MINDFULNESS IN VIRTUAL REALITY

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AGENDA

- Abstract
- Demo
- Scientific Background
- Platforms and Technologies
- System Overview
- Insights and Future Ideas
ABSTRACT

This project is an application that allows the user to practice mindfulness in a virtual reality environment. It uses muse headband to measure real time EEG data of the user, and triggers changes in the environment based on this data, creating a neurofeedback loop. The main purpose of the application is to help the user become more mindful on the long term.
NEUROFEEDBACK

- Neurofeedback is a type of biofeedback that uses real time EEG in an attempt to teach self-regulation of brain function.

- Neurofeedback involves rewarding the user for increasing certain brain waves, through audio or visual stimulus.
 ALPHA WAVES

• Our neurofeedback system targets the alpha waves.

• Alpha waves are neural oscillations in the frequency range of 7.5–13 Hz.

• Research links alpha to relaxation, it dominates during moments of quiet thought and similar meditative states.

• Alpha waves aid overall mental coordination, calmness and alertness.
PLATFORMS AND TECHNOLOGIES

- Oculus Rift
- Unity Game Engine
- Muse 2016 headband
- Mind Monitor
- Microsoft Visual Studio
- Python matplotlib library
SYSTEM OVERVIEW

➢ Muse Headband
➢ Data Transfer Protocols
➢ System State Machine
➢ Classification Algorithm
➢ Neurofeedback in Virtual Reality
➢ Input and Output
MUSE HEADBAND

- Uses brain sensors to detect and measure brain activity.
- Uses FFT to calculate power spectral density of each frequency on each channel.
- Absolute band power is the logarithm of the sum of the Power Spectral Density of the EEG data over that frequency range.
- Transmits data over Bluetooth.

<table>
<thead>
<tr>
<th>Wave</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td>1-4Hz</td>
</tr>
<tr>
<td>Theta</td>
<td>4-8Hz</td>
</tr>
<tr>
<td>Alpha</td>
<td>7.5-13Hz</td>
</tr>
<tr>
<td>Beta</td>
<td>13-30Hz</td>
</tr>
<tr>
<td>Gamma</td>
<td>30-44Hz</td>
</tr>
</tbody>
</table>
DATA TRANSFER

- Data is transmitted by Muse over Bluetooth.
- Mind Monitor mobile application receives data over Bluetooth.
- Mind Monitor transmits data over Wi-Fi using OSC protocol.
- PC receives data using SharpOSC library.
SYSTEM STATE MACHINE

Idle ➔ First bundle received ➔ Calibration ➔ x sec ➔ Phase i ➔ All phases done ➔ Finish

i = last phase
CLASSIFYING MENTAL STATES

• Relative alpha value:

\[
\text{Alpha Relative} = \frac{10^{\text{Alpha absolute}}}{10^{\text{Alpha absolute}} + 10^{\text{Beta absolute}} + 10^{\text{Gamma absolute}} + 10^{\text{Delta absolute}} + 10^{\text{Theta absolute}}}
\]

• Moving average as noise reduction filter.

![Graph showing alpha relative and moving average](image-url)
CLASSIFYING MENTAL STATES

• Thresholds based classification.
• 5 thresholds are calculated at the beginning of each phase based on previous data.
• Calibration period used to determine initial thresholds

\[ T_{th_i} = \text{factor}_i \cdot \text{Alpha Relative Average} \]

• Factors are received as inputs. E.g. \( \text{factors} = [0.3, 0.7, 1.1, 1.3, 1.5] \)
THE SCENE
Feedback

- Feedback is triggered based on mental state.
- Feedback is used to reinforce relaxed mental states and self-regulation of brain function.

Types of Positive feedback:
- Calm sea
- Sunny weather
- Seashells
- Jumping fish
- Music and calm waves sound

Types of Negative feedback:
- Stormy sea
- Strong waves sound, weaker music
INPUT AND OUTPUT

Configurations file:
• Thresholds
• Thresholds phases
• Number of phases
• Calibration duration
• Phase duration
• Window size
• Changes rate
• Log file name
• .csv file name
• Seashells factor
• Fish levels
• Fish Thresholds

Generated at: <current working directory>\UnityApp\MyApp_Data\app_config.txt
LOG FILE

The log file contains all the session’s information in chronological order:

• Summary of the configurations
• Packages that were received from muse headband
• Classification of the mind state
• Positive feedback that was invoked during the session
• Summary of the session

Can be found at <current working directory>\Logs\<file>.txt
.CSV FILE

Contains all the values that were received or calculated during the session:

• Waves values (alpha, beta, gamma, delta, theta)
• Alpha relative
• Alpha average
• Thresholds
• Classification
• Feedback

Can be found at <current working directory>\Logs\<file>.csv
GRAPHS

➢ The results of the session can be plotted using the Plot tab in the application.
➢ Implemented in python – matplotlib.
5 Graphs of the EEG waves during the session:

Absolute Waves Values

- **Alpha Absolute**
  - Time [sec]: 0, 20, 40, 60, 80, 100, 120
  - Wave [Hz]: 0.2, 0.4, 0.6, 0.8

- **Beta Absolute**
  - Time [sec]: 0, 20, 40, 60, 80, 100, 120
  - Wave [Hz]: 0.2, 0.4, 0.6, 0.8

- **Gamma Absolute**
  - Time [sec]: 0, 20, 40, 60, 80, 100, 120
  - Wave [Hz]: 0.2, 0.4, 0.6, 0.8

- **Delta Absolute**
  - Time [sec]: 0, 20, 40, 60, 80, 100, 120
  - Wave [Hz]: 0.2, 0.4, 0.6, 0.8

- **Theta Absolute**
  - Time [sec]: 0, 20, 40, 60, 80, 100, 120
  - Wave [Hz]: 0.2, 0.4, 0.6, 0.8
Alpha relative values during the session:
Alpha relative average during the session:
INSIGHTS AND FUTURE IDEAS

We learnt:
- Unity design, VR world
- Product design and working with customers
- C#, python

We suggest:
- Graphics improvement
- Adding more scenes
- Testing the algorithm and improving based on the results
THANK YOU!