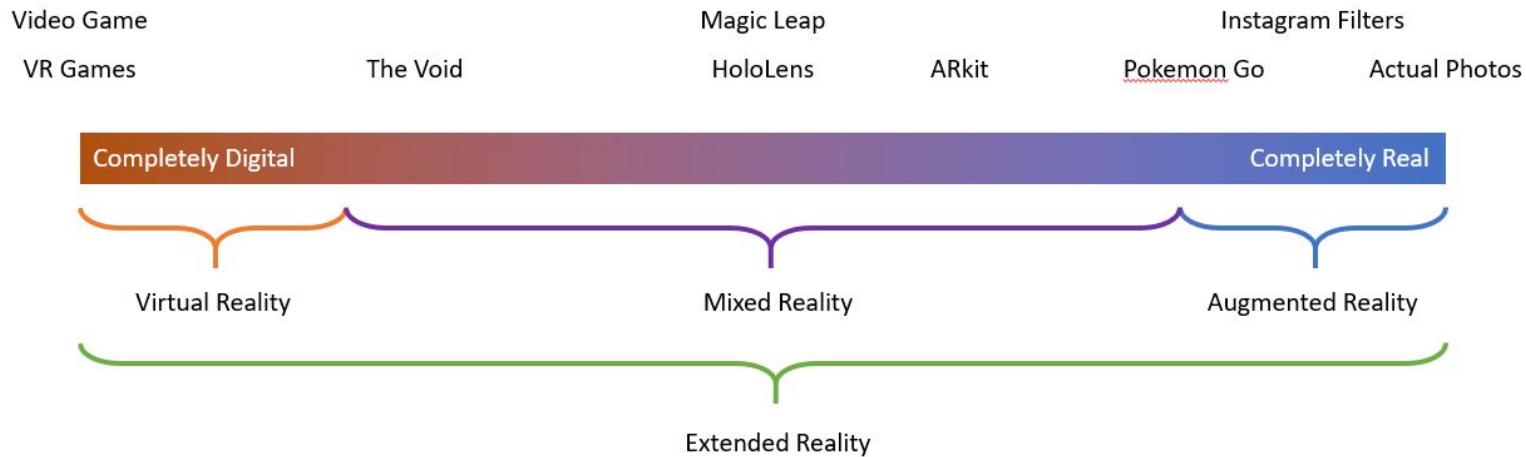


Augmented Reality Technology and Programming

Tianchen Michael Sun
tchsun@ucdavis.edu

VR MR AR

Reality – Virtuality Spectrum



MR Headset

Microsoft HoloLens 2 (2019)
(1st gen in 2016)



Magic Leap (2018)



AR Glasses

Vuzix Blade (2019)



Google Glass Enterprise Edition 2 (2019)



Mobile AR

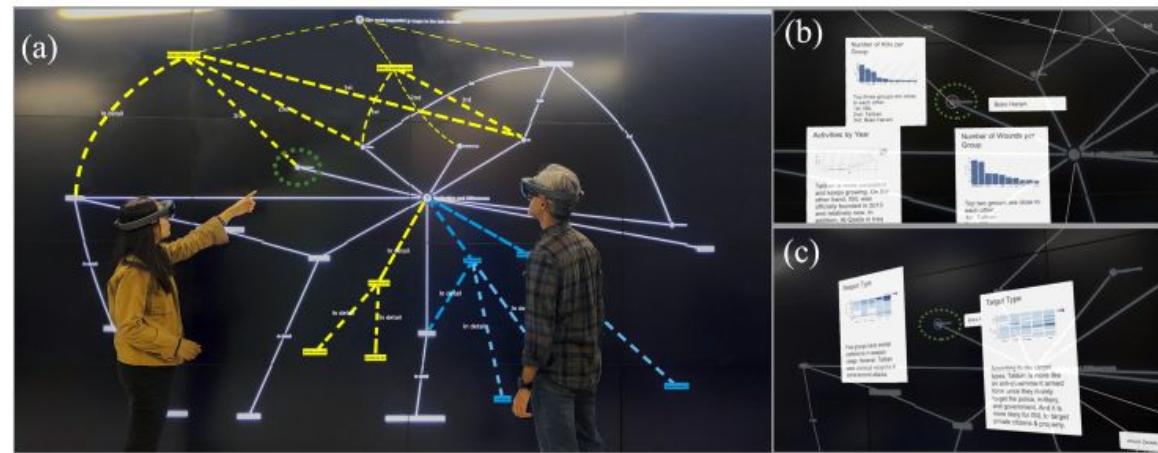
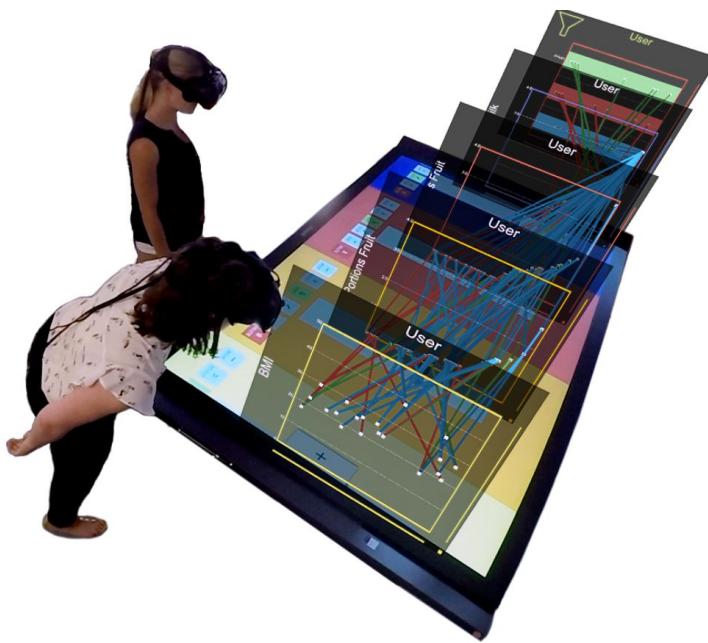
Apple ARkit 3

The screenshot shows the Apple Developer website's Augmented Reality section. At the top, there are navigation links: Discover, Design, Develop, Distribute, Support, Account, and a search icon. Below this, a sub-navigation bar includes Overview, ARKit 3, Reality Composer, AR Quick Look, and Resources. The main content features a large image of a person in a purple shirt standing in a room, with a small yellow toy soldier floating next to them. Above the image is the heading "Get Ready for ARKit 3". A paragraph of text describes the latest features of ARKit 3, such as multi-face tracking and support for collaborative sessions. At the bottom of the page is a large, rounded rectangular image showing the same scene from a different angle, highlighting the AR content.

Google ARCore

The screenshot shows the Google ARCore website. At the top, there are navigation links: Discover, Develop, Distribute, Reference, and Community. The main content features a large image of two people, a man and a woman, looking at a screen together. To the right of the image is the tagline "Build the future. With ARCore, build new augmented reality experiences that seamlessly blend the digital and physical worlds. Transform the way people play, shop, learn, create, and experience the world together—at Google scale." Below the image is a section titled "Dive right in" with the sub-headline "Choose a development environment". It shows four screenshots of different development tools: Android Studio (Android), Unity (Unity), Unreal Engine (Unreal), and Xcode (iOS). Each tool has a "Get started" button below it. At the bottom, there is a "Resources" section with links for Downloads, Guides, APIs, and Forums.

