TED University

CMPE 491

Virtuanance

High-Level Design Report

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1. Introduction

Virtuanance is a virtual reality application that aims to assist in remote maintenance by creating a digital environment that establishes a connection between peers (professionals and technicians). The users will be using a Head-Mounted Device (HMD) to create a digital world around reality and utilize the features for completing maintenance operations. The project will be supporting both audial communications, along with visual communication between users.

The project allows 3d models of machinery, that requires maintenance, to be imported for being able to interact with a digital model during operations for efficiently identifying and solving malfunctions. These models will be fully interactable; smaller parts of the model will be separable from each other. Also, the models will be used to provide visual cues to the technician for quickly finding locations. Tracking algorithms will be used to locate physical machinery and provide the same visual cues on top of the real machine. Users are going to be able to communicate with each other during the operation audial. For better usability, users' hands will be detected and used as input devices, and we aim to remove any hand-held controllers for allowing the users to interact with the real world and digital world seamlessly.

The report contains detailed information about Virtuanance. Details concerning Design goals, software architecture, system decomposition and services are explained in detail.

1.1. Purpose of the System

Certain types of businesses work with complex machinery to produce, monitor and automate their operations, and all these machines malfunction for several reasons. When a malfunction occurs, technicians are tasked with repairing the machine for the business to continue normally. During the malfunctioning time, operations related to the machine are halted until the problem is resolved. This may cause the business to lose millions of dollars while waiting for the problem to be fixed.

The technicians often require assistance from trained professionals for completing the maintenance operations since they do not possess the necessary knowledge, and finding trained personnel is challenging and expensive. There are qualified businesses that provide these personnel to any business that requires it. However, these personnel are not located right next to whoever needs them, so they need to be relocated to assist with the maintenance operation.

Virtuanance aims to eliminate the relocation problem and shorten its time to fix a malfunctioning machine by allowing users to connect digitally. With the features we are going to develop, we aim to increase efficiency and reduce errors during the operation.

1.2. Design Goals

1.2.1. Usability

Usability is one of the key design goals. If the platform is not easy to use or results in slower operations than on-site maintenance, then the project will not have achieved its main purpose.

1.2.2. Utility

The system should cover the maintenance operation from start to end. The users should not feel an urge to look at the manual book because Virtuanance does not provide essential maintenance functionality.

1.2.3. Reliability

The project will work on various machinery of different scale and type (e.g., a jet engine and/or a production line) and treat them the same way. The system will also support working on a larger object or a smaller part of that same object, and the user can choose to work on an entire production line machine or just one segment of it.

1.2.4. Maintainability

The VR/AR sector is advancing rapidly, and changes are being made regularly to hardware and software used in Virtuanance. The project needs to keep up with these advancements and be easy to update to the latest products.

1.2.5. Engagement

One of the key points of Virtuanance is merging the digital environment to the real world. The project will utilize tracking methods to display visual cues on top of a machine (which is in the real world). LeapMotion will be used to eliminate the need for a controller device and use real hands to interact with the digital world. These features should create an engaging environment for enabling users to use Virtuanance for more extended periods.

1.2.6. Performance

In projects that utilize HMD’s, performance is an essential issue since they are trying to create a digital world around the user that is inseparable from the real one. HMD devices mostly aim for a 90+ FPS (frames per second) to appear more natural to the user’s eyes. Virtuanance must keep up with this 90+ target while providing a real-time network connection and rendering possible large models simultaneously.

