The University of Hong Kong

COMP4801

Final Report

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Final Year Project Topic: Application of AR in Employee Training

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Introduction

Idea Background

This final year project is about implementing an application of Augmented Reality (AR) in employee training, especially in property management. It is ubiquitous that different conglomerates and corporations would like to provide many in-job trainings to their employees. However, most of the employee training method are typical lectures or paper materials. These kind of training methods would be too old school and not enough interactive for the employees to picture the real situation in their mind; thus, it would be not enough effective and efficient to train up some skills or mindsets for the employees to handle with different general or extraordinary situation.

Nowadays, everyone is talking about utilizing technology to improve our life these days, AR technology can be one of the solutions to facilitate and enhance our daily life, especially in employee trainings effectiveness. Apart from my internship experience in a property corporation, I find out that implementing AR technology can become a new method to hold employee training. It makes training more interactive and realistic in order to achieve a better result.
Introduction of Augmented Reality (AR)

To begin with, I would like to introduce the concept of Augmented Reality (AR). It is believed that the first time that everyone recognized AR technology was from the day “Pokemon Go” published in the application store. This app has aroused stunning attention from the public. There were full of Pokemon Go players in the street that you can see them running around with their smartphone. Some of the checkpoints of the game were crowded with people over day and night. Concerning the app, one of the highlighted functions is the AR implementation that player can use the real time camera of your smartphone to find Pokemons on the street. From that day on, the potential of AR has been noticed.

Pondering over AR technology, AR is a kind of technology mingling system generated picture or words with human sensors. A typical example of AR is having an augmented picture in the camera of your smartphone. Same as artificial intelligence, AR is also not a new idea. It appeared in many movies before 20th century. However, the AR revolution has started with advances in the popularity of smartphone and different technological appliances.

As smartphones have become ubiquitous, it facilitates ‘Augmented Reality Browsers’, for example, camera, GPS and motion sensors to develop on those devices. After processing the real-time situation, there will be some additional image or information in a layer on top of the real-life situation from the device’s screen.
Project Background

Project Focus

This project will focus on the customer service aspect of employee training. As customer service industry plays an essential and effective role in Hong Kong. Lots of conglomerate and corporations provide a series of training to their employee on how to provide a best service for their customer. This project would like to simulate some real-life situation of dealing with customers’ request on the AR browsers, and the employee will need to choose the most suitable reaction to cope with the customers’ request.

This project would utilize some real-life customer service skills training programs to create some tasks. The project would simulate some cases mentioned in those customer service training programs to demonstrate a more interactive method to train employees. There will be different types of tasks for the employees to deal with, for example, building rapport with customers, delivering service to meet customer needs and dealing with some emergency situations. It will be demonstrated in a role-play method, employees will look around with the AR browsers in a smartphone device, they would find some virtual customers in the AR browsers and they would need to deal with them. By choosing some multiple choices, the customers will react positive or negative emotions to let the employee the choices are correct or wrong.
Overview on the traditional training method – Lecturing

Nowadays, lecture method is a common way to do employee training because it is very convenient and efficient to spread the message or concept to others, especially with larger room sizes. It can reduce teaching costs and time for the corporations and let the employee get to their position as soon as possible. Therefore, lecturing with paper materials is ubiquitous for most corporation, especially in property management aspect, to do employee training.

Advantage of Lecturing

To get deeper on the advantage of lecturing, it gains a high level of teacher control. The lecturer will hold the employee training in an authoritative method. Lecturers can gain the full attention and direction of the lecture room. The courses can be taught in an interesting and inspiring way if the lecturer is high quality. Lecturers can also design the most suitable information to be delivered and how to be delivered according to the situation at that time.

Moreover, lecturing is an effortless approach to the employees. Lecturing makes the learning method effortless for the listeners, since they only need to pay attention to the lecture and take notes to get the relevant information. Employees just need to have a good behavior to take notes and they can absorb the large quantities of ideas in the lecture.
Disadvantage of Lecturing

Apart from the reason and advantages mentioned on the above, there are still as many limitations to the lecture teaching method.

Most people who are against holding employee training with the lecture method believes that the one-way approach of lecturing is not effective for employees to absorb the knowledge in their mind. Pondering over the lecture method, employees are lacking opportunities to have their input or discussion on the concept gained from the lecture. Employees usually sit down at the lecture and take notes of the lecture even they have questions about it. It is not a healthy way to learn a new idea with no two-way interaction.

Furthermore, lecturing requires a high lecturer expectation. Lecturers should be the expert of the specific aspect. At the same time, lecturers may not understand what listeners would be questioning about. While lacking interaction during the lecture method, lecturers may not explain the training materials to the employees clearly. Moreover, the tone and talking speed of the lecturer may sometimes be too hard for listeners to absorb new knowledge, which may influence the effectiveness of spreading the employee training materials in the lecture room.
Lecturing vs AR Approach

It is well believed that the typical lecture method has its advantages in spreading new information on employee training. That’s why lecturing has been used over decades by different corporations in their employee training aspect. However, it has also its drawbacks and limitations, for example, lacking two-way interaction and high expectation on the lecturer, which may result in a relatively not effective demonstration of the employee training materials.

