Chapter 8

Conclusion and Future Work

8.1. Introduction

This chapter summarizes the attention racer system. It was hypothesized that human attention can be used as input for game controlling. In order to prove this hypothesis NeuroSky mind wave mobile headset was used for EEG data acquisition and an artificial neural network was utilized for data classification. The report elaborated in detail about the existing systems, approach of the proposed system, design, implementation and finally the evaluation.

8.2. Conclusions

It was hypothesized that human attention can be used as an input parameter to control an aspect of a racing car game. For data acquisition NeuroSky EEG headset was utilized and the EEG data acquisition process was successful. Then Artificial Neural Network was used for data classification. ANN proved to be effective, efficient and most suitable machine learning technique for data classification and it calculated the attention level swiftly in a dynamic environment successfully.

Finally, agent based car game was developed and the users car speed was controlled by human attention level. And this module was also implemented successfully as anticipated.

The evaluation results in chapter 07 proved that system was successful 70% in detecting human attention level.

Thus, in a concluding note overall system development and evaluation was successful.

Following objectives were asserted in the introduction chapter of the thesis and was executed successfully in various stages of the research.

The goal of this project is to gain knowledge of the two domains, Brain-Computer Interfaces, special methods for analyzing brain waves, and AI techniques for Game design. From this research, a prototype software application should be implemented that is able to read brain wave input from an EEG device, classify them, and make them be part of the, or the only, user input to a game. This Objectives was successfully completed.

1. The EEG signals are commonly decomposed into five EEG sub-bands: delta, theta, alpha, beta and gamma. Hence, the research seek to study about these wave forms extensively to extract the human attention factor. This was successfully completed in technology section.

2. Furthermore, Support vector machines, decision trees and artificial neural networks are powerful machine learning techniques that can be used for EEG signal classification. Among these classification techniques, artificial neural network is one of the most popular technique for EEG classification Thus, the research focuses on developing an artificial neural network for EEG attention classification. This was successfully completed in Design and implementation of the system.

3. Moreover, Autonomous Agent and Multi-Agent Systems is the key in game development. Thus the research seek to develop a car racing game on a multi agent frame work using 3D gaming platform. This was also successfully completed in Design and implementation of the system.

Thus, all the above objectives were met in the research as anticipated.

8.3. Limitations and Future Work

There are several limitations in the system that needs to be addressed, Firstly, the NeuroSky headset takes around 5 seconds to detect noise and notify the attention racer system that user has detached the headset form his head.

Secondly, artificial neural network provided some anomalies 3/10 in detecting attention level despite the effort to use accurate EEG data for training.

As future work, multi electrode headsets can be utilized for EEG acquisition in order improve the accuracy of the output.

Furthermore, mediation, eye blink cognitive features can be used to control more aspects of the game for instance eye blink for acceleration of the car or for braking etc...

8.4. Summary

The chapter summarized about the report and discussed about the evaluation results, and how successful the research was. The limitation of the system was highlighted along with future work. In a concluding not the overall system and research was a success.

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Appendices

Appendix A:

NeuroSky Mindwave Mobile Protocols

A.1 Introduction

This section elaborates on NeuroSky EEG headset and its communication protocols

A.2 Technical Spec

The Mindwave Mobile safely measures and outputs the EEG power spectrums (alpha waves, beta waves, etc), NeuroSky eSense meters (attention and meditation) and eye blinks. The device consists of a headset, an ear-clip, and a sensor arm. The headset's reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, resting on the forehead above the eye (FP1 position). It uses a single AAA battery with 8 hours of battery life.