1.3. Definitions, Acronyms and Abbreviations

HMD: Head Mounted Device

AR: Augmented Reality

VR: Virtual Reality

MR: Mixed Reality. Combination of AR and VR

Technician: The inexperienced user that requires assistance with the maintenance operation

Professional: Experienced personnel that will be helping the technician

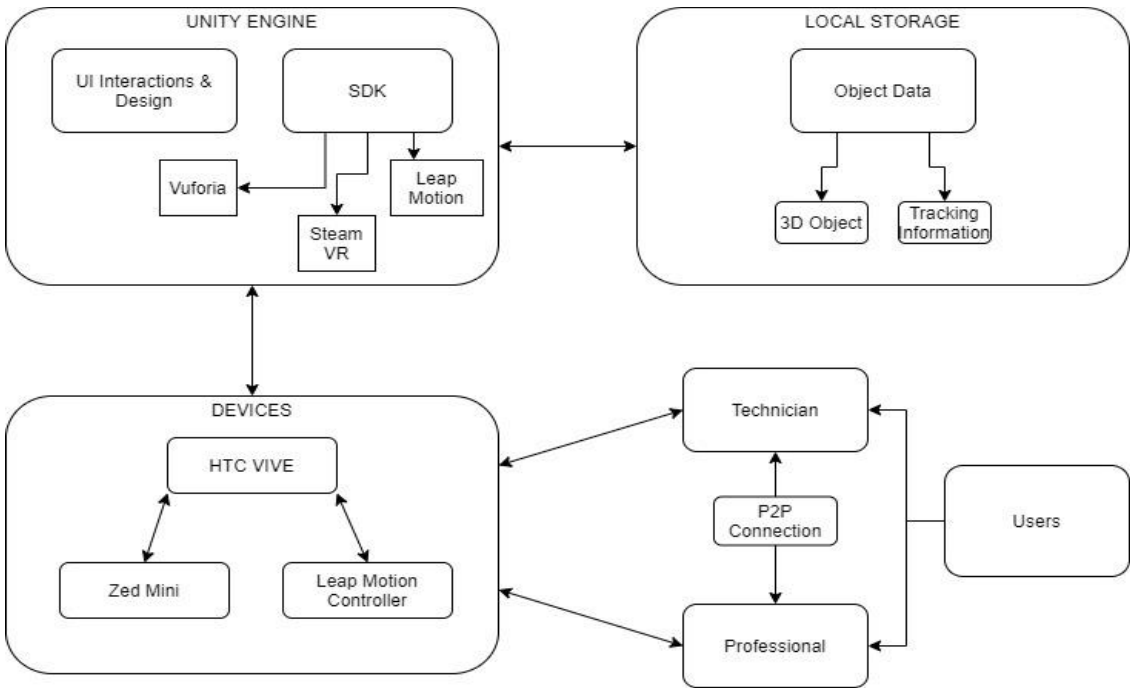
Leap, LeapMotion: A product that utilized infrared cameras to detect hands and translate them into the digital world (the world created in Unity Engine).

1.4. Overview

Virtuanance mainly focuses on connecting a “professional” and a “technician”. The system is designed so that the professional can see whatever the technician is seeing, and the pro can assist by using verbal communication along with placing visual cues to a spot on the digital machinery model. The program will be looking for the machine that is being worked on, and when it is found with the help of tracking algorithms, it will place the cues on top of the real machine. With the help of LeapMotion, user’s hands will act as input devices replacing controllers, keyboards and mouses. The user will be able to access menus and functionalities by preset hand gestures. For example, when the users look at the palm of his/her left hand, a menu is displayed around the hand.