Pinpointing the obstacles that traditional lecturing method has, the AR approach would be an alternative way to demonstrate the information of the employee training materials to enhance the interaction with the employees. At the same time, the AR approach may also create an inspiring experience and memory for the employees to fulfill their training contents.
Advantage of AR Approach

In the first sight, implementing AR approach can bring out an interesting and inspiring experience of learning. When people are using lectures to learn new knowledge, they can only absorb through when they heard and saw. However, people can get an experience of what they see, hear, touch and other styles by using AR approach of employee training. Apart from hearing the lecture, employee can have a real simulation of the situation by using AR approach. They can see the real situation and choose how to react with it. By real-life simulation experience, employees should gain a better and realistic knowledge of their learning materials.

On second thoughts, AR approach can also eliminate risk and safety concerns for doing the employee training. By using AR approach to demonstrate the extreme situations, it can allow employee to train without any potential risks. At the same time, using AR approach not only eliminate the potential consequences, but also allow employees to master the training materials.

Furthermore, AR approach can also have the same advantages of saving training budget and time that lecturing method, and AR approach may do better in some aspect. After the AR training system has been developed, employees can do the training whenever they want. Employees practice as many as they have mastered the training materials and they can do the training with flexible time.

Last but not least, implementation with AR approach will make the employee training become digitalization. The corporation can maintain the employee training and hold new training materials through the system, which makes the administration procedure more effective and efficient.
Feasibility of AR Approach

1. Technical Feasibility
Considering the functional area, although people may not be familiar with the AR implementation and maintenance, the system is not only a simple system so lacking IT knowledge may be a big concern for any corporation using it.

In addition, since corporations are commonly using paper materials or lectures to hold employee trainings, there is no existing system to integrate with the AR employee training system, so the compatibility of our system is high.

2. Economic Feasibility
Cost
After development, the cost consists of the cloud server cost and domain cost, assuming only little maintenance work will be needed to be done in the future.

Benefit
The system would help corporations to manage the employee training record in a more efficient and less time-consuming way so corporations would be able to reduce administration costs. Shortening the average training time of each employees and the new AR training system would also improve learning experience and satisfaction and thus increase effectiveness of the training result.

3. Organizational Feasibility
AR technology application is not common in property management industry and the system does not strategically have conflicts with existing rules and policies of any corporations, corporations would probably accept the system unless the system provides terrible user experience to the employees.
Requirement Analysis

Functional Requirements

Employees want to:
- register account, specifying a username and password for subsequent authentication
- specify a name, contact email address, contact phone number
- change phone number, email address, password or any other modifiable personal/organizational information supplied during registration
- retain access to their account if they forget their password
- view training courses details in my courses list
- view details of all their upcoming training courses required to finish
- send messages to administrator
- receive notification and email

Administrator wants to:
- access to the administration account through user authentication based on username and password
- view details of the training courses
- view statistics of the employee finishing status of the training courses
- add and close training courses
- delete training courses
- receive messages from member
- collect customer personal information
- collect data for analyzing customer’s training behavior
Non-Functional Requirements

- A normal user shall be able to use the System to utilize account management function, AR training courses and message between users and administrator.
- The system shall be available 24 hours a day, 7 days a week, with over 99% available operation time.
- The mean time between failures shall exceed 450 hours.
- The mean time to repair shall be less than 2 hours.
- The maximum defect rate that the application could support is 3% bugs/KLOC (thousands of lines of code).
- The System will be implemented in Unity using C# and Vuforia.
- Guest will not be able to perform messaging, AR training courses and other account management functions besides registration and forget password.
Project Methodology

Decision on the development platform- Unity

Unity will be the priority development platform used in this stage of the project. Although there are several different development platforms on the market, Unity is the most familiar platforms for me to develop AR project. Since I have utilized Unity to create some gaming project in some courses these years, I would be more comfortable to utilize this platform again. Moreover, the Vuforia will be the core developing libraries for the AR project, and there will be some libraries in Unity that is available for building some AR projects, I can make use of the assets on the libraries to build my AR project.

Changes of development platform – From Swift to Unity

The AR project would also make use of some smartphones, the AR project APK would be import to an Android Phone or Apple iPhone for testing. Since smartphone is the most common and popular device to have AR browsers and the required sensors. The AR project would be firstly implemented in smartphone.

In my interim report, Swift was the priority development platform used in that stage of the project. Although there are several different development platforms on the market, I chose to try developing the AR system with Swift because I would like to utilize the AR kit in Swift enabling my development on IOS operating systems. After my interim presentation, I have pondered over the developing tools that I used.