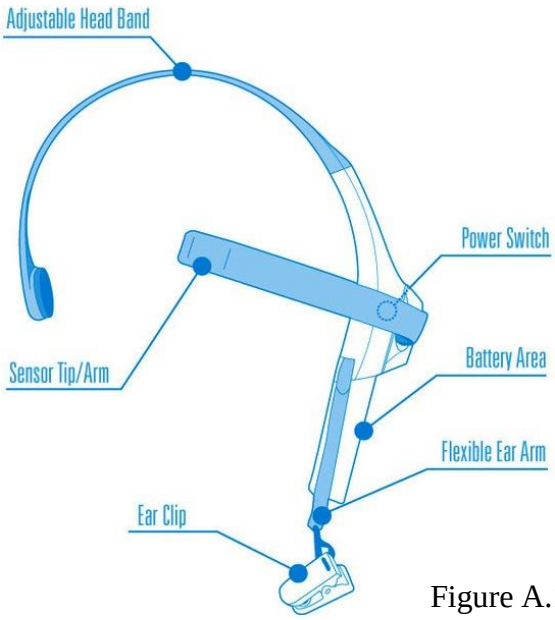

Figure A.1: NeuroSky Headset [38]

A.3 Headset Measures

- Raw-Brainwaves
- Processing and output of EEG power spectrums (Alpha, Beta, etc.)
- Processing and output of NeuroSky proprietary eSense meter for Attention, Meditation, and other future meters
- EEG/ECG signal quality analysis (can be used to detect poor contact and whether the device is off the head)

A.4 EEG Data types

The below table illustrates different types of outputs from NeuroSky headset.

Key	Description	Data Type
Time	TimeStamps of packet received	double
Raw	Raw EEG data	short
EegPowerDelta	Delta Power	uint
EegPowerTheta	Theta Power	uint
EegPowerAlpha1	Low Alpha Power	uint
EegPowerAlpha2	High Alpha Power	uint
EegPowerBeta1	Low Beta Power	uint
EegPowerBeta2	High Beta Power	uint
EegPowerGamma1	Low Gamma Power	uint
EegPowerGamma2	High Gamma Power	uint
Attention	Attention eSense	double
Meditation	Meditation eSense	double
PoorSignal	Poor Signal	double
BlinkStrength	Strength of detected blink. The Blink Strength ranges from 1 (small blink) to 255 (large blink). Unless a blink occurred, nothing will be returned. Blinks are only calculated if PoorSignal is less than 51.	uint

Table A.1: NeuroSky Headset Outputs [38]

A.5 .NET SDK

The below table A2 shows the API reference for .NET.

void Connect(string portName)	Attempts to open a connection with the port name specified by portName.
void ConnectScan()	Attempts to open a connection to the first Device seen by the Connector.
void ConnectScan(string portName)	Same as ConnectScan but scans the port specified by portName first.
void Discount()	Closes all open connections.
void Disconnect(Connection connection)	Close a specific connection specified by Connection.
void Disconnect(Device device)	Close a specific device specified by Device.
void Send(string portName, byte[byteToSend)	Send an array of bytes to a specific port.

Table A.2: NeuroSky Headset API Reference table

Appendix B:

Attention Racer System

B.1 Introduction

This chapter elaborates regarding the attention racer system implementation.

B.2 Main Screen of the application

The Figure B.1 illustrates the main screen for attention racer system. Composed of EEG data acquisition module, neural network module and racing game surface.

Figure B.1: Attention Racer Game Screen

B.3 EEG Data Acquisition Screen

The below screen Figure B.2 illustrates the EEG data gathering screen. This is used to acquire and save EEG attention data.

