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APPLICATION OF BCI TECHNOLOGIES

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Abstract: This paper presents an overview regarding the application of the brain-computer interfaces technologies in the fields of science, health, education, finance, safety and security, human-computer interface, entertainment.

1. INTRODUCTION

As is presented in [Wolpaw2002] a BCI is defined as a communication system in which messages or commands that an individual sends to the external world do not pass through the brain's normal output pathways of peripheral nerves and muscles.

A brain-computer interfaces system has to fulfill the following four conditions:

- **To be direct coupled to the brain**: the system must rely on activity recorded directly from the brain.
- **To have intentional control**: At least one recordable brain signal, which can be intentionally modulated, must provide input to the BCI (electrical potentials, magnetic fields or hemodynamic changes).
- **To be in real time**: The signal processing must offer in real time a control signal.
- **To have feedback**: The user must obtain feedback about the state of the controlled process.

A Brain/Neuronal Computer Interaction (BNCI) differs from BCI only in the first condition; the input signals can also reflect other nervous system activity, such as eye movement (EOG), muscle activity (EMG), or heart rate (HR), electrocardiogram (ECG).

A BCI system has four subsystems:

1. DAQ subsystem (data acquisition from the brain);
2. Signal processing subsystem (pattern recognition and signal processing algorithm)
3. Controlled devices and interfaces (wheelchairs, VR, intelligent environment, speller or robotic device, etc.)
4. Operating environment (user interface, communications procedures between different components of the system and between the system and the environment).

In figure 1 is presented the component of any BCI system as is presented in the [Alison 2011]

Solutions for the BCI system can be offered also by invasive or non-invasive techniques.