The reason that I choose to use Swift at that time, because some features for example notification and IOS synchronization are required to use SceneKit in Swift for implementation. As a result, I have changed to use Swift as the development platform of this project at that time.
However, the technical risks have appeared at those days, I am totally not familiar on designing the user interface and the programming language. Moreover, the app got compiling problems many times when I was trying to compile it and installed on my smartphone. The app would always crash with my iPhone operating systems and it can’t be opened most of the time.

After having got these kinds of technical issues for a month, I decided to change my developing the AR app back to Unity. Since I have former experience on developing gaming app in Unity, the cross compile has also benefitted for me to reduce the time spending on developing in different platforms for future development.

Furthermore, the Vuforia enables AR capabilities to most of the mobile devices. Vuforia can help develop AR functions on mobile devices without the requiring specialized AR sensors, basic cameras and physics sensors in the smartphone. It makes developers easier to apply the AR functions in the app.

On the other hand, it is found that both ARKit and Vuforia have limited depth perception. On the following section, I will mention deeper about the functionality of both ARKit and Vuforia. The horizontal planes, for example, ground and floor can work smoothly in both AR platforms, but the vertical plane detection is still limited in the functionality of these AR platforms.

As a result, some of the functions in the system are needed to be changed, for example, the AR route functions. The difficulty of developing the AR route function is too high, and I have changed it to another format of demonstration. The main AR function demonstration will be changed. A specific image will be used to identify the positions of the AR objects. When the users utilize the camera to look around, the camera will identify the specific image and the relevant AR object will pop out for users to interact with.
Unity VS Swift

Unity: Unity is mature a 3D game developing tools, which is usually linked to VR and AR because the general usage of 3D objects. The programming language of development in Unity is C#. It is usually use for building a PC game and Android or IOS gaming app, especially the games with lots of visual 3D objects like characters, maps, animation effects and physics simulations.

Swift: It is a 3D game engine for native iOS development which is developed by Apple. The programming language of development in Swift is Objective C. Swift is directly integrated in Xcode where it can be found easily in the AppStore.

Vuforia (Unity) VS ARKit (Swift)

Common features of both AR developing platform:
- Motion tracking
- Environmental understanding
- Light metering

<table>
<thead>
<tr>
<th>Advantages of Vuforia (Unity)</th>
<th>Advantages of ARKit (Swift)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better choice on developing a gaming app with lots of 3D objects</td>
<td>Better choice on building an app without lots of 3D objects</td>
</tr>
<tr>
<td>Saves time on building and debugging basic functionality</td>
<td>Easy adoption of AR function in an existing app without amending the UX</td>
</tr>
<tr>
<td>Cross compile to different platforms, for example, Android, IOS and PC.</td>
<td>Easy application of Apple’s UI elements</td>
</tr>
<tr>
<td>More familiar developing platform because I have much experience in developing games with Unity</td>
<td>Easy implementation of iPhone notification and other interaction function</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages of Vuforia (Unity)</th>
<th>Disadvantages of ARKit (Swift)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not able to use the Apple Elements in the User Interface</td>
<td>Not familiar with the development platform and the primary programming language</td>
</tr>
<tr>
<td>Has limited depth perception</td>
<td>More time will be spent on</td>
</tr>
</tbody>
</table>
debugging and testing the basic functionality of the app
- Has limited depth perception

Employee Training Materials

The employee training materials will be some common issues in property management industry. It is a question bank of dealing with customers inquiries on water leakage matters. The user’s role is a property management office and gets this inquiry. He/she needs to step by step answer the questions correctly to finish the training materials.

The above flowchart describes the progress of the question bank. There will be multiple choices for the user to choose. He/she needs to answer the question correctly to proceed to the next question. If he/she answers it correctly, the system will explain why the answer chosen is wrong and let the user to answer the question again until the correct answer has been chosen.

Moreover, there will be also additional video training materials between a question and another question. The video training materials implementation will be left for further development, since the video training materials aren’t available in this stage. If this project has made a great start of success, the video materials will be embedded inside the question bank.
Changes after FYP Interim Presentation

Developing platform changed from Swift to Unity

Mentioned in the above pages, the developing platform will be changed from Swift to Unity because of different technical issues offending the development progress of the project.

There is lots of time spending learning the programming language Objective C at the beginning and the UX of Swift. Moreover, there is also much time consuming on designing and debugging the basic functionality before starting the main functions of the project. These experience makes me ponder over the usage of Swift. After a month using Swift, I have changed back to utilize Unity as my developing tools.

Since Unity is a more familiar platform to me, and the cross compile is convenient to make the project work in different operating system. Some of the functions in the project is easier to development in Unity, for example, the account management function that I have developed before in my previous Unity project. Moreover, the 3D object development is more user-friendly in Unity, since the developing windows is already a 3D developing scene environment. It is easier to figure out the developing result at every stage.
AR Object Demonstration Method

**AR routing function**

At the beginning, I would like to develop the AR routing functions to navigate the employees to the checkpoints. However, it is hard to find a suitable geographical online package for the development and there is hardware matter for some smartphone.

