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Mind Machine Interaction Based Robot for Disables

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Abstracts

This paper elucidates the research and implementation of brain-actuated disability robot. The idea of controlling robot not by manual control, but by mere “thinking” (i.e., the brain activity of human) has fascinated humankind since ever. The robot is controlled through human Brain signal. BCI is a natural way to augment human capabilities by providing a new interaction link with the outside world and is particularly relevant as an aid for paralyzed humans, although it also opens up new possibilities in mind-robot interaction for able-bodied people. Invasive BCI research has targeted repairing damaged sight and providing new functionality for people with paralysis. The intention of this paper is to provide an overview on the subject of Human-Computer Interaction and brain computer interface.

Keywords: Robot intraction.

Introduction

A **disability robot** is a robot designed to help people who have physical disabilities that impede with daily tasks. Disability robotics is a broad category that includes wheelchairs, robotic arms, and other robotic devices that assist disabled persons of all ability levels. This section will provide examples of the many types of robotic devices used to assist disabled persons. The field of expertise that creates such robots is called "disability robotics".

Children with severe disabilities can develop learned helplessness, which makes them lose interest in their environment. Robotic arms are used to provide an alternative method to engage in joint play activities. These robotic arms allows children to manipulate real objects in the context of play activities. Persons with severe disabilities may be assisted with robotic wheelchairs when manual control is not possible. These devices can deter loss of residual skills and frustration. Traditionally wheelchairs either gave control to the person or robot depending on disability level.

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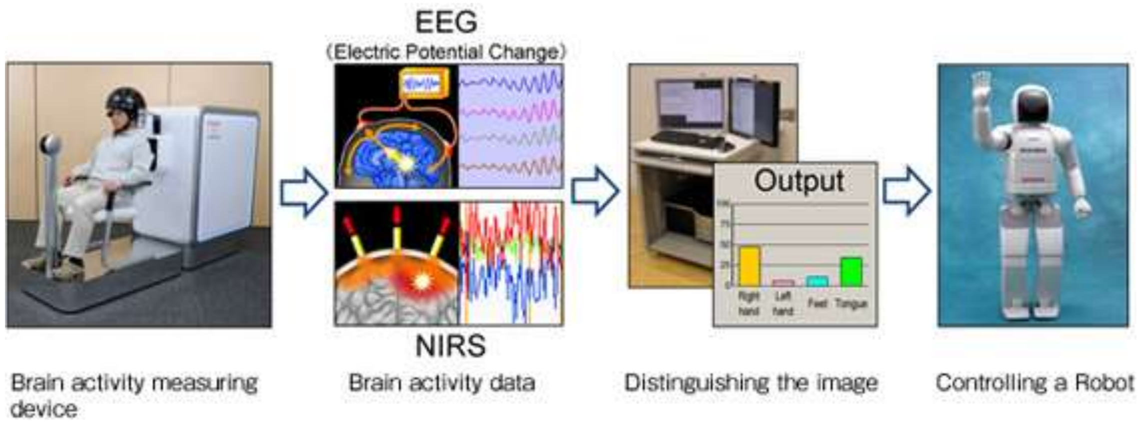
Brain computer interface (BCI)

The growth in Human-Computer Interaction (HCI) field has not only been in quality of interaction,We believe that BCI researchers would benefit greatly from the body of expertise built in the HCI field as they construct systems that rely solely on interfacing with the brain as the control mechanism.



A **brain–computer interface** (**BCI**), sometimes called a **mind-machine interface** (**MMI**), or sometimes called a **direct neural interface** (**DNI**), **synthetic telepathy interface** (**STI**) or a **brain–machine interface** (**BMI**), is a direct communication pathway between the brain and an external device. BCIs are often directed at assisting, augmenting, or repairing human cognitive or sensory-motor functions. Cortical plasticity of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effector channels.