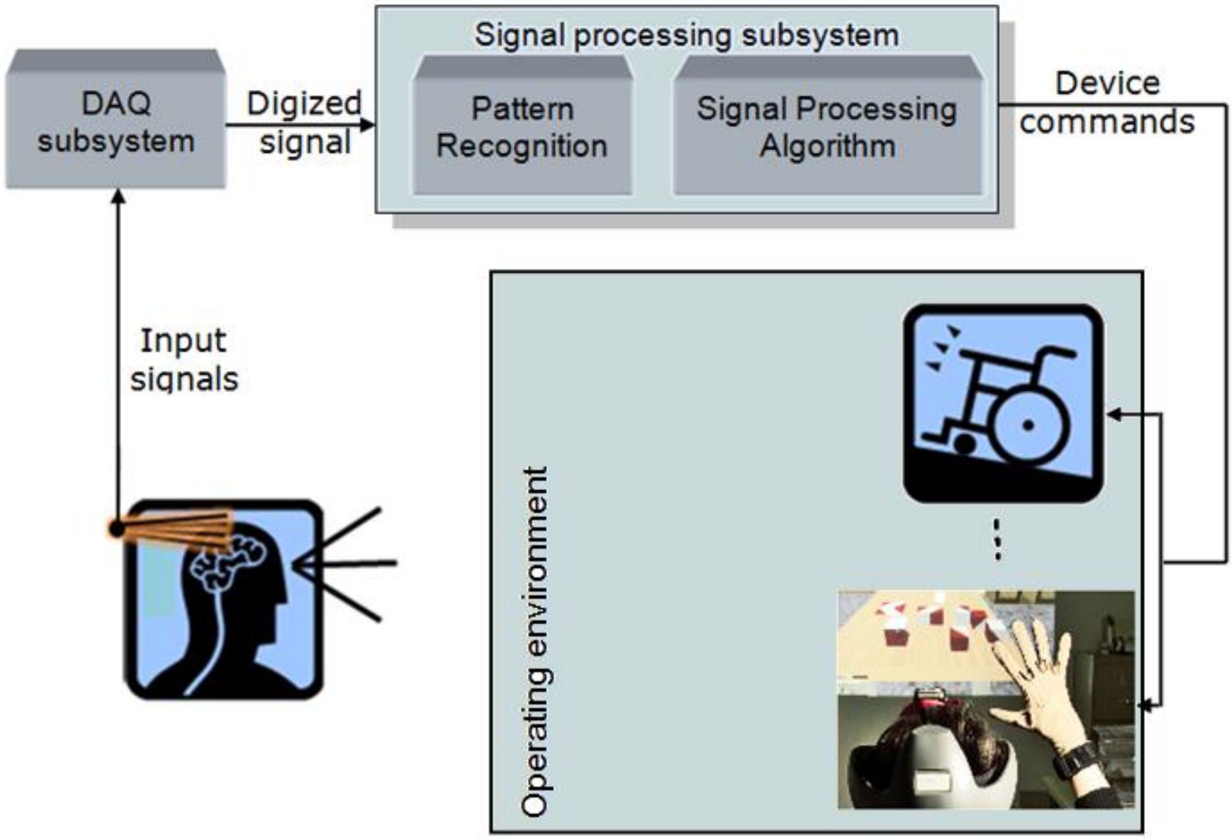

Fig.2 The components of any BCI system (from Allison, 2011).

2. OVERVIEW ON THE BCIs APPLICATION AREA

The BCI technologies have a lot of application areas as is presented in figure 2. Definitely, there are other "undiscovered" application areas that will appear in time as researchers will come up with new applications.

In the entertainment sector there are two main user groups that are using those technologies: gamers and artists. For the first group the BCI techniques try to provide new interaction styles through active BCIs or to enhance game experience through passive BCIs. For the second user group – artists, wants to provide new interaction styles in art.

If we discussed about the safety and security area, three subareas can be identify:

- Forensics;
- Military;
- Process control.

In the forensics domain the BCIs techniques can be used to help monitor criminal knowledge or intent, potential used groups could be policeman and prisons. In army those BCIs techniques could be used to augment and monitor mental performance of soldiers. To monitor attention levels in controllers and determine opportune moment to deliver information to the user is the concept for the process control. In this case the potential user groups could be air traffic controllers, train controllers, car drivers, etc.

