



北京邮电大学



Queen Mary
University of London

Undergraduate Project Report 2021/21

Proof of concept application of Augmented Reality Unity AR Foundation Software

Name:	Ruixue Cao
School:	International School
Class:	2017215112
QM Student No.:	171048380
BUPT Student No.:	2017212923
Programme:	e-Commerce Engineering with Law

Date: 07-04-2021

Table of Contents

Abstract.....	3
Chapter 1: Introduction.....	5
1.1 Overview.....	5
1.1.1 Concept of AR.....	5
1.1.2 About the change in my project.....	5
1.1.3 My project v.s. Other’s.....	5
1.1.4 Significance of my project.....	6
1.2 Objectives.....	6
1.2.1 Project objectives overview.....	6
1.2.2 Detailed Objectives.....	7
1.3 Main Tasks.....	8
1.4 Workplan.....	8
Chapter 2: Background.....	10
2.1 Augmented Reality.....	10
2.1.1 AR v.s. VR v.s. MR.....	10
2.2 AR Technology.....	10
2.2.1 Introduction of AR Foundation.....	10
2.2.2 Introduction of Vuforia.....	11
2.2.3 Introduction of EasyAR.....	11
2.2.4 The significance of select the most suitable AR technology.....	12
2.3 Detailed Introduction of AR Foundation.....	12
2.3.1 AR Foundation’s architecture.....	12
2.3.2 AR Core.....	13
2.3.3 AR Kit.....	13
2.3.4 Roadmap of building an Application in both platform (IOS&Android).....	14
2.3.5 Introduction of Advanced packages.....	14
2.4 Unity3D Engine.....	14
2.4.1 Introduction of the developing scheme(Unity3D+AR Foundation).....	14
2.4.2 Other schemes for building AR Applications.....	15
2.4.3 The reason for choosing “Unity3D+ AR Foundation” to build applications.....	15
2.5 Other Technologies that I use.....	15
2.5.1 Blender.....	15
2.5.2 Adobe Illustrator.....	15
Chapter 3: Design and Implementation.....	16
3.1 Design part.....	16
3.1.1 Design of comparative tests.....	16
3.1.2 Design of the application.....	17
3.2 Implementation part.....	18
3.2.1 Build and Development.....	18
3.2.2 Testing.....	19
Chapter 4: Results and Discussion.....	21
4.1 Application part.....	21
4.2 Testing part.....	31
4.2.1 Version Testing.....	31

Proof of concept application of Augmented Reality Unity AR Foundation Software

4.2.2 Device Testing..... 31

4.2.3 Problems Record..... 31

4.2.4 Assessment of AR Foundation..... 36

4.2.5 Discussion of testing results..... 36

Chapter 5: Conclusion and Further Work..... 38

References..... 39

Acknowledgement..... 40

Appendix..... 41

Risk and environmental impact assessment..... 64

Abstract

Since the worldwide situation due to the COVID-19 pandemic COVID-19 prevents the student to travel and have the project in mobility, the objectives of this project (originally "Improvement of an Augmented Reality Mobile Application for Open Air Museum") have been modified in order to have a project that can be developed remotely. My new project is a proof of concept.

Here are main objectives:

- ✓ **To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software.**
- ✓ **To test the following capabilities of Unity AR Foundation**
- ✓ **To develop in Blender the model and the animation for AR event.**
- ✓ **To compile the application for both Android and IOS and to describe the whole process to take it to the market in both platforms.**

My project is not only to complete the development of related AR applications, but also to explore whether this AR technology is suitable for promotion, and whether developers will encounter problems in the process of using the tool.

摘要

由于 COVID-19 疫情，我原先的需要实地的项目无法进行，因此修改了原项目的目标（最初是“改进户外博物馆的增强现实移动应用程序”），以便有一个可以远程开发的项目。我的新项目是一种概念的证明。

其主要目标如下：

- 使用 Unity AR Foundation 软件开发增强现实的概念验证应用程序
- 测试 Unity AR Foundation 的基本功能
- 在 Blender 中开发 AR 事件的模型和动画。
- 为 Android 和 IOS 编译应用程序。

我的项目不仅仅是完成相关 AR 应用的开发，更是探索这种 AR 技术是否足够成熟适合推广，以及开发人员在使用该工具的过程中会遇到哪些问题，为 AR 技术的未来探索更多可能。

Chapter 1: Introduction

1.1 Overview

In this section, I will include AR's concept and what is my what is my previous project, why I must change my project(due to the impact of the COVID-19) and what my new project is, how it is different from previous one and other peoples', last, my project's significance.

1.1.1 Concept of AR

AR (Augmented Reality) is becoming more and more common in our daily life. Now when people go to museums, they will find that there is always a QR code beside each exhibit. Tourists can scan and watch AR guide explanation, which is interesting and convenient. With the popularization of AR, people have a vague understanding of AR, so from the strict technical definition, what is augmented reality?

Augmented reality(AR) is an interactive experience of a realworld environment. Computer generated enhances objects in the real world virtual objects, and sometimes across multiple sensory modalities. Augmented reality could be defined as a system which has the following three basic features:

- A combination of real and virtual worlds
- Realtime interaction
- Accurate 3D registration of virtual and real objects

1.1.2 About the change in my project

Since the worldwide situation due to the COVID-19 pandemic, COVID-19 prevents the student to travel and have the project in mobility, the objectives of this project (originally "Improvement of an Augmented Reality Mobile Application for Open Air Museum") have been modified in order to have a project that can be developed remotely.

1.1.3 My project v.s. Other's

AR Foundation allows people to work with augmented reality platforms in a multi-platform way within Unity. This package presents an interface for Unity developers to use, but doesn't implement any AR features itself.

There are many differences between my project and previous project: My project is not a version of changing previous sculpture models into something else instead, but to test whether AR foundation could be used to build Augmented Reality applications and compare the existing AR technologies(such as Vuforia). I will no longer use Vuforia to develop AR events, but use AR foundation software instead.of Vuforia, which is a usually used one to build air projects in China and is a simple but much more stable than AR foundation.

For me, I used AR foundation, and tested this relative new technology to find out the compatibility and stability along with lots of functions that Vuforia cannot achieve, and try to find out whether this technology could be applied in all type of AR Applications, whether it has been mature enough for widely promotion.

1.1.4 Significance of my project

AR (augmented reality) is becoming more and more common in our daily life. Now when people go to museums, they will find that there is always a QR code beside each exhibit. Tourists can scan and watch AR guide explanation, which is interesting and convenient. In order to better promote AR technology, a good AR development technology should be mature enough, suitable for the mass mobile terminal, and stable enough in use. My project has carried out a number of development and testing for the current latest technology AR foundation, and will finally get a conclusion on whether the technology can be promoted and applied to multiple scenarios.

1.2 Objectives

1.2.1 Project objectives overview

Since it is going to be a proof of concept, we are not going to use a real environment as a museum or a public place, so I will do all the work at my home with the elements I have at home.

- ✓ To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software.
- ✓ To test the following capabilities of Unity AR Foundation
- ✓ To develop in Blender the model and the animation for AR event.
- ✓ To compile the application for Android and to describe the whole process to take it to the market in Android platforms.

1.2.2 Detailed Objectives

1) Recognition

a) Object Recognition

1. Using two different objects:

- 1) A simpler object, as a cube, a cup, a ball, something that can be easily recognized.
- 2) A complex object like a toy or a little sculpture that have different sides, textures, colors etc.

2. Assessing object recognition with different lights, at least with 3 different kinds of light and shadows.

b) Mark (VuMark and QR) recognition

c) Floor/Plane recognition

Using two kinds of floor:

- 1) One completely plane, single solid colour
- 2) One with a pattern

d) Image recognition

Using also two images:

- 1) One with glossy paper very brilliant colors, golden or silver parts
- 2) One with plane colors, no gloss, no bright

2) AR events:

a) Video

I could choose any available video or audio.

b) Audio

c) Model

I will have to develop a model in blender, something to show when the AR event is triggered. The model should have also texture in its sides. A nice model could be a modern art sculpture for example, that can be built from simple forms (cubes, cylinders, pyramids, etc.) and added colors and textures.

d) Animation

I could animate whatever model I want, a butterfly flying, for example, the sun rising, etc.

e) Buttons or any other way for interaction to switch from one event to other in the same object

1.3 Main Tasks

➤ **Familiarization with Augmented Reality using Unity AR Foundation Software.**

Basically learn knowledge about AR foundation’s capabilities from Vuforia tutorials and Unity web, and follow the tutorial to do some small independent test demo.

➤ **To develop the proof of concept application.**

To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software. To compile the application for both Android and IOS and to describe the whole process to take it to the market in both platforms.

➤ **To test the functionality for several AR recognition features, with several AR events To develop in Blender the model and the animation for AR event.**

➤ **To summarize the results into meaningful set of publishable paper (Journal and/or Conference)**

Summarize all outcomes (must be tangible outputs such as software and simulation) and write down all the documents such as user manuals,etc, and then deliver the final report.

1.4 Workplan

	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-29	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30
Task 1. [Familiarization with Augmented Reality using Unity AR Foundation Software]												
Testing object recognition	X	X										
Testing Mark(VuMark and QR code) recognition	X	X	X									
Testing Floor/plane recognition			X	X	X							
Testing image recognition			X	X	X							
Task 2. [To develop the proof of concept application]												
To develop in Blender the model and the animation for AR event.			X	X	X							

To compile the application for Android				X	X	X	X	X	X				
To compile the application for IOS									X	X			
To describe the whole process and take it to the market in both platforms.				X	X	X	X	X	X	X			
Task 3. [To test the functionality for several AR recognition features, with several AR events]													
Testing AR events (video)								X	X				
Testing AR events (audio)								X	X				
Testing AR events(model)									X	X			
Testing AR events (animation, any other way for interaction)									X	X			
Task 4. [To summarize the results into meaningful set of publishable paper (Journal and/or Conference)]													
Summarizing all works done		X	X	X	X	X	X	X	X	X			
Minor improvement and bug fix								X	X	X	X		
Composing the thesis										X	X	X	
Checking the thesis											X	X	X

Chapter 2: Background

In this section, I will introduce AR and AR technology, AR Foundation and Unity3D engine, as well as other technologies I use.

2.1 Augmented Reality

2.1.1 AR v.s. VR v.s. MR

Virtual reality (or VR), augmented reality (or AR) and mediated reality (or MR) are not technologies but concepts. VR is pure virtual digital picture, mixed reality including AR is virtual digital picture + naked eye reality, Mr is digital reality + virtual digital picture.

Usually, the overlaid information could be constructive or destructive. The experience is seamlessly integrated with the physical world so that this could be perceived as an immersive aspect of the real environment.(Wikipedia contributors 2021a) That is to say, comparing with the wellknown virtual reality, which usually provides an immersive experience with a simulated space to users augmented reality alters one's ongoing perception of a realworld environment.

Unlike VR's immersive experience, AR improves the visual and interactive experience by adding some virtual elements to the real world, while the traditional AR usually observes the real world through the hardware camera, so the earliest AR may be realized by turning on the camera through the mobile phone, and then adding some 3D or 2D visual elements to the screen.

With the development of mobile devices, including mobile phones and smart eyewear, augmented reality technology becomes more and more reachable during these days. Augmented Reality could be easily achieved on the majority of smartphones.

2.2 AR Technology

2.2.1 Intoduction of AR Foundation

AR Foudation is a unified platform for developing all kinds of AR applications. This architecture can accommodate all kinds of underlying SDKs and support the addition of other underlying AR SDKs at present and in the future.

Developers no longer need to care about how to use the SDK for IOS platform and how to use

Proof of concept application of Augmented Reality Unity AR Foundation Software

Android platform. AR Foundation makes a package of them. In this way, people only need to pay attention to the AR application development itself, and its bottom layer will judge by itself and call the corresponding API according to different platforms.

At present, AR Foundation mainly supports the following functions:

	ARCore	ARKit	Magic Leap	HoloLens
Device tracking	✓	✓	✓	✓
Plane tracking	✓	✓	✓	
Point clouds	✓	✓		
Anchors	✓	✓	✓	✓
Light estimation	✓	✓		
Environment probes	✓	✓		
Face tracking	✓	✓		
Meshing			✓	✓
2D Image tracking	✓	✓		
Raycast	✓	✓	✓	
Pass-through video	✓	✓		
Session management	✓	✓	✓	✓

(source:<https://docs.unity3d.com/Packages/com.unity.xr.ARFoundation@2.1/manual/index.html>)

2.2.2 Introduction of Vuforia

Vuforia is a crossplatform augmented reality SDK that enables the creation of augmented reality applications. The SDK uses computer vision technology to recognize and track images and 3D objects in realtime. This image registration capability enables developers to position and orient virtual objects, such as 3D models and other media, along with realworld objects, when they are viewed through the camera of a mobile device. The virtual object then tracks the position and orientation of the image in realtime so that the viewer's perspective on the object corresponds with the perspective on the target. It thus appears that the virtual object is a part of the realworld scene.(Wikipedia contributors 2019)

2.2.3 Introduction of EasyAR

EasyAR is the first free full platform AR engine in China.This AR engine has the following features:EasyAR has good cross platform support features, and can support windows, Mac OS, Android, IOS and other platforms.

However, it lacks powerful functions, such as 3D object recognition, cloud recognition, slam, smart glasses and cloud packaging

2.2.4 The significance of select the most suitable AR technology

The biggest problem encountered in this AR engine selection research is the adaptability of devices, especially Android devices. The mainstream AR technology relies on ARCore, and the ARCore relies on mobile phones, which requires Google ARCore. Now quite a number of mobile phones do not support Google ARCore, and the latest advanced mobile phones do not support it. As a result, AR applications based on the mainstream AR Technology cannot be used.