AR + Visualization Example

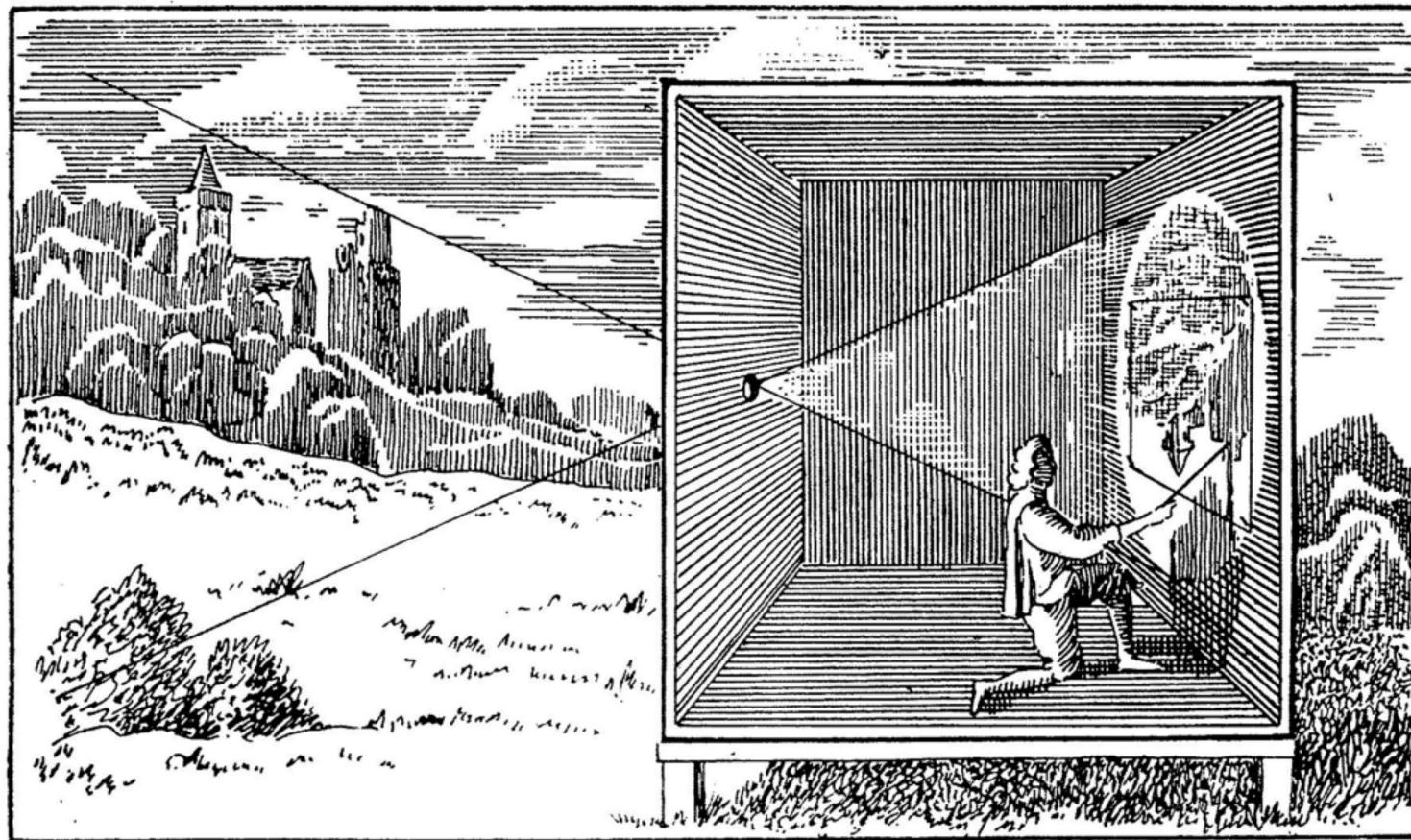


AR + Visualization Example (HoloLens Mixed Reality Capture)

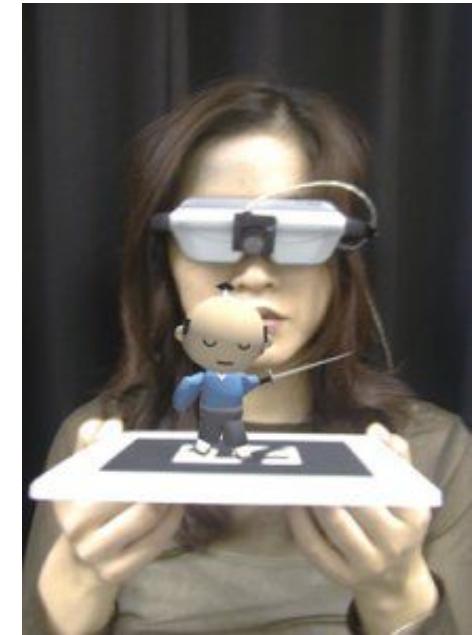
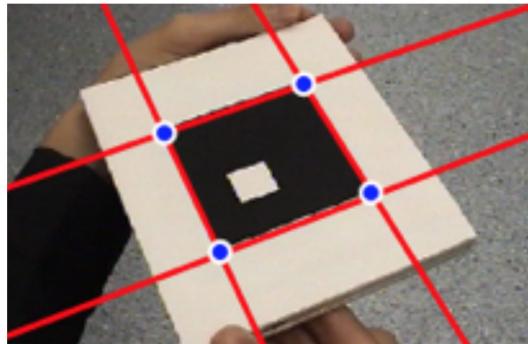
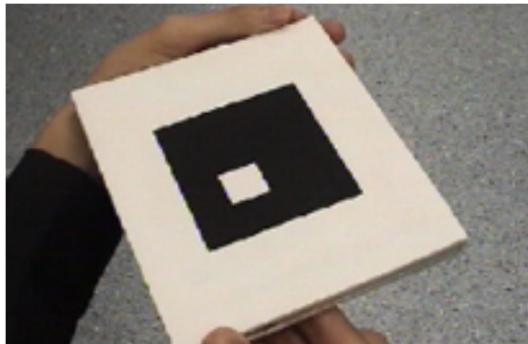
<https://www.youtube.com/watch?v=yOPFs1DJ9vc>



Cameras and AR: find camera-world coordinates



Cameras and AR



ARToolKit (since 1999)

AR device and library in general

- A display showing both real world and digital content
- Spatial sensing
- Interaction with digital content

Unity AR Foundation

Works with ARKit or ARCore

<https://docs.unity3d.com/Packages/com.unity.xr.arfoundation@1.0/manual/index.html>

Samples

Clone or download AR Foundation Samples:

<https://github.com/Unity-Technologies/arfoundation-samples>

Unity Technologies / arfoundation-samples

Code Issues Pull requests Projects Security Insights

Watch 398 Star 645 Fork 168

Example content for Unity projects based on AR Foundation

308 commits 7 branches 0 packages 0 releases 9 contributors View license

Branch: master New pull request Find file Clone or download

tdmowrer Update manifest to latest packages Latest commit 58ea924 13 days ago

Assets Set camera to origin to silence pose driver warning 13 days ago

Packages Update manifest to latest packages 13 days ago

ProjectSettings Updating to Unity 2019.2.2f1. 2 months ago

.gitignore Ignore vscode files 6 months ago

LICENSE.md -Added Unity Companion License 5 months ago

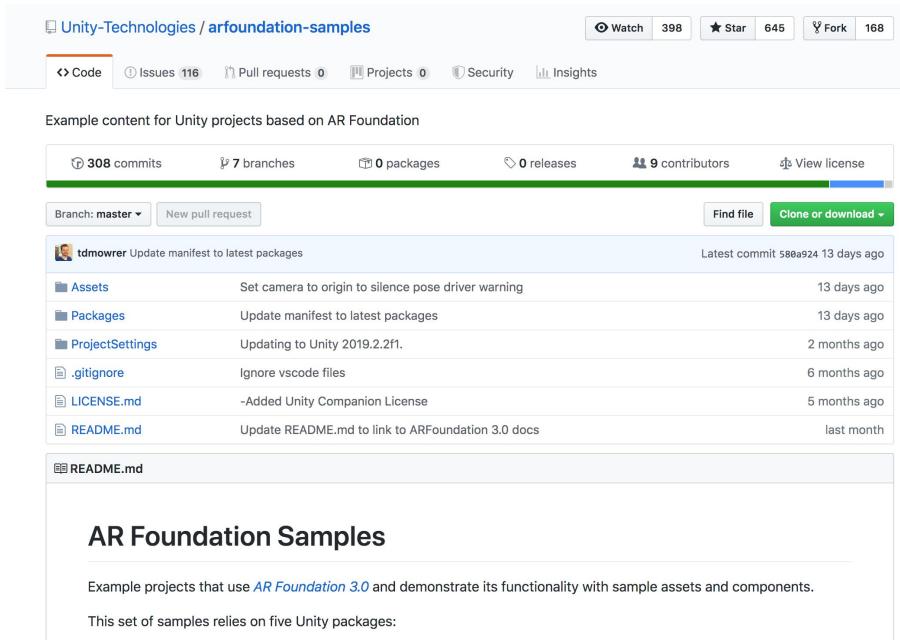
README.md Update README.md to link to ARFoundation 3.0 docs last month

