VIP Project List (March 2021 onwards)

Project 1: C.A.R-VR (Contextual Activity Recognition in Virtual Reality)

Virtual Reality 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. 3D immersive virtual environments (IVE) have successfully been applied to phobias, presence, visualization technologies, quality of experience, and videogames. Users interact with VR by performing various real-world activities such as sitting, running, jumping, etc using handheld controllers or gestures. These activities can be detected using various techniques but there are multiple cues in a scene that reveal what action a person is performing in what situation. For example, a person sitting at a beach could be either enjoying their vacation or performing meditation, in order to detect the precise activity, the scene, and the audio-visual cues can provide an additional source of information.

The goal of this project is to develop a system exploiting the simple observation that actions are accompanied by contextual cues to build a strong real-time action recognition system in Virtual Reality. This will be accomplished by exploring various techniques to identify the actions from the available sensors in VR Head-Mounted Displays and later developing real-time action recognition algorithms by fusing the scene and task-specific contextual information from Virtual Environments. Finally, a demonstration of the developed system integrated with a VR application to show its robustness and reliability.

Project Aims:

1. Explore how to identify and categorize the actions in the VR environment.
2. Explore the techniques to extract the required additional scene and task-relevant contextual information to develop an accurate action recognition system.
3. Provide documentation and a technical report for the project.

Project Outcomes:

1. A novel technique for contextual action recognition system in VR
2. Software to identify basic actions, extract relevant contextual information, and a real-time contextual action recognition system.
3. VR application to demonstrate the robustness and reliability of the developed system.

Student Skills:
C# programming, Unity game engine development, machine learning, python programming

ECL collaborators:
Kunal Gupta, Yun Suen Pai

Project 2: Inter-brain synchrony in Virtual Reality

Project Aims :
Many studies have shown that the brains of two or more people get connected (hyperscanning) when they collaborate in the real world, eg. teaching, conversation, and collaboration between pilot and co-pilot. Our research is trying to expand the hyperscanning research on Virtual Reality (VR). We investigate brain synchronization of people who interact by using VR as a medium. In relation to that, by using EEG, we begin to study the impact of cues inside VR such as non-verbal behaviors and eye-gaze on the brain synchronization.

Skills needed from intern (Both or either of them) :

1. Unity programming
2. Signal processing (with Python programming)

ECL collaborators:
Ihshan Gumilar, Amit Barde

Project 3: Emotion Classification using deep learning methods.

In the time of COVID-19, remote communication is becoming more necessary and the use of avatars within immersive virtual environments (IVE) to facilitate communication is becoming a common way to achieve this. Some examples of this include: VirBELA, Altspace VR and Rec Room. Avatars has some advantages over a standard video conferencing call, such as being able to scale them, having them appear near contextual objects and being able to modify the blend shapes of avatars independent or dependent on the facial expressions and audio of a user, who in this case, would embody the avatar. In order to make the avatar's blend shapes based on the user's facial expressions and audio, we must be able a live video and/or audio stream and convert them to expressions which can be applied to our avatar's blend shapes.

The goal of this project is to develop a system that can accurately detect the expressions of a user and then apply them to an avatar inside the Unity game engine. This would involve exploring deep learning and other relevant methods and creating a model based on either the live video, audio stream or both. Finally, you can create an application to demonstrate your classification model.

Project Aims:

1. Explore deep-learning techniques to classify audio-visual input streams.

2. Exploring datasets and literature relating to emotion and expressions.

Project Outcomes:

1. A classification model that will integrate into the project managers avatar-based remote collaboration system.

2. An application that will demonstrate your classification model. Optionally, we can provide assistance with the unity game engine and C# programming.

3. Documentation of the components of the model you create and how to integrate the output into other systems.

Student Skills:

C/C++ programming, deep learning, computer vision, python programming. Unity/C# experience is nice-to-have but not required.

