UNIVERSIDAD DE GUADALAJARA

CENTRO UNIVERSITARIO DE LOS VALLES

MAESTRÍA EN INGENIERÍA DE SOFTWARE

Author:
Ilse Aribei Hernández Meza

Subject:
Administración de la configuración del software

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Version History

Date	Version	Description	Author
2022-08-26	1.0	Homework	Ilse Aribei Hernández Meza
2022-09-03	1.1	Add context and improve system design	Ilse Aribei Hernández Meza

Table 1: Version History

Title

Design and implementation of a software for the mental control of terrestrial robots with therapeutic purposes

Context

The attention deficit hyperactivity disorder (ADHD) is a psychiatric neurodevelopmental disorder characterized by inappropriate levels of inattention and / or impulsivity and hyperactivity, this affects an estimated between 8% and 12% of the young people in the world being a mental disorder with more presence during childhood Children with ADHD commonly present symptoms of hyperactivity, impulsivity, lack of concentration what triggers another suffering like a poor tolerance of frustration, low self-steam and humor changes that are presented mainly during childhood but also that can persist into adolescence and adulthood in about 50 % of diagnosed cases. Adults with ADHD presents higher rates of college dropout, poor job performance, difficulty keeping a job, and lower wages than peers of similar intelligence as well as higher-risk impulsive behaviors, substance abuse, self-harm, and suicide attempts. However, a timely treatment in childhood can conduce to improve both mental health and style of life during adulthood. Commonly, ADHD treatments are classified in pharmacological, nonpharmacological, and multimodal treatments. Whereas pharmacological treatments are based on the use of different drugs non-pharmacological treatment are based on different strategies such as diet, exercise, cognitive training, behavioral therapy, and neurofeedback. Neurofeedback (NF) it is a non-pharmaceutical and non-invasive neuromodulation technique whose objective is to provide participants with information about their brain functions, in particular, electrical brain activity (electroencephalogram; EEG) during the production of a certain behavior in real time using a brain-computer interface.

Introduction

Social robots are developed as support tools in various health treatments. However, the focus that has been given to these robots has been in 3 areas: physical trainers, care for the elderly and as a tool for therapy in children. Social robots have been used in therapies for children with cancer, cerebral palsy, communication disorders and neurodevelopmental disorders to mention a few. Studies reveal that the use of social robots in therapy for children with autism and in play therapy in hospitals is favorable. The child perceives the robot as a pet or a toy, which allows him to take a pleasant and comprehensive therapy; In addition, the child faces a position of superiority towards the robot, which generates an environment of trust. Robot-assisted therapies and brain training programs in children are becoming more popular, providing benefits for populations with neurological problems, such as pediatric patients diagnosed with attention deficit hyperactivity disorder (ADHD), this being a psychiatric and neurodevelopmental disorder that statistically affects a population of 11% of children worldwide. That is why, at the Centro Universitario de los Valles, a group of professors and students have started with the development of a project called CogniDron-EEG, which aims to be a system with therapeutic purposes for patients with ADHD. A series of exercises are proposed through the mental control of physical drones or in virtual reality scenarios to help train some cognitive functions through therapies with the support of a portable electroencephalogram (EEG), which allows the reading of the brain electrical signals of the patient in real time.

The present work describes the baseline for the development of therapeutic exercises based on the mental control of terrestrial robots and integrate them into the Cognidron-EEG system with the aim of increasing its functionality.

Objectives of a system

General objective

Increase the functionality of the CogniDron-EEG system, through the design and implementation of new exercises to train the functions.

Specific objectives

- Study the CogniDron-EEG module that allows access to the Emotiv epoc+ electroencephalogram data and, if necessary, modify it to integrate the cognitive training exercises to be developed.
- Identify the necessary characteristics in a robot so that it can be considered a social robot.
- Implement in the robot the behaviors necessary for it to be considered a social robot and to be used in therapeutic exercises.
- Design and implement 5 therapeutic exercises.
- Integrate the modules developed in the CogniDron-EEG system.
- Design and implement functionality tests to validate the functionality of the developed modules.
- Design and implement integration tests to validate the correct integration of the modules developed within the CogniDron-EEG system.