Advances in cognitive neuroscience and brain imaging technologies have started to provide us with the ability to interface directly with the human brain. This ability is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain that correspond with certain forms of thought. Researchers have used these technologies to build brain-computer in- terfaces (BCIs), communication systems that do not depend on the brain's normal output pathways of peripheral nerves and muscles. In these systems, users explicitly manipulate their brain activity instead of using motor movements to produce signals that can be used to control computers or communication devices.

Human-Computer Interaction: Definition, Terminology

Human Computer Interaction (HCI) is a discipline which aims at an established understanding and designing of different interfaces between humans and computers in a way that it defines systems that are enjoyable to use, are engaging and are accessible

Sometimes called as Man-Machine Interaction or Interfacing, concept of Human-Computer Interaction/Interfacing (HCI) was automatically represented with the emerging of computer, or more generally machine, itself. The reason, in fact, is clear: most sophisticated machines are worthless unless they can be used properly by men.

This basic argument simply presents the main terms that should be considered in the design of HCI: functionality and usability . Functionality of a system is defined by the set of actions or services that it provides to its users. Usability of a system with a certain functionality is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users. The actual effectiveness of a system is achieved when there is a proper balance between the functionality and usability of a system.

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Intelligent and Adaptive HCI

Intelligent and Adaptive HCI refer to the interaction which supports user tasks such as navigation or manipulation. Intelligent systems are one such consequence. Intelligent HCI designs are interfaces which use some kind of intelligence in perception assisting the user in an innovative and different way. Some examples such as visually tracking the movements of the user, using speech recognition technology to interact dynamically with the user, and pattern recognition, depict the modern day deployment of intelligent designs.

Adaptive HCI is different from intelligent HCI in the sense that it may or may not use intelligence in assisting users. A simple example of adaptive interaction is a Graphic user interaction (GUI) based website which saves the searches and results of the queries user entered in history and uses them in future to search, navigate and suggest results to user.

Existing HCI Technologies

The existing physical technologies for HCI basically can be categorized by the relative human sense that the device is designed for. These devices are basically relying on three human senses: vision, audition, and touch.

The most difficult and costly devices to build are haptic devices . "These kinds of interfaces generate sensations to the skin and muscles through touch, weight and relative rigidity ." Haptic devices are generally made for virtual reality or disability assistive applications.

These new advances can be categorized in three sections: wearable devices, wireless devices, and virtual devices. The technology is improving so fast that even the borders between these new technologies are fading away and they are getting mixed together. Few examples of these devices are: GPS navigation systems, military super-soldier enhancing devices (e.g. thermal vision, tracking other soldier movements using GPS, and environmental scanning), radio frequency identification (RFID) products, personal digital assistants (PDA), and virtual tour for real estate business. Some of these new devices upgraded and integrated previous methods of interaction. As an illustration in case, there is the solution to keyboarding that has been offered by Compaq's iPAQ which is called Canesta keyboard.

HCI Systems Architecture

Most important factor of a HCI design is its configuration. In fact, any given interface is generally defined by the number and diversity of inputs and outputs it provides. Architecture of a HCI system shows what these inputs and outputs are and how they work together. Following sections explain different configurations and designs upon which an interface is based.

1) Unimodal HCI Systems

As mentioned earlier, an interface mainly relies on number and diversity of its inputs and outputs which are communication channels that enable users to interact with computer via this interface. Each of the different independent single channels is called a modality [36]. A system that is based on only one modality is called unimodal. Based on the nature of different modalities, they can be divided into three categories:

1. Visual-Based
2. Audio-Based
3. Sensor-Based

The next sub-sections describe each category and provide examples and references to each modality.