2. Proposed Software Architecture

2.1. Overview

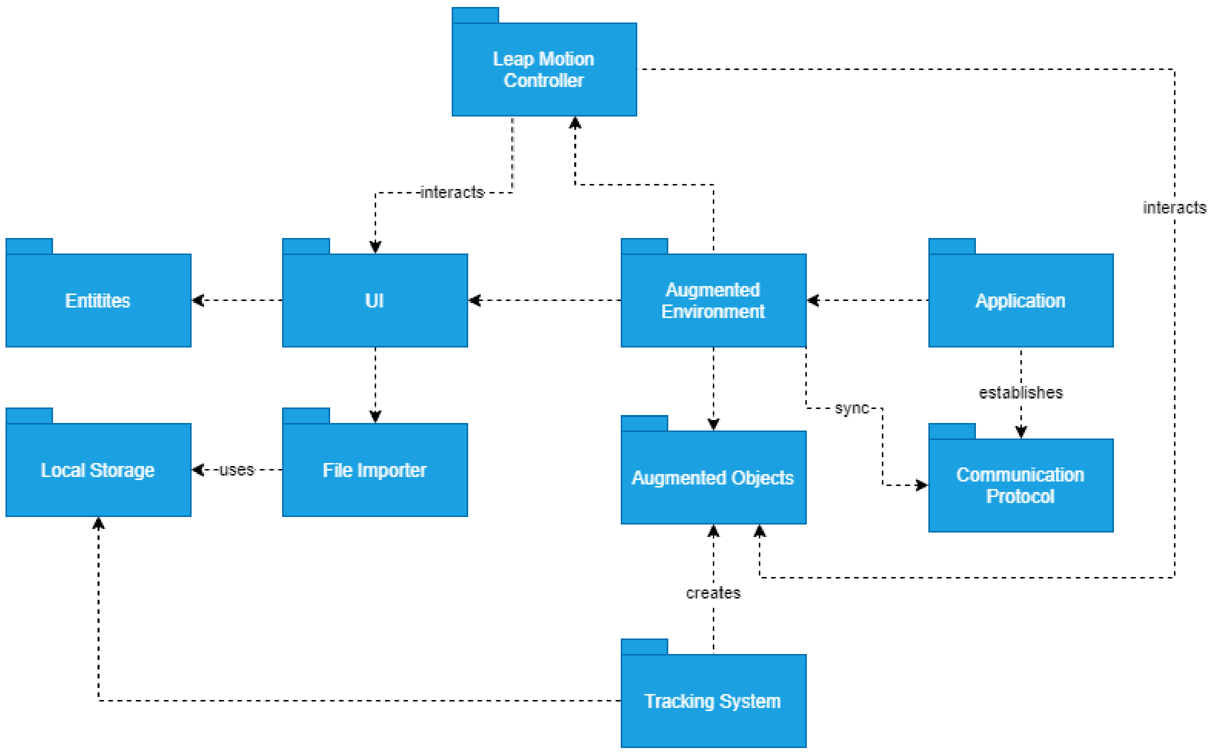


Remote maintenance projects must be built on two different users. These are technician perspective and professional perspective. These users should have different requirements that they can make according to themselves. These requirements may vary depending on the devices they will use. Since our project is based on a mixed reality environment, the Technician should use a mixed reality device. We have observed that having one VR glasses (HTC Vive recommended) and one VR glasses camera (Zed Mini recommended) will work more stable in terms of our program.

Nevertheless, for the professional user, the situation is not as strict as in the Technician. Professional will be able to use mixed reality on many supported devices according to some features.

