Augmented Reality Campus Navigation

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***Abstract*—The main idea of the AR Campus Navigation project is to upgrade the classical concept of campus navigation by using an AR system which provides the real-time direction in front of the user's mobile device screen. With help of Unity's AR Foundation and XR Plugin Management software, necessary for AR developing, as well as other vital plugins, this project offers an easy navigation backed up by real-world landmarks. The comprehensive methodology outlined herein covers the project's key phases: One of the major activities detected is the initial setup, preparation of Unity scene, marker recognition using AR image tracking, script writing for navigation flow diagram and finally deployment. This approach helps eliminate the arbitrary placement of virtual components overlaid on physical spaces and the user interface of the application is logical and easy to navigate.**

Keywords—AR Foundation, Unity, XR Plugin, navigation system, augmented reality, campus navigation.

I. Introduction

Concept of Augmented Reality (AR) has gained importance in the field where designing solutions for changing interaction with digital and physical environments is the most interesting and challenging. AR combines both the virtual and physical environment, offering real-time information or instructions which if incorporated in navigation creates an improved interface. The potential of Unity for such an application is realised in the AR Campus Navigation project, which implements an application for an AR navigation system. The main aim of the project is to provide students, staff and other visitors with easy navigation within a campus, devoid of the general problem of finding landmarks, buildings or other critical structures within and around an unfamiliar vicinity.

1. The Need for AR Campus Navigation

Most extended grounds in learning institutions, business organizations, and even health facilities present difficulty to newcomers and even ordinary users in finding their way around. The conventional information-providing systems, for example, printed maps or signposts, are static and cannot be updated frequently and interactively, which makes people annoyed. Some of this is served well by GPS in mobile applications of map services, but these are as often lacking the fine-grained interior and /or building-level directions needed on campus. Here, the utilisation of AR technology in navigation comes in handy since it creates an enriching, context-sensitive as well as visually interactive form of navigation.

The AR Campus Navigation system deploys AR as a medium to create exciting paths, names and touchable signs and signals on the physical reality as it is seen through a smartphone or any AR device. Thus, the system optimizes users' perception of the environment and offers more appropriate instructions based on users' navigation conditions. For instance, if it is a student who is trying to find a specific lecture theater, or if it is a visitor looking for a cafeteria, it will be very helpful to use virtual arrows together with floating text labels and voice guidance that appear right on top of one's camera.

2. Technology Architecture and Software Development plan

The AR Campus Navigation system outlined in this paper leverages Unity in its development; Unity is an efficient platform for developing 3D/AR applications. Incorporating with properly developed AR toolkits includes Unity AR toolkits such as AR Foundations, Vuforia, or ARkit and ARcore gives the foundation to map out the environment and overlaying digital graphics in real-time. As an example, the Unity AR Foundation toolkit, for instance, enables the project to develop an AR experience compatible with both iOS and Android.

For constructing a navigation system, the team first maps out the campus where the AR content is to be usually overlayed, in a form of 3D map. All the important features on the map have been reinforced by representing the important areas of the campus which include landmarks, buildings, pathways, and entry points. This ensures that the overlaid AR content aligns perfectly with the user's view of the physical environment.

Interactive cues, such as floating icons, text labels, and directional arrows, are designed to provide clear and concise navigation instructions. These cues dynamically update as the user moves, ensuring they remain relevant and context-aware. For instance, if a user deviates from the suggested path, the system recalibrates and provides updated directions to guide them back on track. Voice commands and audio feedback further enhance accessibility, allowing users to interact with the system without relying solely on visual cues.

II. LITERATURE REVIEW

Moving around in a large campuses is a challenge no matter the property — first year students or visitors to the place, but especially newcomers. The size and complexity of our campuses, and the static, and often out of date nature of traditional maps, brings this challenge. These maps give a headier sense of direction but ultimately don't offer real time or personalised guidance in line with what the modern user expects. Augmented Reality (AR) technology fills the gap between the real and the virtual world by overlaying virtual elements onto the real world, providing a creative and interactive experience. The potential of this innovation is to change navigation forever by giving users step by step, real time guidance directly on their mobile device.

The idea of using AR for campus navigation has gained much attention including improving accessibility, usability, and user engagement. AR has been explored in several studies to offer real time, context aware information to guides users within university campuses. [1] showed the AR has the potential in campus navigation through the integration of real time positioning systems, allowing users to seamlessly navigate. Using mobile devices to overlay AR navigation instructions, their system provided an intuitive and interactive user interface. Combining AR with traditional maps enhances user experience in campus settings was discussed in [2]. They work of combining AR with location based services, providing contextualized information, and guiding users from campus to campus. This has enabled these approaches to focus on the effectiveness of AR for delivering real time directions and contextual environment to users to enhance the over all navigation experience.