The is lacking geographical package to support indoor patrolling for property management staff, and it is hard for GPS to locate a precise location to do the navigation.

Furthermore, some of the smartphone is still using single camera, although most of the new smartphones there two years have started to have dual cameras. Smartphone camera with single camera is lacking the capability to sense the depth of the environment. Single camera can always be able to handle horizontal sense but the performance in handling vertical sense is unsatisfactory.

At the end, I amended the routing function by cancelling the AR part. The routing function will be implemented with a floor plan having the checkpoints on it. The employees need to familiarize with the floor plan and find the checkpoints.
AR object demonstration
The demonstration method is changed from getting random AR object in the camera by looking around in a specific location to locate the AR object by a specific picture. To make it clear, the AR functions allow you to define and recognize objects in the real-world and overlay additional content on top of them when they are viewed through the camera screen.

In the interim report, I would like to have the AR object randomly locate in the checkpoint, as well as the AR function of Pokemon Go. However, I would believe that this approach is not inspiring for employee training. Thus, I would like to develop the AR object in a proper place that it will appear in real life, for example, the rubbish will be on the floor and the water leakage will be near the water pipe.

After I searched for different methods to deal with my objective, one of them is to utilize the geographical sense of the smartphone. It means that the AR object will appear according the users’ camera’s Y dimension. When the camera is looking at the ceiling, there will be a respective AR object appearing, a relative AR object can also appear when the sensor notices that the camera is looking at the ground. However, this kind of geographical development is too complicated and the library for this is not completed.

At the end, I have implemented the AR object display function by recognizing objects in the real-world and overlay additional content on top of them when they are viewed through the camera screen of a smartphone. The object being recognized can be any image I want, and the image can be put on a proper place for the employees to find it and get the AR objects.
Business Assumptions and Dependencies

User Identity
There are 2 types of identity of users in the system which Employee and Administrator. Employee can apply for the training courses and check their learning progress. Administrator can edit, add or delete the content of any training courses, view all employees’ learning progress and update the system.

Use Cases

<table>
<thead>
<tr>
<th>Primary Actor</th>
<th>Use Case ID</th>
<th>Use Case</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee</td>
<td>1</td>
<td>AR Training Courses</td>
<td>High</td>
</tr>
<tr>
<td>Guest</td>
<td>2</td>
<td>Register Member Account</td>
<td>High</td>
</tr>
<tr>
<td>Employee</td>
<td>3</td>
<td>Sign In/Out</td>
<td>High</td>
</tr>
<tr>
<td>Administrator</td>
<td>4</td>
<td>Manage Training Courses</td>
<td>Medium</td>
</tr>
<tr>
<td>Employee</td>
<td>5</td>
<td>Edit Member Profile</td>
<td>Medium</td>
</tr>
<tr>
<td>Employee</td>
<td>6</td>
<td>Forget Password</td>
<td>Medium</td>
</tr>
<tr>
<td>Employee</td>
<td>7</td>
<td>View Information</td>
<td>Medium</td>
</tr>
<tr>
<td>Employee</td>
<td>8</td>
<td>Message to the Company</td>
<td>Low</td>
</tr>
</tbody>
</table>
## Detailed Use Cases

<table>
<thead>
<tr>
<th>Use Case Name:</th>
<th>AR Training Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID:</td>
<td>1</td>
</tr>
<tr>
<td>Primary Actor:</td>
<td>Employee, Administrator</td>
</tr>
<tr>
<td>Description:</td>
<td>This use case describes the procedures of the AR employee training procedures</td>
</tr>
</tbody>
</table>

### Stakeholders and Interests:

**Employees:**
- Want to have a simple and interesting process to finish the training content
- Want the training materials presented clearly
- Want to have sufficient interaction in the training process to gain a better experience of learning such training materials

**Administrator:**
- Wants accurate employee training records
- Want a concrete presentation of all training courses
- Want to update the status of the training courses if there is needed to do it

### ID: 1.1 Course Selection

<table>
<thead>
<tr>
<th>Preconditions:</th>
<th>Employee has signed his/her account</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postconditions:</td>
<td>Relative available training courses have been saved in the database</td>
</tr>
</tbody>
</table>

**Normal Flow:** Employee
1. Member navigates the Course Selection Page
2. There will be different training courses available for the employee to choose which one he/she wants to start the training with

**Alternative Flows:** Member
2. Employee chooses a training course that is not available for him/her:
i) The System return an alert message reminding the users that he/she is choosing an unavailable training course
ii) The System returns to Course Selection Page