README.md

AR Foundation Samples

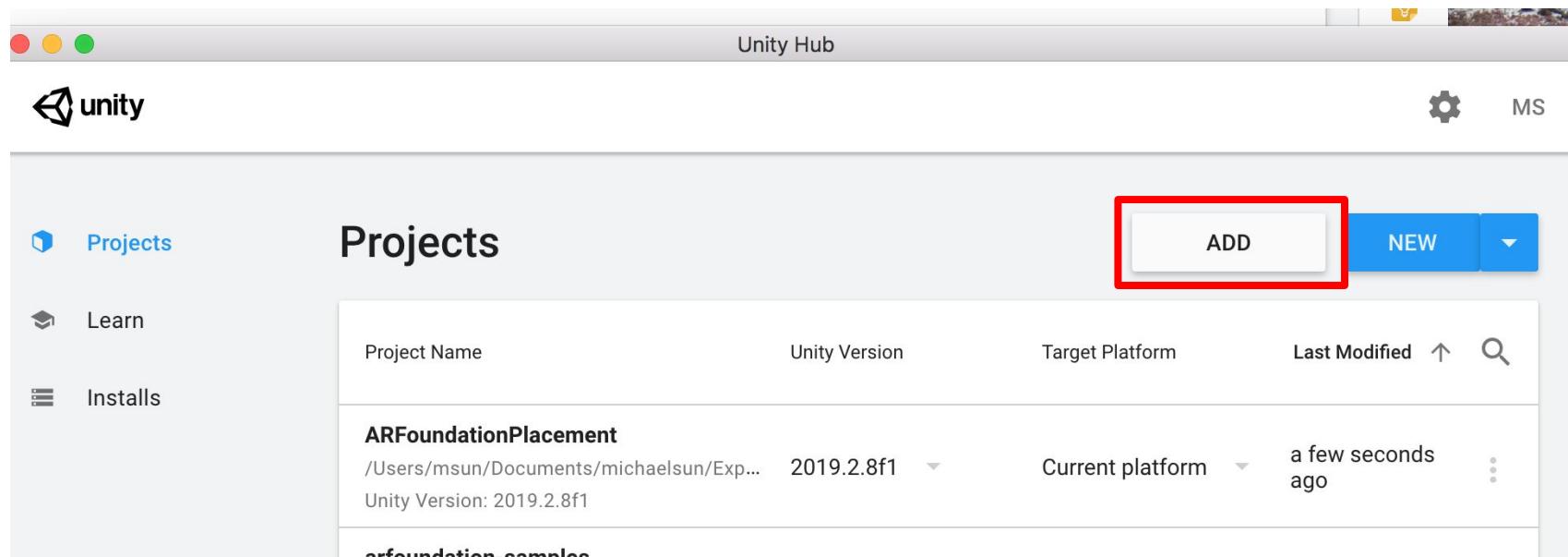
Example projects that use *AR Foundation 3.0* and demonstrate its functionality with sample assets and components.

This set of samples relies on five Unity packages:

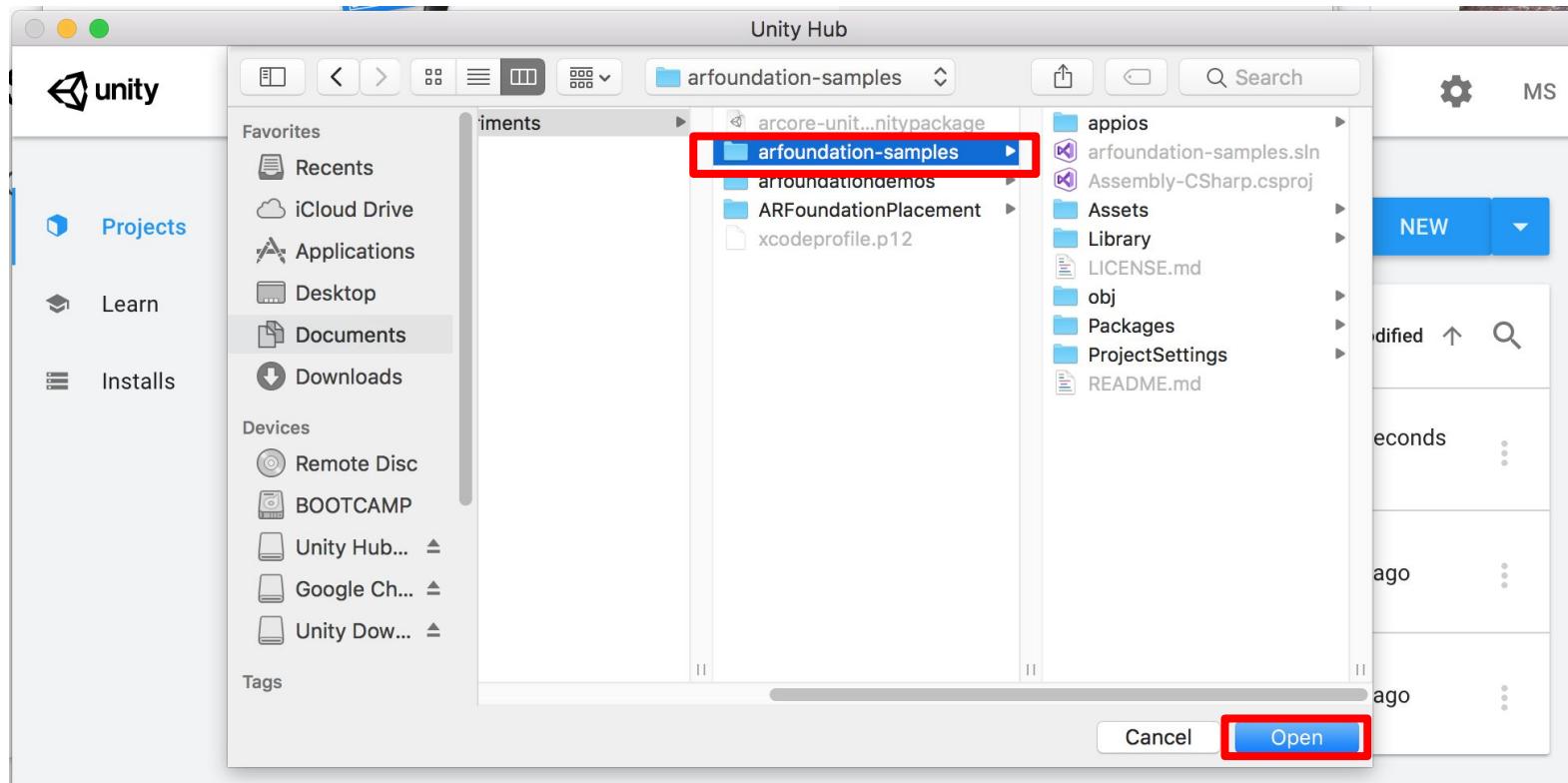


Samples

Open the project with Unity



Samples

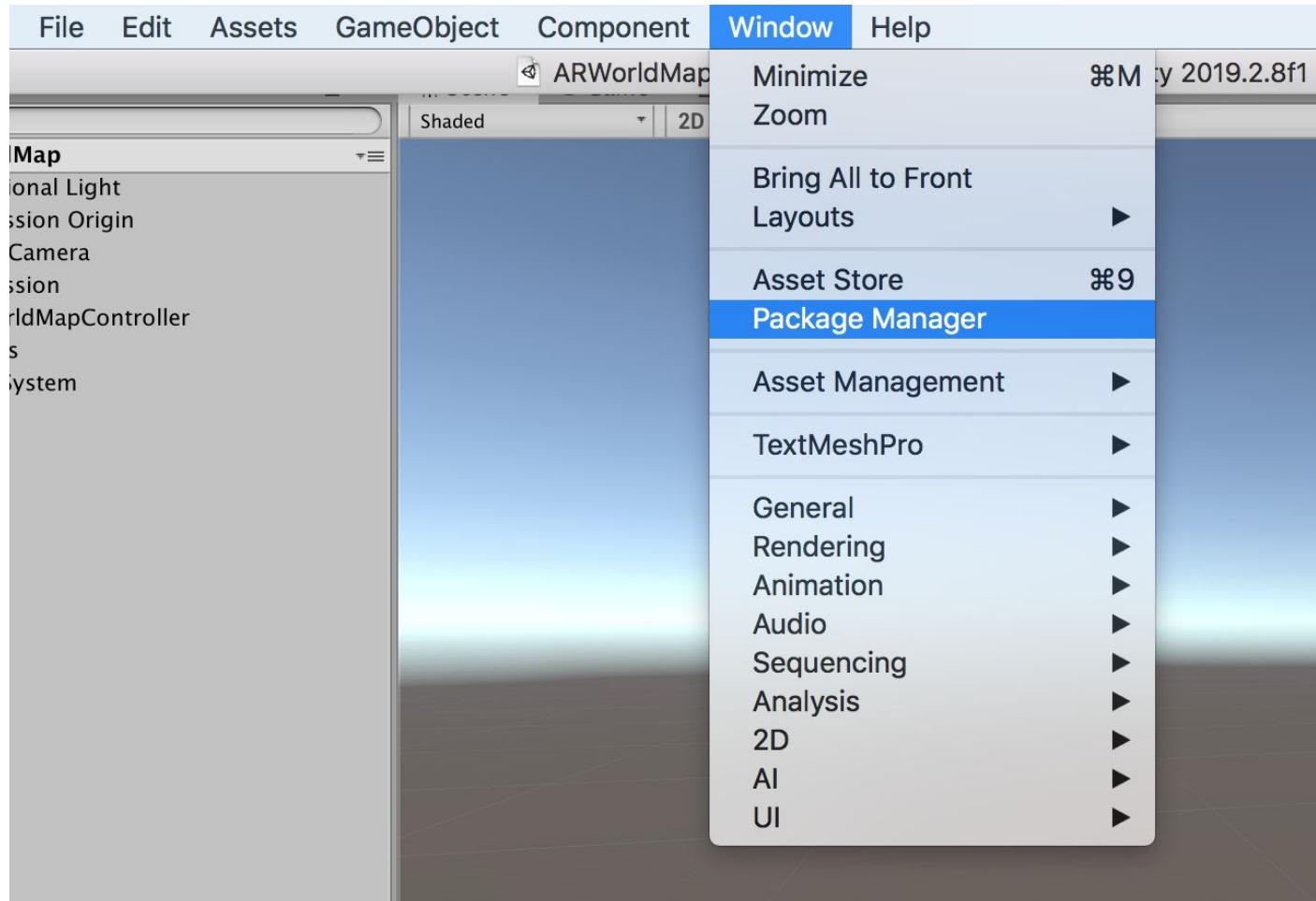


Unity AR Foundation

Window > Package Manager, install

- AR Foundation
- (iOS) ARKit XR Plugin
- (iOS) (Optional) ARKit Face Tracking
- (Android) ARCore XR Plugin

Package



Package

The screenshot shows the Unity Package Manager interface. A search bar at the top contains the text "ar". Below the search bar, a list of packages is displayed. Two specific packages are highlighted with red boxes: "AR Foundation" and "ARCore XR Plugin".

Package	Version	Status
Analytics Library	3.3.2	✓
AR Foundation	preview.3 – 3.0.0	✓
AR Subsystems	preview.3 – 3.0.0	✓
ARCore XR Plugin	preview.3 – 3.0.0	✓
ARKit Face Tracking	preview.3 – 3.0.0	✓
ARKit XR Plugin	preview.3 – 3.0.0	✓
Core RP Library	6.9.1	
Quick Search	1.4.1	
Share WebGL Game	preview – 1.0.5	
Vuforia Engine AR	8.3.9	

AR Foundation

Version 3.0.0 [\[preview\]](#)

[View documentation](#) – [View changelog](#) – [View licenses](#)

com.unity.xr.arfoundation

Author: Unity Technologies Inc.

A collection of MonoBehaviours and C# utilities for working with AR Subsystems.

Includes:

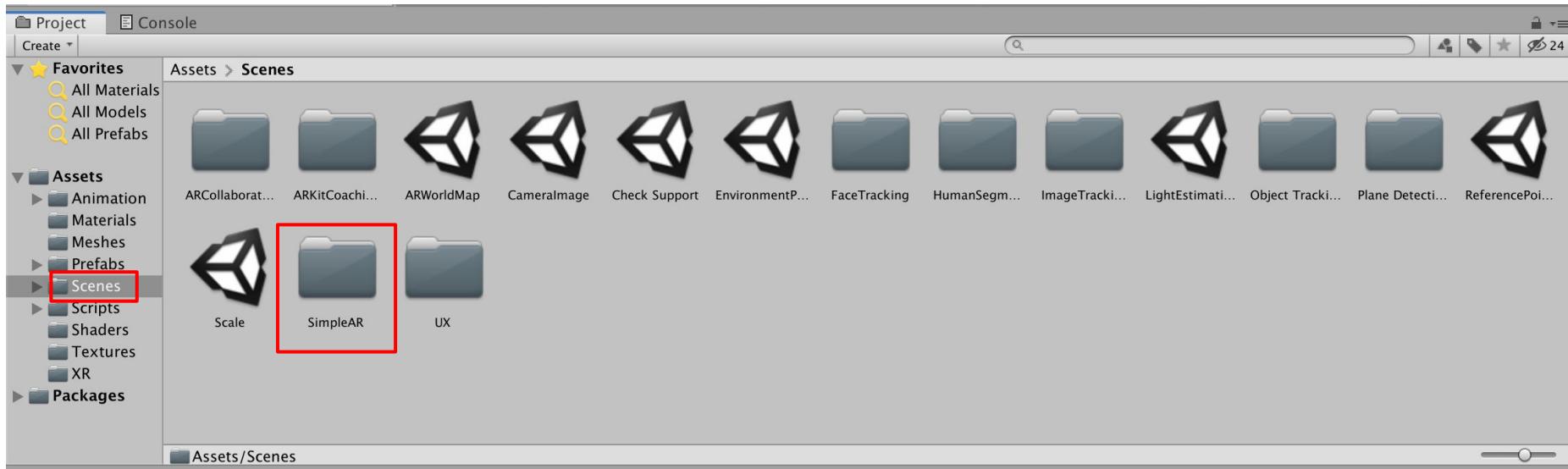
- GameObject menu items for creating an AR setup
- MonoBehaviours that control AR session lifecycle and create GameObjects from detected, real-world trackable features
- Scale handling
- Face tracking

Last update Oct 10, 17:39

Up to date Remove

Sample Scenes

Open Scenes/SimpleAR/SimpleAR



Android/iOS build setup

- Android:

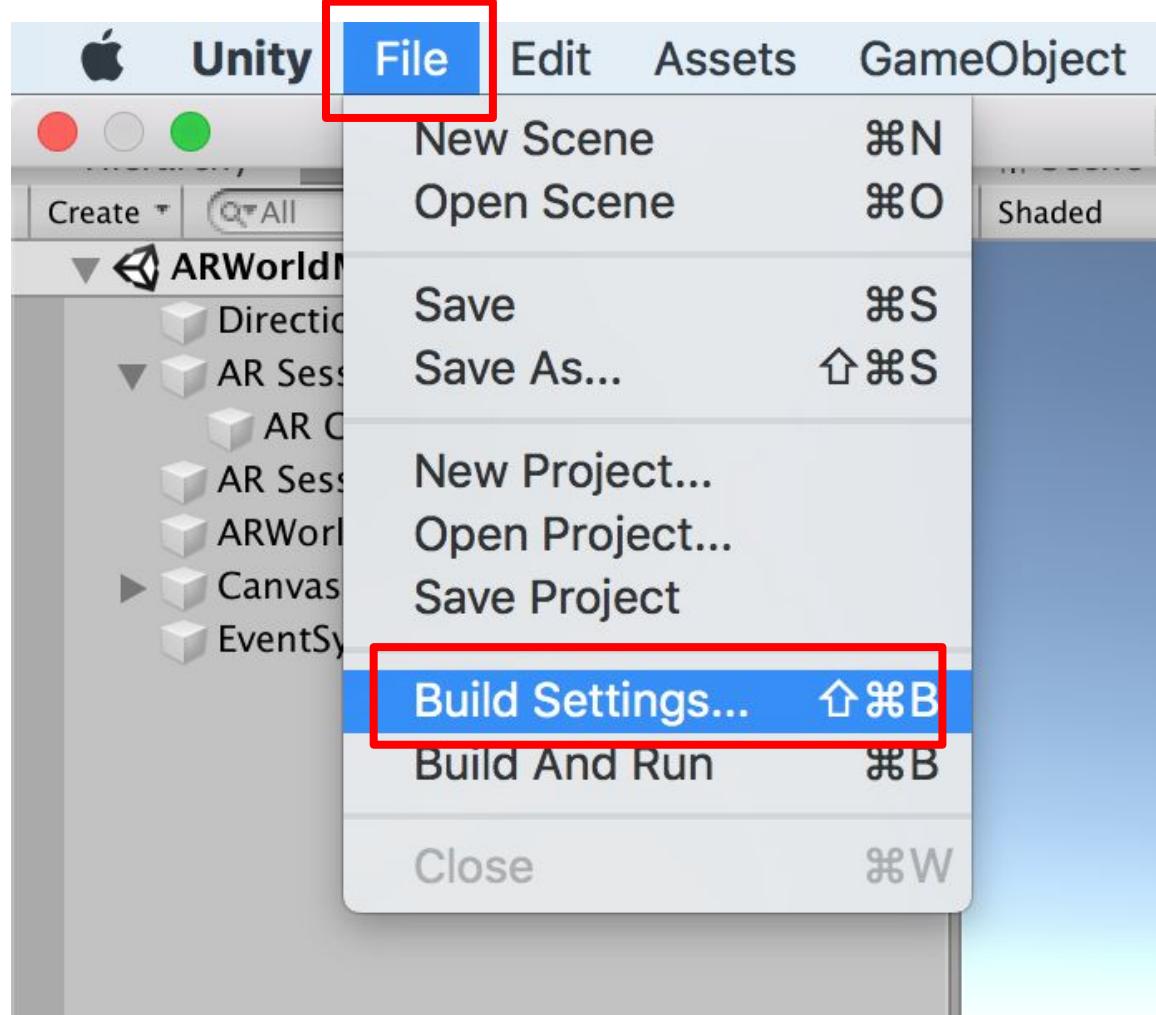
<https://docs.unity3d.com/Manual/android-sdksetup.html>