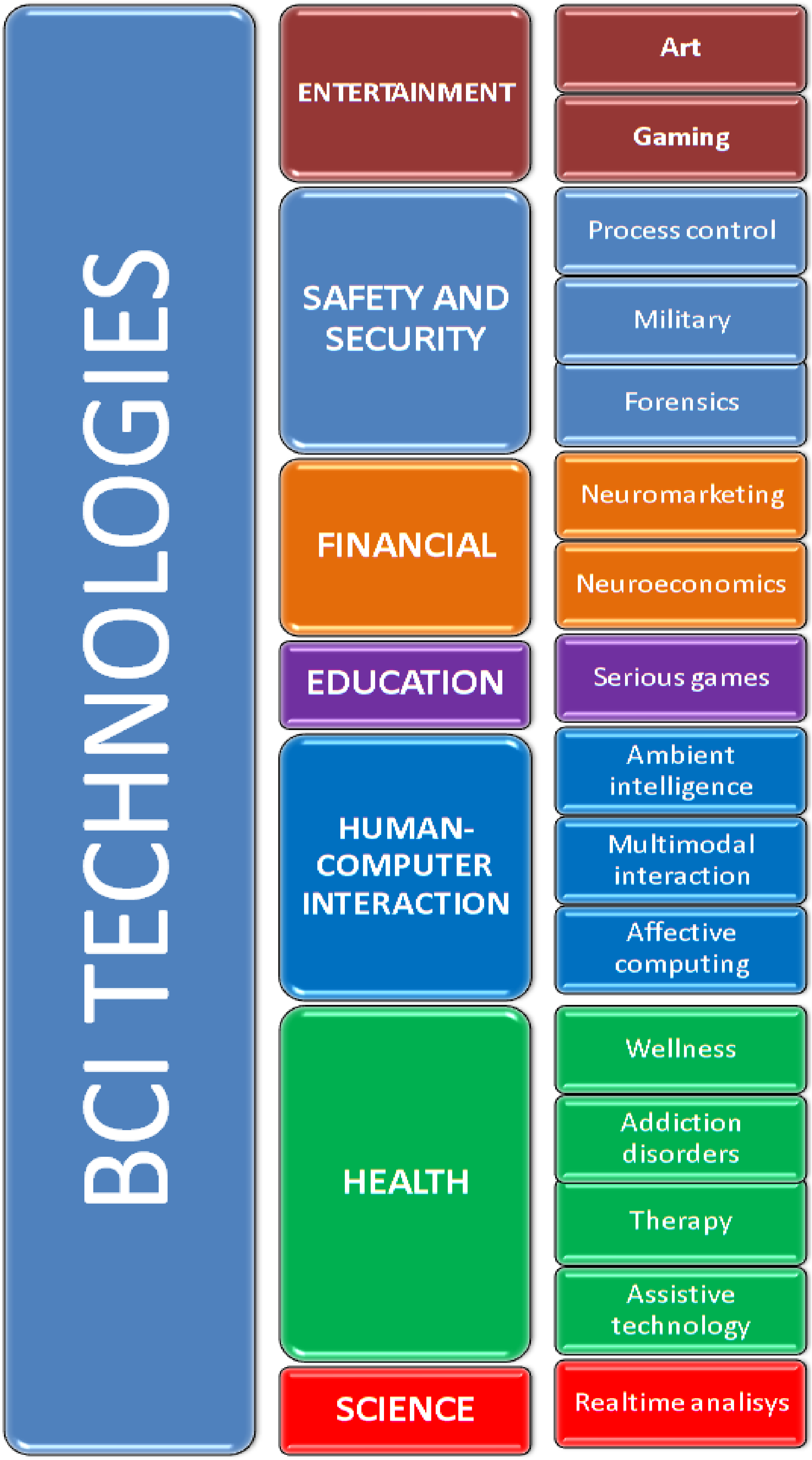

Fig.5 BCI Technologies classification

A new domain appears on the BCIs application map: financial sector with two concepts:

- Neuroeconomics:
- Neuromarketing.

Neuroeconomics concept tries to provide novel tools to study in how humans make financial decisions. Neuromarketing wants to provide novel tools to study in how humans react to advertisement, products or media. In both cases, since classification is possible in real-time, new experimental setups can be made.

Education is a very important sector, where, in the last period, a lot of new learning techniques have appeared. We can mention in this case: e-learning systems, interactive systems, etc. The BCIs techniques want to provide new interaction styles in serious games, and an interactive educational system to facilitate learning and increase brain plasticity.

The BCIs technologies offer three types of application for the Human Computer Interaction (HCI) domain:

- multimodal interaction;
- affective computing;
- ambient intelligence.

For the multimodal interaction the concept is to provide interfaces with an extra input modality (for pilots, individuals with motor disabilities). For the affective computing domain the main idea is to provide interfaces with information about the user state in order to support custom-tailored human-computer interaction (also referred to as “passive BCI”). The “passive BCI” system describes device that directly measure brain activity, and often provide feedback in real-time, but does not require intentional mental activity for each command [2]; [6], [7], [8] and [11]. Passive BCI systems could detect information that individuals generate without any conscious effort, which might reflect frustration, deception, workload, alertness, errors, image detection, etc. For the ambient intelligence the issue is to provide user information to the context system that fully incorporates the relevant information about the system environment and user.

The health domain is the main application area of the BCIs technologies. It includes the following subdomanis:

- wellness;
- addiction disorders;
- therapy;
- assistive technology.

In the wellness area is supposed BCI signal is used to trigger a greater plasticity of the brain than normal occur and therefore can stimulate mental performance and emotional well-being. This is also known as cognitive enhancement.

In the addiction disorders the main idea is to detect any craving in real-time and give immediate feedback to those patients on their brain activity.

The therapy domain has the most BCI application for cortical stroke, Alzheimer’s disease, ADHD, depression, schizophrenia, autism, epilepsy, psychopathy. The main idea in the therapy is to provide neurofeedback to the patients, which could initiate or accelerate brain plasticity in damaged or disordered cortical networks.

The last one is used to provide assistive technology to physically disabled persons (persons with tetra- or quadriplegia, locked-in patients).

3. CONCLUSION

BCI systems develop in a variety of areas. New applications emerge, such as rehabilitation of patients with motor impairments, entertainment, testing and validation of systems with target users in smart environments and BCI technologies for scientific research and diagnostics respectively. BCIs are gaining more and more attention in academia, business, technology community, the media as well as the general public.

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