<table>
<thead>
<tr>
<th>ID: 1.2 Map Routing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preconditions:</strong></td>
</tr>
<tr>
<td>Employee has signed his/her account</td>
</tr>
<tr>
<td>Employee has selected a training course</td>
</tr>
<tr>
<td><strong>Postconditions:</strong></td>
</tr>
<tr>
<td>Relative map has been saved in the database</td>
</tr>
<tr>
<td><strong>Normal Flow:</strong></td>
</tr>
<tr>
<td>Employee</td>
</tr>
<tr>
<td>1. Employee navigates the Map Routing Page</td>
</tr>
<tr>
<td>2. There will be some checkpoints showed in the map</td>
</tr>
<tr>
<td>3. There will be a special image in the checkpoints for the employees to find out</td>
</tr>
<tr>
<td><strong>Alternative Flows:</strong></td>
</tr>
<tr>
<td>Employee</td>
</tr>
<tr>
<td>2. Employee wants to stop training:</td>
</tr>
<tr>
<td>i) Employee can press the return button to stop training and return to the Course Selection Page</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID: 1.3 AR object display</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preconditions:</strong></td>
</tr>
<tr>
<td>Employee has signed his/her account</td>
</tr>
<tr>
<td>Employee has selected a training course</td>
</tr>
<tr>
<td>Employee has arrived the checkpoint</td>
</tr>
<tr>
<td><strong>Postconditions:</strong></td>
</tr>
<tr>
<td>The relative AR object linked to the real image has been saved in the database</td>
</tr>
<tr>
<td><strong>Normal Flow:</strong></td>
</tr>
<tr>
<td>Employee</td>
</tr>
<tr>
<td>1. Employee navigates the Map Routing Page</td>
</tr>
<tr>
<td>2. Employee arrives at the checkpoint</td>
</tr>
<tr>
<td>3. Employee presses the searching button and the system will show the camera screen</td>
</tr>
<tr>
<td>4. Employee can search for the AR object</td>
</tr>
<tr>
<td>5. The AR object relative to property management problems will appear on top of a special image</td>
</tr>
<tr>
<td>6. Employee can press the AR object</td>
</tr>
</tbody>
</table>
### Alternative Flows:

**Employee**

1. Employee wants to stop training:
   - i) Employee can press the return button to stop training and return to the Course Selection Page

### ID: 1.4 Q&A functions

#### Preconditions:
- Employee has signed his/her account
- Employee has selected a training course
- Employee has arrived the checkpoint
- Employee has pressed on the AR object

#### Postconditions:
The Q&A question bank has been saved in the database

#### Normal Flow:
- **Employee**
  1. Employee presses the AR object
  2. A property management question relative the AR object will appear for the employees to answer
  3. Employee finish the training courses after he/she has finished answering all questions

#### Alternative Flows:
- **Employee**
  1. Employee wants to stop training:
     - i) Employee can press the return button to stop training and return to the Course Selection Page
  3. Employee answer the question incorrectly
     - i). The system will return to the question that employee answers wrongly for he/she to answer it again until he/she answers correctly
Brief Use Cases

Use Case 2: Register Member Account

Main Success Scenario
1. Guest registers a new Member account.
2. The System presents the Member Registration Form.
3. Guest fills in the form.
4. Guest submits the form.
5. The System undergoes data validation.
6. Guest is redirected to Main Page, registered as Member and signed in.

Use Case 3: Sign in/Out

Main Success Scenario

Sign In
1. Member/Administrator proceeds to sign in.
2. The System presents the Sign in Form.
3. Member/Administrator fills in username and password.
4. Member/Administrator confirms the username and password.
5. The System undergoes data validation.
6. The System displays the Main Page for Member/Administrator.

Sign Out
1. Member/Administrator proceeds to sign out.
2. The System represents the main page of the System.

Use Case 4: Manage Training Courses

Main Success Scenario
1. Administrator proceeds to Managing Training Courses Page.
2. The System presents the current training courses lists.
3. The System will display the statistics of specific training courses after the administrator has clicked into one of it.
4. Administrator can perform changes to the training courses, for example, open the course, close the course or delete the course.

Use Case 5: Edit Member Profile

Main Success Scenario
1. Member proceeds to the Profile Page.
2. The System presents existing account information in the editable form.
3. Member performs changes to the form and submits the changes.

Use Case 6: Forget Password
Main Success Scenario
1. Member proceeds to the Forget Password Page.
2. Member is prompted to fill in the email address associated and submits the form.
3. The System presents notification page to proceed changing Password with the email sent. Member/Administrator receives an email at the registered email address containing a token to reset the Password on the System.
4. Member clicks on the URL token.
5. Member fills in the new Password and Re-enter Password entries.
6. The System presents confirmation page that Password is successfully changed.

