulation to give a sense of force applied to an object, providing extended control of a robotic hand over the Internet.
- A primitive form of telegraphic communication was realized directly between the nervous systems of two people.
- A wheelchair has been successfully driven using neural signals.
- Like the behaviour of a small collection of robots, the colour of the gem has changed as a result of neural signals.

In most, if not all, of the above cases, the trial may be considered useful for purely therapeutic reasons, e.g., ultrasonic may be useful for a sensory blind individual; telegraphic communication can be very useful for certain types of motor neuron disease.

However, each experiment can also be viewed as a potential form of enhancement for an individual beyond the human norm. The author didn't need to have the implant for medical purposes to overcome a problem, instead, the experiment was done purely for scientific discovery. So, the question arises: how far should things go? Development using brain-computer interfaces opens up new technological and intellectual opportunities of all kinds; however, it also raises some different ethical considerations that need to be addressed directly.

When experiments of the type described above involve healthy individuals who do not need repair of a brain-computer interface, it is difficult to accept the operation for therapeutic purposes, rather when the primary goal of the implant is to improve the individual's abilities. Indeed, when conducting such experiments, the author specifically wanted to explore real, practical development possibilities.

From the experiments, it is clear that external input is a practical possibility that has been successfully tried, but improving memory, thinking in many dimensions, and communicating with

thought alone is another obvious potential - but realistic - benefits, and the latter has been explored to some extent. To be clear, all this seems possible for people in general.

As we currently have, ethical approval from the local authority governing the hospital where the procedure is performed is required in all cases to proceed with implantation, and also the consent of the trial, if appropriate for a research procedure. and the relevant institution's ethics committee. If a piece of equipment such as an implant is to be used on many people, this is quite different from Devices Agency's approval. Interestingly, there is no need for general ethical clarity from any social institution, but the problems are complex.

However, looking at future business impacts, coupled with societal aspirations to communicate more effectively and perceive the world more richly, it can trigger a market desire. Ultimately, direct brain-to-brain communication, possibly using implants of the type described, is a tremendously exciting proposition that ultimately results in the transfer of thoughts, feelings, emotions, colours, and basic ideas directly from the brain to the brain. While this raises many questions about how to work in practice, it would be foolish not to move forward to achieve it.

But then we come to the big questions. Since communication is an extremely important part of human intelligence, anyone with this type of implant will certainly increase their intelligence significantly. This will prolong intellectual performance in society, with the implanted section performing better than those who simply choose to remain human. Will this leave ordinary people far behind the evolutionary ladder, leading to a digital divide, a "us and them" situation? Well, we'll just have to see!

NON-INVASIVE BRAIN-COMPUTER INTERFACES

For some, the brain-computer interfaces of the kind described above are perhaps a very far step right now, especially if it means directly interfering with the brain. As a result, the most studied brain-computer interface to date is the interface that includes electroencephalography, and this is due to several factors. The first is non-invasive; therefore, there is no need for surgery due to the risk of infection and/or side effects. As a result, the ethical approval requirements are significantly less and the associated costs are significantly lower than for other methods, as the electrodes are readily available.

EEG is also a portable procedure involving electrodes that are simply glued to the outside of a person's head and can be installed in a laboratory with relatively little training, little knowledge, and very little time - then and there.

The number of electrodes used for experimental purposes can range from a small number to well over 100 for those trying to achieve



better resolution. As a result, individual electrodes can be attached to specific positions or a cap in which the electrodes are pre-positioned. The care and handling of the electrodes differ significantly between experiments in which the electrodes were positioned dry and outside the hair, and between experiments in which the hair was shaved and gels were used to improve contact.

Some studies are mostly in the medical field, for example, to examine the onset of epileptic seizures in patients; however, the application spectrum is common. A few of the most typical and/or interesting are included here to give you an idea of the possibilities and work in progress rather than providing a complete overview of the current state of the game.

Typical are topics where subjects learn to use a computer cursor in this way. However, it should be noted that even after significant training periods, the process is slow and usually requires several trials before achieving success. Along the same lines, several research groups have used EEG recordings to turn on lights, control a small robotic vehicle, and control other analogue signals. A similar method was used using a 64-electrode skullcap to enable a quadriplegic person to perform simple hand movement tasks through stimulation via embedded nerve controllers.

It is also possible to evaluate the uniqueness of specific EEG signals, particularly in response to associated stimuli, potentially as a means of identification. Meanwhile, interesting results were obtained using EEG in determining the intended finger touches with high accuracy. This is useful as a quick interface method and a possible prosthetic method.

While the EEG experiment is relatively inexpensive, portable, and easy to set up, it is still difficult to see its widespread use in the future. It certainly has a role to play in externalizing some aspects of brain function for medical purposes, and these practices will undoubtedly increase over time. However, it is considered unrealistic that normal people are likely to walk around without the need for a steering wheel while wearing an electrode cap; It is much more likely to have fully autonomous vehicles on the roads.

CONCLUSION

In this manuscript, we looked at several different cybernetic enhancements and the resulting types of artificial intelligence. Experimental cases have been reported to indicate how humans, and/or animals for that matter, can fuse with technology in this way, raising a plethora of social and ethical considerations as well as technical issues. In each case, reports of actual practical experimentation have been given, rather than just a theoretical concept.

In particular, when considering robots with biological brains, it could mean human brains

operating in a robot body. Therefore, should we give these robots rights in some way? If one were turned off, would that be considered cruelty to robots? More importantly at this time, should such research go ahead anyway? Before long, we may have robots whose brains are made up of human neurons that have the same kind of capabilities as the human brain.

In the section on a general-purpose invasive brain implant as well as the use of implants for therapy, a look was taken at the potential for human improvement. Extrasensory input has already been done scientifically, extending the nervous system to the internet and a basic form of thought communication. So, it is likely that many humans will modernize and become part of the machine themselves. It can mean that ordinary humans are being left behind as a result. If you could be improved, would there be a problem?

Next comes a section on more classic EEG electrodes which are positioned on the outside and are therefore encountered much more frequently. Unfortunately, the resolution of such electrodes is relatively poor and indeed they are only useful for monitoring and not for stimulation. Therefore, the issues around them are somewhat limited. We may be able to use them to learn a little more about how the brain works, but it's hard to see them ever being used for very sensitive control operations when several million electrodes feed the information transmitted by each electrode.

In addition to taking a look at the procedures involved, this article also aimed to look at some of the likely ethical and social issues. However, some technical issues were also considered to open a window on where developments are heading. In each case, however, a solid foundation has been planted on practical technology and realistic future scenarios rather than mere speculative ideas. In a sense, the general idea is to open up a sense of reflection so that the additional experimentation we are now going to witness can be guided by the resulting feedback.

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