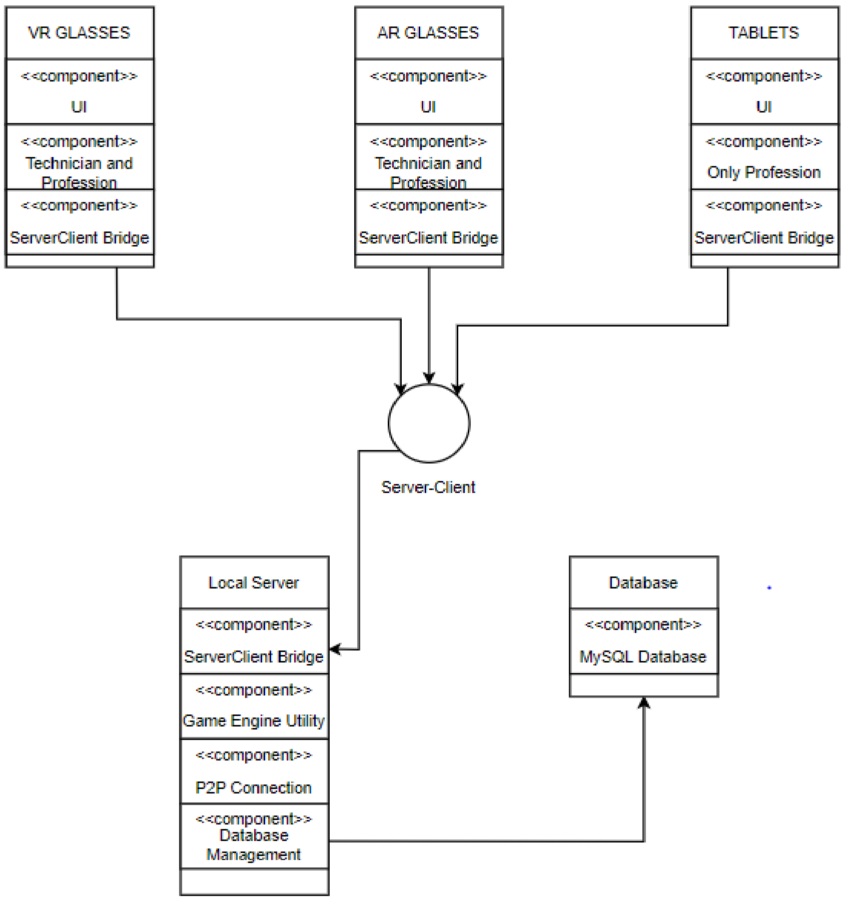
Also, the connection of devices to game engines may vary from user to user. These will be evaluated according to user comments while making the project in the future.

2.2. Subsystem Decomposition



Virtuanance works similar to Model-View-Controller design architecture. The technician will use Leap Motion to manipulate the objects in the augmented environment and interact with the User Interface entities. This final augmented environment can be viewed by augmented reality tools such as AR glasses. The augmented objects are created by the tracking system, which uses local storage to find what to track and when to track them. The technician will be able to communicate with the expert using peer to peer communication protocol. All the augmented environment data will be sent to the expert if the connection is established

2.3. Hardware/Software Mapping



Three main pieces of hardware can be used in Virtuanance. The first of these is VR glasses. When sufficient resources are provided, a mixed reality environment will be obtained by attaching an external camera to the VR glasses. Both professional and Technician can use this method. On the other hand, remote maintenance projects are generally designed for AR glasses. Therefore, Virtuanance may be operated with AR glasses as well. In this case, a VR headset or mixed reality will not be required, and HMD related will be flexible. The tablet, another device used in Virtuanance, can only be valid for the profession. In this case, it will act as it wishes, independent of the product from the professional maintenance perspective.

Virtuanance is mainly being built as a defence industry project. Therefore, defence industry companies or any companies to be given are expected to create their servers and use this software—the place where 3D models and connections will be kept in local storage.

2.4. Persistent Data Management of Local Storage

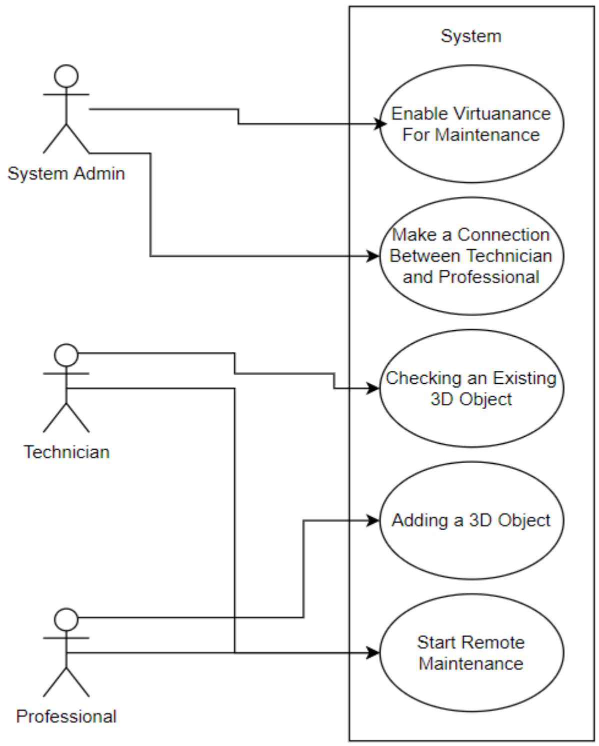
In local storage, there are 3D object models among persistent data. Therefore, users need to implement the object they will remote maintenance themselves before the project starts. The physical copy of the 3D model must be in the Technician after it is implanted. When the model is added, tracking information will be created and saved to local storage. Thus, when working on the same 3D object, it will not be necessary to create tracking information from scratch every time.