- iOS:

<https://docs.unity3d.com/Manual/iphone-accountsetup.html>

- XCode needed

Build



Build

Build Settings

Scenes In Build

- Scenes/HumanSegmentation/HumanBodyTracking3D
- Scenes/HumanSegmentation/HumanSegmentationImages
- Scenes/ImageTracking/ImageTracking
- Scenes/LightEstimation
- Scenes/Object Tracking/ObjectTracking
- Scenes/Plane Detection/FeatheredPlanes
- Scenes/Plane Detection/TogglePlaneDetection
- Scenes/Scale
- Scenes/SimpleAR/SimpleAR
- Scenes/UX/SampleUXScene

0

Add Open Scenes

Platform

-  PC, Mac & Linux Standalone
-  iOS
-  Android
-  tvOS
-  PS4
-  Xbox One
-  WebGL
-  Facebook

iOS

Run in Xcode

Run in Xcode as

Symlink Unity libraries

Development Build

Autoconnect Profiler

Script Debugging

Scripts Only Build

Latest version

Release

Compression Method

Default

Learn about Unity Cloud Build

Player Settings...

Switch Platform

Build And Run

Build

Build Settings

Scenes In Build

- Scenes/HumanSegmentation/HumanBodyTracking
- Scenes/HumanSegmentation/HumanSegmentation
- Scenes/ImageTracking/ImageTracking
- Scenes/LightEstimation
- Scenes/Object Tracking/ObjectTracking
- Scenes/Plane Detection/FeatheredPlanes
- Scenes/Plane Detection/TogglePlaneDetection
- Scenes/Scale
- Scenes/SimpleAR/SimpleAR
- Scenes/UX/SampleUXScene

Platform

- PC, Mac & Linux Standalone
- iOS
- Android
- tvOS
- PS4
- Xbox One
- HTML
- WebGL
- Facebook

Player Settings...

Project Settings

- Audio
- Editor
- Graphics
- Input
- Physics
- Physics 2D
- Player**
- Preset Manager
- Quality
- Script Execution Order
- Tags and Layers
- TextMesh Pro
- Time
- VFX
- RUNTIME
- XR
- ARCore Build Settings
- ARKit Build Settings
- XR Plugin Management
- ARCore
- ARKit
- Input Helpers
- XR Tracking

Player

Enable Frame Timing Stats

Identification

Bundle Identifier **com.vidi.arsamples**

Version* 0.1

Build 0

Signing Team ID

Automatically Sign

Configuration

Scripting Backend IL2CPP

Api Compatibility Level* .NET Standard 2.0

C++ Compiler Configuration Release

Use incremental GC (Experimental)

Use on-demand resources*

Accelerometer Frequency* 60 Hz

Camera Usage Description* Camera required for AR

Location Usage Description*

Microphone Usage Description*

Mute Other Audio Sources*

⚠️ Audio input from Bluetooth microphones is not supported when Mute Other Audio Sources is off.

Prepare iOS for Recording

Force iOS Speakers when Recording

Requires Persistent WiFi*

Allow downloads over HTTP (nonsecure)*

▶ Supported URL schemes*

Disable HW Statistics*

Target Device iPhone + iPad

Target SDK Device SDK

Target minimum iOS Version **11.0**

Enable ProMotion Support

Requires ARKit support

Automatically add capabilities

▶ Defer system gestures on edges

Hide home button on iPhone X

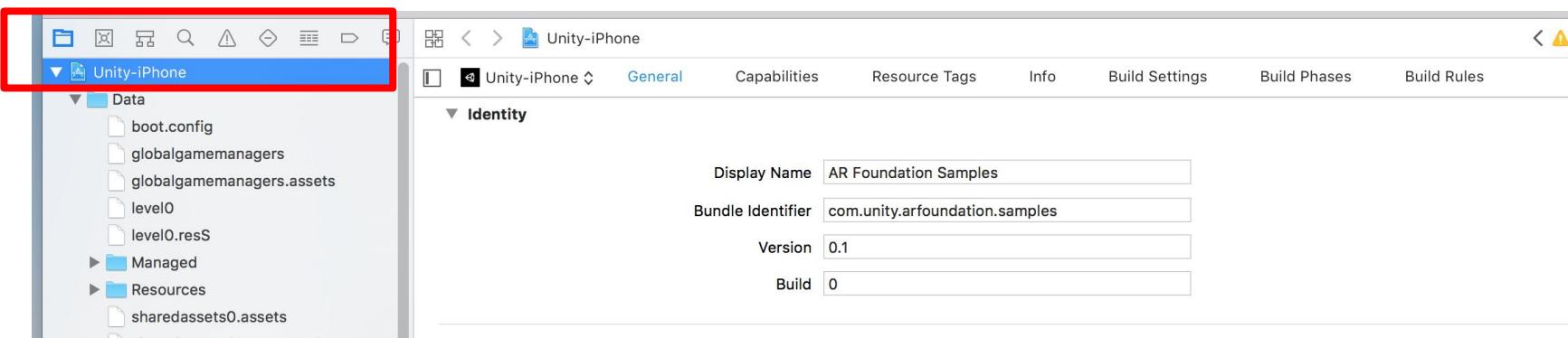
Render Extra Frame on Pause

Enable Custom Background Behaviors

Architecture ARM64

Scripting Define Symbols UNITY_POST_PROCESSING_STACK_V2

Build - iOS



Build - iOS

▼ Signing

Automatically manage signing
Xcode will create and update profiles, app IDs, and certificates.

▼ Signing (Release)

Provisioning Profile 

Team None

Signing Certificate None

Status  "Unity-iPhone" requires a provisioning profile.
Select a provisioning profile for the "Release" build configuration in the project editor.

▼ Signing (ReleaseForProfiling)

Provisioning Profile 

Team None

Signing Certificate None

Status  "Unity-iPhone" requires a provisioning profile.
Select a provisioning profile for the "ReleaseForProfiling" build configuration in the project editor.

▼ Signing (ReleaseForRunning)

Provisioning Profile 

Build - iOS

▼ Signing

Automatically manage signing

Xcode will create and update profiles, app IDs, and certificates.

Team None

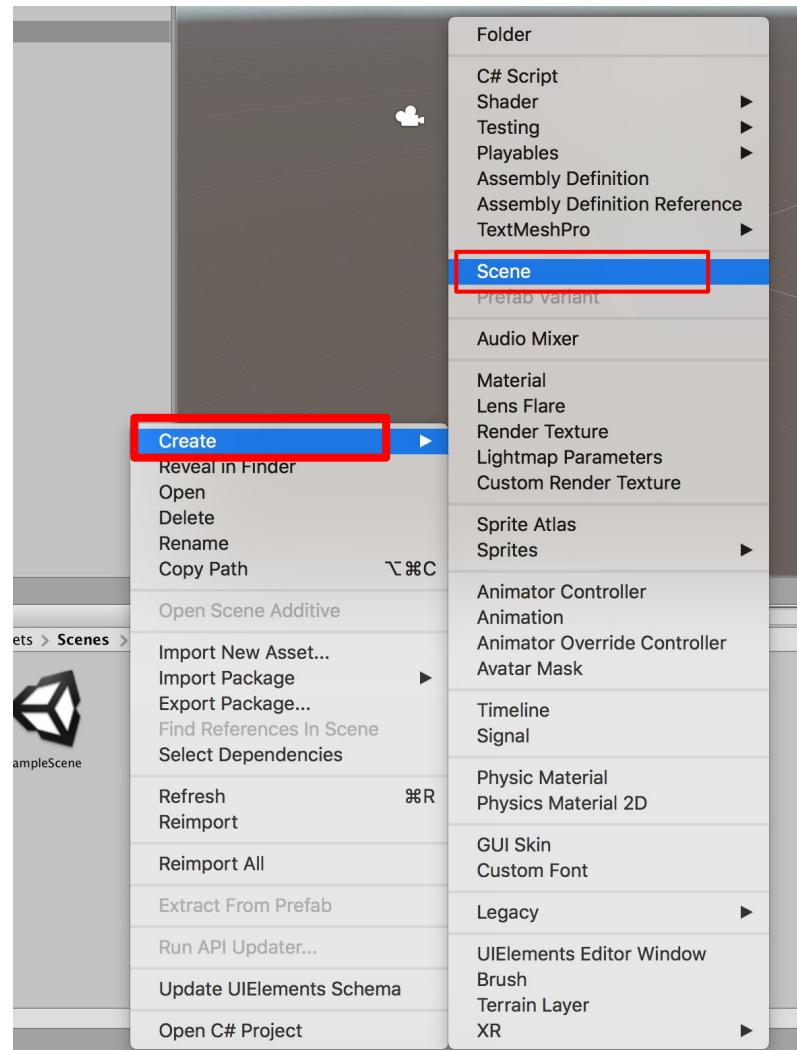
Provisioning Profile Tianchen Sun (Personal Team)

Signing Certificate Add an Account...