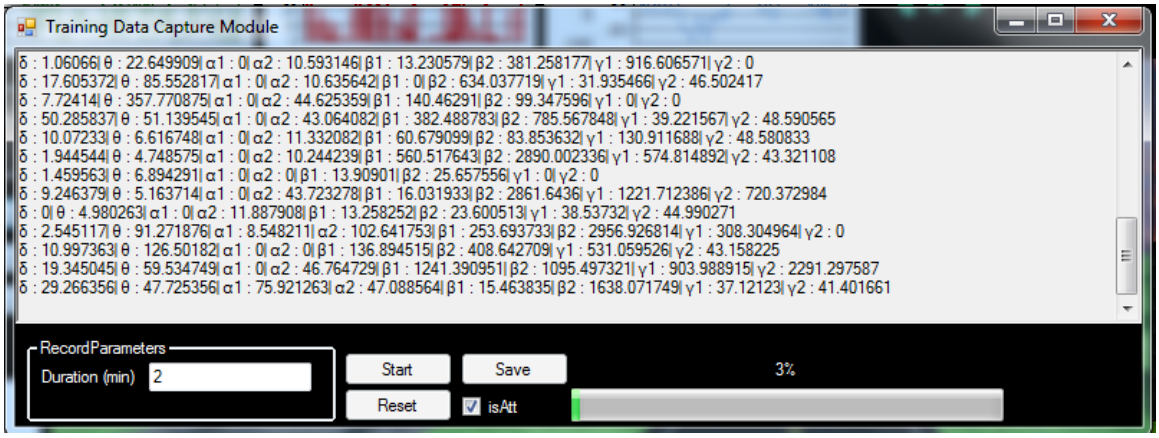

Figure B.2: EEG data gathering screen

B.4 Artificial neural network training screen

The blow Figure B.3 illustrates artificial neural network training module that is been utilized for ANN training.

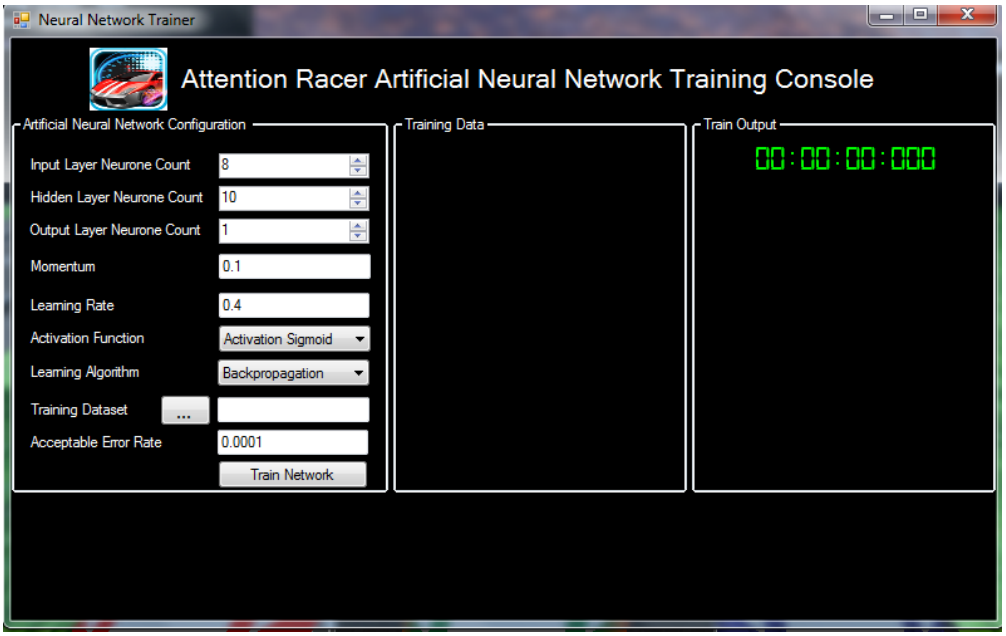

Figure B.3: Artificial neural network training screen

B.5 Console Logger

The below figure displays the console logger of the attention racer system which logs all the messages.

