House in Your Head

Team G1-FrigidWaters

System Requirements Specification

Cycle # 1

Date: 10/27/2014

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1 Introduction

1.1 Purpose

The purpose of this document is to describe the requirements of the House in Your Head system. The remaining sections define the scope of the project, introduce necessary language and definitions, give an overview of the project, and lay out the requirements for the system.

1.2 Scope

This system is intended as a way for users to make basic state changes in an automated home setting using a Brain Computer Interface. Basic states to be changed are characterized by having a binary setting (on or off). This system also includes a user interface that is controlled by binary actions. Complex systems with multiple or intermediate states are out of the scope of the Brain Computer Interface portion of this project. Some settings that have multiple states can be maintained by a administrator. This administrator will need to do so via a mouse and keyboard.

The potential users of this system will be people who suffer from ALS, as well as the administrators who will be assisting the general users set up the program and software. Dr. Sara Feldman, The ALS Center of Hope at Drexel University, and Professor Jeff Salvage are the primary stakeholders and sponsors of this project.

1.3 Definitions, Acronyms, and Abbreviations

EEG Can refer to:

- Electroencephalography - Recording of the brain's electrical activity
- Electroencephalogram - The device that is used to record the brain's electrical activity

Emotiv The electroencephalogram hardware device, created by Emotiv Limited, used to read the user's brain activity (EEG)

Brain Computer Interface (BCI) The class of devices that the Emotiv belongs to

Amyotrophic Lateral Sclerosis (ALS) A neurodegenerative disorder that our target users suffer from. The main characteristics of ALS that we are concerned with in the scope of this project are the limited movement and mobility to complete paralysis.

1.4 Overview

Section 2 discusses the background and context of this system and indicates general requirements and constraints. Section 3 lists specific requirements for the system.

2 Overall Description

2.1 Product Perspective

2.1.1 System Interface

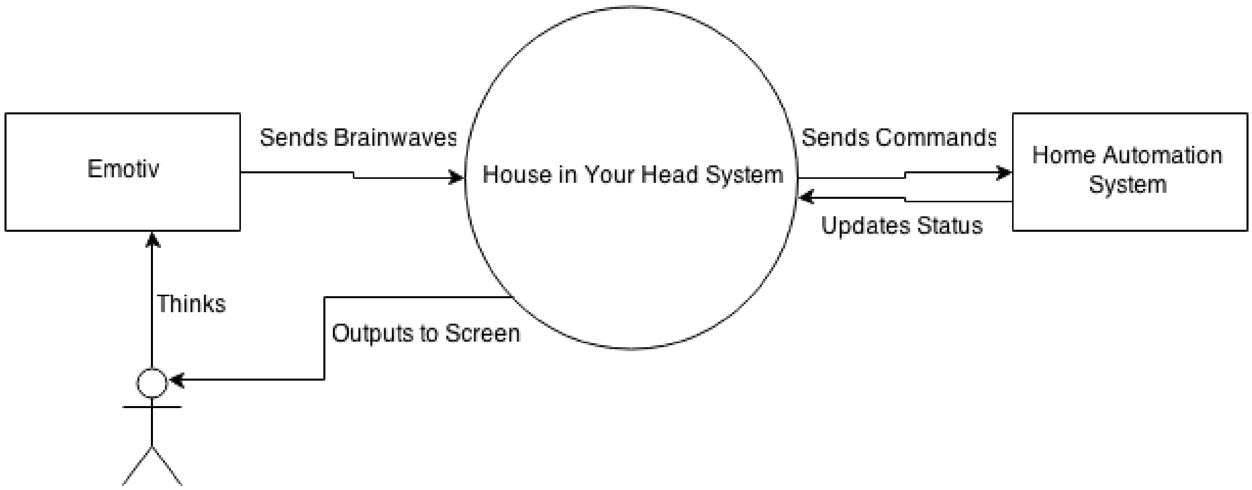

Figure 1: Context Diagram of the system

The user wears an Emotiv headset which sends information about their thoughts to the connected computer. From here, the information is interpreted and sent to the home automation controller. The home automation controller controls the home components such as the television and lights.

2.1.2 User Interface

The user interface consists of the Emotiv device which is attached to the user's head and reads their brain's electrical impulses. These are converted into commands that are then used as input. The exact input will be one of two states – neutral or active. The user will use the Emotiv as input to interact with the graphical user interface.