Status ! Signing for "Unity-iPhone" requires a development team.

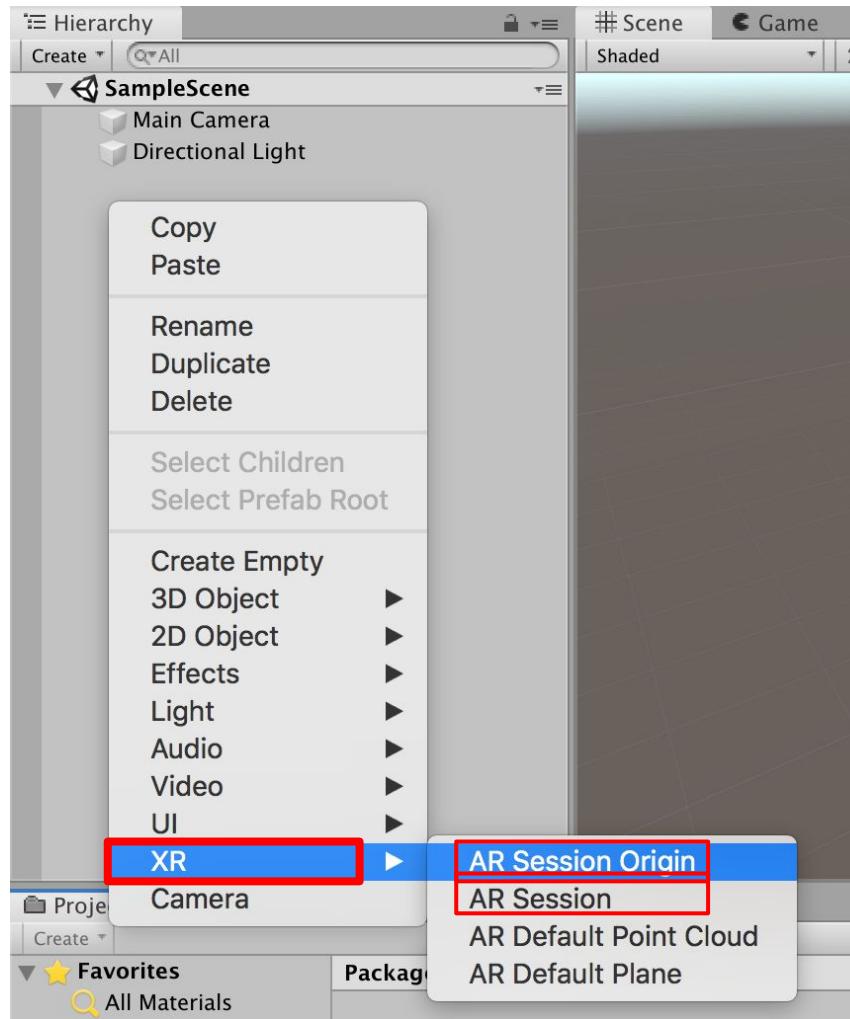
Select a development team in the project editor.

