INTELLIGENT DEVICE CONTROL USING BRAIN MACHINE INTERFACE

Project Reference No.:*45S_BE_2644*

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Keywords

EPF, IOS, Android, Face Recognition, Database, Machine learning, CMake, Dlib, PyCharm, Android studios.

Introduction

Designing smart environment is an active area of research where data is sensed and used to improve life for people. One source of data is the human brain were using Brain Computer Interface (BCI), information is gathered to aid in controlling devices in smart and new way. The brain-computer interface provides a path to transfer information between the brain and the computer, for which no noticeable muscle movement in the body is required. After receiving information from the brain, the user's brain activity is translated into a message or a command. The BCI system's most common application is in the medical field and helps quadriplegic patients. To help patients, they are required to generate suitable brain signals via mental imagination of the demanded motor activity; subsequently, recorded brain activities are processed to move a wheelchair device. Besides, BCIs are also successfully utilized for other purposes, including psychology, neuromarketing, game and entertainment, smart house, and virtual reality. Today, different brain-computer interface systems are introduced and categorized based on their stimulation paradigms and electrode implantation site.

One of the most significant paradigms is using imagery EEG signal, as it is non-invasive, low-cost, and encompasses high temporal resolution. Besides, neurological studies suggest the voluntary movement of specific limbs or imagination of certain action can both activate similar areas of the brain. In this EEG paradigm, EEG signals produced by the neuronal activity of the brain are recorded from the scalp surface [10,11]. After that, imagery signals are identified, classified and subsequently transformed into a control message that is applied to the prosthetic device as an input. Nonetheless, the main challenge of motor imagery-based-BCI is to be an optimal and reliable system. Accordingly, several studies highlighted the significance of μ and β rhythms signal for pre-processing of motor imagery signals.

To improve understanding of nerve signals and how they can be used to control an actuator, this study intends to build a wheelchair control system through nerve signals. The intent of this work is to implement an Arduino robot to simulate a brainwave-controlled wheelchair for paralyzed patients with an improved controlling method. This project describes a non-invasive Brain-actuated Wheelchair which acquires the signals from various electrodes placed according to the International 10-20 electrode setup for Electroencephalograph (EEG). The brain signals are processed to determine the direction of the movement of the wheelchair. It has been shown that the patient is able to achieve EEG controlled cursor, limb movement, a prosthesis control and even has successfully communicated by means of a Brain-computer Interface (BCI). The signals are detected to observe the path to estimate the movement of the wheelchair. The specific signals have been observed for the sensing of the left and right directions. The work presented here mainly uses simple unipolar electrode to capture EEG from the forehead to build a control for electric wheelchairs for paralyzed patients. Then, normalized β, α, θ and δ waves to construct two signals such as meditation and attention. Additionally, we can also extract the eye-blinking signals from BCI. Therefore, attention and eye-blinking signals can be collected as the control signals through a communication interface and an electrical interface is used for the electric wheelchair.

Objective

A BCI measures brain activity and translates it into a form that can allow machines to compensate for lost or damaged brain functions, provide supplementary or augmented functions, or entrain lasting improvements in existing functions. One source of data is the human brain were using Brain Computer Interface (BCI), information is gathered to aid in controlling devices in smart and new.

(a) To design mobility device for shifting patients, moving physically challenged people from one place to another by means of self-propelling.
(b) To aid the patients to achieve a command-based movement of wheelchair using Electroencephalogram (EEG) signals.
(c) To reduce user effort in controlling the wheelchair and to ensure safety during movement.
(d) Designing smart environment is an active area of research where data is sensed and used to improve life for people
(e) Enable additional System applications to be intentionally controlled via the monitoring of brain signal activity.
(f) Restoring the quality of life for quadriplegic person.

Methodology

A brain-computer interface (BCI) system provides communication between computer and mind of pupils. This interface can be based on brain activity during muscular movements or the changes of the rhythms of brain signals. The BCI based control system is composed of five main units: signal acquisition unit, signal pre-processing unit, feature extraction unit, classification unit, and action unit that controls motors of the wheelchair.

In Signal acquisition, raw synchronised EEG signal is streamed directly from NIC Enobio 8 device. The raw EEG has a low signal-to-noise ratio due to its small amplitude peak-to-peak, and includes a variety of rhythms identified by their frequency range, location, and other aspects related to the brain function. The signals are then digitized and transmitted to a computer.

The pre-processing stage, consisting of three sections: In the first section, the information related to the imagination command tasks (μ and β rhythms) is extracted using Butterworth Band Pass filtering with the order of 3.

