CS CAPSTONE PROBLEM STATEMENT

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DESIGN AND IMPLEMENTATION OF A FRAMEWORK FOR BIO-INFORMED 3D USER INTERACTION

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Abstract

Advances in immersive technologies are making it possible for people to work manufacturing jobs from virtual reality environments. In order to improve the experience, we intend to study the effects of specific environmental factors on the time perception of VR users. To complete the study, we must attach bio-informed sensors to VR users and modify their environment based on the sensor data. We propose an application programming interface (API) to handle communication between VR applications and the bio-informed sensors. This project concerns the research, design, and implementation of an API such that experimental data can be collected. A user study will accompany the project to test the performance of the API as well as collect initial data for the overall goal of understanding the effects of environmental factors on VR time perception.

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1 Detailed Problem Description

Over the last few years, virtual reality (VR) and other immersive technologies have rapidly grown in popularity. Users are spending increasing amounts of time in virtual reality worlds, with some immersing in VR for periods exceeding 8 hours. As VR technology becomes more prevalent, we must study how elements of a VR environment can affect its user's cognitive and physiological experience. Understanding these elements will allow us to deliberately affect them, thereby increasing our ability to create a positive user experience. This requires us to design and implement a system architecture that allows us to modify specific elements in a virtual world and measure the resulting effect on user experience. We are concerned with the user's perception of time as a specific aspect of cognition which we can measure due to its importance to all varieties of virtual experience. By creating an application-driven implementation of a responsive virtual system, we can test the viability of a system which collects and responds to user physiological data to enhance a measurable aspect of user experience, in this case time perception.

Time perception is defined as a person's subjective experience of the passage of time. While the rate of passage of time is constant, perception of time is different for each individual and can be linked to many factors. Particularly, we would like to study the impact of an individual's surroundings in a VR setting on time perception. Such environmental factors may include light quality, actor movement, movement of the sun, ambient sound, environmental realism, and many others. For example, a loud, busy party scene with hundreds of people, blaring music, flashing lights, and constant movement may alter the user's perception of time compared to a calm outdoors scene. We intend to individually test each environmental factor to determine how it may alter an individual's time perception.

In a VR environment, a person's surroundings can be easily manipulated making it an ideal environment in which to investigate time perception. While a user is in a virtual world, we can collect biometric data such as body temperature, heart rate, and eye tracking, to infer information about their perception of time. The primary problem is that there is no current way to link a VR environment with these bio-informed sensors. Without a link between the sensors and the VR environment, it is difficult to adapt the environment based on sensor data to perform an experiment.

Results from this study can have a major impact on manufacturing shop safety and efficiency. Particularly, smart machines with enhanced visualization capabilities allow workers to remotely operate them through a virtual interface. By understanding the perception of time in VR, we can provide recommendations on how to improve cyber-physical work environments. We expect that properly configuring these environments will have a positive impact on development costs, time-to-market, employee safety, and general efficiency for an industrialized company.

2 Proposed Solution

In order to answer the question of how certain environmental factors alter perception of time, we need to develop an application programming interface (API) to handle communication between VR applications and bio-informed sensors. This API is intended to interface between bio-informed sensors and a game development engine, such as Unity or Unreal Engine 4. More specifically, our solution will read information from multiple (yet undetermined) sensors, and provide functions which allow these results to be queried by the Unity scripts. This middle-ware will be encapsulated as a plugin for the game development engines so it is portable.

Additionally, our solution will provide an observer script which will continually read and analyze sensor data. Within this script, a researcher can define certain triggers which can automatically modify the VR scene when sensor data reaches certain thresholds. This is useful because the script can experimentally test multiple levels of environmental

factors in real-time without input from a researcher. The observer script will operate with the goal of altering the VR environment in real-time in response to user physiological condition.

Furthermore, to test the API and run a user study, multiple models in Unreal Engine 4 or Unity will need to be constructed. These models will contain multiple levels of the specific environmental factors we will be focusing on. Based on previous research, the target factors are light quality, actor movement, movement of the sun, ambient sound, and environmental realism. These scenes will enable the API to be tested as well as allow empirical data collection for the specific environmental factors they contain.

3 Performance Metrics

First and foremost, our solution must have a working prototype of the middle-ware API. This means that VR applications will be able to query information from bio-informed sensors through the provided API. In addition, the API will be able to receive messages from VR applications indicating the state of the user. The working prototype needs to be time efficient and operate at near real-time, with only minimal delay. As of now, it is impossible to define a threshold for this delay, but it must be less than humanly perceivable for certain operations.

Next, the API needs to be composed of independent modules following the single responsibility principle. Each module must have a unique set of responsibilities such that there is no redundant functionality. The hardware must function independently of the software and the software must operate independently of the game engine. This modularity allows the API to function regardless of any hardware or game engine changes, thus reducing the cost of maintaining the system.

In addition, there must be a working scene in Unreal Engine 4 or Unity which can connect to the API and a VR headset. The scene needs to respond to messages from the API which indicate changes in environmental levels. This scene will allow us to test the API with real bio-informed sensors and measure user data.

Finally, a lab study will be performed with randomly selected participants to investigate user time perception in our VR environments. The system as a whole must function such that this study can be conducted. This requires all major components: sensors, firmware, API, VR application, VR headset, and host computer to be correctly configured to collect meaningful data.