2.1.3 Hardware Interfaces

The Emotive device transmits the EEG to the computer through Bluetooth to a receiver which attaches to a Windows computer's USB port.

2.1.4 Software Interfaces

The Emotiv framework provides a set of functions which allows access to the EEG data.

2.1.5 Communication Interfaces

The system will have no direct network communication.

2.1.6 Memory Constraints

The system will be run on consumer systems, so its RAM footprint must be limited accordingly.

2.1.7 Operations

The system has two modes of operation, calibration, and active. Calibration consists of having the Patient (as described in section 2.3) train the system to associate certain brainwaves with actions.

Active mode occurs after calibration has finished, and is the general operations described in this document.

2.1.8 Site Adaption Requirements

The system must be able to run in both a home and a healthcare setup. No modifications will be required to change between these two environments.

2.2 Product Functions

- Gather EEG data from the user
- Analyse and filter the EEG data to make a reliable signal
- Provide user with a menu from which to select home automation actions
- Perform selected home automation actions

2.3 User Characteristics

Two categories of users are considered:

Patients are those suffering from ALS who are the primary users of the system. The severity of the disorder in each patient can range from limited mobility to full paralysis; the system assumes the latter.

Caretakers are individuals not suffering from ALS who are responsible for Patients. They are assumed to be present during system setup and administrative tasks, but **not** during other use cases.

2.3.1 Use Cases

Scenario Name: Calibrate for Patient

ID number: UC005

Description: Caretaker sets up and calibrates the system for a Patient.

Trigger: Caretaker puts the device on a Patient, starts the software and makes the menu selection to calibrate the device.

Type: External

Major Inputs:

Description	**Source**
EEG data	Patient (via device)
Supporting data	Patient (via Caretaker)

Major Outputs:

Description	Destination
Instructions and menus	Patient, Caretaker

Major Steps Performed:

1. Begin calibration routine.
2. Confirm that device is functioning correctly.
3. Guide Patient and Caretaker through calibration steps.
4. Save calibration data and display confirmation message.

Scenario Name: Turn Lights On

ID number: UC010

Description: Patient turns a light on. (This is a representative home automation task; others will work similarly.)

Trigger: Patient wants to turn a light on and thinks the activation thought.

Type: External

Major Inputs:

Description	Source
EEG data	Patient (via device)

Major Outputs:

Description	Destination
Menu display	Patient
Light activation signal	Home Automation System

Major Steps Performed:

1. Display initial menu on screen.
2. Accept thought input from user and accept selection when appropriate level of certainty is met.
3. Display next menu on screen and repeat until leaf (turn lights on task) is reached.
4. Display confirmation screen and send signal to turn lights on.
5. Return to idle state.

2.4 Constraints

One of the most immediately obvious constraints on the entire system is the user's muscular degeneration. This limitation is the inspiration for the system and the prime motivator for this project and must be kept in mind at all times.

Another constraint is the average user's familiarity with computer systems. An interface that may work well for an experienced programmer may not work well for an inexperienced computer user. Designing for the inexperienced user is necessary.

A final issue is that users may have other medical issues that need to be kept in mind. Those that occur with ALS are most important, as are vision issues, specifically color blindness, as the primary feedback from our system to the user will be visual. A user that cannot distinguish between different shades may be completely unable to use key features of the system. For example, if button toggles are set up as a red-green selector, then a red-green colorblind user will be unable to use those toggles.

2.5 Assumptions and Dependencies

There are many assumptions contained in the design of the system. First and foremost is that users must have the ability to read and write English. While the system can later be adapted to other languages, being unable to interact with a user interface in English will make the system impossible to work with.

The Emotiv requires a large amount of concentration, so any user needs to be able to concentrate to effectively use it. If a user cannot concentrate, their commands will not be recognized by the program.

A user of the system is assumed to be able to see or hear options in the program. A user that is unable to see or hear will have no other methods of interfacing with the program, making it unusable.

Users of the system must have access to all of the equipment required to power a computer, as well as reliable electricity service. Without this, the device and the computer it interfaces with will not work.

Additionally, the computer that the user owns must meet the minimum system requirements. Without this assumption, the program may behave unpredictably.

