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
- 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

Code snippet:

```matlab
function [out] = cog_load(fname, EEG_CHS, EXT_CHS, ACC_CHS, notch)
% Input number of files and desired name of output file here
NumberOfFiles = 2;
XLFileName = 'Down1.xls';

for i=1:NumberOfFiles
    fname = strcat('down', num2str(i), '.cog');
    %fname = 'down1.cog';
    EEG_CHS = 32;
    EXT_CHS = 0;
    ACC_CHS = 3;
    notch = 1;

    % System parameters to convert raw ADC units to physical units
    VREF_EEG = 2.5;
    GAIN_EEG = 3;
    SCALE_EEG = 2^32;
    ISTM = 2^32 - 9;
    EEG_TO_VOLTS = 2*VREF_EEG/(GAIN_EEG*SCALE_EEG);

    % Parameters of Aux Box v1
    VREF_EXT = 4.75;
    GAIN_EXT = 0.5;
    SCALE_EXT = 2^32;
    EXT_TO_VOLTS = VREF_EXT/GAIN_EXT/SCALE_EXT;

    % Accelerometer based on ADXL327 at 2.5V supply
    VREF_ACC = 2.5;
    SCALE_ACC = 2^24;
```

National Aeronautics and Space Administration
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/DIcz46cy4y

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.

National Aeronautics and Space Administration
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

IMAGINE ENTERTAINMENT

BRIAN GRAZER

“APOLLO 13” KATHLEEN QUINLAN JAMES HORN

RITA RYACK ALDRIC L'AULI PORTER MICHAEL BOSTICK MIKE HILL DAN HANLEY

MOTHER MARY MICHAEL CORENBUTTH DEAN CUNDEY TODD HALLOWELL JIM LLOVELL

JEFFREY KLUGER WILLIAM BROYLES, JR. AL REINERT BRIAN GRAZER

RON HOWARD COMING SOON A UNIVERSAL PICTURE
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