1. Visual-Based HCI

The visual based human computer interaction is probably the most widespread area in HCI research. Considering the extent of applications and variety of open problems and approaches, researchers tried to tackle different aspects of human responses which can be recognized as a visual signal. Some of the main research areas in this section are as follow:

• Facial Expression Analysis
• Body Movement Tracking (Large-scale)
• Gesture Recognition
• Gaze Detection (Eyes Movement Tracking)

2. Audio-Based HCI

The audio based interaction between a computer and a human is another important area of HCI systems. This area deals with information acquired by different audio signals. While the nature of audio signals may not be as variable as visual signals but the information gathered from audio signals can be more trustable, helpful, and is some cases unique providers of information. Research areas in this section can be divided to the following parts:

• Speech Recognition
• Speaker Recognition
• Auditory Emotion Analysis
• Human-Made Noise/Sign Detections (Gasp, Sigh, Laugh, Cry, etc.)
• Musical Interaction

This section is a combination of variety of areas with a wide range of applications. The commonality of these different areas is that at least one physical sensor is used between user and machine to provide the interaction. These sensors as shown below can be very primitive or very sophisticated.

1. Pen-Based Interaction
2. Mouse & Keyboard
3. Joysticks
4. Motion Tracking Sensors and Digitizers

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5. Haptic Sensors
6. Pressure Sensors
7. Taste/Smell Sensors

2) Multimodal HCI Systems

The term multimodal refers to combination of multiple modalities. In MMHCI systems, these modalities mostly refer to the ways that the system responds to the inputs, i.e. communication channels [36]. The definition of these channels is inherited from human types of communication which are basically his senses: Sight, Hearing, Touch, Smell, and Taste. The possibilities for interaction with a machine include but are not limited to these types.

Therefore, a multimodal interface acts as a facilitator of human-computer interaction via two or more modes of input that go beyond the traditional keyboard and mouse. Multimodal interfaces incorporate different combinations of speech, gesture, gaze, facial expressions and other non-conventional modes of input. One of the most commonly supported combinations of input methods is that of gesture and speech.

An interesting aspect of multimodality is the collaboration of different modalities to assist the recognitions. For example, lip movement tracking (visual-based) can help speech recognition methods (audio-based) and speech recognition methods (audio-based) can assist command acquisition in gesture recognition (visual-based).

Applications of multimodal

Few examples of applications of multimodal systems are listed below:

• Smart Video Conferencing
• Intelligent Homes/Offices
• Driver Monitoring
• Intelligent Games
• E-Commerce
• Helping People with Disabilities

Multimodal Systems for Disabled people

One good application of multimodal systems is to address and assist disabled people (as persons with hands disabilities), which need other kinds of interfaces than ordinary people. In such systems, disabled users can perform work on the PC by interacting with the machine using voice and head movements. Figure 4 is an actual example of such a system.

Two modalities are then used: speech and head movements. Both modalities are active continuously. The head position indicates the coordinates of the cursor in current time moment on the screen. Speech, on the other hand, provides the needed information about the meaning of the action that must be performed with an object selected by the cursor.

Synchronization between the two modalities is performed by calculating the cursor position at the beginning of speech detection. This is mainly due to the fact that during the process of pronouncing the complete sentence, the cursor location can be moved by moving the head, and then the cursor can be pointing to other graphical object; moreover the command which must be fulfilled is appeared in the brain of a human in a short time before beginning of phrase input.

Emotion Recognition Multimodal Systems

A natural human-computer interaction cannot be based solely on explicitly stated commands. Computers will have to detect the various behavioural signals based on which to infer one's emotional state.

People are able to make prediction about one's emotional state based on their observations about one's face, body, and voice. Studies show that if one had access to only one of these modalities, the face modality would produce the best predictions. However, this accuracy can be improved by 35% when human judges are given access to both face and body modalities together.

The authors attempted to fuse facial and voice data for affect recognition. Once again, remaining consistent with human judges, machine classification of emotion as neutral, sad, angry, or happy was most accurate when the facial and vocal data is combined.

They recorded the four emotions: "sadness, anger, happiness, and neutral state". The detailed facial motions were captured in conjunctions with simultaneous speech recordings. Results show that the emotion recognition system based on acoustic information only give an overall performance of 70.9 percent, compared to an overall performance of 85 percent for a recognition system based on facial expressions. This is, in fact, due to the fact that the cheek areas give important information for emotion classification.

