Connectome

Connecting Minds

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Advisor

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Stakeholder

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Imagine not being able to tell your family that you love them...
Targeted Users

- ALS patients
- Patients with limited mobility
- Initial symptoms include loss/impairment of:
  - Speech
  - Swallowing
  - Movement of arms
  - Extremities
- Patients have an ever declining quality of life
Existing Solutions

• Assistive technologies:
  • Eye Tracking
  • Sip and Puff System
  • Brain Computer Interface (BCI)

• Research grade BCIs are:
  • Expensive ($20,000+)
  • Time consuming to set up

Is there a cost-effective BCI option for recreational applications?
Emotiv EPOC+

Hardware:
- 14-channel wireless EEG
- Designed for contextualized research and advanced brain computer interface applications
- $800 and widely available
A hardware/software solution specifically designed to allow a person with ALS to communicate with friends and family using social media - specifically Twitter
Connectome Demo
Training Paradigms
Adaptive Learning

DURATION + POWER + ACCURACY
Technologies

- **Emotiv**: Transmits Activity
- **Crashlytics**: Log Errors
- **Access Twitter API**
- **epoc SDK**: C#
- **Unity**: User Computer
Development Tools
## Development Tools

<table>
<thead>
<tr>
<th>#</th>
<th>Status</th>
<th>Title</th>
<th>Author</th>
<th>Opened</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open</td>
<td>Tweet information not displayed after clicking older tweets</td>
<td>hssanNS</td>
<td>4 days</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Open</td>
<td>Don’t allow users to message people that aren’t their friends.</td>
<td>TheBenderman</td>
<td>5 days</td>
<td>0</td>
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<tr>
<td>3</td>
<td>Open</td>
<td>Selection manager doesn’t deactivate when logging out</td>
<td>TheBenderman</td>
<td>5 days</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Open</td>
<td>Twitter Profile Issue - Tweets menu, some buttons don’t work, others don’t do anything</td>
<td>TheBenderman</td>
<td>8 days</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Open</td>
<td>Twitter Conversations Issue - Back button bad behaviour</td>
<td>TheBenderman</td>
<td>8 days</td>
<td>0</td>
</tr>
</tbody>
</table>
Development Tools
Standards

• **Software:**
  - UML 2.0 Standard
  - Microsoft C# Coding Conventions
  - Nielsen's Ten Heuristic Principles
  - Shneiderman’s Eight Golden Rules

• **Clinical:**
  - 21 Code of Federal Regulations
    - Protection of Human Subjects
Best Practices

- Variable Naming Conventions
- **Decentralized Version Control**
- Exception Handling
- Paired Programming
- **Develop Iteratively**
- Component Architectures
- Design Patterns
System Architecture

Social Media APIs

Connectome Software

Emotiv SDK

Emotiv Headset

Emotiv Account Services

User
Design Patterns

IMPLEMENTATION

Mediator

Builder

Template
Keyboard

Configurable:
- JSON

Interchangeable:
- Grid
- QWERTY
- Phrases
Alternative Designs

- **Web Application**
  - Pros: Social Media APIs, ease of impl.
  - Cons: Send Emotiv data over connection

- **Desktop Application with JS/HTML**
  - Pros: Social Media APIs
  - Cons: Emotiv SDK, Arch. technologies

- **Java Desktop Application with Swing**
  - Pros: Emotiv SDK, ease of implementation
  - Cons: UI Development, Social Media APIs
Alternative Designs
Alternative Designs
Alternative Designs
Testing

• **Software:**
  o Unit
  o Integration
  o Performance
  o Acceptance

• **User:**
  o Internal
  o Patient
Testing - Procedure

- **Subjects**
  - 6 Connectome Team Members
  - 2 ALS Patients

- **Objectives**
  - Standardized Approach
  - Comfort Patient
  - Test Multiple Paradigms

- **Format**
  1. Equipment and Software Setup
  2. Create Emotiv Profile
  3. Complete Adaptive Training
  4. Attempt Twitter
Testing
Results - Ideal

No false positives in either Neutral or Active states
Results - Type A

- No false positives in Neutral state
- Active state is sustained for significant duration
Results - Type B

- No false positives in Neutral state
- Active state is maintained, but with intermittent false positives
Results - Type C

Neutral

Active

Many false positives in both Neutral and Active states
Results - ALS Patients

Subject 1

TYPE B

Subject 2

TYPE C

Further Training Necessary
Design Patterns

Bridge
Use Cases

User 1:
Training Results:
• High Accuracy Score
• Low Power Score

User 2:
Training Results:
• Low Accuracy Score
• High Power Score
Future Directions

- Conduct more testing across a wider subject pool
- Collect raw EEG data
- Test different data interpreters to robustly create slider thresholds
- Dynamic User Settings
- Improved Keyboard
- Adaptive Training Improvements
- Additional Social Media Implementations
Twitter Demo
Adaptive Training - Accuracy
Adaptive Training - Streak
ALS Patient Testing

- **Sample Size** = ~ 1
- **Testing Location** = Patient’s home or Temple University Clinic
- **Duration** = 2 to 4 hours
- **Paradigms** = 1 to 2
- **Procedure**
  - Equipment and Software Setup
  - User Profile Creation
  - Adaptive Training Within Connectome
  - Twitter
Metrics

▷ Upon command, how many Tweets can a trained user send out in a span of X minutes?

▷ Is there any improvement in Adaptive Training scores pre and post testing?

▷ Usability and HCI Concepts for Connectome Application
Hardware Challenges

▷ Reliability
  - Consistency of commands
  - Signal strength and clarity
  - Sampling rate
  - Noise from EMG electrodes

▷ Compatibility
  - No cross-device implementation