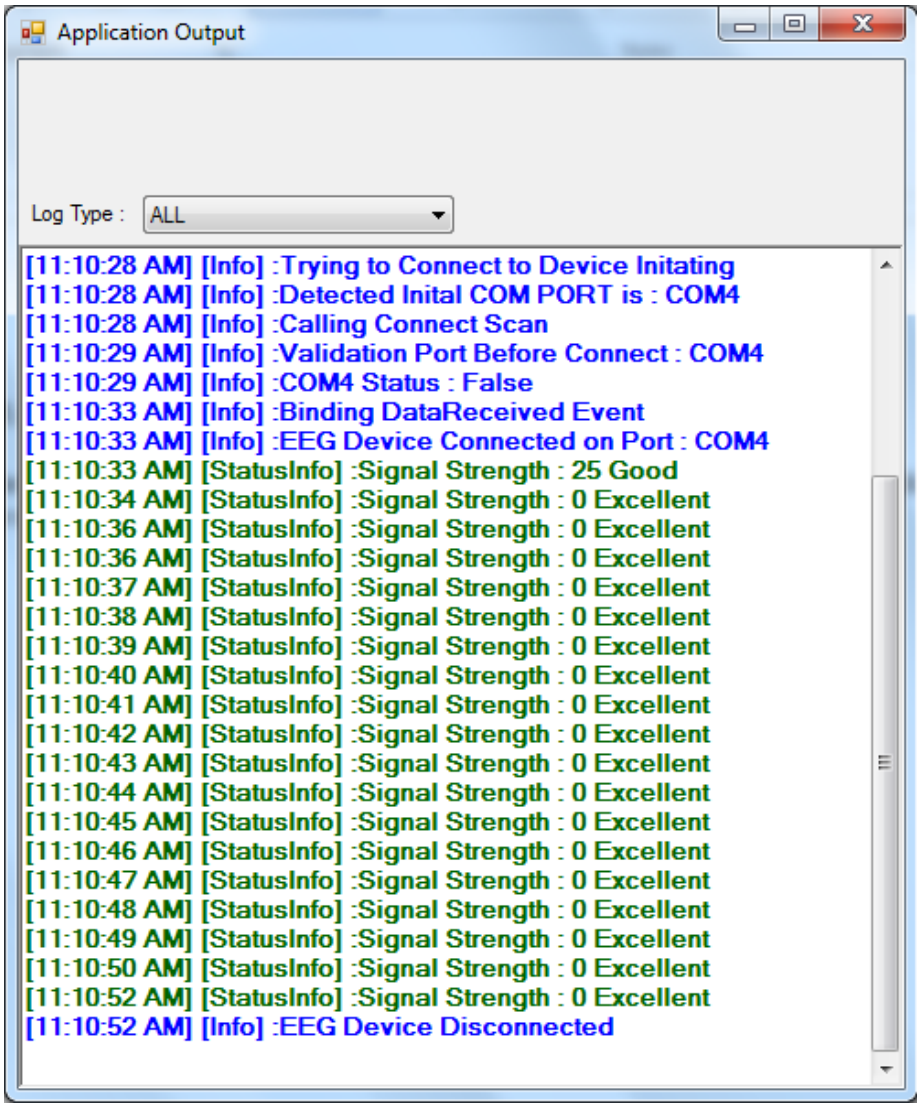

Figure B.4: Console Logger of Attention Racer

Appendix C:

Attention Span Test and Brain Game

C.1 Introduction

This chapter elaborates the details about attention span test and brain game used in evaluation phase.

C.2 Attention Span Test

The attention Span test questioner can be obtained from the below link.

http://psychologytoday.tests.psychtests.com/bin/transfer?req=MTF8MzM2MXwxMTExNTMyNHwwfDE=&refempt=

10 questions will be asked in 5 minutes and participants in evaluation are supposed to answer them. Once the test is completed marks will be calculated and participants above 75% attention span level is selected for evaluation. Sample questioner is listed below.

Attention Span Test

10 questions, 5 min.

1 2

1. Do you get distracted easily (e.g. by background noise, other people's conversations, etc.)?

- ○ Yes
- ○ Sometimes

- ○ No

2. How often are you late for work or an appointment?

- ○ Quite often
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never

3. How often do you catch yourself daydreaming at work?

- ○ Quite often
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never

4. Do you jump from task to task because you just can't seem to focus long enough to finish one completely?

- ○ Yes
- ○ Sometimes
- ○ No

5. How do you deal with boring, repetitive tasks?

- ○ I'm fine with them; I have very little trouble getting them done.
- ○ I don't mind them, but I may end up needing a break from time to time.
- ○ I can't stand them - they bore me out of my skull.