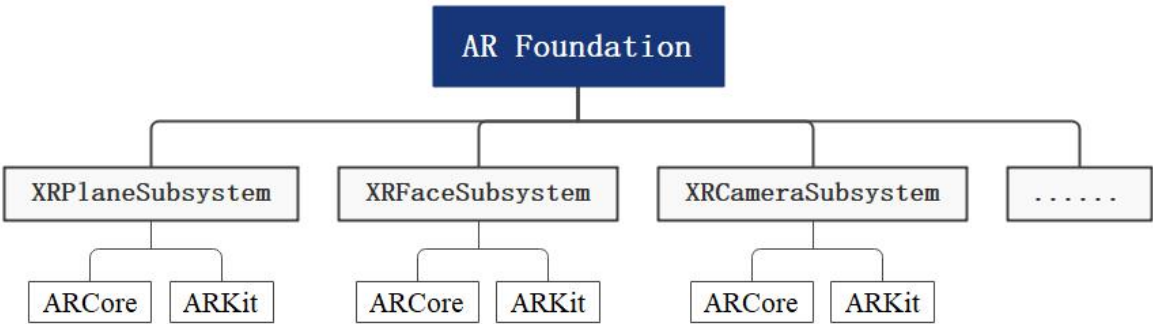
Therefore, it is necessary to choose the most suitable AR engine in development.

2.3 Detailed Introduction of AR Foundation

2.3.1 AR Foundation’s architecture

AR Foudation is built on a series of subsystems. Subsystem handles the implementation of platform specific modules. For example, XRPlanesubsystem is responsible for plane detection and display functions. In addition, it also calls different underlying SDKs automatically according to different platforms. From the perspective of the caller, it only calls the functions of XRPlanesubsystem, regardless of whether the final implementation is based on IOS or Android, that is, it is transparent to the platform.

This architecture provides platform independent functions for the upper layer, and the lower layer can incorporate different underlying SDKs in the future development, so as to achieve the final goal of one-time development and cross platform deployment. The architecture is as follows:



SDK	Description
AR Foudation	AR Foundation integrates the underlying API encapsulation of ARKit and

	ARCore into a unified and open framework, and provides some additional practical functions, such as session lifecycle management, and monobehavior, which is used to show the detected functions in the environment.
Google ARCore SDK for Unity	The SDK provides native APIs for the important AR functions supported by ARCore, and exposes these APIs to Android platform in unity to facilitate developers to call them.
Unity ARKit Plugin	The plug-in is the ARKit unity plug-in developed by unity company, which is used to build ARKit applications in unity. It exposes the ARKit Objective-C API of C # language in unity for developers to call. The plug-in also provides some auxiliary functions, which can make use of the front and back cameras compatible with IOS devices.

2.3.2 AR Core

ARCore is Google’s platform for building augmented reality experiences. Using different APIs, ARCore enables your phone to sense its environment, understand the world, and interact with information. Some of the APIs are available across Android and iOS to enable shared AR experiences.(Google 2021a)

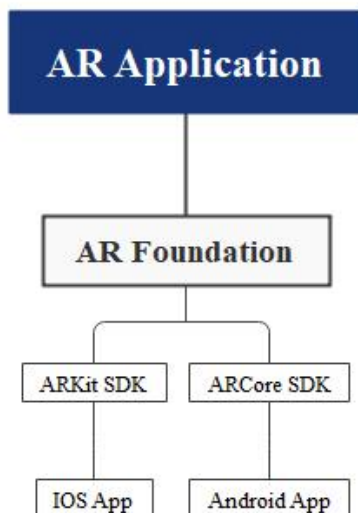
2.3.3 AR Kit

ARKit is the newly introduced Augmented Reality API developed by Apple, used on iPhone/iPad devices. This API is only available to users of devices with Apple A9 and later processors.

The ARKit API provides functionalities like face tracking, image tracking, world tracking, object detection, orientation tracking, positional tracking, and etc.(Apple 2021a)

Comparing with other AR SDK, ARKit could leverage the TrueDepth camera(Apple 2021b) on some of the iOS devices. The TrueDepth camera provides much more accurate face recognition and tracking functionality when compared with traditional cameras. The builtin Animoji(Apple 2021c) is implemented using this feature

2.3.4 Roadmap of building an Application in both platform (IOS&Android)



2.3.5 Introduction of Advanced packages

The goal of AR Foundation is not limited to ARKit and ARCore. Its goal is to build a unified and open AR development platform. Therefore, AR Foundation is likely to incorporate other AR SDKs in the next development to further enrich the AR development environment.

For example, AR is still in preview state: The package serves as unity 2019.3. The toolkit provides a set of components that enable users to quickly and easily build interactive and immersive experiences. Our goal is to implement general augmented reality without coding (AR) And virtual reality (VR) Interaction.

2.4 Unity3D Engine

2.4.1 Introduction of the developing scheme(Unity3D+AR Foundation)

Unity3D is a multi platform integrated game development tool developed by unity technologies, which makes it easy to create interactive content such as 3D video games, building visualization, real-time 3D animation and so on. It is a comprehensive integrated professional game engine.Unity is a crossplatform game engine developed by Unity Technologies. The engine offers a primary scripting API in C#, and provide an easy to use drag and drop functionality. For 3D games, Unity allows specification of texture compression,mipmaps, and resolution settings for each platform that the game engine supports, and provides support for bump mapping, reflection mapping, parallax mapping,

Proof of concept application of Augmented Reality Unity AR Foundation Software

screenspace ambient occlusion (SSAO), dynamic shadows using shadow maps, rendertotexture and fullscreen postprocessing effects.(Wikipedia contributors 2021b)

2.4.2 Other schemes for building AR Applications

Use the native development environment of each platform to develop AR application: the same AR content should be developed separately for different platforms. Even if it's just an AR application for handheld devices, ARCore may be used to build Android devices, ARKit to build IOS devices, and magic leap and hololens also have their own SDKs.

2.4.3 The reason for choosing “Unity3D+ AR Foundation” to build applications

The main reason we chose Unity3D+ AR Foundation is that Unity3D can get augmented reality experience through a more visual method, and can be easily deployed on multiple platforms, which greatly reduces the complexity of development.

The launch of AR foundation implements a mission of unity all the time - to realize "build once, multi platform deployment". With AR foundation, developers don't have to solve the problem of platform differences one by one for each platform.

2.5 Other Technologies that I use

2.5.1 Blender

Blender is a free and open source 3D computer graphics software tool set for making animated movies, visual effects, art, 3D printing models, motion graphics, interactive 3D applications, and computer games. Blender's functions include 3D modeling, UV unfolding, texture, raster graphics editing, manipulation and skinning, fluid and smoke simulation, particle simulation, flexible body simulation, sculpture, animation, matching movement, rendering, motion graphics, video editing and synthesis. (Wikipedia contributor 2021c)

We mainly use blender as a tool to create 3D model.

2.5.2 Adobe Illustrator

Adobe Illustrator is a vector graphics editor developed and sold by adobe. VuMark is a bar code design used by Vuforia. It allows free customization and brand conscious design, while encoding data and targeting as AR. The VuMark design is fully customizable, so you can have a unique VuMark for each individual object. I use this tool to create VuMarks. (Vuforia 2021)

Chapter 3: Design and Implementation

In this part, I will first state the design part, and then state the implementation part. The design part is divided into the design of comparative experiment and the design of application program; the implementation part is divided into two parts: software development and testing.

3.1 Design part

3.1.1 Design of comparative tests

Note that there are many functions that are provided in AR Foundation, I am going to develop and test the most mainstream functions that maybe used in the reality. And the version combination I chose to test is based on the forum’s discussion, they are most commonly used combination or the most stable(LST version) one.

Support Funtionalities		AR Foundation	Vuforia
Recognition	3D Objective Recognition		✓
	2D Objective Tracking	Image Tracking	Multi-model? ✓
		QR Code Tracking	Extract information? ✓
		Plane Recognition	Materials? ✓
	Face recognition	Face mesh	Multi-face? -
		Face pose	At nose -
AR Events	video		
	Audio effect		Loop? Just once?
	animation		
Interactions	buttons		Back?Select?
	User-interaction with objects		Re-shape?

Functions that need to be tested

ARFoudation	ARCore XR plugin	AR Subsystems	ARKit XR plugin	Unity3d	Compile?
4.0.2	4.0.4	4.0.1	4.0.2	2019.3.5f1	Successful
3.13	3.13	3.13	3.13	2019.4.20f (LST)	Successful

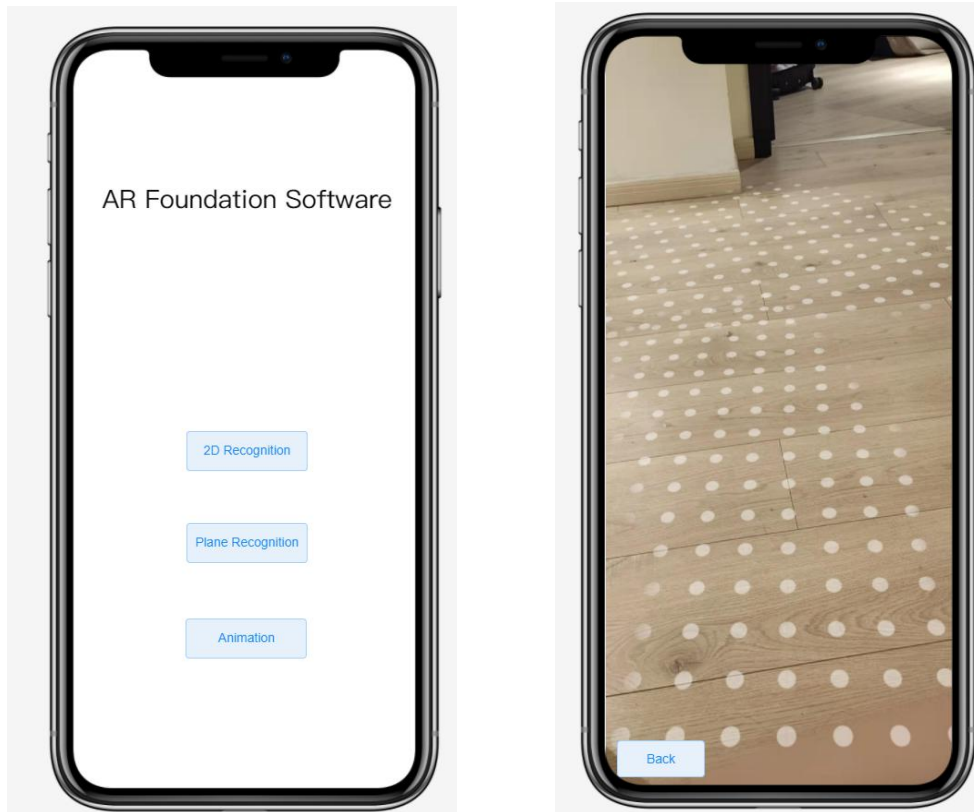
2.1.8	2.1.11	2.1.2	2.1.9	2019.4.0f1	Successful
2.1.16	2.1.16	2.1.16	2.1.16	2019.3.5f1	Successful

The version combination I am going to test

3.1.2 Design of the application

3.1.2.1 UI

- Prototype



- Icon Design

(need to add)

3.1.2.2 Functions design

There are 3 independent standalone applications:

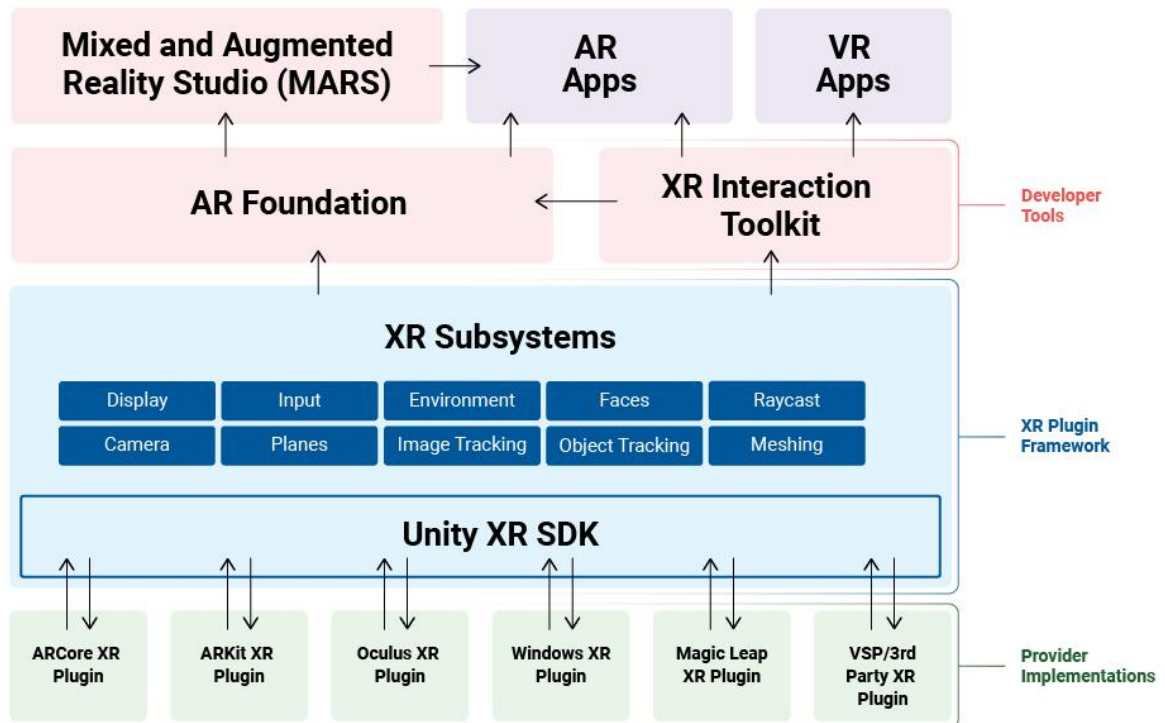
- A. Android Application that all functions are utilizing front camera
- B. Android Application that all functions are utilizing rear camera
- C. IOS Application that can do 3D Object recognition

Note: The reason for building two applications for Android is because of the conflicts between invoking of front camera for face-recognition and rear camera for the other recognition.