ECL collaborator:

Jonathon Hart

Project 4: Recognizing emotion in conversational audio

Emotion can be expressed by a mixture of behavioural and physiological changes in the body. Talking about the emotion is one of the behavioral responses to emotional stimuli which helps people to regulate emotions. Analysing the content of human speech is one of the most popular ways for recognizing emotions. In this project we want to know how state of the art speech analysis methods and available software work in analyzing emotion, compare them and find the best way for labeling conversational audio. Finally we want to label the experimental conversations with the appropriate method.The output of this project will be used as the labels of other data in the parent project which is multimodal emotion recognition.

Aims

1. Exploring audio to text tools
2. Exploring available software in text analysis
3. Exploring the state-of-the-art models and dataset in text emotion recognition
4. Exploring audio signal processing methods

Project Outcomes:

1. Providing a script which can convert audio data to text and apply sentiment analysis
2. Developing a classification and feature extraction method for audio emotion recognition
3. Providing a literature review

Student Skills:

Python programming, familiar with deep learning, familiar with sentiment analysis strategies

Project duration: 6 month
ECL collaborator: Nastaran Saffaryazdi

Project 5: How physiological signals change in response to various emotional stimuli

Human body creates various physiological changes in response to emotional stimuli to regulate emotions. Changes in body temperature, heart rate, blood pressure, respiration rate and sweating are examples of physiological changes. By measuring these physiological changes we can recognize emotions. In this project we focus on GSR and PPG signals which measure skin conductance and heart rate changes and want to see how these signals change in response to different stimuli including emotional videos and emotional conversations. Also, we want to find a correlation between each emotional state and changes in these signals by applying some pattern recognition methods on experimental data.

Aims

1. Exploring how to extract heart rate variability and Respiration rate from PPG signals and recognize emotion based on them?
2. Explore how phasic and tonic components of GSR signal change in different emotions?

Project Outcomes:

1. Finding a pattern for recognizing emotion using PPG and GSR in various experimental setup
2. Finding the most emotional chunk of data based on explored patterns

Student Skills:

Python programming, signal processing, machine learning

Project duration

3 months

ECL collaborator: Nastaran Saffaryazdi

Project 6: A VR Editor for Volumetric Recordings

We have developed a system that can use multiple depth sensing cameras to record point clouds of people performing tasks, or locations. These can be viewed in Virtual Reality (VR) and used for a variety of applications such as training. However, the point clouds sometimes contain extra data in them, such as recordings of part of the background of a person.

The goal of this project is to develop a simple immersive VR editor which will allow a person to go into VR and view the recorded point cloud and edit it to remove the unneeded data. This could be done by using VR controllers which will allow for selection and deletion of data points in a very natural way. Once the data has been deleted the dataset should be able to be saved and reused in other AR/VR applications.

Part of the project could be to design an intuitive interface for editing the volumetric data, and also conducting user studies to compare different interface/interaction techniques.

In order to do this project the intern should have access to VR hardware.

Aims

1. Create a VR editing tool for immersive editing of point cloud datasets
2. Creating an intuitive interface for the immersive editing tools

Project Outcomes

1. Working software that can be used for point cloud editing
2. A technical report/research paper describing the work done

Student Skills:

Unity programming (or desire to learn), C# programming, access to VR equipment.

Project duration

3-6 months

ECL collaborator: Mark Billinghurst, Prasanth Sasikumar

Project 7: 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 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 works, 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 conversational analysis of collaborative AR systems.
2. A conference paper, detailing results

Student Skills:

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

Project Duration: 3 - 6 months

ECL Collaborator: Louise Lawrence

Project 8: Development of a Graphical User Interface for Radar Sensor Integration

A robust and user-friendly graphical user interface (GUI) is essential in ensuring that a toolkit is usable to not only professionals, but hobbyists and enthusiasts as well. The goal of this project is to design and develop a Python-based GUI to interface with the radar sensors we are currently working on. The sensor itself will include its unique hardware configuration that needs to be modeled in the GUI accurately. Additionally, we expect the GUI to include features like sensor visualization, server/client connection and monitoring, as well as machine/deep learning model training.

Project Aims:

1. To design a user-friendly GUI for our proposed toolkit.
2. To integrate useful features like hardware mapping, server/client connection, accurate sensor visualization, and machine/deep learning model training.
3. To provide documentation and technical report for the project.