Functional requirements

The requirements are

Code	Name	Importance degree
RF-01	Expression to indicate that the robot is ready to start therapy	High

Description	When choosing to carry out a therapy using the robot, it must make both a motor and an auditory expression indicating that the robot is ready to support the therapy. Additionally, the robot must voice a message that reinforces the movement it made		
Input	**Source**	**Output**	**Restrictions**
Confirmation of starting therapy	User	Auditory and motor expression	Motor and auditory expression will be limited according to the characteristics of the robot used
Process	Once the user selects and confirms the therapy, the robot will make a motor and auditory expression indicating that it is ready to start with the therapy.		

Table 2:RF-01

Code	**Name**		**Importance degree**
RF-02	Custom settings		High
Description	Before starting the session, you will have the option to make a custom configuration. That is, if the therapist chooses Personalize interaction, the robot must ask the patient what his name is. This information must be temporarily stored and used when the robot expresses phrases to motivate the patient. That is, the phrases must be personalized using the patient's name		
Input	**Source**	**Output**	**Restrictions**
Confirmation of Customize Interaction Patient Name	User	Temporary name storage patient	It will only be personalized if the therapist selects Personalize Interaction
Process	The therapist selects Personalize interaction and later the robot asks the patient for the name, which will be used by the robot when emitting phrases addressed to the patient		

Table 3: RF-02

Code	**Name**		Importance degree
RF-04	Control certain programmed movements in the Nao robot according to the data obtained from the EEG		High
Description	The data obtained from the EEG device will be used so that the robot performs or not the programmed actions according to the therapeutic exercise.		
Input	**Source**	**Output**	**Restrictions**
brain activity data	User	Patient name storage	The movements to be controlled will be previously programmed
Process	The system obtains the data from the EEG device in real time, in turn, it sends them to the robot so that the robot performs or not the programmed actions according to the therapeutic exercise		

Table 5: RF-04

Code	**Name**		**Importance degree**
RF-03	Obtaining information on brain activity		High
Description	Obtain the data of the patient's brain activity in real time using the electroencephalogram device Emotiv epoc+		
Input	Source	Output	**Restrictions**
brain activity data	User	Temporary storage of the patient's brain activity data	
Process	The patient puts on the EEG device and the system will obtain data on the patient's brain activity		

Table 4: RF-03

Code	Name		Importance degree
RF-05	Implement at least 5 therapeutic exercises		High
Description	At least 5 different therapeutic exercises should be implemented		
Input	**Source**	**output**	**Restrictions**
brain activity data	User	therapeutic exercises	Therapeutic exercises are limited by the characteristics of the robot
Process	At least 5 therapeutic exercises will be designed and implemented, of which the therapist will have the freedom to choose the exercise to be implemented		

Table 6: RF-05

Code	Name		Importance degree
RF-06	Therapeutic exercise "Score goal"		High
Description	One of the 5 therapeutic exercises will consist of creating the allusion to the patient that the Nao robot scores a goal. The robot movements necessary to score a goal will be previously programmed and will be executed according to the general information		
Input	**Source**	**Output**	**Restrictions**
brain activity data	User	Therapeutic exercise "Score goal"	The therapeutic exercise will be executed according to the information received from the EEG and the type of exercise (excitatory or inhibitory)
Process	The EEG device will send the data to the computer and the computer will process and send it to the robot, the robot will execute the exercise according to the data received and obtained from the EEG		

Table 7: RF-06

Code	Name	Importance degree
RF-07	Therapeutic exercise "Score goal"	High

Description	One of the 5 therapeutic exercises will consist of creating the allusion to the patient that the Nao robot scores a goal. The robot movements necessary to score a goal will be previously programmed and will be executed according to the general information		
Input	**Source**	**Output**	**Restrictions**
brain activity data	User	Therapeutic exercise "Score goal"	The therapeutic exercise will be executed according to the information received from the EEG and the type of exercise (excitatory or inhibitory).
Process	The EEG device will send the data to the computer and the computer will process and send it to the robot, the robot will execute the exercise according to the data received and obtained from the EEG		