6. You're on the phone with a friend just as your favorite TV show starts. How difficult would it be for you to pay attention to the conversation?

- ○ Extremely difficult
- ○ Very difficult
- ○ Somewhat difficult
- ○ Slightly difficult
- ○ Not at all difficult

7. When reading a book or magazine, how often do you find yourself re-reading the same paragraph or skipping ahead?

- ○ Quite often
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never

8. Do you have a knack for noticing details (e.g. typos in a document)?

- ○ Yes
- ○ No

9. Do you lose your patience easily?

- ○ Yes
- ○ Sometimes
- ○ No

10. How often do you interrupt people during conversations?

- ○ Quite often
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Almost never

C.3 Brain game Design for attention data Acquisition

Brain game "The Squeaking Mouse" was developed by AARP systems and URL for the game can be found in below link.

http://braingames1.aarp.org/the_squeaking_mouse.html

The participants were requested to wear the NeuroSky Headset mobile and interact with this game for EEG data Acquisition. Below figure illustrates the game Screens.

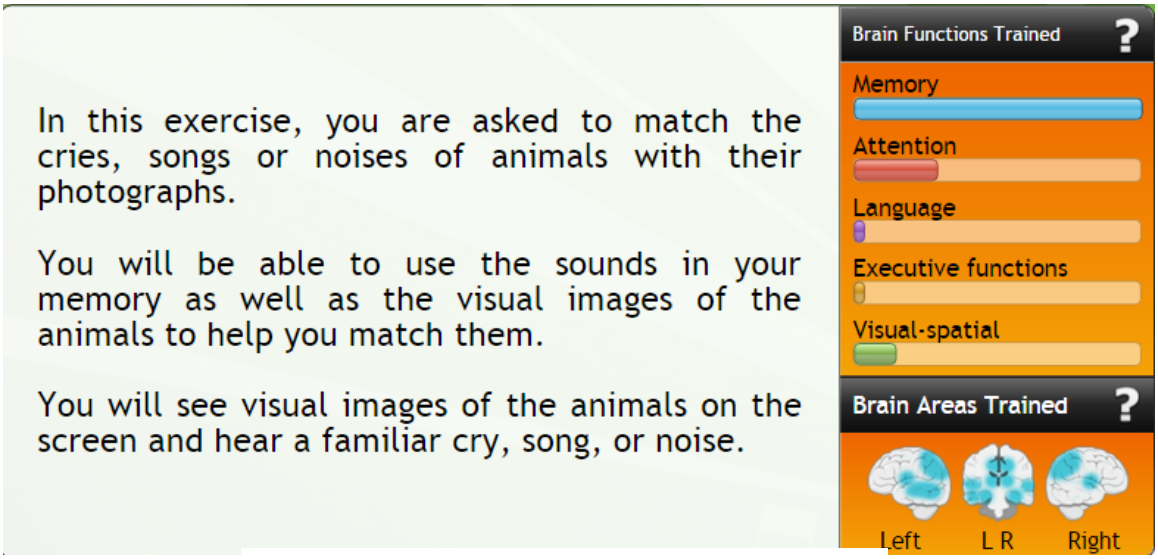

Figure C.1: The Squeaking Mouse Intro Screen

The below screen allows the user to perform required configurations to the system.