In the second section, to highlight each channel's information and source localization, a high-Laplacian spatial filter is applied. Furthermore, in the third section, the combined wavelet and Mutual Information method are used for selecting the optimal EEG channels.

Next, after pre-processing, Feature extraction is the process of analysing the digital signals to distinguish pertinent signal characteristics (i.e., signal features related to the person's intent) from extraneous content and representing them in a compact form suitable for translation into output commands. These features should have strong correlations with the user's intent. Because much of the relevant (i.e., most strongly correlated) brain activity is either transient or oscillatory, the most extracted signal features in current BCI systems are time-triggered EEG or ECoG response amplitudes and latencies, power within specific EEG or ECoG frequency bands, or firing rates of individual cortical neurons.

Environmental artifacts and physiologic artifacts such as electromyographic signals are avoided or removed to ensure accurate measurement of the brain signal features. The resulting signal features are then passed to the classification algorithm, which converts the features into the appropriate commands for the output device (ie, commands that accomplish the user's intent).

The commands from the classification unit, operate the external device, providing functions such as wheelchair movement, cursor control, and so forth.

The device operation provides feedback to the user, thus closing the control loop. Our primary device is smart wheelchair which also analysis environment through sensors, make smart decision and controls the movement of the wheelchair.

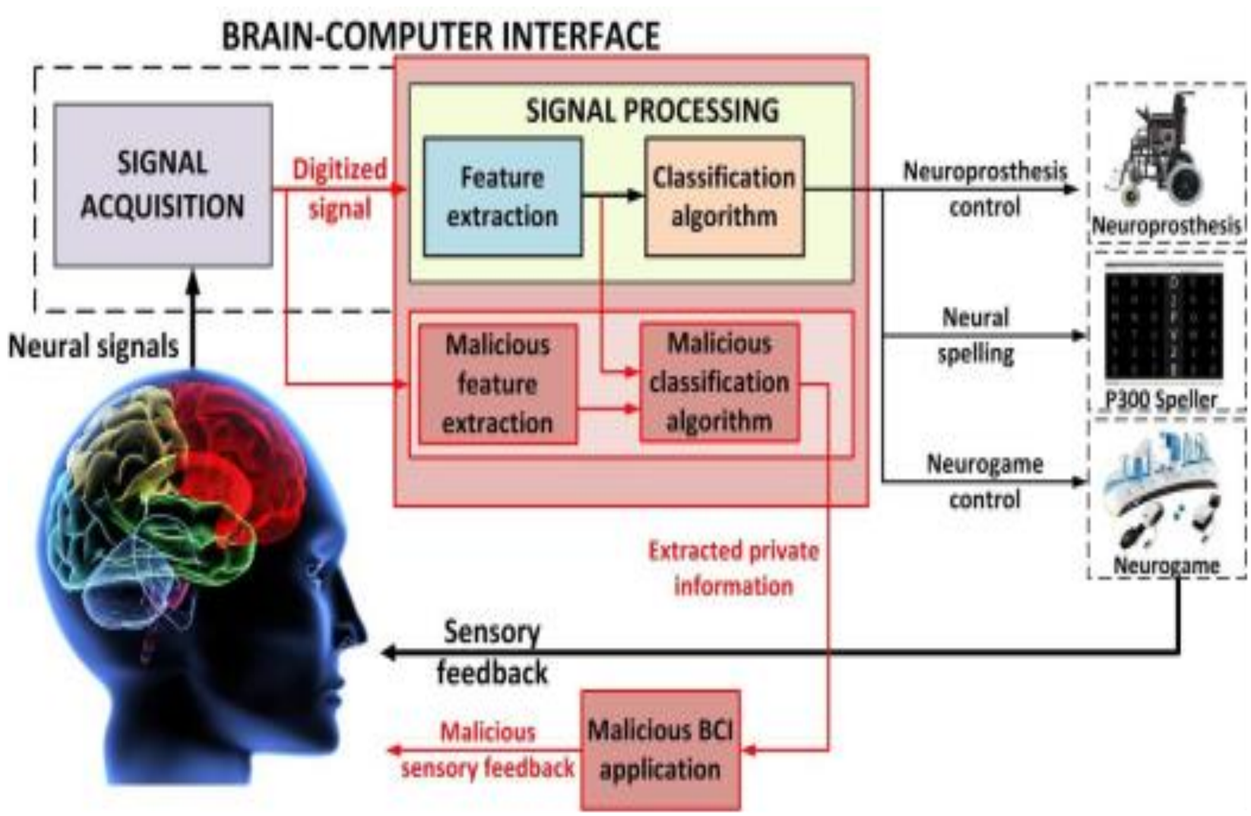
(a) This smart device also has additional Plug-in applications as follow.