Uses

1. It helps physically disabled persons by carrying some objects from one place to another place using the arm structure in the robot.
2. It guides the blind persons to reach a particular Destination.
3. It is used to guide visitors in an organization by providing information about the facilities available.
4. Because of the presence of the Real-time Clock (DS1307), time-based control of the robot is possible. For example, it is used in hospitals to inform patients to take the tablets at the right time.
5. It is used in hazardous places.

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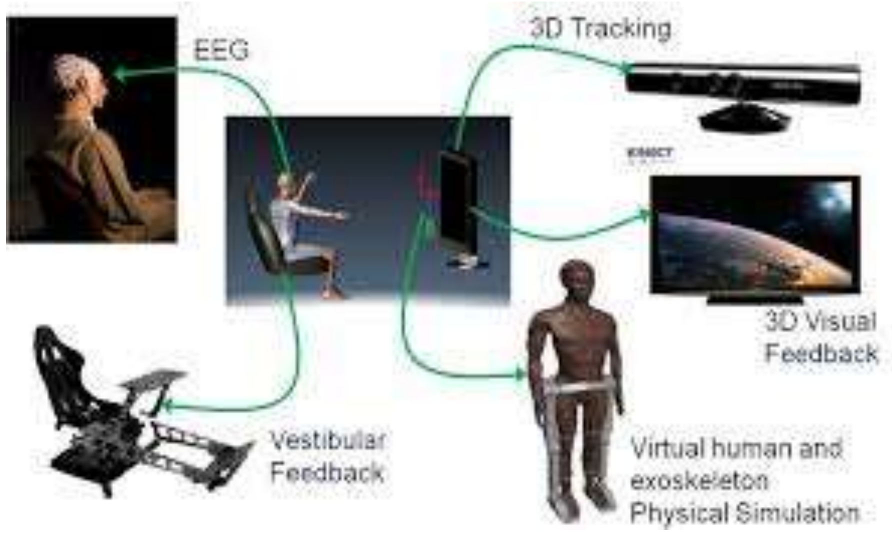
6. The photo electric sensor in the robot will sense the obstacles and it will make decisions according to the obstacles it encounters.

The Evolution of BCIs and the Bridge with Human Computer Interaction

The evolution of any technology can generally be broken into three phases. The initial phase, or proof-of-concept, demonstrates the basic functionality of a technology. In this phase, even trivially functional systems are impressive and stimulate imagination.



In the second phase, or emulation, the technology is used to mimic existing technologies. The first movies were simply recorded stage plays, and computer mice were used to select from lists of items much as they would have been with the numeric pad on a keyboard. Similarly, early brain-computer interfaces have aimed to emulate functionality of mice and keyboards, with very few fundamental changes to the interfaces on which they operated. It is in this phase that the technology starts to be driven less by its novelty and starts to interest a wider audience interested by the science of understanding and developing it more deeply.

Finally, the technology hits the third phase, in which it attains maturity in its own right. In this phase, designers understand and exploit the intricacies of the new technology to build unique experiences that provide us with capabilities never be- fore available.

Considering human limitations, disabilities, and design

All humans have limitations in their physical capabilities. Some are immediately visible, others are not. When designing from an HCI perspective, you start realizing that limitations are often discussed in terms of disabilities. The application of HCI to supporting and enhancing the physical capabilities of humans is one of the most promising application areas. Strides in biomedical engineering mean that there is research to support the blind or those with low vision, those who are deaf or have impaired hearing, and people with limited mobility.

