Investigating Brain-Computer Interface Technology for NASA applications

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Habitability and Human Factors
Who am I?
About Me

- University of Rhode Island
  - B.S. Biomedical Engineering Degree
  - B.S. Electrical Engineering Degree
  - M.S. Electrical Engineering
  - Bio-Neuro Brain Modulator
A NASA Intern

- DO5 Cargo Integration and Operations
  - Assembly Operations Handbook
  - MRM-1 Russian Research Module Schematics
- \textit{EA3 System Architecture and Integration Office}
- Design and Development Branch
- Wrote LabVIEW control programs to control systems on board
Investigating BCI

- Exploratory Study on Brain-Computer Interface Technology (BCI)
  - IT labs alternative mode of control
- Electroencephalography (EEG)
  - Measures electrical activity along the scalp
- Brain-Computer Interface
  - Creates a pathway from the brain to a device
Investigating BCI

- Investigate Brain-Computer Interface Technology (BCI)
  - Evaluate the feasibility of BCI’s for use as a control system
    - Human factors component
  - Compare operation and efficiency of 3 various BCI headsets
  - Collect raw brain-wave data on specific thoughts and emotions
  - Use correlation algorithms to map thoughts to controls
  - Integrate real-time data to control a quadcopter
  - Create and document installation and testing procedures
  - Think about other potential applications
Investigating BCI

1 Electrode

512 Hz sampling rate

16 electrodes

128 SPS

32 electrodes

128 SPS
Documenting

- Installation process
  - Skype calls
  - Avoid pitfalls
  - References to files and information

Testing

- Procedures and notes
- Guidelines
- How to process the data
Testing

- Mind Map Setup
- Directional
  - Neutral
  - Left, Right
  - Up, Down
  - 100 trials, 15 seconds each
- Emotional states
  - Anxious, happy, sad
  - Frustrated, concentrating
  - 50 trials, 15 seconds each
Handling Data

- Emotiv
  - CSV Converter
- Cognionics
  - MATLAB
    - Process multiple batches
    - Automatically add headers
    - Create file name of choice
Challenges

- **Human Factors aspect**
  - Test length and comfort, Noise issues, Sensitivity to mental state
Results

Deliverables

- Data sets
  - Over 300 Directional and emotional trials
- Installation manuals
- Testing procedures
  » Estimates for setup
  » Comfort levels

Big Picture Contributions

- Jump start
- Challenges
Human Factors Risks

Mitigate Risks for:

- Tasks
  - Mental states and fatigue
- Training
  - Feedback performance
- Human-Computer Interactions
  - Design interfaces to display information in a way that makes sense.
Moving Forward

- Use another program to access real-time data
- Neurosky data
- Collaborate with group in EV to integrate this data with their systems
- Run our data through analysis to try and find correlation between trials and directions
  - Polarized especially
Social Media to Gather Human Factors Information

- Can we get useful Human Factors information from social media?
  - Out of my element
  - Focus on Twitter
  - Reid Wiseman
  - Found sites to go back to day one (Topsy)
  - What’s the best way to do this?
Adaptation, Equipment, and Training

First day on the job. Frustration was frequent in 0g! pic.twitter.com/D1cz46cy4y

Still adjusting to zero g. Just flipped a bag upside down to dump out the contents. #doesntworkhere

Two months in space. Floating is excellent but my brain still needs to visualize a ceiling, 2 walls, floor. Not fully there yet.

Know that odd pain when you hit your funny bone? 2-3 times a day up here hitting various handrails.
Procedure for Documentation and Recommendations

- Utilized a website to automatically archive tweets
- Export these to Excel
- Added formulas to automatically detect pull out timestamp and picture link
- Automatically make hyperlink
- Keywords / risks

- Social media could be a good tool
  - Instagram for equipment and visual information
  - Facebook, Tumblr
Knowledge Gained

- A lot of experience with different BCI technologies
- Human factors perspective – piece of the puzzle
- User point of view and research
- Improved documentation and procedure writing skills
- Investing time
- Patience and one on one teamwork
Thank you

- Mihriban Whitmore
- Lauren Merkle
- Mai Lee (Not Cyrus) Chang
- Frank Delgado
- Shelby Thompson
- Ron “Big Deal” McNeel
- Kendall Youngstrom
- All of NSBRI
Where Next

- NASA
- International Space University M.S.
- Engineering World Health
- Full-Time
"Houston, we have a problem."

ORION 13
Investigating BCI

- Neurosky
  - Games
  - SDK
  - Concentration
    - Frequency range

<table>
<thead>
<tr>
<th>Brainwave Type</th>
<th>Frequency range</th>
<th>Mental states and conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td>0.1Hz to 3Hz</td>
<td>Deep, dreamless sleep, non-REM sleep, unconscious</td>
</tr>
<tr>
<td>Theta</td>
<td>4Hz to 7Hz</td>
<td>Intuitive, creative, recall, fantasy, imaginary, dream</td>
</tr>
<tr>
<td>Alpha</td>
<td>8Hz to 12Hz</td>
<td>Relaxed, but not drowsy, tranquil, conscious</td>
</tr>
<tr>
<td>Low Beta</td>
<td>12Hz to 15Hz</td>
<td>Formerly SMR, relaxed yet focused, integrated</td>
</tr>
<tr>
<td>Midrange Beta</td>
<td>16Hz to 20Hz</td>
<td>Thinking, aware of self &amp; surroundings</td>
</tr>
<tr>
<td>High Beta</td>
<td>21Hz to 30Hz</td>
<td>Alertness, agitation</td>
</tr>
</tbody>
</table>
Investigating BCI

- Emotiv
  - Expressiv Suite
  - Affectiv Suite
  - Cognitiv Suite
  - Testbench
  - Keystrokes
Investigating BCI

- Cognionics
  - EEG reader
  - Map
  - Impedance
  - Signal readout
Hobbies