2.5. Access Control and Security

The first thing we bring as a control to use the Virtuanance program is the account and password system. Thus, any unwanted person will not enter the program even when physically accessing the device. Simultaneously, the program's login system is only used to match and connect between Technician and professional in the same environment. Users who do not match their information in local storage will not interact with each other. This system will increase the security of the program.

Another thing to do in terms of security is to store the program on local servers. The Technician and professional will communicate with each other by providing the peer-to-peer connection. This project, which will be used mainly for the defence industry, is a measure taken against those who want to access this program and steal information since a server that other users can access from any central server will not be established.

2.6. Boundary Conditions



2.6.1. Initialization

In order to use for users of Virtuanance, the system administrator must authorize these users. Next, it creates a p2p connection which amongst those users (depending on which one is Technician or Professional) that it can intercept. When users enter Virtuanance, they must first define the object they will perform remote maintenance. First, Technician adds a new 3D object to the program, then the professional checks if this file is correct. After all this, the Technician and professional can make remote maintenance as they wish.

2.6.2. Termination

Unless a user shutdowns the Virtuanance or logouts from the application they will remain logged in. After they logged out or shutdown, in order to use the program, they have to log in to their account again.

2.6.3. Failure

In any case that prevents users or system admin from receiving data from each other (p2p connection failure or connection loss), the system will be disabled until the connection is restored.

3. Subsystem Services

3.1 Entities

Entities are the elements on the UI that the user can interact by using the leap motion controller. These elements will help the technician while he is doing his job with the help of an expert. The entities have consisted of buttons and scroll bars.

3.2 UI

This subsystem is the interface which hosts the entities. UI will be developed with the Unity interface, with several Unity plug-ins such as file importer and object importer. There will be two UI's, one is for the main menus and augmented UI. Main menu UI's are used to launch the environment, import trackables and the objects to be augmented, and view previously imported trackables and the objects augmented in the application. The other UI, augmented UI, will be used in the main application's screen, interacting with pre-defined hand gestures.

3.3 File Importer

File importer is the subsystem which allows users to interact with their system and import any trackables and the objects they wish. After selecting their files, the files will be transferred to pre-defined locations in the local storage.

3.4 Local Storage

Local storage is the subsystem which is used by file importer for storing the imported files. It is also accessed by tracking system in order to get the trackables that will be imported and used by the tracking system at run time. The storage used in this application will be dynamic, and it will be located in the file system of the application.