New Scene



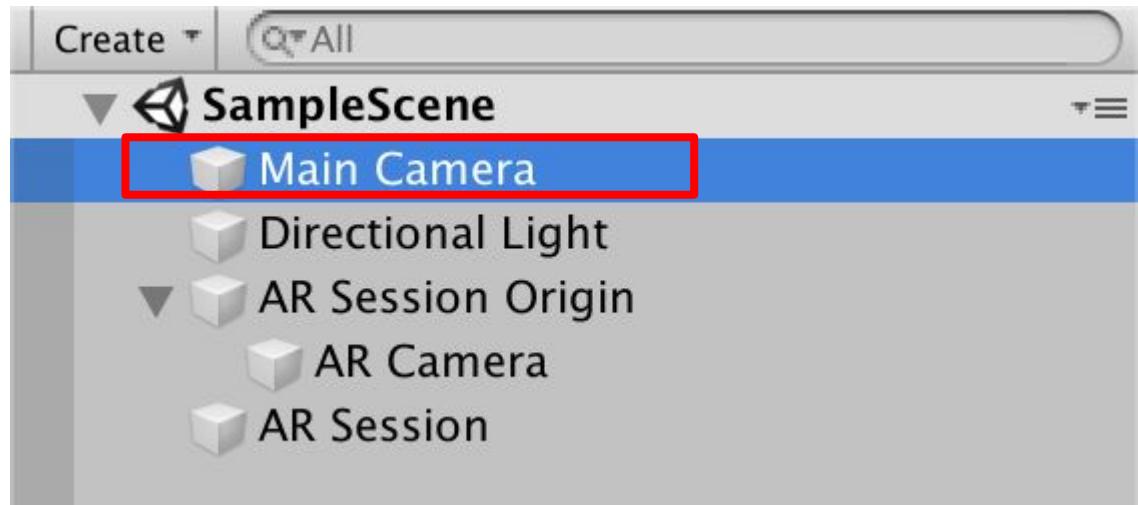
New Scene

Add AR Session and
AR Session Origin



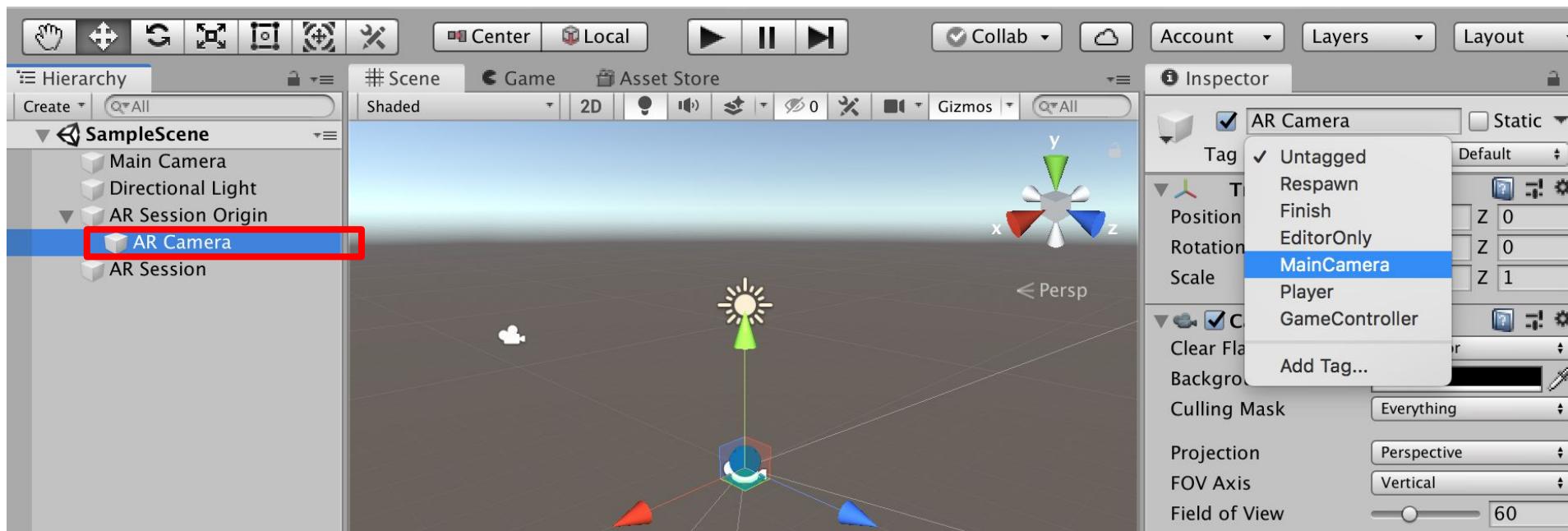
New Scene

Delete Main Camera



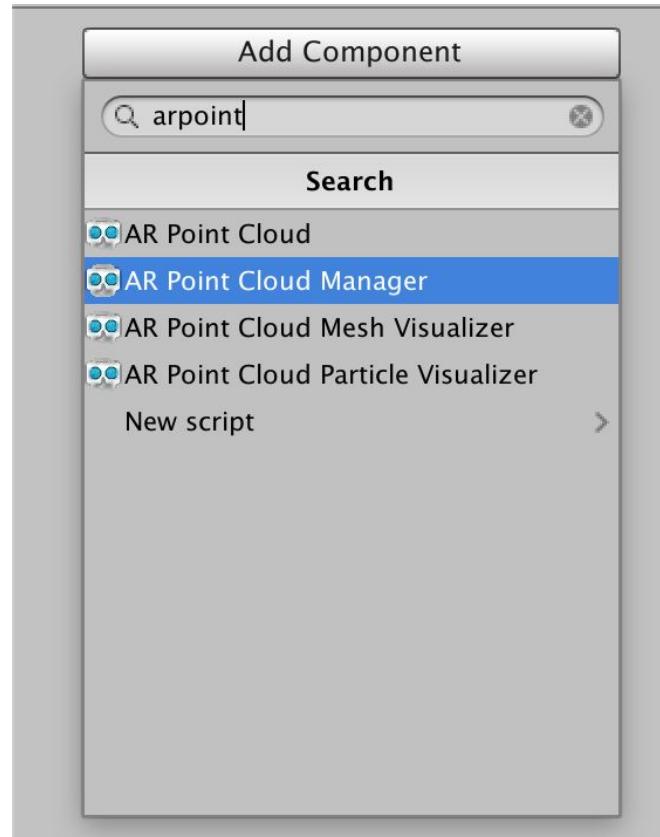
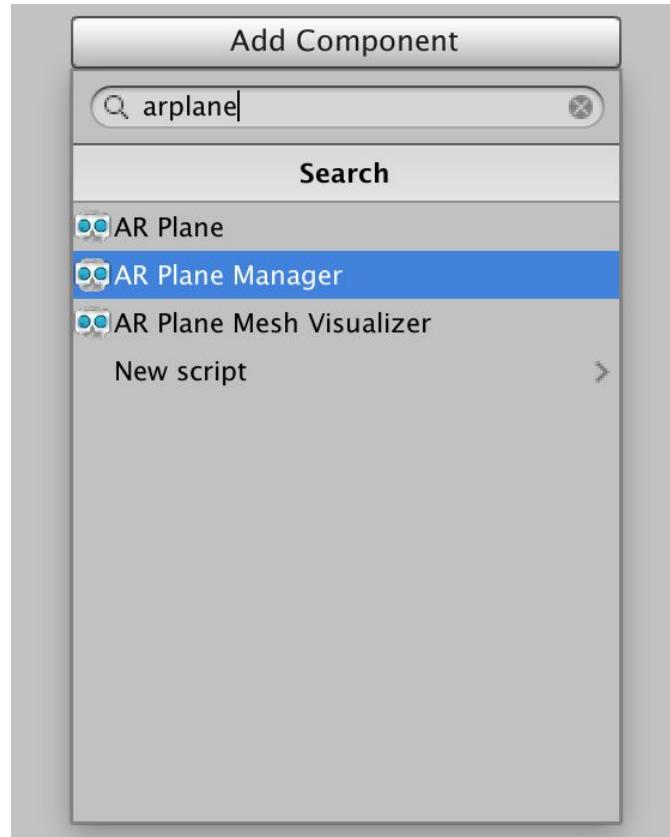
New Scene

Select AR Camera in AR Session Origin



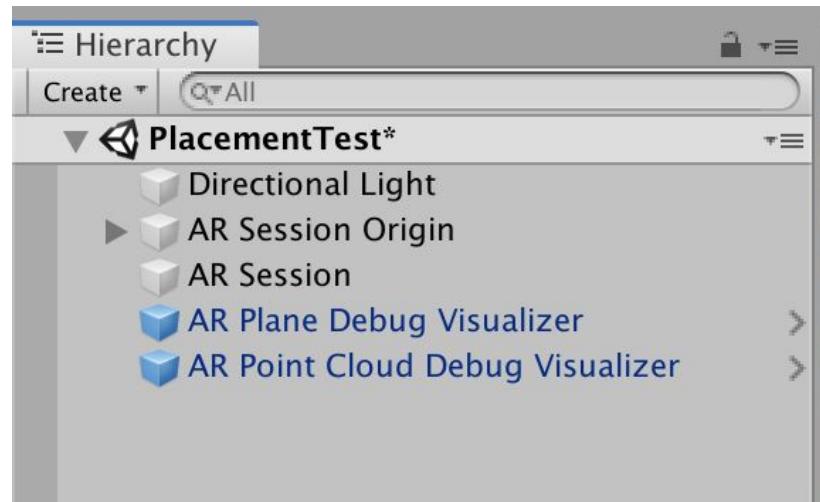
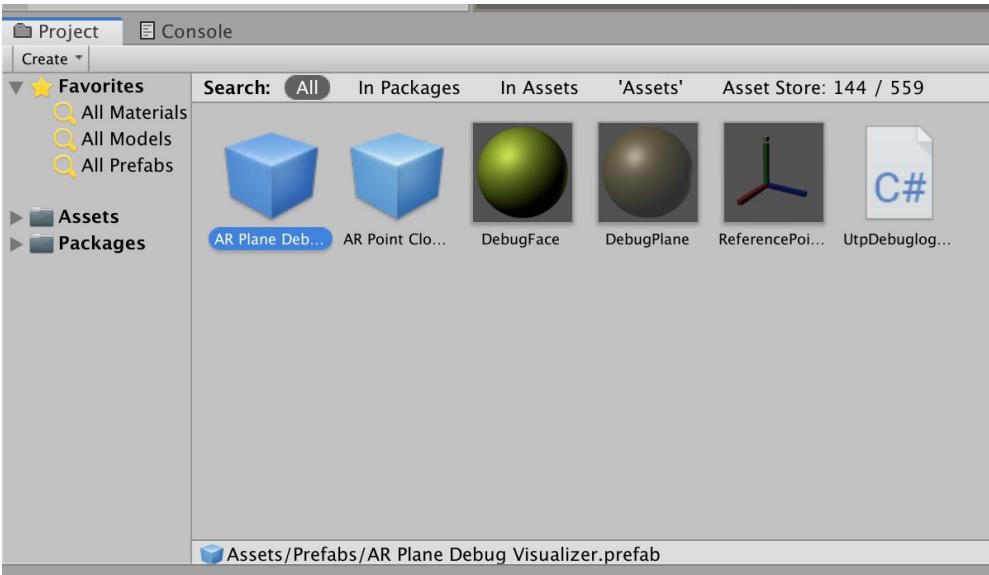
New Scene

In Inspector,
Add components



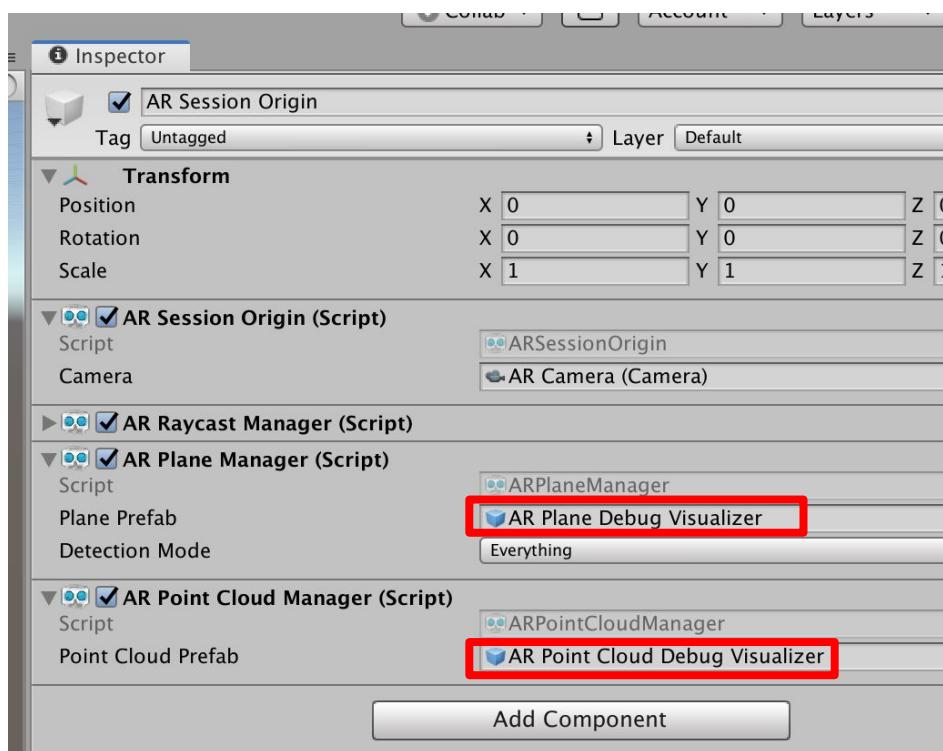
New Scene

In Project, Search “debug”,
Drag **AR Plane Debug Visualizer** and **AR Point Cloud Debug Visualizer** into the scene