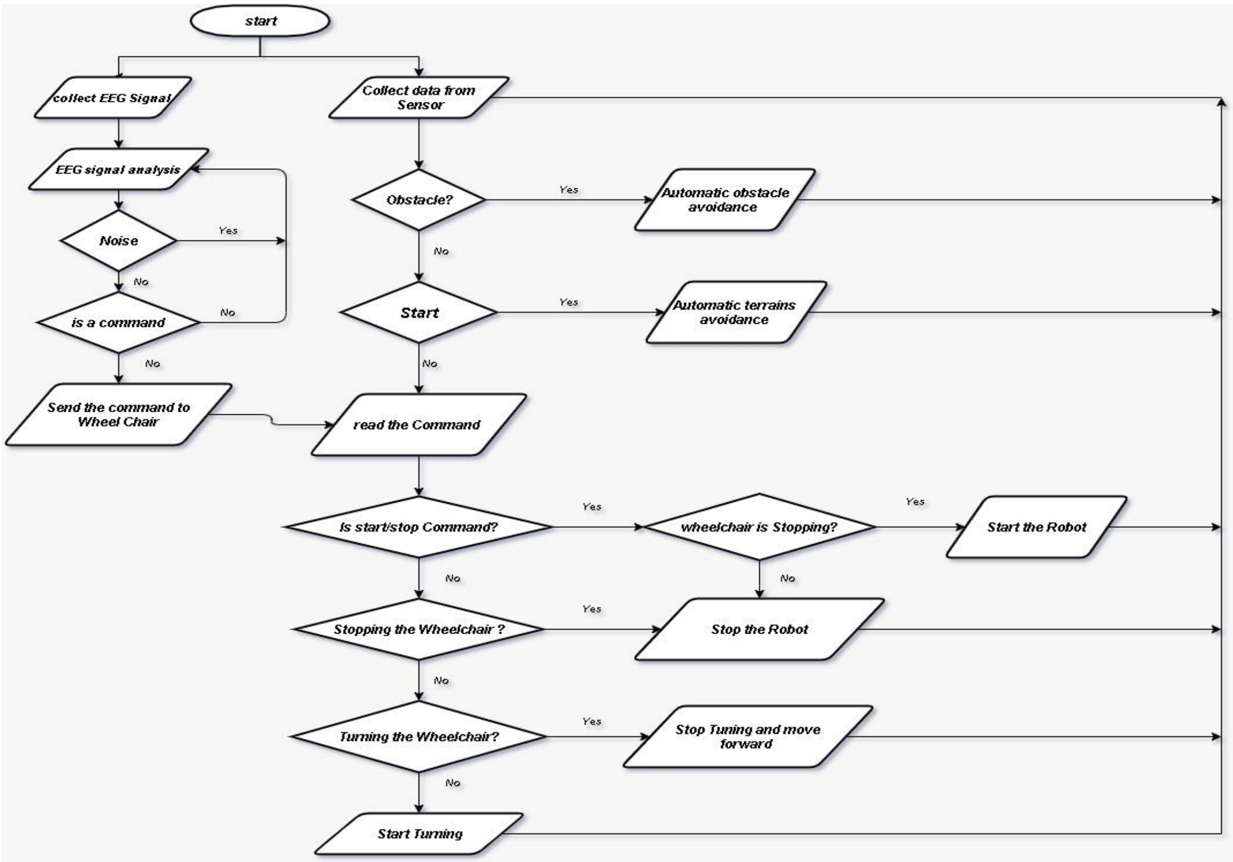
(b) HealthCare System, which monitors the brain signal and if any disordered activity is detected, it immediately notifies the nearest hospital and calls for ambulance.

(c) Neurogaming System, gives the User to collaborate with a console without operating a conventional controller

(d) Sleep detector System, detects user is sleeping or not and if person is sleeping, alerts him when it senses any danger in the environment.

(e) Smart Environment, Controls the light on/off and other Smart home Devices.





Results and Discussions

As mentioned in the methodology, we have considered few existing datasets and trained the prediction algorithms for the datasets based on the signal processing techniques mentioned. Below tables are the results for the datasets.

CLASSIFIERS	ACCURACY
LOGISTIC REGRESSION	57.3%
SVC	62.63%
DECISION TREE CLASSIFIER	89.29%
RANDOM FOREST CLASSIFIER	96.21%
GRADIENT BOOST CLASSIFIER	81.29%
K NEIGHBORS CLASSIFIERS	89.78%