Table 8: RF-07

Code	**Name**		**Importance degree**
RF-08	show exercises		High
Description	The user will be able to visualize the available exercises and select the one that he deems convenient to carry out the therapy		
Input	**Source**	**Output**	**Restrictions**
List of exercises with a description of what each exercise does	Database	List of therapeutic exercises displayed on the screen	
Process	The EEG device will send the data to the computer and the computer will process and send it to the robot, the robot will execute the exercise according to the data received and obtained from the EEG		

Table 9: RF-08

Code	**Name**	**Importance degree**

RF-09	Show the next move to be made by the robot		Medium
Description	The user will be able to visualize the next movement that the robot will perform once the patient reaches the expected threshold		
Inputs	**source**	**Outputs**	**Restrictions**
brain information	Electroencephalogram	The display will show the next exercise to be performed	The exercise will be displayed on the therapy screen and this movement will be executed as long as the threshold is reached by the patient.
Process	An image will be displayed in the central part of the exercise screen that indicates what the robot's next movement will be, once the patient reaches the desired threshold and depending on whether the exercise is inhibitory or excitatory, the image will be updated showing the following movement		

Table 10: RF-09

Code	**Name**		**Importance degree**
RF-10	Implement the “generate” and “consult reports” functions		Medium
Description	The functions of "generating" and "consulting reports" will be integrated into the module		
Input	**Source**	**Output**	**Restrictions**
Data regarding therapy	Database	A report with the data corresponding to the therapy that can be viewed by the therapist	
Process	The user will see an option on the screen that will allow him to generate a report with relevant data from the therapeutic session and can consult it in the section corresponding to the reports		

Table 11: RF-10

Code	Name		Importance degree
RF-11	Implement existing function to change threshold parameters		High
Description	The therapist will be able to change the parameters of the indicated threshold with an integer numerical value between 0 and 100		
Input	**Source**	**Output**	**Restrictions**
Whole number between 0 and 100	Therapist	Change of position of the line representing threshold and threshold for therapy	Threshold values can only be integers between 0 and 100
Process	The therapy threshold represented by a red line located on the neurofeedback bar will be positioned on the bar according to the value corresponding to the one entered by the therapist, visually indicating the threshold value that the user must reach for the robot to perform the next move		

Table 12: RF-11

Code	Name		Importance degree
RF-12	Integrate the option to choose the type of exercise "excitatory or inhibitory"		High
Description	The therapist will be able to choose whether the therapeutic exercise will be inhibitory or excitatory.		
Input	**Source**	**Output**	**Restrictions**
Type of exercise: Excitatory or inhibitory	Therapist	The movements of the robot will be executed according to the type of exercise	The type of exercise will be selected by the therapist before starting therapy
Process	Before starting the cognitive training exercise, the therapist should indicate whether the exercise is inhibitory or excitatory. The behavior of the robot will be according to the type of therapeutic exercise		

Table 13: RF-12

System design

Use cases

The use cases of the system are shown below describes the interaction between actors and functionalities of the module to develop.

Actors

Actors are two, the main actor is the therapist. Therapist function is to guide therapy and to be the operator of system and the main user. He has access to all modules through his account.

Second actor is patient. Patient will not directly use the system; he is only observer but not editor. Him register in system is responsibility of therapist. Him role is to receive therapy and use the electroencephalogram and to proportionate brain activity.

Modules

Select device: This function is represented by a screen and its function is permit therapist choosing between the different disponible devices to give therapy, current exists one functional device, a physical drone.

Start training: Start training permits therapist star cognitive training. When the therapist presses the button to refers start training the cognitive training will start and the movements of robot depending on brain activity and kind of exercise.

Modify threshold: The threshold is a "goal" that the user is expected to reach using their brain activity. It is represented by an integer numeric value from one to 100 and can be modified manually or automatically.

Select threshold: Permit user select a kind of threshold for therapy, it can be manual or automatic.

Record session: Permit user save important information of therapy in the data base.

Capture observations: Permit to therapist write relevant information about therapy.

List patient: This function allows the therapist to choose the patient through a drop-down list that appears in screen. Patient must be previously registered in database.