3.2 Implementation part

3.2.1 Build and Development

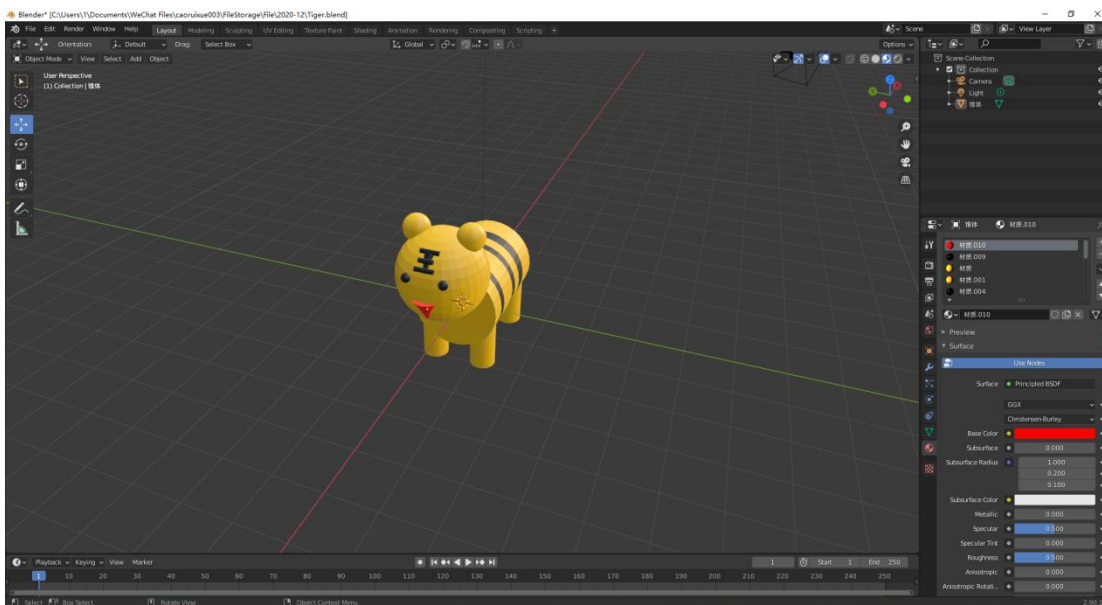
3.2.1.1 Technology Stack of my application



(source:<https://docs.unity3d.com/Manual/XRPluginArchitecture.html>)

3.2.1.2 Model developing

I use blender to build the model. It is an ugly tiger.



3.2.1.3 Functions to implement

- Android Applications
 - IOS Application
- (need to be added)

3.2.2 Testing

For the test part, I plan to carry out equipment test, platform test and version compatibility test. Huawei mate10 and Xiaomi series mobile phones declared by Google's official website (link) are selected as Android terminal test environment. We use iPad air 3 and iPhone 11 to test the IOS environment. The platform test selects multiple versions of Unity3D to develop the same project; the version compatibility test selects multiple versions of Unity3D engine + different versions of AR Foudation to develop.



Huawei devices



Proof of concept application of Augmented Reality Unity AR Foundation Software

Xiaomi device that I use to test


The expected result is that AR Foundation can be perfectly presented on most different mobile phones and mobile terminals, and verify that it is very friendly to developers, and can replace Vuforia and other AR technologies to a certain extent.

Chapter 4: Results and Discussion

4.1 Application part

Here, I list all functions that developed using AR Foundation in details.

1. QR recognition

 ImageQRcode.apk	2021/2/18 2:48	APK 文件	19,671 KB
---	----------------	--------	-----------



If the application recognizes the definite QR Code, it will show the information that QR Code contains on the top of the prefab.

2. 2D Image recognition

If the application recognizes the definite image, it will show a banana model.

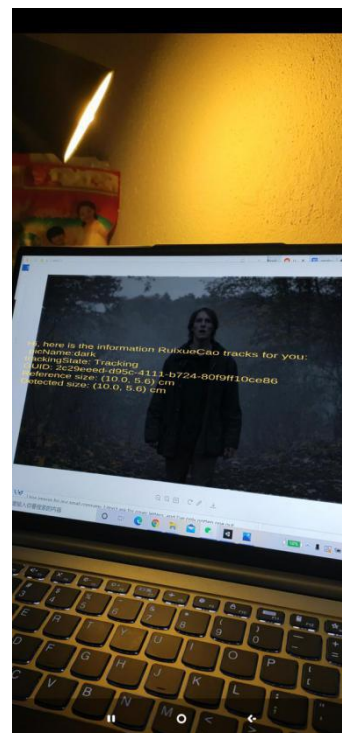
Proof of concept application of Augmented Reality Unity AR Foundation Software



1) One with glossy paper very brilliant colors, golden or silver parts





2) One with plane colors, no gloss, no bright



3. Plane recognition

(more need to be added)

 featheredPlane.apk	2021/2/18 2:53	APK 文件	18,002 KB
 togglePlane.apk	2021/2/18 2:10	APK 文件	18,139 KB

1) One completely plane, single solid colour (Toggle plane detection)

Proof of concept application of Augmented Reality Unity AR Foundation Software



If clicked the button, it will hide the AR plane.

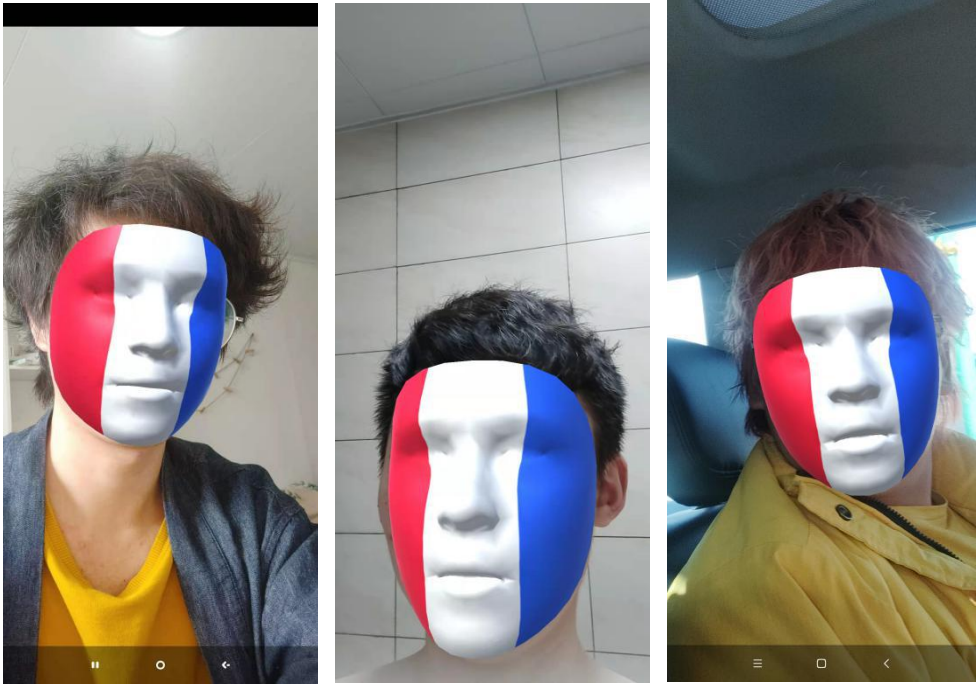
2) One with a pattern



Proof of concept application of Augmented Reality Unity AR Foundation Software

faceMest.apk	2021/2/18 14:56	APK 文件	18,054 KB
facePose.apk	2021/2/18 3:06	APK 文件	18,053 KB

4. Face Mesh



If the application recognizes people’s face, it will show some mask-like mask on the face.

5. Face Pose

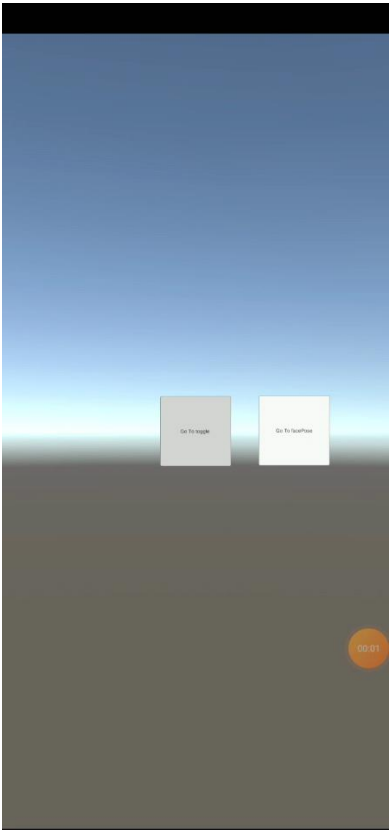


If the application recognizes people’s face, it will show .a coordinate system.

Proof of concept application of Augmented Reality Unity AR Foundation Software

The origin of the coordinate system is located on the nose of the person. With the rotation of the person's head, the coordinate system will rotate accordingly.

6. User-interaction with buttons



A

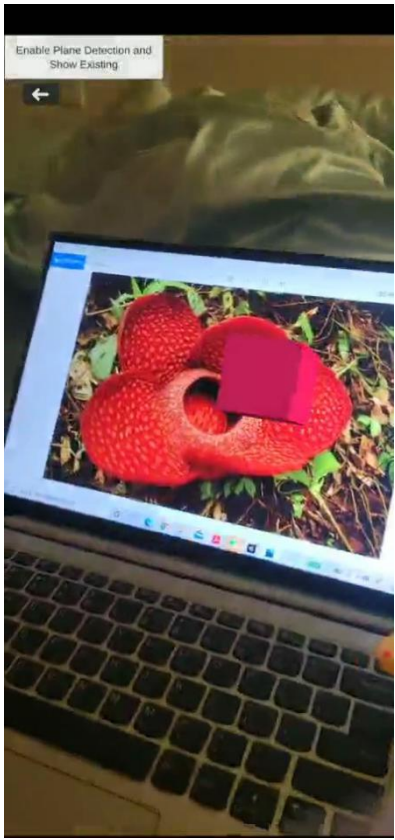


B

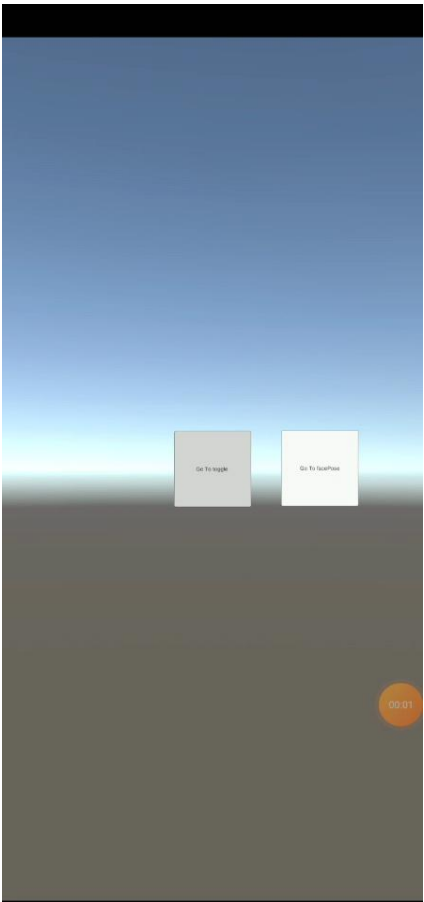
Proof of concept application of Augmented Reality Unity AR Foundation Software



C



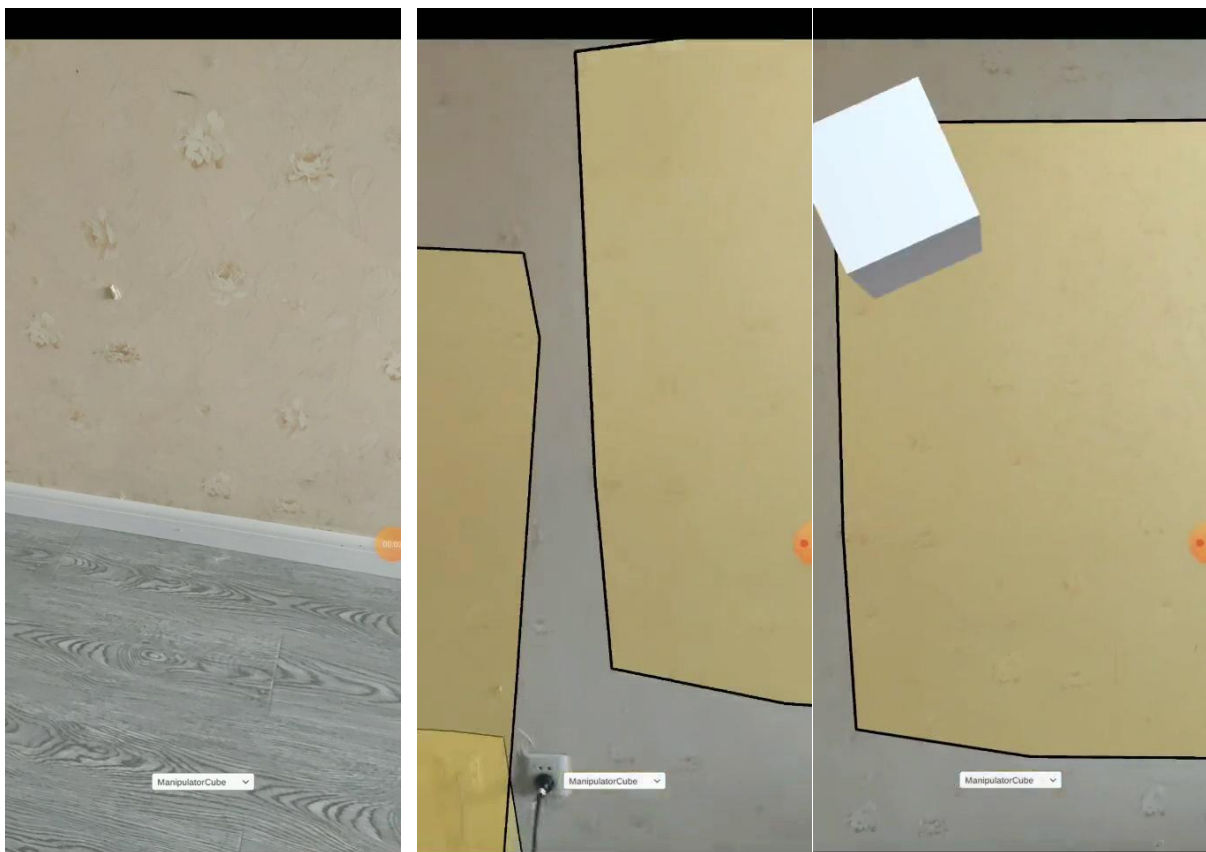
D



E

- 1) User clicks the left button at the homepage(A), then will go to the definite scene(B).
- 2) When recognizing a toggle plane, it will appear the model(a default plane)(B)
- 3) If user clicks the button on the left-top corner of the screen, the plane model will disappear(C)
- 4) If recognize the definite picture(the red flower), it will appear the pink cube on the top of the picture(D)
- 5) User could click back button(at the left-top corner) to go back to the homepage(E)