Use Case 7: Message to the Company
Main Success Scenario
Send Message to Company by using Contact function
Member:
1. Member browses to Contact page
2. Member writes a message
3. Member sends the message to the company
Read Message
Administrator:
1. Administrator browse to Messages page
2. System displays all read and unread messages
User Case Diagram

Register Member Account

- Fill in Registration form
- Submit Registration form
- Account Confirmation

Guest
Sign in/out

Edit Member Profile
Forget Password

Message to the Company
Technical Details

AR Engine

In this project, Vuforia will be used as the AR engine for development. It has the same capabilities that ARKit and ARCore have, as well as their own new features, for example VISLAM for markerless AR experience.

The Vuforia Fusion has solved the fragmentation in AR development, for example, sensors and cameras. The engine will handle the basic functionality for you and there is not extra work to handle the syntax part.
License Key for the AR app development

When an AR app is utilizing Vuforia to develop, it needs a license key. A license key can only be used in a single project. A unique license key is needed to be created for each Vuforia Engine project, though you can use the same license key for all OS versions of the project.

After I have created a license key, the Device, VuMark, and Cloud Databases functions can be applied in the project by using the Vuforia Target Manager.

The following picture is the license key of this project

The following image shows that key added into the project
Images recognized by the AR object display function

By using Vuforia, you can add an image you wish the camera recognized for you to implement the AR displaying function. There are different types for you to choose, but this time we are going to implement recognizing a single image for this project.
After an image is added into the database, it is stored for implementing the AR object display functions.

The System will rank the capability of the image that is uploaded. A simple image with high resolution gains a higher ranking.

<table>
<thead>
<tr>
<th>Target Name</th>
<th>Type</th>
<th>Rating</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Single Image</td>
<td>5⭐️⭐️⭐️⭐️⭐️</td>
<td>Active</td>
</tr>
<tr>
<td>2</td>
<td>Single Image</td>
<td>4⭐️⭐️⭐️⭐️⭐️</td>
<td>Active</td>
</tr>
<tr>
<td>1</td>
<td>Single Image</td>
<td>3⭐️⭐️⭐️⭐️⭐️</td>
<td>Active</td>
</tr>
</tbody>
</table>

After the image has been added, the number of images used shall be changed according to the numbers of image uploaded. Otherwise, the system can’t choose the images for the AR display functions.
Details of AR Employee Training Courses

Login Page

Employees and Administrators can type their username and password in the login page in order to sign-in to the system.

For employees, they can choose the training courses according to their needs. In this stage, there are only three training courses in this stage, which are dealing with water leakage matter, rubbish in the back stairs matter and the mouse hygiene matter.

任務 1: 處理上下層滲水問題
任務 2: 處理後樓梯垃圾問題
任務 3: 處理老鼠問題
After they have chosen the specific training courses, there will be a map telling the employees where the checkpoints are.

When they arrive at the checkpoint, they can turn on the camera in the app and find the specific image in an A4 paper. When they find the specific A4 paper, they can find an AR object upon the specific paper, which the AR object will be related to the property management matter for the employees to solve.
After the employee has clicked on the AR object, it will proceed to the Q&A section. The employee needs to answer the question with the correct answer. If the employee chooses a wrong answer, the question bank includes the explanation why the wrong answer is not correct. Thus, the system will return to the question that the employee answers wrongly and let him/her to choose again until the correct answer is chosen.

What should you do

- stay int the store and call 9-1-1
- stay int the store and call 9-1-1
- stay int the store and call 9-1-1
- stay int the store and call 9-1-1

After the employee has answered all the question of the training courses correctly, he/she will finish the training course and return to the Course Selection Page.
Experiments and Results

Test Strategy

1. Conformance-directed testing
   The aim of conformance-directed testing is to establish conformance to requirements or specification. Typical data will be designed as test cases and check whether the result is matching the requirements and features, as well as the degree of satisfaction. This approach will rely on a non-specific fault model.

2. Fault-directed testing
   Fault-directed testing seeks to reveal implementation faults inside the system. A specific fault model will be designed to select points from input space that will be used to probe for faults.

3. User Acceptance Testing
   User acceptance testing (UAT) will be performed in the last phase of the system testing process. During UAT, actual customers will be invited to use the system to make sure it can handle required tasks in realistic scenarios, according to requirement specifications.
Exploratory Test

Purpose
Exploratory test is mainly used to explore the user interface and correctness of information displayed. By standing on users’ perspective without knowledge of coding of the system, we may able to figure out the blind spots that are not discovered during the system development process and hence develops improvements.

I had complied 6 time of tests for Exploratory Test in total which are distributed according to the requirements in different phrases. In conclusion, Exploratory Test helps to strengthen the reliability by identifying opportunities, bugs and issues for each test case.

Opportunity
Beautify the User Interface
- Adopt aesthetic template on internet
- Adopt responsive design according to screen size
- Choose a theme color for whole website and justify the background color of pages about information
- The alignment of content in registration form and login can be managed better

Enhancement/Complement for System Functions
- Show reminder for which data is missed

Enhance the Information Provided to Users
- Provide more photos as reference for users

Bugs
User Interface Distortion
- The menu bar on top may cover the content or be hard to see due to the background under some situations.
- The position of page will change when the page is arrived by scrolling up or down.