2.6 Apportioning of Requirements

During the first term, we will focus on getting a reliable signal from the EEG and developing the initial ideas for our user interfaces. For the second term, we will mostly finish those two tasks and begin working on the home automation portion of the project. The final term will consist of finishing the integration with the home automation portion and resolving any remaining issues.

3 Specific Requirements

3.1 External Interfaces

This section gives a description of the hardware and software interfaces. Also included is a basic prototype of the UI.

3.1.1 System Interfaces

SR105 The system will accept input from the Emotiv device and distinguish at least two thought-states of the patient.

SR110 The system will interface with a home control system to turn lights on and off upon user request.

SR115 The system will interface with a home control system to operate a television upon user request.

SR120 The system will interface with a home control system to adjust the thermostat upon user request.

See figure 1 for a context diagram of the system.

3.1.2 User Interfaces

SR205 At the top of the screen, there will exist a loading bar. By concentrating, the bar will load to the right. By not concentrating, the bar will load to the left.

SR210 This load will happen over a period of one to two seconds.

SR215 When the bar reaches an end, that choice is selected and the next bar shows up.

SR220 This requires all the information to be binary searchable.

SR225 If the capability exists to include more bits than just a simple concentrating or not concentrating, then more choices can be had and the non-concentrating state will not need to be used for the loading bar.

See Figure 2 for mockups.

3.2 Functions

SR205 - Calibrate

Input: EEG data, supporting data from Caretaker

Action: Derive calibration parameters for the Patient

Output: Calibration parameters (internal; to be saved)

Notes: The parameters (including the input thoughts requested from the user) should be chosen to give a reliable signal. Recalibration should be possible, as Patients' thought patterns may change over time.