In general, the technological foundation of AR based campus navigation systems is currently based on integration with mobile applications, GPS and specific AR development platforms. For AR based navigation solutions, ARCore (Google's AR framework) and Vuforia (platform for AR applications) are highly used. An AR based campus navigation system was developed in [3] using ARCore to demonstrate how AR can provide real time location based information with good precision. The augmented visuals are provided by these systems which use smartphone sensors and cameras to give the users direction and positioning. An empirical study on the National Taiwan University campus was conducted using [4] that designed a mobile AR navigation system using Unity3D and Vuforia SDKs. AR navigation was shown to be practical in real world complex environments like university campuses with their system showing how easy it is to implement and the versatility of development tools to create interactive AR experiences.

User centric design is a cornerstone behind AR based campus navigation systems' application. They focused on developing a campus navigation system for the visually impaired individuals. [5] For users with visual impairments, this study, which resulted in the creation of the "Divya Dristi" application, combined smartphone based AR with auditory feedback for the purpose of navigation. Such user centered solutions show how AR can be applied to meet accessibility needs and that campus navigation systems take into account a large group of users. [6] explored the integration of AR with GPS for mobile campus touring systems with a case study on how AR can enhance cultural campus activities. This user centric approach enables AR applications to be properly designed that attract students, faculty and visitors through a personalized experience based on their requirements.

For campus based navigation, [7] tried integrating AR with the deep learning techniques employing neural networks for object recognition further improving the precision of navigation system. Studies have combined for advanced technologies dealing with image processing and machine learning for improving the accuracy and efficiency of AR-based campus navigation systems. The image processing mechanisms required for autonomous AR navigation systems were investigated by [8]. Based on this, they proposed a system that takes advantage of visual data in smartphone camera to process environmental information and to give accurate navigational instructions. The AR integration with image processing makes the system capable of real time object and landmark identification to provide users with a more immersive and reliable method of navigation.

A systematic review of AR navigation research was conducted by [9], identifying major challenges of battery consumption, compatibility of the devices, and continuous updates in dynamic environments. These challenges in future research could be addressed by contending with new tracking technologies, enhancing the performance of AR applications, and leveraging more sophisticated data analysis techniques, like machine learning for predictive navigation.

Most AR navigation systems today are designed for outdoor environments, but indoor navigation is another area of considerable need for research, such as in university campuses, libraries or museums. [10] studied marker based AR for indoor library navigation, through a case study at a university library in China. The library used AR to display visual markers that pointed users to different spots throughout the library illustrating that AR can be applied to indoor spaces. Navigation in large, multi floor buildings where traditional means may not work can be served by indoor AR navigation systems. An indoor navigation system using AR using the Unity and Vuforia SDKs as discussed in [11] for a case study in a university campus. The indoor positioning systems were combined with AR to guide users to specific rooms and locations in the building with step by step directions. The studies shown here show how well AR can work in indoor campus settings where navigation is difficult, due to the absence of natural landmarks.

Having the promising advancement in AR based campus navigation systems, there are still several challenges to solve. This includes the requirement of high precision location tracking, effective real time data integration and the ability to scale up to large campuses with difficult environment.

III. BACKGROUND

AR uses sophisticated technologies like GPS, computer vision, and 3D modelling to make the physical world more engaging with digital content. This can mean embedding virtual arrows on pathways, highlighting important landmarks, or showing contextual building and facility information. They can hold up their smartphones or tablets and instantly get directions layered over their camera view showing them how to get where they want to go without any confusion. This type of navigation is especially helpful when traditional signs may be insufficient or unclear, as on sprawling university campuses, theme parks, airports, and hospitals.

Making such applications possible has been made possible through recent progress in mobile AR technology. Today, mobile devices have powerful processors, high resolution cameras, gyroscopes, and accelerometers—crucial for good AR experience. Additionally, Unity software platforms, coupled with Unity's AR Foundation framework, has made development of AR applications relatively easy for developers. The AR Foundation from Unity provides a cross platform interface for Android and iOS and supports surface detection, real time tracking, and occlusion handling. With these tools, developers can now build AR apps that offer navigation and a great experience to users.

The capability to enhance user interaction with environment is by far one of the most exciting things about AR navigation. Whereas traditional maps or digital 2D interfaces, AR combines 3D models, animations and other interactive elements. One example of this would be a university navigation app that allows user virtual guide to three-dimensional tour campus and leads user to the destination with additional information regarding the facilities around it or historical landmarks. This level of interaction not only improves on navigation intuitiveness but it also bridges a level of engagement that traditional methods can't match. It's no longer passive users that receive information, but active participants in the journey.

Initial Setup and Environment Configuration:

Install required SDKs and plugins for Unity (e.g., ARCore/ARKit, XR Plugin Management).

Configure Unity to use device-specific rendering and XR capabilities.

Scene Preparation:

Delete default camera and global components, replace with AR Camera.