Wrong Link or Information Displayed
- No page will be directed when “Learn More” button is pressed
- The position in map is not precise enough
Issues
User Interface Arrangement
- The resolution of photos chosen for display is too low
- The 3D object may change the screen size

Maintenance Concerns
- The map details in map routing page are hard coded. The maintenance may be difficult for changing the details.

Unit Test

Purpose
Unit Test is carried out to make sure the reliability and performance of the functions of the system. A set of Inputs is fed to validate the output from the system.

Method
During elaboration 2 stage to construction stage, unit test is performed manually according to test cases. Each test case is probing one unit of the system which represent a use case. The test focuses on major use cases including AR object displaying function, Q&A function, account management. Following the flow stated in the test case, we would compare the output with the expected result after inputting test data so as to determine whether the case is passed or failed and seek for defects in the system. To ensure acceptable level of reliability and performance, we would look for 100% of pass rates of all test cases over the project period.
Results

AR Training Courses (Employee)

<table>
<thead>
<tr>
<th>Unit:</th>
<th>Course Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Bug(s):</td>
<td>1. The courses image uploaded can’t display in the Course Selection Page</td>
</tr>
<tr>
<td></td>
<td>2. The description of each courses can’t be displayed in the message box</td>
</tr>
<tr>
<td>Pass Rate after Construction Stage:</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit:</th>
<th>Map Routing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Bug(s):</td>
<td>1. The map image uploaded can’t display in the Course Selection Page</td>
</tr>
<tr>
<td></td>
<td>2. The checkpoint can’t be displayed clearly on the map</td>
</tr>
<tr>
<td>Pass Rate after Construction Stage:</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit:</th>
<th>AR object display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Bug(s):</td>
<td>1. The camera did not respond to implement the AR object display functions if the room lights are too dark</td>
</tr>
<tr>
<td></td>
<td>2. The image printed is not high resolution enough for the camera to recognize the image and display the AR objects</td>
</tr>
<tr>
<td>Pass Rate after Construction Stage:</td>
<td>100%</td>
</tr>
<tr>
<td>Unit:</td>
<td>Q&amp;A functions</td>
</tr>
<tr>
<td>-------</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| Significant Bug(s): | 1. There is an infinite loop of a question  
2. The message box of the question is not large enough to hold all the words in the question |
| Pass Rate after Construction Stage: | 100% |
User Acceptance Test (UAT)

Purpose

The User Acceptance Test (UAT) is performed to ensure the usability of the system. It focuses on evaluation of ease of use by understanding the experience and reflection of the end users when they try on the system.

Method

A survey is performed to gather information from the end users. HKU students are invited to rank the level of ease of use of the AR system after performing functions on the app such as AR object functions, Q&A functions and account management. I have successfully made survey on 30 users from 2 to 10 April 2018.

Results

Generally, testers do not feel difficult in using the app. There are 54%, 71% and 52% users find it easy to use the AR object functions, Q&A functions and account management respectively. 60% and 53% testers think it is easy to use other function like viewing information and the routing functions.

There are five factors to determine the ease of performing functions, including learnability, efficiency, memorability, errors & error frequency and satisfaction. To understand which the main criteria from the user perspectives is, I asked them to rank the importance of the five factors when they are deciding how easy to perform functions. From the results, users regard the learnability and efficiency as the most important factors to use the website easily, which are 52% in total. Generally, the ease of use of the website is ensured by the positive results from the survey in terms of learnability, efficiency as well as error and error frequency.

Moreover, some feedback from testers is collected for the system improvement. Some users commented on confusing user interface like the similar outlooks of purchase order and repair order on same order page. Some testers also suggested that more
instructions or hints for the important fields can be provided before registering an account. Overall, nearly 60% testers are satisfied with the AR system.
## Risk Management

<table>
<thead>
<tr>
<th>Risk ID and Name</th>
<th>Description</th>
<th>Mitigation Strategy</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>[RISK-1] Documentation error</td>
<td>There may be possibility of documentation error to lead misunderstanding, as a result of deviation or even failure of the project. Owing to inexperience, the risk of documentation error may increase.</td>
<td>During the development process, I will practice on documentation skills by reading online resources and reviewing the documentation periodically so as to minimize the risk.</td>
<td>3</td>
</tr>
<tr>
<td>[RISK-2] New technologies adopted for the product</td>
<td>The AR developing platform will be implemented through Vuforia. I did not have any experience of developing AR platforms ever. Thus, I need much more time to study and get familiar with the developing platform and library to build the feature. This will hinder the development process in the construction stage.</td>
<td>Studying more in the Internet and watching more lecture video in YouTube to make myself familiarize with AR developing platform (Vuforia).</td>
<td>8</td>
</tr>
</tbody>
</table>
| [RISK-3] User and functional requirements | It is sophisticated to satisfy every requirement in the early development process. The user and functional requirements may also change over time as some may not be clearly stated in the...
beginning. These may lead to failure to fulfil all the requirements.