Priority: Must Have

SR210 - Activate menu via EEG

Input: EEG data

Action: Detect activation signal

Output: Display menu

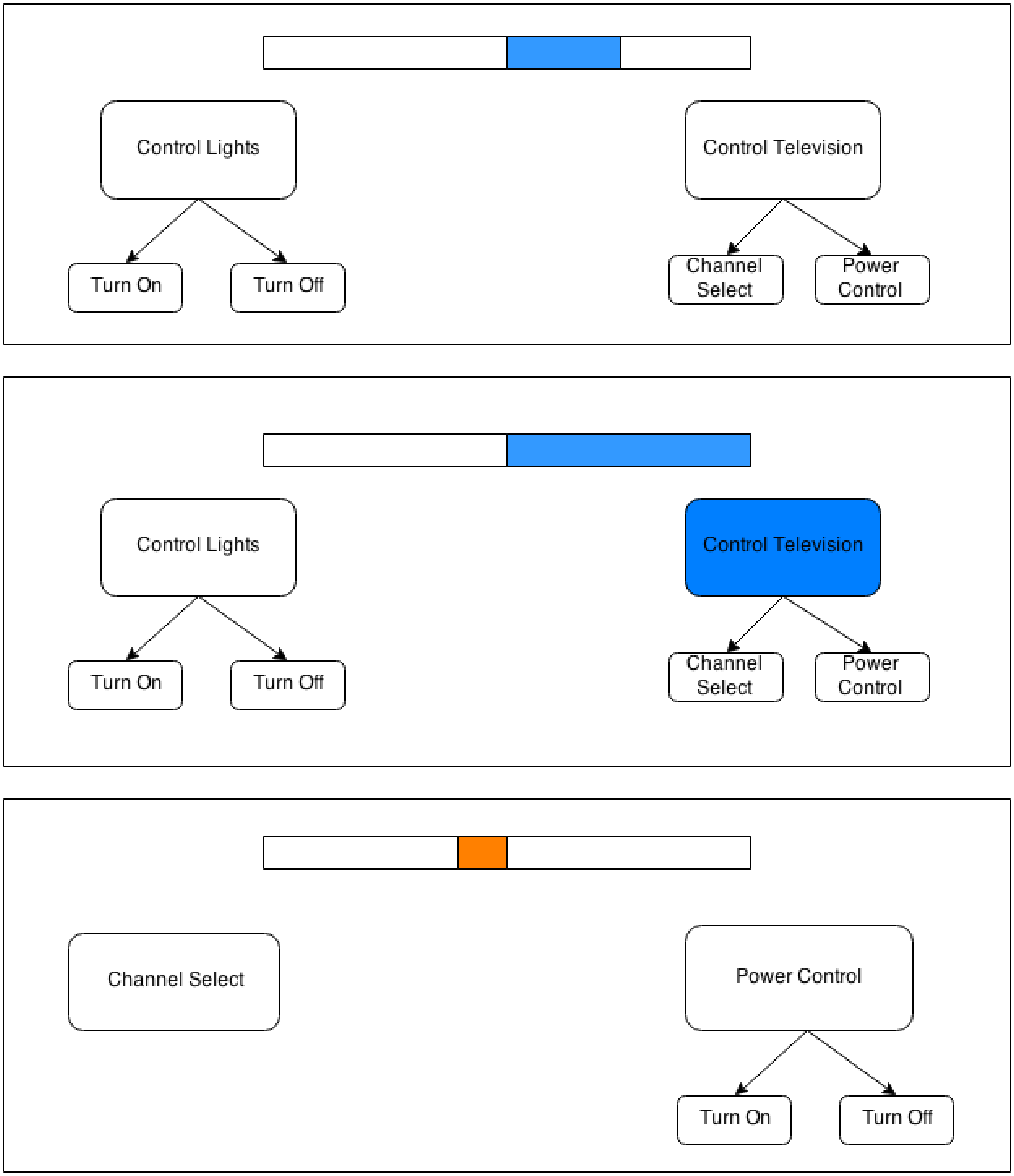

Figure 2: As the user concentrates, the bar fills up. When it reaches the end, the next binary choice will take its place

Notes: Necessary for fully-paralyzed patients; others may have some other method of activation. Depends on calibration data.

Priority: Must Have

SR215 - Perform Home Automation Action

Input: EEG data

Action: Interpret signal as menu selections

Output: Signal to HAS corresponding to user request

Notes: Depends on calibration data

Priority: Must Have

3.3 Performance Requirements

SR305 The system must use less than 512 MB of RAM at all times while running.

SR310 The system must use less than 5 GB of persistent storage space when installed.

SR315 The system must run smoothly on a 3.2 GHz Intel i3 processor.

SR320 The system will support one and only one terminal.

SR325 The system will support one and only one user at a time.

SR330 90% of time, menu selection must take less than 5 seconds.

SR335 A trained user must be able to select 10 options within 2 minutes.

3.4 Logical Database Requirements

SR405 The system will store calibration data for one user.

3.5 Design Constraints

The basic hardware that we will be using is a new technology to most of us involved in this project, so there will be a bit of learning curve there that could lead to some constraints. We are also aware that the hardware and sensors can be a bit unreliable and a bit hard to work with. The accuracy of the sensors greatly impacts the data that we receive and have to work with on the software, so that is another big system constraint. However, we have already begun taking all of these into consideration while discussing the outline and future plans for this project.

3.5.1 Standards Compliance

SR505 We must comply to the input standards of the Emotiv device

SR510 We must comply to the output standards of the home automation system

The system does not need to comply with any external standards.

3.6 Software System Attributes

3.6.1 Reliability

SR612 The system must fail to detect a selection no more than 10% of the time.

SR615 The system must unintentionally select no more than once every 30 minutes.

3.6.2 Availability

SR622 The system must be able to run for 24 hours without restarting 99% of the time.

3.6.3 Security

SR632 The system must have no network communication.

SR635 The system must not log client interactions other than storing calibration data..

3.6.4 Maintainability

SR642 The menu selections must be defined by a configuration file.

SR645 New home automation features must be able to be added through a configuration file.

3.6.5 Portability

SR652 The system will run on all Windows 7 and Windows 8 machines meeting the minimum requirements.

Table of Contributions

	Section	Writing	Editing
1	2.2, 2.6, 3.3, 3.4, 3.6	Kyle Patron	Michael Conway
2	1, 2.1, 3.1	Joe Muoio	Michael Conway
3	2.4, 2.5	Sam Bever	Michael Conway
4	3.2	Michael Conway	Kevin Zakszewski
5	1, 2.3	Kevin Zakszewski	Michael Conway

I certify that:

- This paper/project/exam is entirely my own work.
- I have not quoted the words of any other person from a printed source or a website without indicating what has been quoted and providing an appropriate citation.
- I have not submitted this paper / project to satisfy the requirements of any other course.

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Grading

The grade is given on the basis of quality, clarity, presentation, completeness, and writing of each section in the report. This is the grade of the group. Individual grades will be assigned at the end of the term when peer reviews are collected.