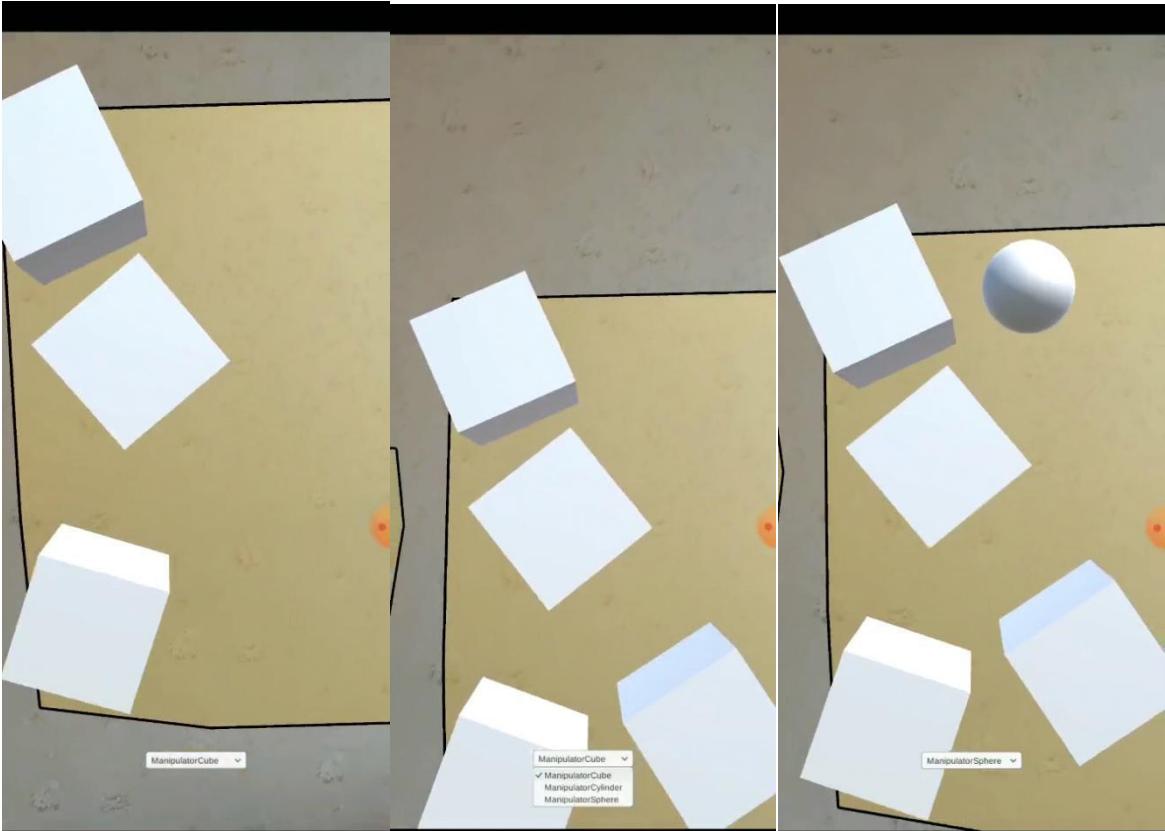
7. User-interaction with models



A

B

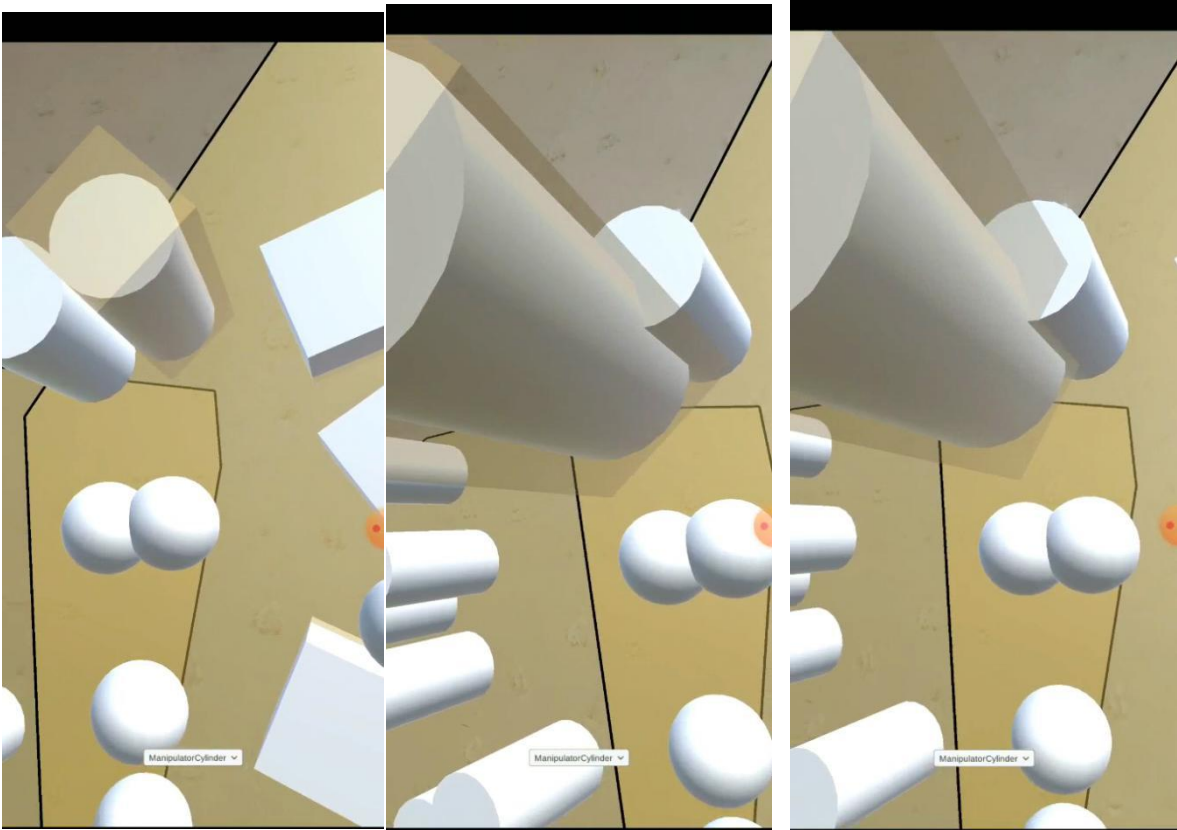
C



D

E

F



G

H

I

Proof of concept application of Augmented Reality Unity AR Foundation Software

- 1) The user opens the application and selects different models (A) from the drop-down menu.
- 2) When the application recognizes a plane, the Yellow plane model preform (B) will appear.
- 3) The user clicks any point on the screen to realize the interactive function of "place model on plane" (C).
- 4) The user can click multiple points to place the object model (D)
- 5) The user can also change the model through the drop-down menu (E), where the cube is replaced by a sphere (F).
- 6) User can click the model that has been placed on the plane at will, and the model enters the selected state (G), and can rotate and zoom in / out the model (H) (I)

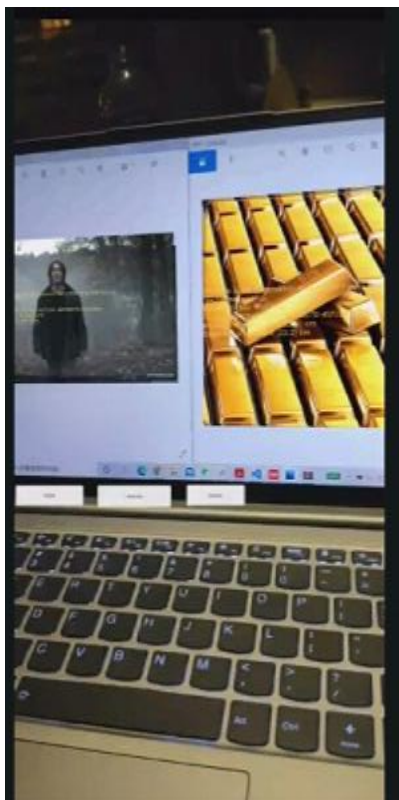
8. User-interaction with models

(need to be added)

9. 3D Object recognition and tracking

(pics need to be added)

10. Multi-image recognition



(More explanation need to be added)

11. For audio and video function, maybe it is not possible to write down to make readers directly understand.

4.2 Testing part

4.2.1 Version Testing

ARFoundati on	ARCore XR plugin	AR Subsystems	ARKit XR plugin	Unity3d	Compile ?	Issue?
4.0.2	4.0.4	4.0.1	4.0.2	2019.3.5f1	Successful	For some projects, it will show: <small>An error occurred while resolving packages: Package com.unity.xr.subsystems@4.0.1 has invalid dependencies: com.unity.subsystemregistration: Resolved version [1.0.5] does not satisfy requested version Package com.unity.xr.management@3.2.10 has invalid dependencies: com.unity.subsystemregistration: Resolved version [1.0.5] does not satisfy requested version</small> Many developers on stackoverflow still facing this problem and Unity's technologists have looked into the problem.
3.13	3.13	3.13	3.13	2019.4.2 of (LST)	Successful	Not discover yet, seems good compatibility A developer on stackoverflow points out this perfect
2.1.8	2.1.11	2.1.2	2.1.9	2019.4.0f1	Successful	Not discover yet, seems good compatibility
2.1.16	2.1.16	2.1.16	2.1.16	2019.3.5f1	Successful	For some projects, it will show: <small>Failed to generate ARCore reference image library 'ReferenceImageLibrary' UnityEngine.GUIUtility:ProcessEvent(Int32, IntPtr)</small>

Implicit requirements: I suppose Android sdk >= 26, (version 24 failed building apks)

4.2.2 Device Testing

(ongoing)

4.2.3 Problems Record

4.2.3.1 Developing

1. Android equipment issue

- See <https://developers.google.com/AR/discover/supported-devices?hl=zh-cn>

All of my family numbers are using HUAWEI 's newest products, and are not supported by ARCore.

So I tested these functionalities with my friend's Xiaomi, in the future I will test with more. Must equipped with Google play Service!

- Users **must** use the compatible equipment both with Android API level and supported equipment.

Proof of concept application of Augmented Reality Unity AR Foundation Software

Android 7.0 or higher

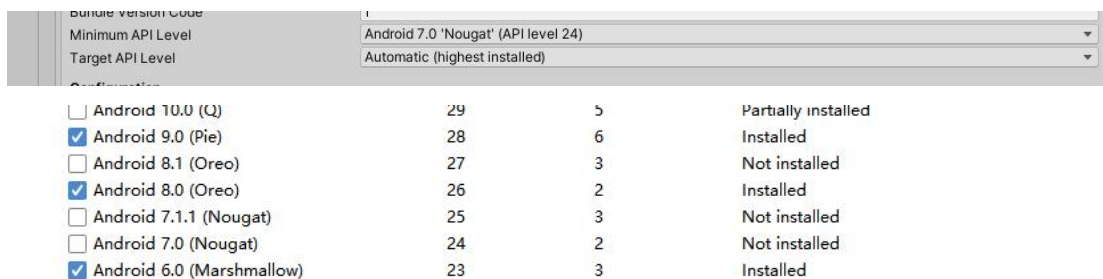
If your application is an AR optional application, please modify the minSdkVersion statement:

minSdkVersion ≥ 14 (API Level 14)

If your application is an AR essential application, please modify the minSdkVersion statement: minSdkVersion ≥ 24 (API Level 24)

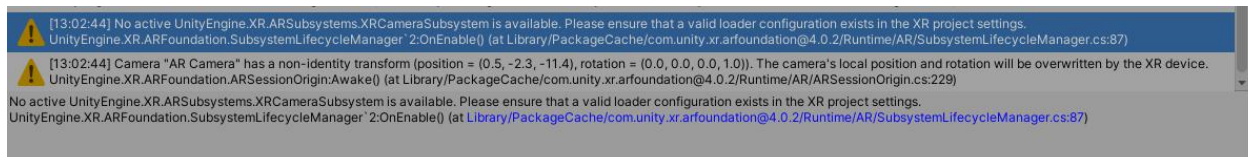
2. Because ARCore only supported by Android 7.0 or higher, I must go to Android Studio (SDK Manager), to download Android 7.0 or higher.

Note: When using Android 10.1 (API level 31), The incompatibility between the too new API version and the old version of unity will cause many bugs when packaging apk.