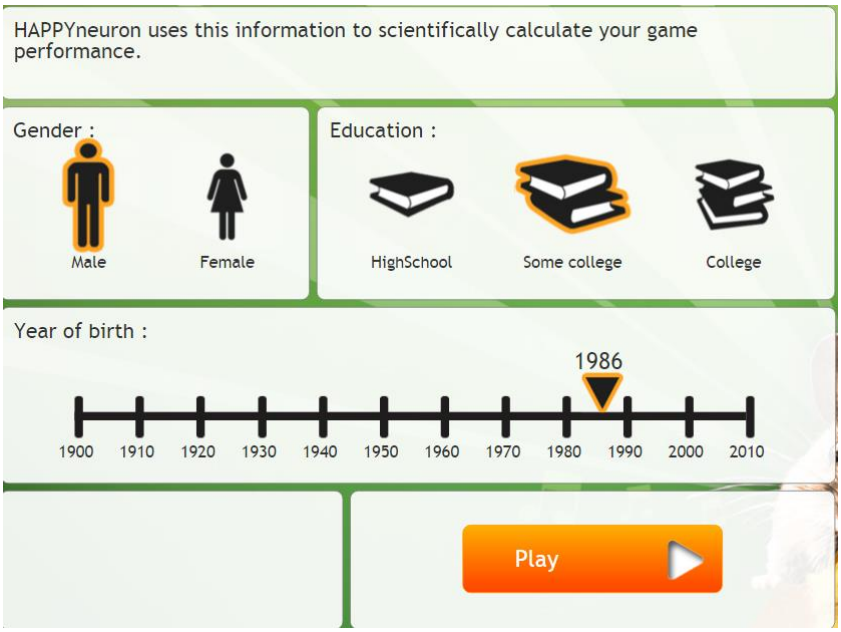

Figure C.2: The Squeaking Mouse Configuration Screen

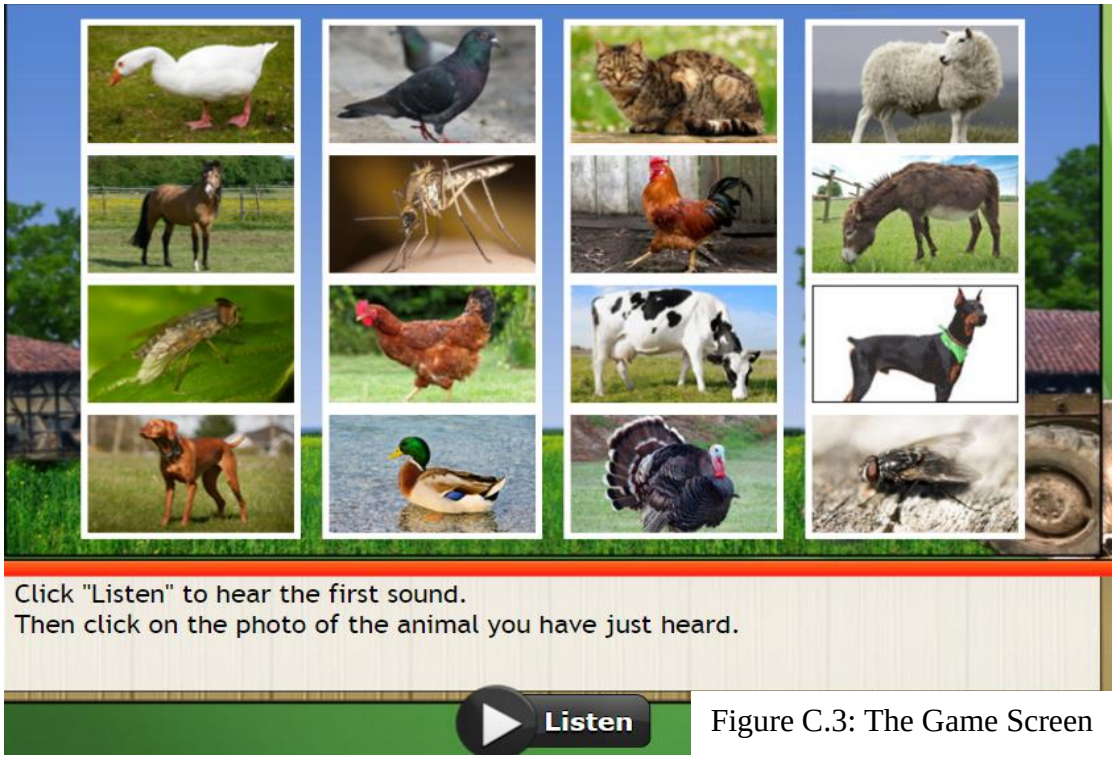

Figure C.3: The Game Screen