<table>
<thead>
<tr>
<th>Mitigation Strategy</th>
<th>Selecting a development tools that I am familiar with. Meanwhile, I will arrange regular meetings with professors to ask for recommendations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude</td>
<td>5</td>
</tr>
</tbody>
</table>
Conclusion and Future Works

Conclusion on the development progress of the project

There are lots of obstacles on developing such an AR project. It is hard to adopt a new app development programming language within few months. The technical risks of doing an app development project should be considered carefully before the start of construction stage.

Although this AR project is not a software development project with clients that change their requirement frequently, the function details and the demonstration method of such functions change frequently too. Due to the difficulties of developing some functions, some of them has been amended and some of them has changed the demonstration method. However, this kind of obstacles can’t easy to notify before the development process started. Therefore, these matters are easily to be eliminated. An alternative way to reduce these kinds of situations is to develop the project with a platform that you are familiar with. It is easier to solve the problems and find a solution when you are developing with a platform that you always use it.
Conclusion on the completeness of the project

To achieve a completeness of the AR employee training project, the main AR function has been completely developed. Despite the fact that the functions details and the demonstration method of the AR main function of this project has been changed many times, the AR function really helps with doing the employee training and create a better environment for employees to learn the training materials.

At the end, I have chosen the way of displaying the AR object by recognizing a real image, and the AR object will display on top of it. I finally choose this approach because of keeping the training materials more inspiring. By requiring the employee patrolling with the route designed and arrive at the checkpoints, employee can have a clearer memory on the patrolling route and will train up their mind on looking around to find out whether there is a matter happened. By displaying an AR object in a proper place, it can simulate a more realistic situation for the employees to deal with. Moreover, it can train employees on noticing the same kind of matters in similar places afterwards.

Some of the side functions, for example, message the corporation and communicate with the IT support department is not developed in this stage. These kind of side functions can be developed afterwards. During this stage, the main AR functions will be developed with the highest priority to fulfill the main requirement of the AR training project.
# Project Schedule and Milestones

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Stage</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep2018 – Oct2018</td>
<td>Planning</td>
<td>Detailed project plan&lt;br&gt;Project Webpage</td>
</tr>
<tr>
<td>Nov2018</td>
<td>Researching</td>
<td>Confirmation of customer service training materials</td>
</tr>
<tr>
<td>Dec2018</td>
<td>Designing</td>
<td>User Interface Design&lt;br&gt;Graphic Design</td>
</tr>
<tr>
<td>Jan2019 – Apr2019</td>
<td>Construction</td>
<td>Alpha version worked in smartphone devices</td>
</tr>
<tr>
<td>May2019</td>
<td>Testing and Debugging</td>
<td>Beta version of the project</td>
</tr>
</tbody>
</table>

![Project Schedule Diagram]

**Diagram:**

- Planning
- Researching
- Designing
- Construction
- Testing and Debugging
**Constraints and Limitations**

**Inadequacy of Human Resources**

The project duration is short, but the project scope is rather large and complicated implementation is required for the system operation. With only 6 team members, it results to tight schedule and heavy workload for members.

**Insufficiency of System Security**

The current version of Wing Woo Sail Maker System includes several measures to maintain the system security and data security, such as user authentication, database access level and data validation. Comparing to our ideal system, it should be complemented with antivirus firewall, private networking (e.g. VPN) and service auditing for better supervision and protection of our system. However, without sufficient time and technology, we are not able to perform ideal security features.

**Lack of Fraud Tolerance System**

Similar to the reason of lack of resources and time, we are not able to design a fraud tolerance system for supporting our system. It means that we are unable to comply automatic recovery, such as simply roll-back recovery. In addition, there are possible ignorance of defects as no logs of system actions are recorded.
Future Works
For the future development, the remain side functions can be developed. After that, there are some comments from the testers of the functions that users may want for the system. Some of the ideas and comments will be treated inside the future plan of the project.

| Different Language Version of the App | • Favor different customers’ need  
• Facilitate the elder employees to use the app |
|-------------------------------------|-----------------------------------------------------------------------------------|
| Online technology Service           | • Provide employees support so they could contact the IT supporting department directly  
• Provide more convenient and faster reply than using email |

Maintenance concern of the project

| Technical Support Button | • Provide technical support for Employees  
• Report bugs found by Employees  
• Contact maintenance team directly for more immediate bug fixing |
|--------------------------|---------------------------------------------------------------------|
| Back-up Server Support   | • Store the log  
• Disaster recovery  
• Ensure the System can run normally even one of the servers is malfunction |
References