Bundle version code	Minimum API Level	Target API Level		
	Android 7.0 'Nougat' (API level 24)	Automatic (highest installed)		
<input type="checkbox"/>	Android 10.0 (Q)	29	5	Partially installed
<input checked="" type="checkbox"/>	Android 9.0 (Pie)	28	6	Installed
<input type="checkbox"/>	Android 8.1 (Oreo)	27	3	Not installed
<input checked="" type="checkbox"/>	Android 8.0 (Oreo)	26	2	Installed
<input type="checkbox"/>	Android 7.1.1 (Nougat)	25	3	Not installed
<input type="checkbox"/>	Android 7.0 (Nougat)	24	2	Not installed
<input checked="" type="checkbox"/>	Android 6.0 (Marshmallow)	23	3	Installed

3. When doing projects with image tracking:




Line 87 shows:

```
/// 
/// Creates the <c>TSubsystem</c>.
/// 
/// Stops the <c>TSubsystem</c>.


```

Solution on the Internet:

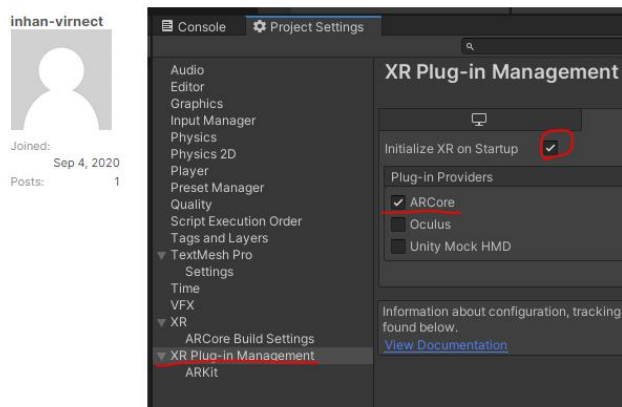
Proof of concept application of Augmented Reality Unity AR Foundation Software

 **tdmowrer** commented on May 22, 2020 Collaborator ...

Well, have you ensured "that a valid loader configuration exists in the XR project settings"? ARFoundation now uses XR Management to decide which provider to use (because there could be multiple options). See <https://docs.unity3d.com/Manual/configuring-project-for-xr.html> for details. Basically just tick the "ARCore" and/or "ARKit" boxes in Project Settings > XR Plugin Management.

 **noppefoxwolf** commented on May 22, 2020 Author ...

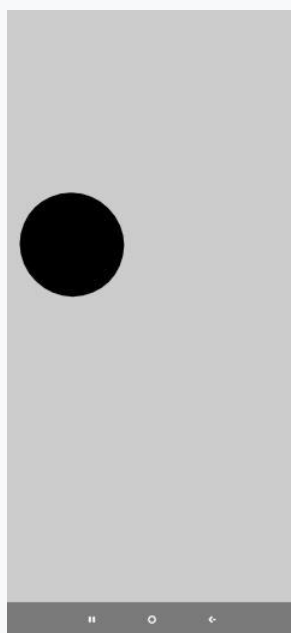
@tdmowrer Thank you very much. I resolved issue.



@timmy2get Thank you! It's working at my android device.

For most of developers, it works; For me, it did not work.

Each time when I run the testing app, it will first show the pic below, then crash.



Here is the log I generated from Android developer mode device debugging application:

Level	Time	PID	TID	Applicati...	Tag	Text
						d_render_to_texture GL_KHR_robustness GL_KHR_robust_bu _EXT_draw_elements_base_vertex GL_OES_draw_elements_ba ted_textures GL_EXT_buffer_storage GL_EXT_external_bui ray GL_EXT_texture_filter_anisotropic
W	02-17 11:05:40.034	26323	29886	?	Unity	No active UnityEngine.XR.ARSubsystems.XRCameraSubsyste ensure that a valid loader configuration exists in the
W	02-17 11:05:40.034	26323	29886	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Lir
W	02-17 11:05:40.035	26323	29886	?	Unity	No active UnityEngine.XR.ARSubsystems.XRImageTracking? Please ensure that a valid loader configuration exists: ings.
W	02-17 11:05:40.035	26323	29886	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Lir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401931): avc: granted (write) tyShaderCache" dev="sdcardfs" ino=665507 scontext=ur: 7,c512,c768 tcontext=u:object_r:sdcardfs:s0 tclass=dir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401932): avc: granted (add_name bf713628390495c6ec745eec555d4a09" scontext=ur:untrust c768 tcontext=u:object_r:sdcardfs:s0 tclass=dir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.194 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = 25, in_flags = 0x100380f out_flags =
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.194 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0x390f out_flags = 0
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401933): avc: granted (create) 713628390495c6ec745eec555d4a09" scontext=ur:untruste 68 tcontext=u:object_r:sdcardfs:s0:c9,c257,c512,c768 t
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.198 26323:29957 D/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	addLayerName, tid:29957
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.199 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0xa0f out_flags = 0x
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.199 26323:29957 D/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	addLayerName, tid:29957
I	02-17 11:14:36.838	29230	32403	?	Unity	d_render_to_texture GL_KHR_robustness GL_KHR_robust_bu _EXT_draw_elements_base_vertex GL_OES_draw_elements_base_vertex GL_EXT_protect ted_textures GL_EXT_buffer_storage GL_EXT_external_buffer GL_EXT_EGL_image_ar ray GL_EXT_texture_filter_anisotropic
I	02-17 11:14:36.838	29230	32403	?	Unity	XRGeneral Settings awakening...
I	02-17 11:14:36.838	29230	32403	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Line: 35)
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	type=1400 audit(0.0:76411448): avc: granted (read) for pid=29230 name="lec4 a48440947bce7fd5fb9efaaffc5f" dev="sdcardfs" ino=1052024 scontext=ur:untrust
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	type=1400 audit(0.0:76411449): avc: granted (read open) for pid=29230 path= "/storage/emulated/0/Android/data/com.aaaa.aaaa/cache/UnityShaderCache/lec4a4 8440947bce7fd5fb9efaaffc5f" dev="sdcardfs" ino=1052024 scontext=ur:untruste _app:s0:c8,c257,c512,c768 tcontext=u:object_r:sdcardfs:s0 tclass=file
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	[02-17 11:14:39.253 29230:32476 I/]
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0x17 out_flags = 0x17

Then I found it may be because of my android equipment's incompatibility of ARCore!

4. BuildFailedException: "ARCore Supported" (Player Settings > XR Settings) refers to the built-in ARCore support in Unity and conflicts with the "ARCore XR Plugin" package....
5. Player setting, Android project, Android API level must be greater than or equal to 24;
6. Player setting, XR plug in management, check ARCore and ARKit;
7. Player setting, delete Vulkan. Android does not support Vulkan;
8. ARSession.state The running status of the engine can be obtained, which can be used to detect whether the AR Foundation supports the device subsystem.descriptor.supports To see if it is supported. Note that the engine and subsystem must be running before they know whether they support it.

4.2.3.2 Consoling

Conflicts in dependency(need to be added)

Gradle issues(A very normal issue that will be met by almost all beginners)

4.2.3.3 Playing

1) Android flash back

Reason 1: the device does not support AR function, and forced to install Google play services for AR

Solution: first uninstall the local Google play services for AR, and then check whether the device supports AR function

Reason 2: there is a fatal bug

Solution: Download and install Android studio to view the log

2) IOS flash back

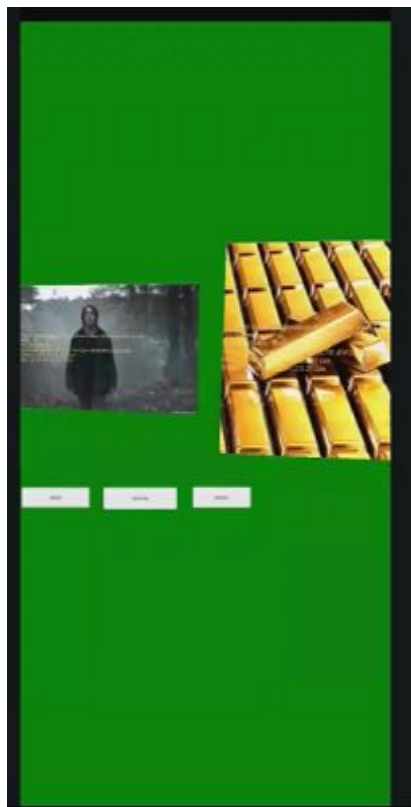
Reason 1: no camera rights

Solution: apply for camera permission

Reason 2: there is a fatal bug

Solution: check the log in XCode

3) Green screen issue



The normally running software will suddenly appear green screen and disappear in an instant.

4.2.4 Assessment of AR Foundation

AR Foundation encapsulates the interface well and is easy to use. The latest functions released by ARCore and ARKit are provided in time, and the versions are constantly optimized;

If AR Foundation version and unity version have matching requirements, packaging the latest version in unity 2019 will fail;

After AR Foundation configuration error, there is no community to ask and answer, so we can only compare the sample scenario to find the problem bit by bit;

If the environment is too dark, the device motion tracking may "lose tracking", because it occurs in all slams based on image recognition

4.2.5 Discussion of testing results

(wait for all test to be done)

- Basic function support: Vuforia > AR Foundation

Vuforia have done some AI optimization on the basic functions of ARCore and ARKit, and the effect is better in theory

- Advanced function support: AR Foundation > Vuforia

AR Foundation only encapsulates ARCore and ARKit, and supports the latest advanced functions best

Vuforia is the underlying packages, and the latest advanced functions of ARCore and ARKit cannot be supported in time

- URP project support:

Support: AR Foundation, Vuforia

- Device adaptability: Vuforia ~ AR Foundation

Vuforia and AR Foundation are limited to ARCore and ARKit support

(PS: Huawei AR has more adaptation support for Huawei mobile phones) 【add references】

- Unity friendliness: AR Foundation > Vuforia

AR Foundation is originally packaged by unity. The package can be downloaded directly and updated at any time.

Proof of concept application of Augmented Reality Unity AR Foundation Software

Vuforia is also supported by unity embedding.

- Development friendliness: AR Foundation > Vuforia

Easyar official website provides a complete use of expository and sample projects, and can ask development questions in the community at any time, very friendly

AR Foundation provides a complete sample project on GitHub, and the interface encapsulation is good, so it is friendly to use.

Chapter 5: Conclusion and Further Work

(Write after all things done)

References

- Wikipedia contributors (2021a). *Augmented reality* — *Wikipedia, The Free Encyclopedia*. https://en.wikipedia.org/w/index.php?title=Augmented_reality&oldid=952477093. [Online; accessed 22April2021].
- Apple (2021a). *ARKit*. <https://developer.apple.com/documentation/ARKit>. [Online; accessed 7April2021].
- (2021b). *Tracking and Visualizing Faces*. https://developer.apple.com/documentation/ARKit/tracking_and_visualizing_faces. [Online; accessed 22April2021].
- (2021c). *How to use Animoji on your iPhone and iPad Pro*. <https://support.apple.com/en-us/HT208190>. [Online; accessed 22April2021].
- Google (2021a). *ARCore*. <https://developers.google.com/AR/discover>. [Online; accessed 7April2021].
- Wikipedia contributors (2019). *Vuforia Augmented Reality SDK* — *Wikipedia, The Free Encyclopedia*. https://en.wikipedia.org/w/index.php?title=Vuforia_Augmented_Reality_SDK&oldid=915325078. [Online; accessed 7April2021].
- Miranda Katz (2021). *Augmented Reality Is Transforming Museums*. <https://www.wired.com/story/augmented-reality-art-museums/>. [Online; accessed 22April 2021].
- Casa Batllo (2021). *Useful Information*. <https://www.casabatllo.es/en/visit/>. [Online; accessed 22April2021].
- Graham Thomas (2015). *Augmented Reality film launches at the Natural History Museum*. <https://www.bbc.co.uk/rd/blog/2010-12-augmented-reality-film/launche>. [Online; accessed 22April2021].
- Wikipedia contributors (2021b). *Unity (game engine)* — *Wikipedia, The Free Encyclopedia*. [https://en.wikipedia.org/w/index.php?title=Unity_\(game_engine\)&oldid=949330256](https://en.wikipedia.org/w/index.php?title=Unity_(game_engine)&oldid=949330256). [Online; accessed 7April2021]

Acknowledgement

After a year's hard work, my graduation project has come to an end. At the same time, I would like to express my gratitude to the teachers, experts, scholars and classmates who helped me and supported me.

First of all, I would like to express my heartfelt thanks to my mentors for their painstaking efforts in every link from the topic selection, conception to the final draft of the project. Even if we didn't go to Valencia offline to carry out the project due to the epidemic, even online, the two mentors were very patient and responsible to me. They have provided me with a lot of help in the process of writing my thesis, and their opinions and opinions are very important. The suggestion inspired me a lot.

In the development process, I refer to a lot of official documents and tutorials, thank you to the software developers!

Secondly, I would also like to thank the students who are looking for help! I often borrow their mobile devices for testing, thank them very much for their help and patience.

I would also like to thank upv and QMUL for their cooperation. Thank you for your valuable opportunity to participate in the overseas graduation project.

In addition, I would like to express my thanks to the experts who reviewed my thesis in advance! Due to my limited time, energy and ability, I still have many regrets about the fields involved in this paper. Your criticism and suggestions will become my motivation for further study.