Project Outcomes:

1. Comprehensive software toolkit for radar sensor integration.
2. International conference research paper submission.

Student Skills:
Python programming, signal processing, machine/deep learning, Unity development (optional)

Project Duration:
3-6 months

ECL Collaborator:
Tamil Selvan, Yun Suen Pai

Project 9: An analysis of human thermographic image and development of its application

Thermographic technology is increasingly demanding with the surge of people's interest in public health, especially due to the COVID-19 pandemic. In this project, we want to investigate the use of the technology towards the post-COVID era; daily use of thermography analysis in our remote communication to improve the user experience (UX). We are working on an analysis of human face thermography to elicit human emotion arousal / cognitive load level with few VIP students, and this would be a following project to develop an application based on the same. We will design and develop an application which enhances remote collaboration or communication experience over the Internet, where utilizing thermal information, then evaluate its usability or performance. You will be working on a prototype software development, where you are free to develop any application (i.e. a discrete mobile app for communication or a Unity3D plugin to utilize the thermal image analysis data).

Project Aims:

1. Design an application of thermography analysis, where you can understand human's emotion arousal / cognitive load level with it, towards its use in our daily life.
2. Evaluating effectivity and usability of the system adaptation (i.e. how much the application supports user's communication with someone)

Project Outcomes:

3. An application or a toolkit that utilizing thermal image analysis to enhance human communication
4. Research paper on the design of application and its usability evaluation

Student Skills:

- (must have) basic knowledge of C/C++ coding (preferable: experience with openFrameworks)
- (welcome) knowledge about image processing / digital signal processing
- (welcome) knowledge about machine learning and it's coding using Python
- (welcome) experience in mobile app development / web app development
- (welcome) experience in VR/AR/MR project development using Unity 3D

Project Duration:

3-6 months

ECL Collaborator:

Ryo Hajika, Yun Suen Pai

Project 10: Sharing Heart Rate feedback in collaborative training

We have developed a system that can use multiple depth-sensing cameras to record point clouds of people performing tasks or locations. These can be viewed in Virtual Reality (VR) and used for various applications such as training. We want to incorporate additional input modalities such as heart rate, skin conductance, EEG, and ECG to enhance training effectiveness.

This project aims to develop a simple heart rate monitoring system and use machine learning to predict the user's emotion to a certain accuracy. We would then use this information to see the instruction delivery in collaborative training. As part of demonstrating the training system, we created a motorcycle engine assembly task. An instructor would guide a local person to fix certain parts of the engine remotely. With this addon, we would be able to study the effect of sharing physiological information in instruction delivery.

Part of the project could be to design a system for collecting and analyzing heart rate(Device: Empatica E4 Wristband) and predicting emotion. Also, conducting user studies to compare the effect of sharing such information in collaborative training.

Aims

1. Create a system for predicting emotion using heart rate sensors

Project Outcomes

1. Working software that can be enhance remote collaboration
2. A technical report/research paper describing the work done

Student Skills:

Python (or C#) programing, Machine Learning, Unity programming (or desire to learn),

Project duration

3-6 months

ECL collaborator: Prasanth Sasikumar, Huidong Bai, Ali Reza

Project 11: Mixed Reality Spatial Learning Tool for Zoom

We have developed an MR application that integrates with existing teleconferencing solutions like Zoom. The application grants a window to the virtual environment where users can demonstrate actions in a 3D space. We brought in a camera(more like a selfie stick) to the virtual environment and exposed this camera feed as a real connected camera. And thereby enabling teleconferencing solutions like zoom, skype, hangouts to use this feed. This setup allows users to showcase complex 3D objects and structures within a 2D video conferencing. We used Oculus Quest for the implementation. This project will explore multiple participants' use cases in a virtual environment, demonstrating/sharing information via video conferencing. We will also explore the application's feasibility to run as a standalone on a wearable MR device.

The project's focus would be: incorporating multiplayer functionalities, multiple avatar representations, showing hand gestures, and highlighting eye gaze.

