VIP Project List 2021 (Session 3)

Project 1: Neurophysiological Measures of Working Memory and the Cognitive Pupillary Response on Memory Tasks

Cognitive Load (CL) is one of the critical states that have a significant impact on student performance in learning content. When it comes to learning, the Cognitive Load Theory (CLT) states that the human mind can't keep more than 7±2 chunks of information in the Working Memory (WM). Previous research has shown several methods in the measurement of the CL with physiological cues. The aim of this project is to dynamically measure CL using EEG and Eye Tracking Information (such as pupil dilation) captured during learning and investigate the impact of CL on student performance.

In this project, we look at known Event-Related Potentials (ERP) events such as N400 as well as the Power Spectrum of alpha, beta, and theta bands. Our goal is to compare these two factors at different difficulty levels of learning with our eye information such as pupil dilation and find similar relations in eye information. This involves significant investigation time to analyze the data we have, using EEGLAB tools and another alternative python plug-in. In the end, we will also try to implement an existing Machine Learning algorithm/method such as SVM to run on our EEG data in order to measure CL and student memory state.

Student Skills:

Python programming, Machine Learning, EEGLAB, MATLAB.

Student Background:

Has knowledge of EEG/ERP, Psychology or Machine Learning

ECL collaborators:

Ted Ahmadi

Project 2: Inter-brain synchrony in Virtual Reality

Project Aims :
Many studies have shown that the brains of two or more people get connected (hyper scanning) when they collaborate in the real world, eg. teaching, conversation, and collaboration between pilot and co-pilot. This results in synchronization of electrical activity in the brain, which can be measured by using tools such as EEG sensors in a technique known as hyperscanning.

Our research is trying to explore hyperscanning research in Virtual Reality (VR). We investigate the brain synchronization of people who interact by using VR as a medium. We are also beginning to study the impact of cues inside VR such as non-verbal behaviors and eye-gaze on brain synchronization.

This project would be suitable for a student who is interested in Virtual Reality, psychology, and measuring brain activity.

Student Skills:

Skills or interests in Unity programming and/or Signal processing (with Python programming)

Student Background:

A background in either Engineering, Computer Science, Psychology and/or Neuroscience

ECL collaborators:
Ihshan Gumilar, Amit Barde

Project 3: Streamlined Physiological Analysis Unity Plugin for Virtual Reality Development

Virtual Reality (VR) is one of the most powerful technologies at present that uses immersive computer graphics, stimulating experiences, and provides the sensation of being physically present in real-world situations. With the advancement of wearable sensing technologies, the use of physiological information such as electroencephalogram (EEG), electrodermal activity (EDA), and heart rate variability (HRV) to determine users' internal states while interacting with virtual environments has been extensively studied. However, there are very few methods available to streamline the data collection, preprocessing, analysis, and representation of physiological cues in VR systems.

Through our system, we would like to address this issue and provide a framework for VR developers to integrate our in-house physiological analysis python library with Unity to provide relevant and important information on a real-time basis. Our goal is to demonstrate a toolkit capable of interacting with Octopus Sensing[1], a physiological processing library, to collect multiple physiological signals, process, and visualize for offline and real-time analysis.

Project Aims:

1. Understand VR researchers' requirements of using physiological sensing in their research.
2. Explore optimum techniques to integrate Octopus Sensing with Unity to provide minimum latency and data loss.
3. Explore user interface and interaction designs based on the gathered requirements.
4. Provide documentation and a technical report for the project.

Project Outcomes:

1. User-centered toolkit for VR interfacing with Octopus Sensing to collect, process, and analyze the physiological data
2. VR application to demonstrate the usability and user experience of the developed system.

Student Skills:
(A candidate is not required to have all of these skills, having at least 2 of these could be a plus)

- C# programming, Unity development,
- VR User Interface Design,
- Sensor integration with Unity,
- Python programming

ECL collaborators:
Kunal Gupta, Nastaran Saffaryazdi

[1] https://octopus-sensing.nastaran-saffar.me/

Project 4: Conversational Analysis of Augmented Reality Collaborative

Conversational analysis is one technique used for evaluating collaborative Augmented Reality (AR) systems. The goal of the project is to complete a detailed conversation analysis, using recordings and machine-produced transcripts. The transcripts require some tidying up, including speakers to be correctly identified, and timestamps of all spoken words, including any overlapping speech. The conversational analysis involves identifying types of sentences and phrases used. This information will be used to generate statistics about the conversational analysis.

Project Aims:

1. Detailed conversational analysis of recordings from user studies on collaborative AR
2. Understanding of users' speech patterns and interactions (overlaps, silences, responses, deictic statements, questions)

Project Outcomes:

1. Methodology for the conversational analysis of collaborative AR systems.
2. A conference paper, detailing results

Student Skills:

Skillset to analyze data, Office (Excel, Word) or Google (Sheets, Docs), R Studio (optional)

Project Duration:

3 - 6 months

ECL Collaborator:

Louise Lawrence

Project 5: Using Virtual Characters for Cognitive Treatment

This project explores how a virtual character could be used to provide treatment for people with cognitive disabilities. We want to create a VR experience where a character could interact with a real person in a typical situation, such as ordering food in a cafe. We will then measure the person's response using a range of different physiological sensors (heart rate, GSR, etc) to detect the person's emotional state and have the character respond accordingly. For example, if the person is feeling stressed the character might be able to change their language to make the person feel less stressed.

Student Skills:

Experience with developing in Unity and interest in VR, interest in the data processing
Access to VR head-mounted display

Project Duration:

3 - 6 months

ECL Collaborator:

Mark Billinghurst

Project 6: User Interface Development for the Jitsi360 tour platform

The Empathic Computing Laboratory has been developing a 360 video conferencing platform that allows people to live stream 360 videos of their surroundings. This can be used for virtual tourism or teaching among other applications. The 360 videos can be viewed on the desktop, mobile phone, or even in virtual reality.
As part of this project, a number of improvements need to be done to the user interface, such as adding support for zooming into the video or identifying where people are looking in the images. Work also needs to be done on an administrator interface that makes it easy to upload pre-recorded content and make virtual tours.
The would be a great project for a student with web development skills and who is interested in telepresence or remote tourism applications.

Student Skills:

Experience with web development, especially the React-Native framework
Background and experience with deploying code on servers

Project Duration:

3 months

ECL Collaborator:

Mark Billinghurst

Project 7: Mixed Reality Remote Collaboration

This project explores how collaborative Mixed Reality applications can be developed that involve scanning and sharing elements of the real world. Using the new Lighthouse AR SDK from Niantic labs people with mobile phones can scan and create 3D models of their surroundings in real-time. This work will explore how this could be used to connect with remote people and enable them to share the same surroundings. The remote users could be in VR headsets and so be immersed in a user's real space while collaborating with them in real-time.

Student Skills:

- Experience with Unity development and Android or iOS development
- Interesting and remote collaboration in AR/VR

Project Duration:

3-6 months

ECL Collaborator:

Mark Billinghurst