Select patient: Therapist can select one registered patient of the drop-down list.

Select exercise: This function permit to choose one of the programed exercises available in the system. Exercises are different and depends on the selected device (Robot or drone).

List exercise: This function allows the therapist to choose the exercise through a drop-down list that appears in screen.

Control the robot: This function consists in control some movements and behaviors programed on robot through brain information obtained of patient in real time. Movements depends of kind of exercise.

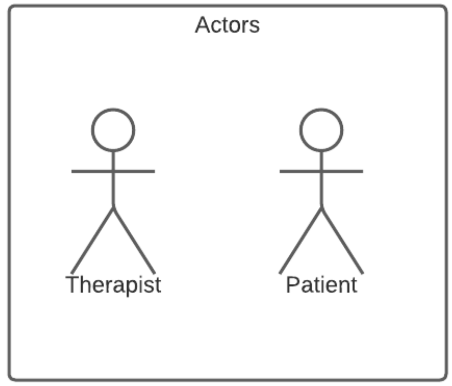

Figure 1: Actors

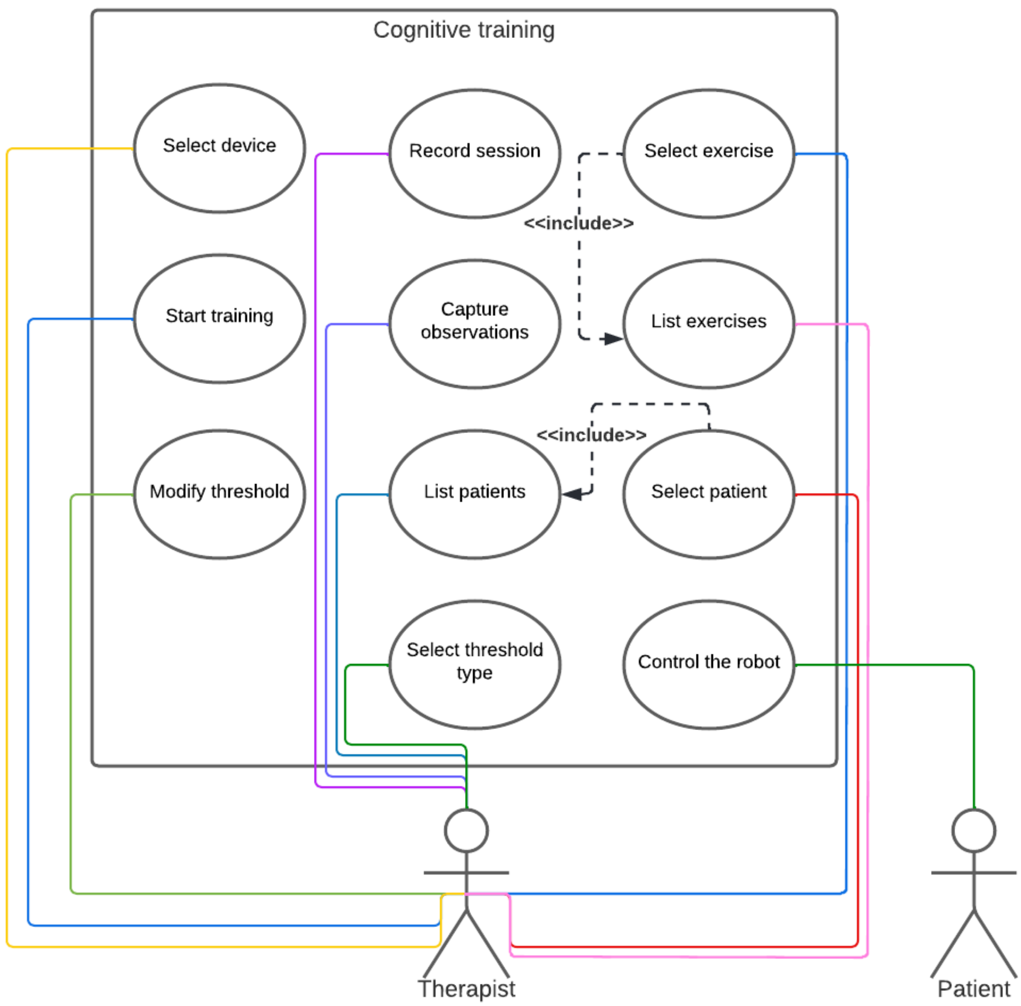

Figure 2: Use case "Cognitive training"

Interface design

Below are shown interface design of two windows: Select device and neurofeedback therapy. The first window is the connection of Cognidron-EEG with the module to realize, if therapist select the option “Robot”, will be open the second one window. The most important window is the second one because in this the therapeutic exercises are realized and permit to connect with the robot.