Project Outcomes

1. Literature Review - Explore similar existing solutions and find the gap.
2. Develop an open-source framework that would work tethered systems with the scope to expand to mobile VR devices as standalone.

Student Skills:

Unity programming (or desire to learn), C# programming, access to VR equipment.

Project duration

3-6 months

ECL collaborator: Prasanth Sasikumar, Huidong Bai, Max Collins, Alaeddin

Project 12: Measuring Presence in Real-Time Using Neurophysiological Signals in VR

Presence is an integral part of virtual reality environments and higher presence often is considered to increase experience in VR. However, current methods of measuring presence relies heavily on post-experience questionnaires which are often biased, dishonest, and contain subjective errors. This project will explore an alternative method of measuring presence in real-time using neurophysiological signals such as heart rate (ECG), GSR, and brainwaves (EEG).

The primary outcome of the project will be a machine learning model that can use these multiple signals to detect presence in real-time. This model will be used in a user study to measure presence in a stressful and a calm VR environment.

Project Duration: 6 months

Student Skills:

Unity, Machine learning, C# programming

ECL Collaborators: Arindam Dey (UQ), Amit Barde

Project 13: Effects of Visual Cues on Brain Synchronization in VR

Project Aims :
Recent studies have shown that people's brain activity becomes synchronized with others' (inter-brain synchrony) during social engagement and collaborations in real-world but there is almost no research on investigating brain synchronization in VR. We have developed a unity program in which two remote collaborators participate in a visual search task to find some objects while their brain signals are being recorded to see how their brain act and which parts of the brains get connected during collaboration. In this study, we also investigate how implementing different visual cues in a visual search task in VR can affect brain synchronization when two collaborators focus on specific objects (while we give them a shared focus-point using visual cues). During the study, we measure their brains signals simultaneously (EEG hyperscanning) and process the signals to find correlations between people's brains during a collaborative task.

Skills needed from intern (Both or either of them) :
Unity programming (implementing visual cues such as laser pointer, drawing virtual lines, etc.)

Aims

1. Exploring the effects of visual cues on brain synchronization in collaborative VR
2. Could be extended to another project with similar concept in AR

Project Outcomes

1. Working software that can be enhance remote collaboration
2. A research paper describing the results

Project Duration: 3-6 months

ECL collaborators:
Ashkan Hayati, Gun Lee, Amit Barde

Project 14: Hypertraining: Leveraging Brain Synchronicity for AR Training

Hyperscanning is about the simultaneous measurement of brain signals from 2 or more individuals. This allows us to assess their brain synchronicity, allowing us to leverage this for many kinds of human-computer interactions, learning, and training methodologies. In the augmented reality (AR) space, there have been several researches on training as well, often on using different kinds of visualization and interaction methods. However, there has been some lack of related works regarding how hyperscanning can be leveraged for AR-based training.

The goal of this project is to develop and evaluate a system that trains users in AR using hyperscanning. To do so, we divide this work into two phases: AR development and EEG signal processing. In the AR development phase, we will look into point cloud reconstruction, recording and playback, to facilitate training tasks. A potential application to validate would be an AR drumming task between a novice and an expert. An expert playing a drum set will be recorded with a depth camera and reconstructed in the AR environment. The novice can then train by following the playback of the recording. We are also interested in evaluating the effect on perspectives like positioning opposite to the expert and positioning from the expert's viewpoint. To evaluate the effectiveness, we move on to the second phase; EEG signal processing. When recording the expert, we will log their EEG signals simultaneously. This allows us to then compute the brain synchronicity of the novice with the recorded signals of the expert.

Project Aims:

1. To explore the potential use of hyperscanning methods for AR-based training.
2. To understand how different perspectives in AR affects brain synchronicity in training
3. To provide documentation and a technical report for the project.

Project Outcomes:

1. Research article regarding the use of hyperscanning in AR for training.
2. AR software that can playback point clouds for offline learning.
3. Software for both offline and online brain signal streaming, as well as computing brain synchronicity.

Student Skills:

Unity game engine development, C# programming, python programming

ECL collaborators:

Prasanth Sasikumar, Yun Suen Pai