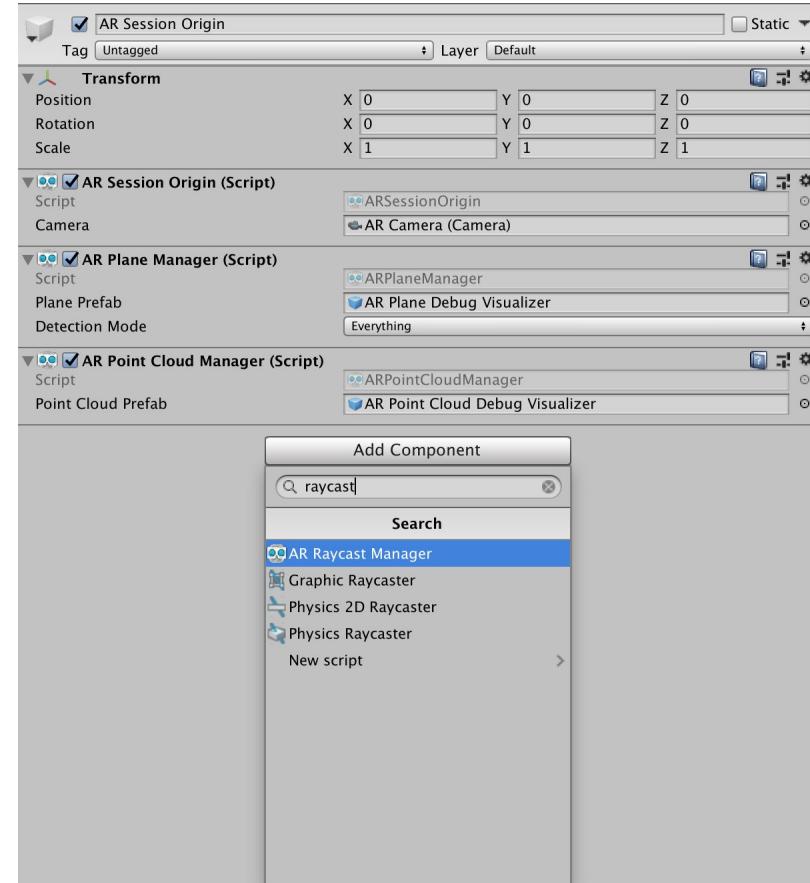
New Scene

Select **ARSessionOrigin**,in Inspector,
drag **ARPlaneDebugVisualizer** to **ARPlaneManager's**
Plane Prefab slot
drag **ARPointCloudDebugVisualizer** to
ARPointCloudManager's Point Cloud Prefab slot



Programming: Tap to place cube on plane

Add **ARRaycastManager** to
ARSessionOrigin

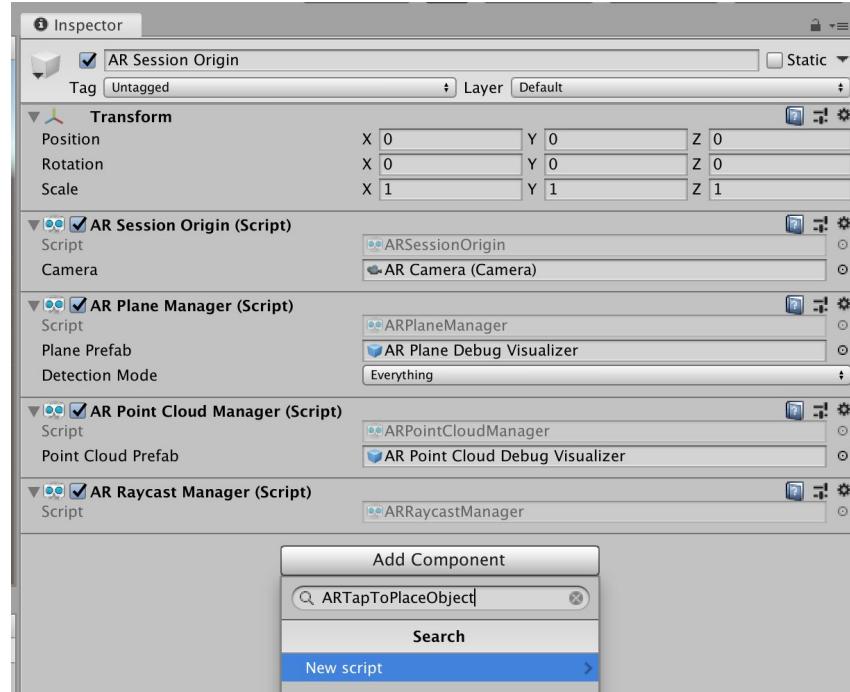


Programming: Tap to place cube on plane

Create a new script

ARTapToPlaceObject.cs to

ARSessionOrigin, open it for editing

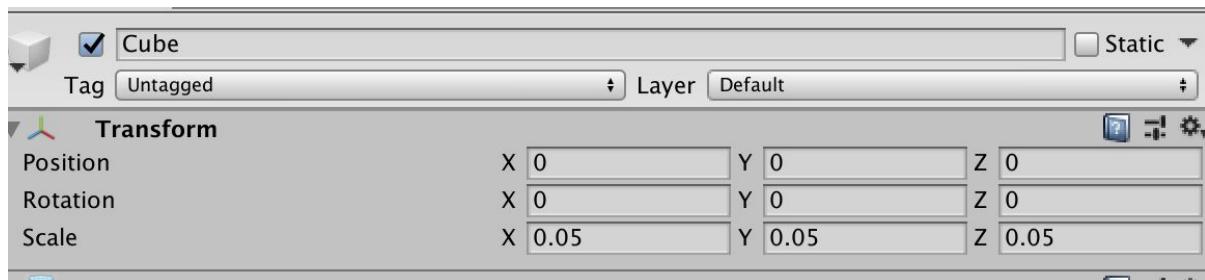
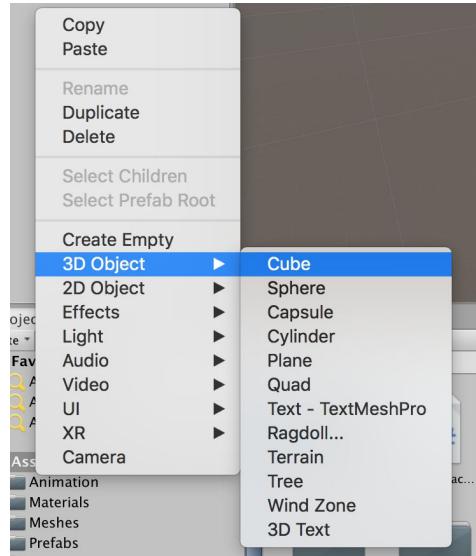


ARTapToPlaceObject.cs

```
1  using System.Collections;
2  using System.Collections.Generic;
3  using UnityEngine;
4  using UnityEngine.XR.ARFoundation;
5  using UnityEngine.XR.ARSubsystems;
6
7  public class ARTapToPlaceObject : MonoBehaviour
8  {
9      public GameObject cube;
10
11     private ARRaycastManager _arRaycastManager;
12     private List<ARRaycastHit> _hitList;
13
14     // Start is called before the first frame update
15     void Start()
16     {
17         _arRaycastManager = GetComponent<ARRaycastManager>();
18         _hitList = new List<ARRaycastHit>();
19     }
20
21     // Update is called once per frame
22     void Update()
23     {
24         // cast a ray from the center of the screen
25         Ray screenCenterRay = Camera.main.ViewportPointToRay(new Vector3(0.5f, 0.5f));
26         bool isValidHit = _arRaycastManager.Raycast(screenCenterRay, _hitList, TrackableType.PlaneWithinPolygon);
27         // if the ray hits a plane
28         if (isValidHit)
29         {
30             ARRaycastHit hit = _hitList[0];
31             // place the cube indicator at the center of the screen
32             cube.SetActive(true);
33             cube.transform.SetPositionAndRotation(hit.pose.position, hit.pose.rotation);
34             // create a cube when user touch the screen
35             if (Input.touchCount > 0)
36             {
37                 Touch touch = Input.GetTouch(0);
38                 if (touch.phase == TouchPhase.Began)
39                 {
40                     Instantiate(cube, cube.transform.position, cube.transform.rotation);
41                 }
42             }
43         }
44         else
45         {
46             cube.SetActive(false);
47         }
48     }
49 }
```

Programming: Tap to place cube on plane

Create a cube object, resize it to (0.05, 0.05, 0.05)



Programming: Tap to place cube on plane

Drag the cube to **ARTapToPlaceObject**