Figure 3: Screen "Select device"

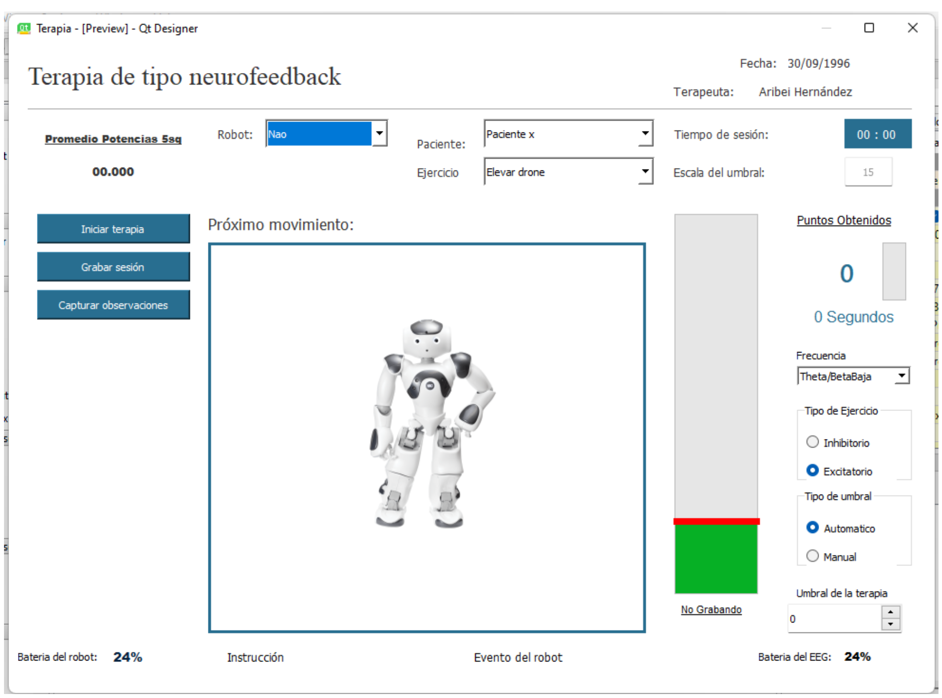

Figure 4: Screen "Neurofeedback training"

Test design

Static tests will be carried out on the documentation and requirements in order to find possible inconsistencies, unit tests testing each function individually, functional tests to test if the system meets the requirements and integration tests to verify the correct integration of the module to the system Cognidron-EEG.

Static tests: Static tests will be performed by the developer and the project advisor throughout the documentation process.

Unit tests: they will be carried out by the developer and will be white box. These tests will be performed during the coding stage. The release of functions and methods will be conditional on the success of the unit tests.

Functional tests: The functional tests will be carried out by the developer and will be a positive and a negative at least for each functional requirement.

Integration tests: These tests will be carried out by the developer and will verify the correct integration of the module to the cognidron-EEG system. They will be carried out once the first prototype of the module to be developed has been completed.

The tests will be limited by time, it is estimated that the first prototype of the module will be finished in January 2023, however, this may be subject to change.

Human resources

The following is a list of the people involved in the project and the role they play.

Name	**Role**	**Liability**
Dr. Antonio Cervantes Alvarez	Project consultant	Give feedback and advise the developer throughout the development process
Dra. Sonia Lopez Ruiz	Project consultant	Give feedback and advise the developer throughout the development process
Ilse Aribei Hernández Meza	Developer	Design and develop the module
Dr. Jahaciel Molina del Río	Client	Provide requirements