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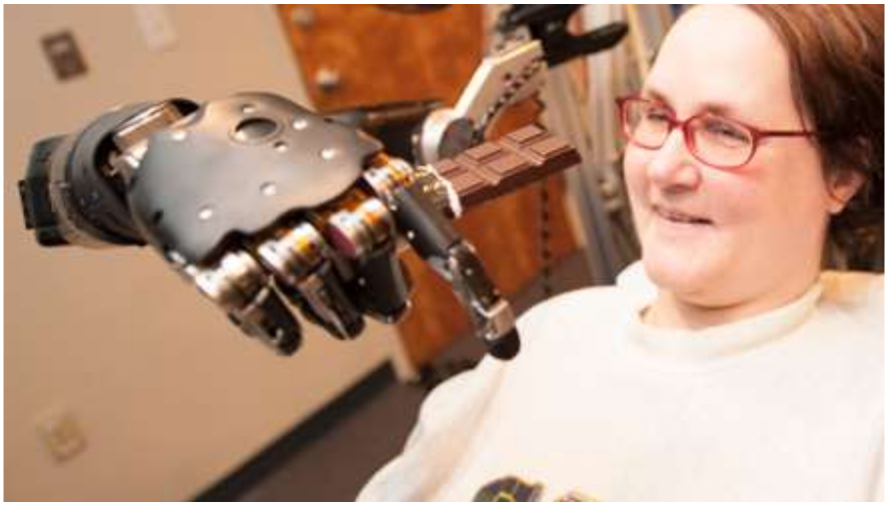

Using BCI for disabled people

Probably the most widely accepted neural prosthesis in human use is the cochlear implant, which substitutes a small computer chip for the damaged inner ear control organ to enable sound waves to be transformed into electrical signals the brain can interpret. Other research has focused on restoring vision for the blind with implantable systems to transmit visual information. One other possible application is the restoration of motor control for patients with movement disorders, a population numbering ≈2 million in the United States alone. In an especially tragic situation, brain system stroke can leave patients in a locked-in state with minimal eye movements and no speech, but full cognitive functions. Among the other diseases that could be helped by BMIs are degenerative disorders (amyotrophic lateral sclerosis or Lou Gehring disease, multiple sclerosis, muscular dystrophy), brain or spinal cord injury, or cerebral palsy. When a disconnection of the main motor pathway occurs, the information generated in the motor cortical areas cannot travel through the pyramidal tract to reach the executing organ, the muscles. There are several possible approaches in how to overcome this disconnect in the signal pathway: (1) activation of intrinsic alternate pathways (anatomical compensation); (2) repair or regeneration of the damaged pathway (anatomical recovery); and (3) bypassing the damaged area by means of a BMI (functional recovery).

People with paralysis control robotic arms using brain-computer interface

A new study in *Nature* reports that two people with tetra plegia were able to reach for and grasp objects in three-dimensional space using robotic arms that they controlled directly with brain activity. They used the BrainGate neural interface system, an investigational device currently being studied under an Investigational Device Exemption. One participant used the system to serve herself coffee for the first time since becoming paralyzed nearly 15 years ago. On April 12, 2011, nearly 15