Appendix

- Specification, part 1 and part 2
- Early-term Progress Report
- Mid-term Progress Report
- Supervision log

Project Specification Form Part 2 - Student

学院 School	International School	专业 Programme	e-Commerce Engineering with Law		
姓 Family name	Cao	名 First Name	Ruixue		
BUPT 学号 BUPT number	caoruiXue@bupt.edu.cn	QM 学号 QM number	171048380	班级 Class	2017215112
论文题目 Project Title	Proof of concept application of Augmented Reality Unity AR Foundation Software				

<p>论文概述</p> <p>Project outline</p> <p>Write about 500-800 words</p> <p>Please refer to Project Student Handbook section 3.2</p>	<p>Since the worldwide situation due to the COVID-19 pandemic COVID-19 prevents the student to travel and have the project in mobility, the objectives of this project (originally "Improvement of an Augmented Reality Mobile Application for Open Air Museum") have been modified in order to have a project that can be developed remotely.</p> <p>There are many differences between my project and previous project: My project is not a version of changing previous sculpture models into something else instead, but to test whether AR fundamental software could be used to build Augmented Reality applications. I will no longer use Vuforia to develop AR events, but use AR fundamental software instead. Besides, I am going to test all kinds of recognition and AR events with several characters.</p> <p>Project new objectives:</p> <p>Since it is going to be a proof of concept, we are not going to use a real environment as a museum or a public place, so I will do all the work at my home with the elements I have at home.</p> <ul style="list-style-type: none"> ✓ To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software. ✓ To test the following capabilities of Unity AR Foundation <ul style="list-style-type: none"> 1) Recognition <ul style="list-style-type: none"> a) Object Recognition <ul style="list-style-type: none"> 1. Using two different objects: <ul style="list-style-type: none"> 1) A simpler object, as a cube, a cup, a ball, something that can be easily recognized. 2) A complex object like a toy or a little sculpture that have different sides, textures, colors etc. 2. Assessing object recognition with different lights, at least with 3 different kinds of light and shadows. b) Mark (VuMark or QR) recognition c) Floor/Plane recognition <ul style="list-style-type: none"> Using two kinds of floor: <ul style="list-style-type: none"> 1) One completely plane, single solid colour 2) One with a pattern d) Image recognition <ul style="list-style-type: none"> Using also two images: <ul style="list-style-type: none"> 1) One with glossy paper very brilliant colors, golden or silver parts 2) One with plane colors, no gloss, no bright 2) AR events: <ul style="list-style-type: none"> a) Video <ul style="list-style-type: none"> I could choose any available video or audio. b) Audio <ul style="list-style-type: none"> I could choose any available video or audio. c) Model <ul style="list-style-type: none"> I will have to develop a model in blender, something to show when the AR event is triggered. The model should have also texture in its sides. A nice model could be a modern art sculpture for example, that can be
---	--

	<p>built from simple forms (cubes, cylinders, pyramids, etc.) and added colors and textures.</p> <p>d) Animation I could animate whatever model I want, a butterfly flying, for example, the sun rising, etc.</p> <p>e) Buttons or any other way for interaction to switch from one event to other in the same object</p> <ul style="list-style-type: none"> ✓ To develop in Blender the model and the animation for AR event. ✓ To compile the application for both Android and IOS and to describe the whole process to take it to the market in both platforms. <p>Main Tasks:</p> <ul style="list-style-type: none"> ➤ Familiarization with Augmented Reality using Unity AR Foundation Software. Basically learn knowledge about AR foundation’s capabilities from Vuforia tutorials and Unity web, and follow the tutorial to do some small independent test demo. ➤ To develop the proof of concept application. To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software. To compile the application for both Android and IOS and to describe the whole process to take it to the market in both platforms. ➤ To test the functionality for several AR recognition features, with several AR events To develop in Blender the model and the animation for AR event. ➤ To summarize the results into meaningful set of publishable paper (Journal and/or Conference) Summarize all outcomes (must be tangible outputs such as software and simulation) and write down all the documents such as user manuals,etc, and then deliver the final report. <p>Tutorial Materials:</p> <ol style="list-style-type: none"> 1. This is a tutorial about how to integrate Unity application into Android application, and it is the tutorial which we followed when creating this application: https://forum.unity.com/threads/integration-unity-as-a-library-in-native-android-app.685240/ 2. This is about the AR Foundation platform in Unity: https://www.coursera.org/learn/handheld-AR 3. Some of the API may have changed. To fully understand the code, you are suggested to carefully learn these components: https://developer.android.com/jetpack 4. To be continued...
<p>道德规范</p>	<p>Please confirm that you have discussed ethical issues with your Supervisor using the ethics checklist (Project Handbook Appendix 2).</p>

Proof of concept application of Augmented Reality Unity AR Foundation Software

Ethics	[Yes]
	N/A (My project is not related to any ethics issues)
中期目标 Mid-term target	The proof of concept AR application for Android (including recognition and AR events)

Work Plan (Gantt Chart)

Fill in the sub-tasks and insert a letter X in the cells to show the extent of each task

	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-29	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30
Task 1. [Familiarization with Augmented Reality using Unity AR Foundation Software]												
Testing object recognition	X	X										
Testing Mark(Vumark and QR code) recognition	X	X	X									
Testing Floor/plane recognition			X	X	X							
Testing image recognition			X	X	X							
Task 2. [To develop the proof of concept application]												
To develop in Blender the model and the animation for AR event.			X	X	X							
To compile the application for Android				X	X	X	X	X	X			
To compile the application for IOS									X	X		
To describe the whole process and take it to the market in both platforms.				X	X	X	X	X	X	X		
Task 3. [To test the functionality for several AR recognition features, with several AR events]												
Testing AR events (video)							X	X				
Testing AR events (audio)							X	X				
Testing AR events(model)								X	X			
Testing AR events (animation, any other way for interaction)								X	X			
Task 4. [To summarize the results into meaningful set of publishable paper (Journal and/or Conference)]												
Summarizing all works done		X	X	X	X	X	X	X	X	X		
Minor improvement and bug fix							X	X	X	X		
Composing the thesis									X	X	X	
Checking the thesis										X	X	X

Project Early-term Progress Report

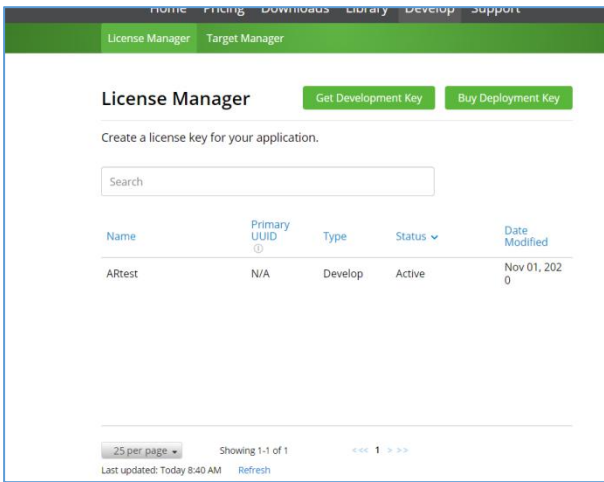
学院 School	International School	专业 Programme	e-Commerce Engineering with Law		
姓 Family name	Cao	名 First Name	Ruixue		
BUPT 学号 BUPT number	2017212923	QM 学号 QM number	171048380	班级 Class	2017215112
论文题目 Project Title	Proof of concept application of Augmented Reality Unity AR Foundation Software				

已完成工作 Finished work:

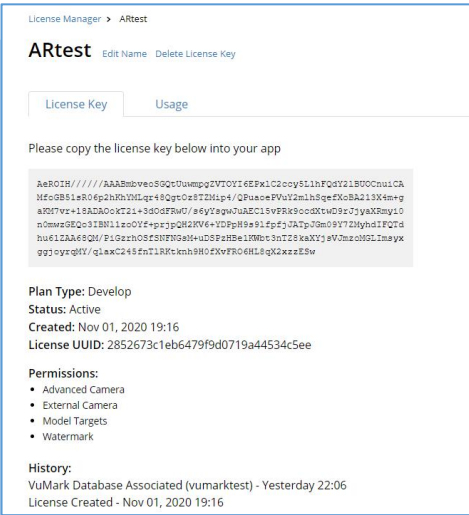
First, I got familiar with Unity3D and Vuforia, and came across several environment issues.

Using Vuforia:

1. Image Recognition



Name	Primary UUID	Type	Status	Date Modified
ARtest	N/A	Develop	Active	Nov 01, 2020



ARtest Edit Name Delete License Key

License Key Usage

Please copy the license key below into your app

```
AeR03H/////AAABbbwec89QdUwmpqVTOYI6E5FwLCoocy5L1bFodV21800CnuLGA
MfoQ851eR06p2h3hVnMLq+4QgtOe8T2M1p4/QPuaeePVuV2mlh5qgeXv8Aa21X4m+g
a30Tvr+18A2A0oK721+340dF8MG/86Y7agw7uAEC15vFRk8o0dXcW09rCjyaXRmy10
nOmwr2E0o31BN11zo0Vf+pr3pQh2RV6+YDpH9e91fpf3JATp-J0m09V7ZMyhd1FQ7d
hu612AA68QM/P1GzrHO8F5NF9G8H+uDSFzHBe10MbC3nT28kaXyJ8V7mz0MGL1mayx
ggj-yvqW/q1axC243fnT1Rkcmh8H0EXvFR06ML8qX2zxxE5w
```

Plan Type: Develop
 Status: Active
 Created: Nov 01, 2020 19:16
 License UUID: 2852673c1eb6479f9d0719a44534c5ee

Permissions:

- Advanced Camera
- External Camera
- Model Targets
- Watermark

History:

VuMark Database Associated (vumarktest) - Yesterday 22:06
 License Created - Nov 01, 2020 19:16

reddragon

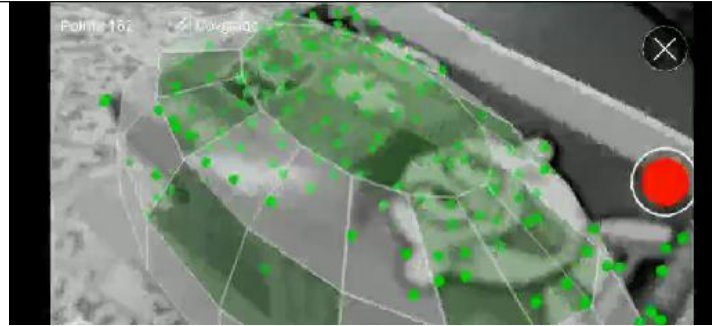
Single Image

★★★★★ Active

Nov 03, 2020
22:46

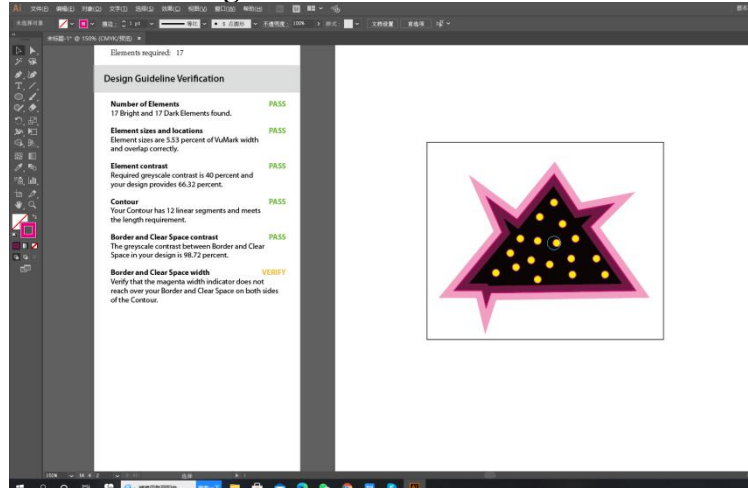


2. Object Recognition



3. VuMark Recognition

a. VuMark Design



vumarktest [Edit Name](#)

Type: VuMark
License Key: ARTtest

Targets (1) Database Access Keys

Add Target Download

Target ID: 245303b741674e8caed01499569680d8
Added: Yesterday 22:09
Modified: Yesterday 22:09

Target Name	Type	ID Length	Status	Date Modified	
<input type="checkbox"/> pikachu	Numeric2		Active	Yesterday 22:09	Generate VuMark

b. Extract information from VuMark



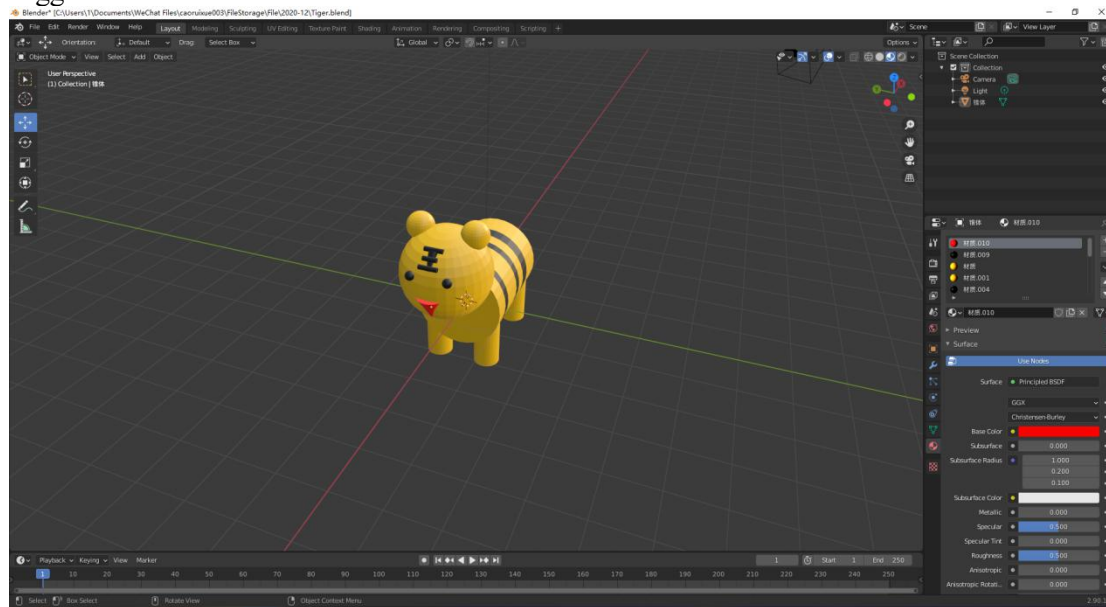
Then, there are many differences between my project and previous project: My project is not a

version of changing previous sculpture models into something else instead, but to test whether AR fundamental software could be used to build Augmented Reality applications. I will no longer use Vuforia to develop AR events, but use AR fundamental software instead. Besides, I am going to test all kinds of recognition and AR events with several characters.

Using AR Foundation Software:

After so many problems, environment configuration was done.

For Model event, I developed a model in blender, something to show when the AR event is triggered.