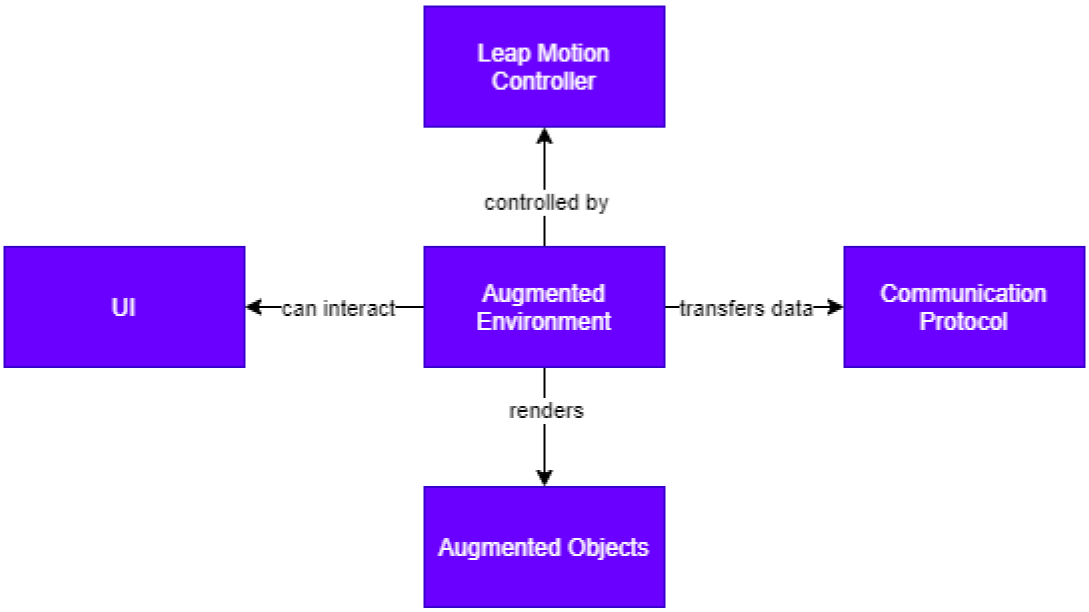
3.5 Tracking System

The tracking system is the subsystem which is provided by Vuforia Engine, and it is used to create augmented objects whose data is stored in the local storage. The tracking system will process the data stored in the local storage to determine which trackables are matched with which trackers, as well as how to locate them in the real environment by accessing their locational data. This subsystem's outcome is creating the virtual objects that users can interact with their hands via the leap motion controller.

3.6 Augmented Objects

This subsystem consists of the objects previously imported by users using the file importer and created by tracking system after acquiring the trackable position, which was also imported and matched with the user's object previously. The data for augmented objects are located in local storage. These objects are intractable, and their data can be transferred between the technician and expert via a communication protocol.

3.7 Augmented Environment



This subsystem is responsible for establishing the interaction between the other four subsystems, namely UI, Leap Motion Controller, Augmented Objects and Communication Protocol. UI can be viewed and interacted in the augmented environment by the leap motion controller. Along with the UI, another interactable aspect of this subsystem are augmented objects, which is again can be interacted with by leap motion controller. All the data created in this environment can be sent to the expert using a communication protocol.

3.8 Leap Motion Controller

Leap Motion Controller is the subsystem that allows interaction with the augmented environment, which contains UI and augmented objects. This subsystem helps to recognize the user's hands and use them as the main controller in the augmented environment with the information it has received from the Leap Motion device. The user will activate UI with a pre-defined hand gesture and manipulate objects created by the tracking system.

3.9 Communication Protocol

Communication protocol syncs the augmented environment on the technician’s device to the expert’s AR device. It transfers the view with some of the UI elements and the augmented object's data on the technician’s device to the expert’s device.

3.10 Application

Application is the subsystem that connects the communication protocol and the augmented environment and connects them with the main menu UI.

4. Glossary

AR: (Augmented Reality) It is an interactive experience of a real-world environment where the objects in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

HMD: It is a display device, worn on the head or as part of a helmet (See Helmet-mounted display for aviation applications), that has a small display optic in front of one (monocular HMD) or each eye (binocular HMD).

HTC Vive: The brand of VR glasses that we use for this project

Leap Motion Controller: it is an optical hand tracking module that captures the movements of your hands with unparalleled accuracy.

Vuforia: It is an augmented reality software development kit for mobile devices that enables augmented reality applications. It uses computer vision technology to recognize and track planar images and 3D objects in real-time.

VR: (Virtual Reality) It is a simulated experience similar to or completely different from the real world. Applications of virtual reality can include entertainment (i.e. video games) and educational purposes (i.e. medical or military training).