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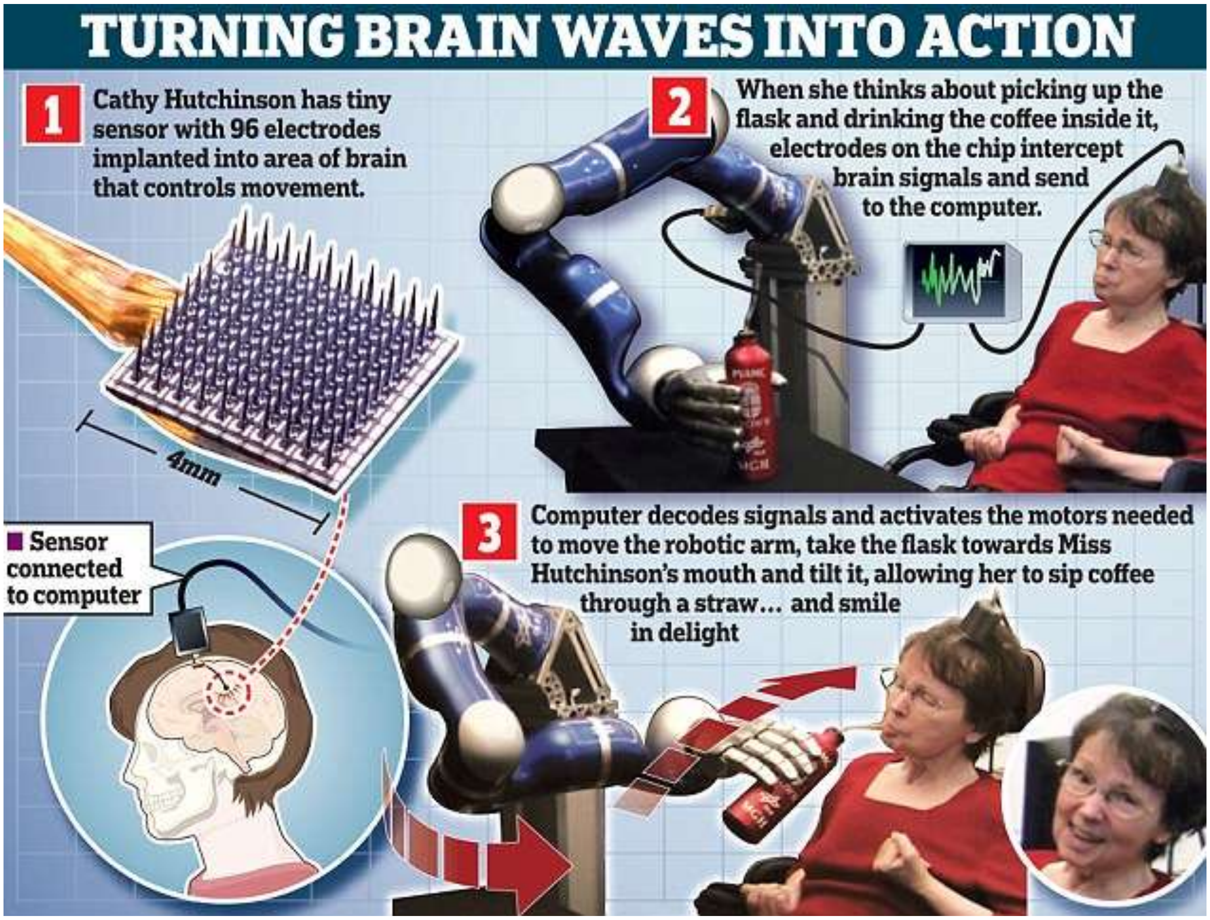

years after she became paralyzed and unable to speak, a woman controlled a robotic arm by thinking about moving her arm and hand to lift a bottle of coffee to her mouth and take a drink.

BCI for space applications

As mentioned before, development of non-invasive brain-controlled robotic devices is the most relevant for space applications, where environment is inherently hostile and dangerous for astronauts who could greatly benefit from direct mental teleoperation of external semi-automatic manipulators. Such a kind a brain-actuated control should increase the efficiency of astronaut's activity that is of primary interest as mental commands could be sent without any output delays—as it is the case for manual control in microgravity conditions. Furthermore, robotics aids would be highly useful to astronauts weakened by long stays in microgravity environments.

Conclusion

Real-time control of brain-actuated devices, especially robots, is the most challenging for BCI and the most relevant for space applications. In this paper, we give an overview of a sophisticated discipline called Human

Computer Interaction (HCI) from a modernistic perspective which is in accordance with the increasing dependence of humans on technology, as well as taking a positive action against the nefarious nature of humans which can result in harmful use of such high level technologies. This new direction aims to replace Millions of people worldwide suffer from sensorimotor deficits caused by neurologic injuries, diseases or limb loss. the common interaction techniques with the intelligent, innovative and adaptive design methods. The main idea behind BMIs is to employ the activity of healthy motor brain areas, which in many cases of paralysis remain capable of generating motor commands despite being disconnected from the body effectors, to control artificial tools that restore the patient's mobility. Brain controlled Robot has been designed to support and expand the physical capabilities of its users, particularly people with physical disabilities.

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