Tutorial Materials:

5. This is a tutorial about how to integrate Unity application into Android application, and it is the tutorial which we followed when creating this application:

<https://forum.unity.com/threads/integration-unity-as-a-library-in-native-android-app.685240/>

6. This is about the AR Foundation platform in Unity:

<https://www.coursera.org/learn/handheld-AR>

7. Some of the API may have changed. To fully understand the code, you are suggested to carefully learn these components: <https://developer.android.com/jetpack>

是否符合进度？ On schedule as per GANTT chart?

[YES/NO]

YES

下一步 Next steps:

In the next step, I will continue test the following capabilities of Unity AR Foundation.

1) Recognition

a) Object Recognition

1. Using two different objects:

1) A simpler object, as a cube, a cup, a ball, something that can be easily recognized.

2) A complex object like a toy or a little sculpture that have different sides, textures, colors etc.

2. Assessing object recognition with different lights, at least with 3 different kinds of

light and shadows.

- b) Mark (VuMark or QR) recognition
- c) Floor/Plane recognition

Using two kinds of floor:

- 1) One completely plane, single solid colour
- 2) One with a pattern
 - d) Image recognition

Using also two images:

- 1) One with glossy paper very brilliant colors, golden or silver parts
- 2) One with plane colors, no gloss, no bright

2) AR events:

- a) Video
I could choose any available video or audio.
- b) Audio
I could choose any available video or audio.
- c) Model
I will have to develop a model in blender, something to show when the AR event is triggered. The model should have also texture in its sides. A nice model could be a modern art sculpture for example, that can be built from simple forms (cubes, cylinders, pyramids, etc.) and added colors and textures.
- d) Animation
I could animate whatever model I want, a butterfly flying, for example, the sun rising, etc.
- e) Buttons or any other way for interaction to switch from one event to other in the same object

And build an Application containing all the functions above for Android platform.

Project Mid-term Progress Report

学院 School	International School	专业 Programme	e-Commerce Engineering with Law		
姓 Family name	Cao	名 First Name	Ruixue		
BUPT 学号 BUPT number	2017212923	QM 学号 QM number	171048380	班级 Class	2017215112
论文题目 Project Title	Proof of concept application of Augmented Reality Unity AR Foundation Software				
是否完成任务书中所定的中期目标？Targets met (as set in the Specification)? [YES]					
已完成工作 Finished work: Project objectives overview: Since it is going to be a proof of concept, we are not going to use a real environment as a museum or a public place, so I will do all the work at my home with the elements I have at home. ✓ To develop a proof of concept application of Augmented Reality using Unity AR Foundation Software. ✓ To test the following capabilities of Unity AR Foundation					

- ✓ **To develop in Blender the model and the animation for AR event.**
- ✓ **To compile the application for both Android and IOS and to describe the whole process to take it to the market in both platforms.**

For Android applications with all functions, I have completed the development and testing part.

● **Development part**

1) Recognition

a) Mark (VuMark or QR) recognition

b) Floor/Plane recognition

Using two kinds of floor:

- 1) One completely plane, single solid colour
- 2) One with a pattern

c) Image recognition

Using also two images:

- 1) One with glossy paper very brilliant colors, golden or silver parts
- 2) One with plane colors, no gloss, no bright

2) AR events:

a) Video

I could choose any available video or audio.

b) Audio

I could choose any available video or audio.

c) Model

I will have to develop a model in blender, something to show when the AR event is triggered. The model should have also texture in its sides. A nice model could be a modern art sculpture for example, that can be built from simple forms (cubes, cylinders, pyramids, etc.) and added colors and textures.

d) Animation

I could animate whatever model I want, a butterfly flying, for example, the sun rising, etc.

e) Buttons or any other way for interaction to switch from one event to other in the same object

- Each of the single scene has canvas and some of them has set button to interact for further integration

12. QR recognition



ImageQRcode.apk

2021/2/18 2:48

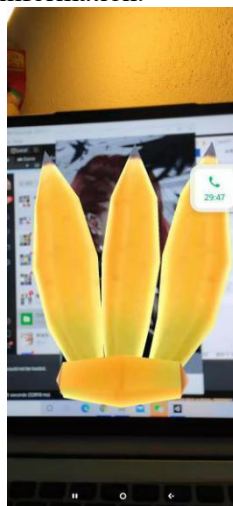
APK 文件

19,671 KB



13. Image recognition

Test with a model appears instead of the information.



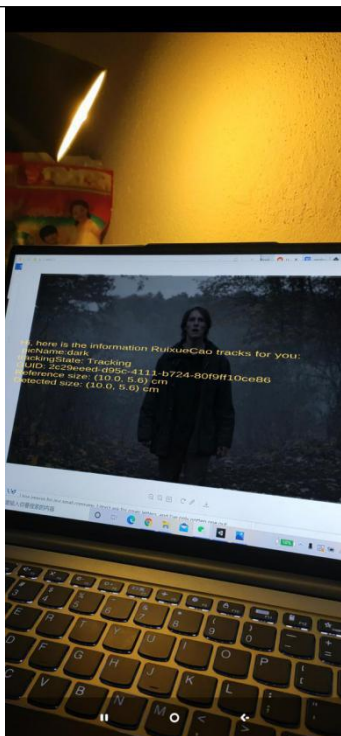
3) One with glossy paper very brilliant colors, golden or silver parts






4) One with plane colors, no gloss, no bright





14. Plane recognition

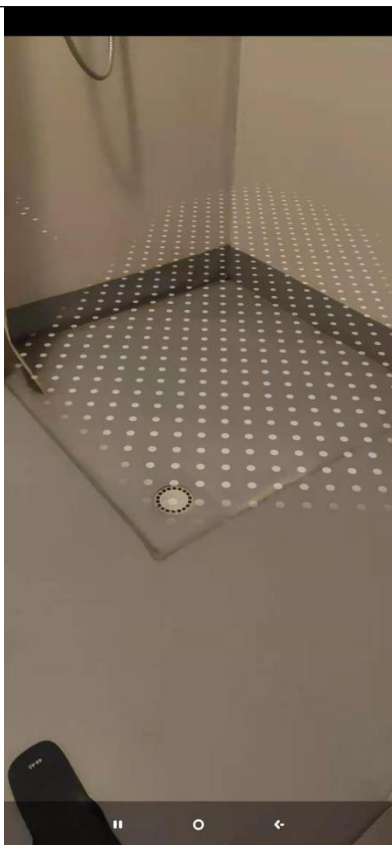
 featheredPlane.apk	2021/2/18 2:53	APK 文件	18,002 KB
 togglePlane.apk	2021/2/18 2:10	APK 文件	18,139 KB

2) One completely plane, single solid colour
(Toggle plane detection)



If clicked the button, it will hide the AR plane.

2) One with a pattern



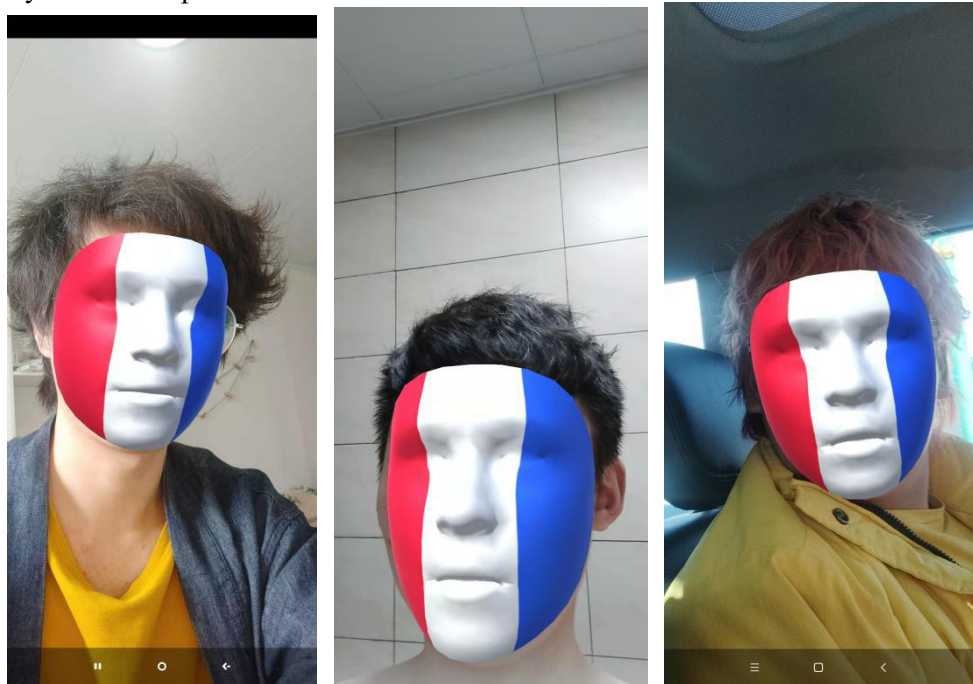
I have also tried with face pose and face mesh functions, you can test them using apks.

faceMest.apk	2021/2/18 14:56	APK 文件	18,054 KB
facePose.apk	2021/2/18 3:06	APK 文件	18,053 KB

15. Face Mesh

(Randomly choosing 3 colors to be the material, seems like French flag.....)

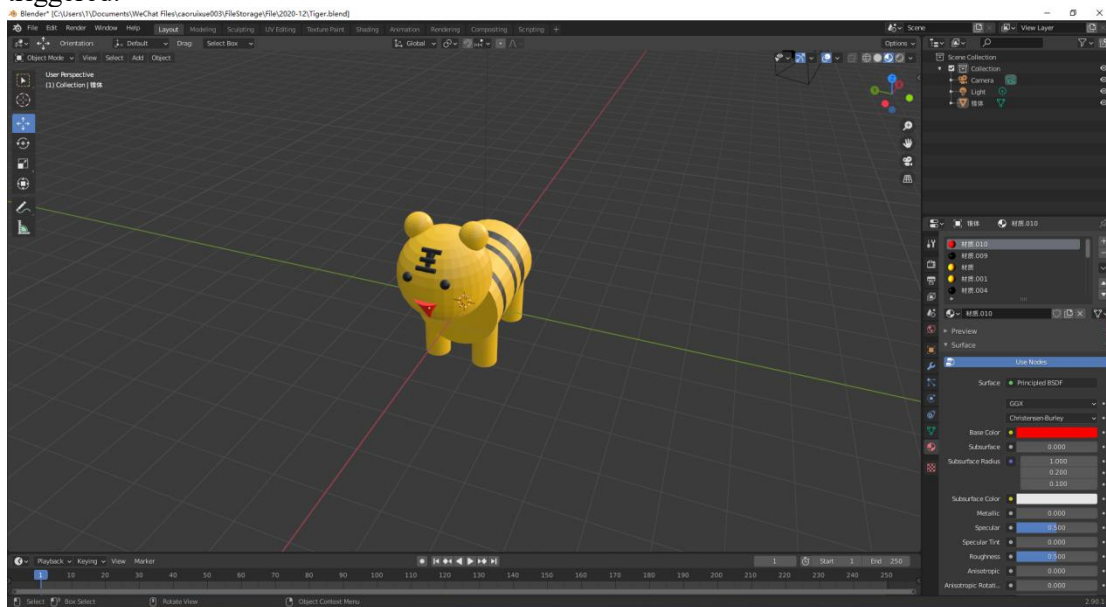
Test with my friends' help



16. Face Pose



6. For Model event, I developed a model in blender, something to show when the AR event is triggered.



● Testing part

1. Testing Equipment Record

Every HUAWEI equipment did not work, but for XIAOMI, they worked.



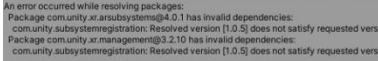
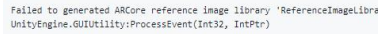
The test equipments I used at home. None of them works.



I asked my friend for help, this XIAOMI works.

2. Version testing

I have test these compatibility in different version of unity

ARFoudation	ARCore XR plugin	AR Subsystems	ARKit XR plugin	Unity3d	Compile ?	Issue?
4.0.2	4.0.4	4.0.1	4.0.2	2019.3.5 fl	Successful	<p>For some projects, it will show:</p>  <p>Many developers on stackoverflow still facing this problem and Unity's technologists have looked into the problem.</p>
3.13	3.13	3.13	3.13	2019.4.2 of (LST)	Successful	<p>Not discover yet, seems good compatibility A developer on stackoverflow points out this perfect</p>
2.1.8	2.1.11	2.1.2	2.1.9	2019.4.0 fl	Successful	<p>Not discover yet, seems good compatibility</p>
2.1.16	2.1.16	2.1.16	2.1.16	2019.3.5 fl	Successful	<p>For some projects, it will show:</p> 

BEST

Implicit requirements: I suppose Android sdk >= 26, (version 24 failed building apks)

9. Android equipment issue

- See <https://developers.google.com/AR/discover/supported-devices?hl=zh-cn>

All of my family members are using HUAWEI 's newest products, and are not supported by ARCore. So I tested these functionalities with my friend's Xiaomi, in the future I will test with more.

Must equipped with Google play Service!

- Users **must** use the compatible equipment both with Android API level and supported equipment. Android 7.0 or higher

If your application is an AR optional application, please modify the minSdkVersion statement:
 minSdkVersion ≥ 14 (API Level 14)

If your application is an AR essential application, please modify the minSdkVersion statement:
 minSdkVersion ≥ 24 (API Level 24)

10. Because ARCore only supported by Android 7.0 or higher, I must go to Android Studio (SDK Manager), to download Android 7.0 or higher.

Note: When using Android 10.1(Api level 31), The incompatibility between the too new API version and the old version of unity will cause many bugs when packaging apk.

Bundle Version Code	Minimum API Level	Target API Level	Installation Status
Android 10.0 (Q)	29	5	Partially installed
<input checked="" type="checkbox"/> Android 9.0 (Pie)	28	6	Installed
<input type="checkbox"/> Android 8.1 (Oreo)	27	3	Not installed
<input checked="" type="checkbox"/> Android 8.0 (Oreo)	26	2	Installed
<input type="checkbox"/> Android 7.1.1 (Nougat)	25	3	Not installed
<input type="checkbox"/> Android 7.0 (Nougat)	24	2	Not installed
<input checked="" type="checkbox"/> Android 6.0 (Marshmallow)	23	3	Installed

11. When doing projects with image tracking:

[13:02:44] No active UnityEngine.XR.ARSubsystems.XRCameraSubsystem is available. Please ensure that a valid loader configuration exists in the XR project settings.
 UnityEngine.XR.ARFoundation.SubsystemLifecycleManager`2:OnEnable() (at Library/PackageCache/com.unity.xr.foundation@4.0.2/Runtime/AR/SubsystemLifecycleManager.cs:87)

[13:02:44] Camera "AR Camera" has a non-identity transform (position = (0.5, -2.3, -11.4), rotation = (0.0, 0.0, 0.0, 1.0)). The camera's local position and rotation will be overwritten!
 UnityEngine.XR.ARFoundation.ARSessionOrigin:Awake() (at Library/PackageCache/com.unity.xr.foundation@4.0.2/Runtime/AR/ARSessionOrigin.cs:229)

No active UnityEngine.XR.ARSubsystems.XRCameraSubsystem is available. Please ensure that a valid loader configuration exists in the XR project settings.
 UnityEngine.XR.ARFoundation.SubsystemLifecycleManager`2:OnEnable() (at Library/PackageCache/com.unity.xr.foundation@4.0.2/Runtime/AR/SubsystemLifecycleManager.cs:87)

Line 87 shows:

```

/// 
/// Creates the <c>TSubsystem</c>.
/// 
protected virtual void OnEnable()
{
    EnsureSubsystemInstanceSet();

    if (subsystem != null)
    {
        OnBeforeStart();

        // The derived class may disable the
        // component if it has invalid state
        if (enabled)
        {
            subsystem.Start();
            OnAfterStart();
        }
    }
}
/// 
/// Stops the <c>TSubsystem</c>.
    
```

Solution on the Internet:

Proof of concept application of Augmented Reality Unity AR Foundation Software

tdmowrer commented on May 22, 2020 Collaborator ...

Well, have you ensured "that a valid loader configuration exists in the XR project settings"? ARFoundation now uses XR Management to decide which provider to use (because there could be multiple options). See <https://docs.unity3d.com/Manual/configuring-project-for-xr.html> for details. Basically just tick the "ARCore" and/or "ARKit" boxes in Project Settings > XR Plugin Management.

noppefoxwolf commented on May 22, 2020 Author ...

@tdmowrer Thank you very much. I resolved issue.

The screenshot shows the Unity Project Settings window. On the left is a sidebar with categories like Audio, Editor, Graphics, etc., with 'XR Plug-in Management' selected. The main panel is titled 'XR Plug-in Management' and has a sub-section 'XR' with a 'Project Settings' icon. Under 'XR', there is a checkbox for 'Initialize XR on Startup' which is checked and circled in red. Below that is a 'Plug-in Providers' section with three options: 'ARCore' (checked), 'Oculus', and 'Unity Mock HMD'. At the bottom, there is a link for 'View Documentation'.

@timmy2get Thank you! It's working at my android device.

For most of developers, it works; For me, it did not work.

Each time when I run the testing app, it will first show the pic below, then crash.

The screenshot shows a vertical mobile application interface. It consists of a solid grey background with a single, solid black circle centered horizontally and vertically. At the bottom of the screen, there is a dark grey navigation bar with three white icons: a square, a circle, and a triangle pointing left.

Here is the log I generated from Android developer mode device debugging application:

Level	Time	PID	TID	Applicati...	Tag	Text
						d_render_to_texture GL_KHR_robustness GL_KHR_robust_bu _EXT_draw_elements_base_vertex GL_OES_draw_elements_be ted_textures GL_EXT_buffer_storage GL_EXT_external_bui ray GL_EXT_texture_filter_anisotropic
W	02-17 11:05:40.034	26323	29886	?	Unity	No active UnityEngine.XR.ARSubsystems.XRCameraSubsyste ensure that a valid loader configuration exists in the
W	02-17 11:05:40.034	26323	29886	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Lir
W	02-17 11:05:40.035	26323	29886	?	Unity	No active UnityEngine.XR.ARSubsystems.XRImageTrackingS Please ensure that a valid loader configuration exists ings.
W	02-17 11:05:40.035	26323	29886	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Lir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401931): avc: granted { write } tyShaderCache" dev="sdcards" ino=665507 scontext=ur: 7,c512,c768 tcontext=u:object_r:sdcards:s0 tclass=dir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401932): avc: granted { add_name bf713628390495c6ec745eec555d4a09" scontext=ur:untrust c768 tcontext=u:object_r:sdcards:s0 tclass=dir
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.194 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = 25, in_flags = 0x100380f out_flags =
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.194 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0x380f out_flags = 0x
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	type=1400 audit(0.0:76401933): avc: granted { create } 713628390495c6ec745eec555d4a09" scontext=ur:untrustec 68 tcontext=u:object_r:sdcards:s0:c9,c257,c512,c768 t
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.198 26323:29957 D/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	addLayerName, tid:29957
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.199 26323:29957 I/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0xa0f out_flags = 0xa
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	[02-17 11:05:40.199 26323:29957 D/]
W	02-17 11:05:40.189	26323	26323	?	UnityGfxDeviceW	addLayerName, tid:29957
						d_render_to_texture GL_KHR_robustness GL_KHR_robust_bu _EXT_draw_elements_base_vertex GL_OES_draw_elements_base_vertex GL_EXT ted_textures GL_EXT_buffer_storage GL_EXT_external_buffer GL_EXT_EGL_i ray GL_EXT_texture_filter_anisotropic
I	02-17 11:14:36.838	29230	32403	?	Unity	XRGeneral Settings awakening...
I	02-17 11:14:36.838	29230	32403	?	Unity	(Filename: ./Runtime/Export/Debug/Debug.bindings.h Line: 35)
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	type=1400 audit(0.0:76411448): avc: granted { read } for pid=29230 nam a48440947bce7fd5fb9efaaffc5f" dev="sdcards" ino=1052024 scontext=ur: ed_app:s0:c8,c257,c512,c768 tcontext=u:object_r:sdcards:s0 tclass=file
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	type=1400 audit(0.0:76411449): avc: granted { read open } for pid=2923 "/storage/emulated/0/Android/data/com.aaaa.aaaa/cache/UnityShaderCache 8440947bce7fd5fb9efaaffc5f" dev="sdcards" ino=1052024 scontext=ur:un _app:s0:c8,c257,c512,c768 tcontext=u:object_r:sdcards:s0 tclass=file
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	[02-17 11:14:39.253 29230:32476 I/]
W	02-17 11:14:39.249	29230	29230	?	UnityGfxDeviceW	[CAF]: mask_idx = -1, in_flags = 0x17 out_flags = 0x17

Then I found it may be because of my android equipment's incompatibility of ARCore!

尚需完成的任务 Work to do:

- Debug (fixxed the bug I have mentioned before)
- Integrate all functions into one apk (now they are seprate apks)
- Develop "The proof of concept AR application" for IOS system (including recognition and AR events)
- Test "The proof of concept AR application" for IOS system (including recognition and AR events)

存在问题 Problems:

1. In image recognition function, when one image been tracked, follows with another image "wanted" to be tracked, it will show like this: After a while, the first one will then disappear.



2. ARCore support in Unity may conflict with some old ARCore XR Plugin versions.

```
[13:34:11] BuildFailedException: "ARCore Supported" (Player Settings > XR Settings) refers to the built-in ARCore support in Unity and conflicts with the "ARCore XR Plugin"
UnityEditor.XR.ARCore.ARCorePreprocessBuild.EnsureARCoreSupportedIsNotChecked () (at Library/PackageCache/com.unity.xr.arcore@3.1.3/Editor/ARCoreBuildProcess
```

```
Failed to generated ARCore reference image library 'ReferenceImageLibrary'
UnityEngine.GUIUtility:ProcessEvent(Int32, IntPtr)
```

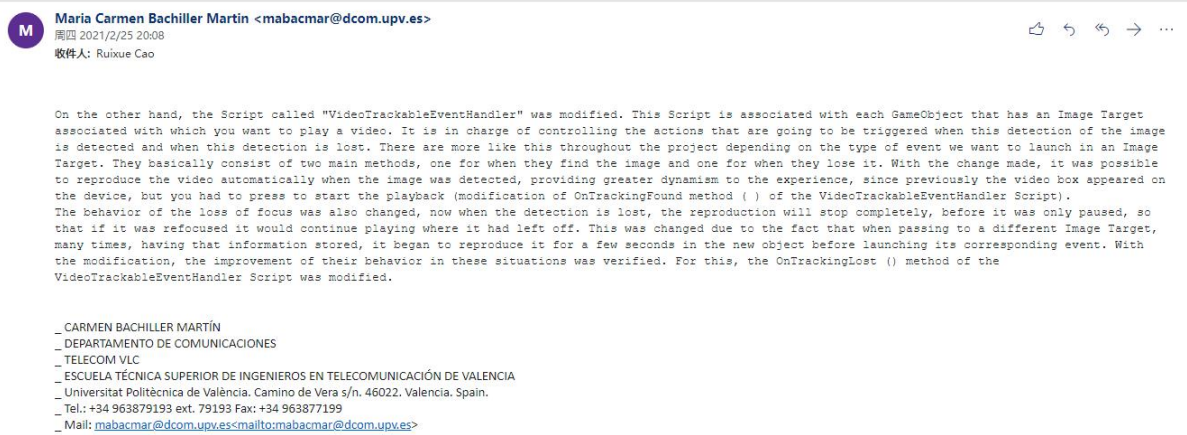
12.

Viewed all solutions and discussions, I found several developers mentioning version issues. After trying out every possible solution, I decide to re-install another version of unity and other packages.

拟采取的办法 Solutions:

Each solution is corresponding with the problem stated above.


1. I have discussed with my tutors, and will try to do so to solve the issue



2. Go to Project Settings, manually uncheck the check box:



3. His recommendation works.



大卫·杰克 已评论 on Aug 27, 2020 · 已编辑

我也坚持这一点。您能否说出要使用哪个urp版本+ arfoundationversion + ar kit插件版本+统一版本。我呆了过去10天。我使用unity 2019.4和aslo尝试使用ar foundation 2.0和4.0..for urp。它不只是渲染

我最终使用的是：

Unity 2019.4.4f1
AR Foundation 3.1.3
AR子系统3.1.3
ARCore XR插件3.1.4
ARKit XR插件3.1.3
XR插件管理3.2.13

但是我同意-在给定与XR相关的软件包数量的基础上，决定使用哪个版本有点令人困惑。文档中的表格会很棒（或类似的东西）。

Source: <https://github.com/Unity-Technologies/AR Foudation-samples/issues/119>
<https://forum.unity.com/threads/AR Foudation-imagetracking-sample-scene-doesnt-generate-image-database.684208/>

论文结构 Structure of the final report:
My current idea is that:
1 Introduction
1.1 Objectives
1.2 Work plan
2 Background
3 Design and Implementation
4 Testing
5 Result and Discussion
6 Conclusion and Future Work
References

Appendix:
User Manual
Survey

Project Supervision Log

学院 School	International School	专业 Programme	e-Commerce Engineering with Law		
姓 Family name	Cao	名 First Name	Ruixue		
BUPT 学号 BUPT number	2017212923	QM 学号 QM number	171048380	班级 Class	2017215112
论文题目 Project Title	Proof of concept application of Augmented Reality Unity AR Foundation Software				
Date: 07-10-2021 Supervision type: online meeting					

Summary: First meeting

Date: 14-10-2021

Supervision type: online meeting

Summary: Discuss what to do:

- Installing unity, vuforia and the resto of SW that the project requires

Open the project in Unity and see how the project was built up and what the project does

- Writing down what you have understood and what you don't have understood

Date: 21-10-2021

Supervision type: online meeting

Summary: discussed the VuMark and QR Code design and recognition, and what to do next:

Tasks: 1. Obeject 2. VuMark

Date: 11-11-2021

Supervision type: online meeting

Summary: Specify what I need to do, answering some of my questions about develop using Vuforia or AR Foundation Software

Date: 12-11-2021

Supervision type: email

Summary: about arrangement of meetings

Date: 19-11-2021

Supervision type: online meeting

Summary: discussed the problem I had met

Date: 25-11-2021

Supervision type: online meeting

Summary: discussed the draft specification

Date: 9-12-2021

Supervision type: online meeting

Summary: discussed the problem I had met

Date: 12-12-2021

Supervision type: email

Summary: change in next week meeting

Date: 11-1-2021

Supervision type: email

Summary: about meetings

Date: 25-2-2021

Supervision type: online meeting

Summary: discussed the things I had done and what to do next:

Integrate all apks into one independent apk, and modify the implementation of plane recognition part of my work

Date: 25-2-2021

Supervision type: email

Summary: A solution of tracking lost

(Need to add)

Risk and environmental impact assessment

We will assess the level of risk and environmental impact from the following four aspects.

Hinder the smooth completion of the project. Because our project is software oriented, we don't think we have any risk and environmental impact during the development process.

Therefore, the impact that may hinder the completion of the project will not occur. The level of possibility is zero and the level of consequence is zero. The production result is zero, which means there is no risk in this area.

Potential harm to people and / or animals. The software itself only needs users interact with the device. This may not do any damage to other creatures. Therefore the possibility level and consequence level are both zero. The production result is zero so there is no risk in this regard.

Potential harm to the environment. Our project does not affect any environmental resources, so we do not highlight energy consumption or waste disposal. The level of possibility is zero and the level of consequence is zero. The production result is zero, which means there is no risk in this area.

Potential economic losses to the project or other individuals or organizations. No additional resources have been used since the entire development process, without economic impact.

In addition, when using applications, users only need their mobile devices. Our application will not increase any potential damage to the user's device. Therefore, the consequences of the possible risk are zero. The production result is zero, which means there is no risk.