Align build configuration to device-specific needs.

Image Tracking Setup:

Integrate AR Tracked Image Manager and connect it to a reference image library.

Configure image tracking triggers for real-time AR elements.

Path Rendering:

Use Line Renderer for visual navigation paths with adjusted width and color.

Fig. 1 Key Parts of Functioning

IV. METHODOLOGY

The AR Campus Navigation project employs a systematic approach to design and implement an augmented reality based navigation system. Here we outline the detailed workflow of developing this project alongside highlighting the sequential steps involved from scratch to deployment.

1. **Initial Setup and Installation**

1.1 Installing Required Files and Extensions

Android SDK and XR Capabilities: Install the necessary Android SDK tools and configure Unity to support extended reality (XR) applications. This step ensures compatibility with ARCore (Android) or ARKit (iOS).

Unity XR Plugin Management: Enable XR Plugin Management in Unity to integrate AR functionalities. Plugins such as AR Foundation, ARCore XR Plugin, and ARKit XR Plugin are configured depending on the target platform.

2. Unity Scene Configuration

2.1 Preparing the Scene

Deleting Default Components: Remove the default Main Camera and Global Volume to prevent conflicts with the AR Camera, which will handle rendering and AR functionalities.

Setting Up Device-Specific Rendering:

Change the Unity editor's build configuration from Not Specified to Device. This step ensures that the application uses device-specific rendering and tracking options for AR.

Camera Alignment:

Adjust the Y-offset of the AR Camera to zero, aligning it with the ground plane to ensure accurate placement of virtual elements.

2.2 Graphics Configuration

Material Optimization:

Use the Universal Render Pipeline (URP) with the Unlit shader for AR objects to minimize lighting conflicts and optimize performance.

Set the surface type to Transparent to overlay AR elements without obscuring the real-world view.

Base Map Intensity Adjustment:

Modify the Base Map intensity to control object opacity, ensuring AR elements are distinguishable while blending with real-world surroundings.

2.3 Object Placement and Lighting

Scene Object Arrangement:

Arrange virtual objects such as walls, navigation targets, and pathways to correspond with real-world campus landmarks.

Baking Lighting Settings:

Precompute static lighting (baking) with a reduced light radius (e.g., from 0.5 to 0.1) for enhanced visual consistency.

Bake light and shadow data to improve rendering efficiency in AR scenes.

3. XR Setup and AR Features

3.1 Setting Up Image Tracking

AR Tracked Image Manager:

Add the AR Tracked Image Manager under the AR

Session to enable image-based tracking. This component associate's specific images with corresponding virtual objects or navigation instructions.

Reference Image Library:

Create and assign a serialized Reference Image Library to the XR Origin. This library contains predefined images for recognition, triggering specific AR actions.

3.2 Navigation Line Creation

Line Renderer Configuration:

Add a Line Renderer component to display visual navigation paths.

Fine-tune the line width to ensure it is prominent without obstructing the user's view of the real-world environment.

4. Scripting and Code Integration

4.1 Navigation Logic

Custom Navigation Script:

Develop a script (NewIndoorNav.cs) to handle navigation logic, including:

User position tracking.

Pathfinding algorithms.

Dynamic directional cues.

Prefab-Based Modularity:

Transfer tracked image data to Prefabs to streamline AR element management and avoid duplication within the scene hierarchy.

4.2 Script Assignment

Attach the navigation script to the TrackedImage Prefab, enabling real-time image recognition and corresponding navigation actions.

Organize the script within a designated folder (e.g., IndoorNavigation) for maintainability.

5. Deployment and Testing

5.1 Player Settings for XR

Enable XR Plugin Management:

Configure XR Plugin Management in Unity's Player Settings.

Select the appropriate AR plugin (ARCore for Android or ARKit for iOS) to ensure compatibility with the target device.

Build Profile Configuration:

Define build profiles in the Unity Registry for different platforms, optimizing performance settings for AR applications.

5.2 Device Connection and Testing

Real-Time Testing:

Connect the development environment to a secondary device via its IP address for real-time debugging and testing. This step allows iterative refinement of the AR navigation experience.

Deploy to Target Device:

Build and deploy the application to target devices for field testing within the campus environment.

6. Final Integration

6.1 AR System Components

Drag and configure the following components into the New Indoor Nav script to finalize the AR navigation system:

Player: The AR Camera representing the user's perspective.

Tracked Image Manager: The XR Origin handling the AR environment.

Tracked Image Prefab: Instantiates recognized images within the scene.

Line Renderer: Displays navigation paths.

6.2 Post-Build Refinements

Conduct iterative testing and debugging to address any rendering or navigation inaccuracies.

Validate the accuracy of virtual elements against real-world campus locations.

V. WORKFLOW

Figures included showcase the step-by-step setup and final outputs.

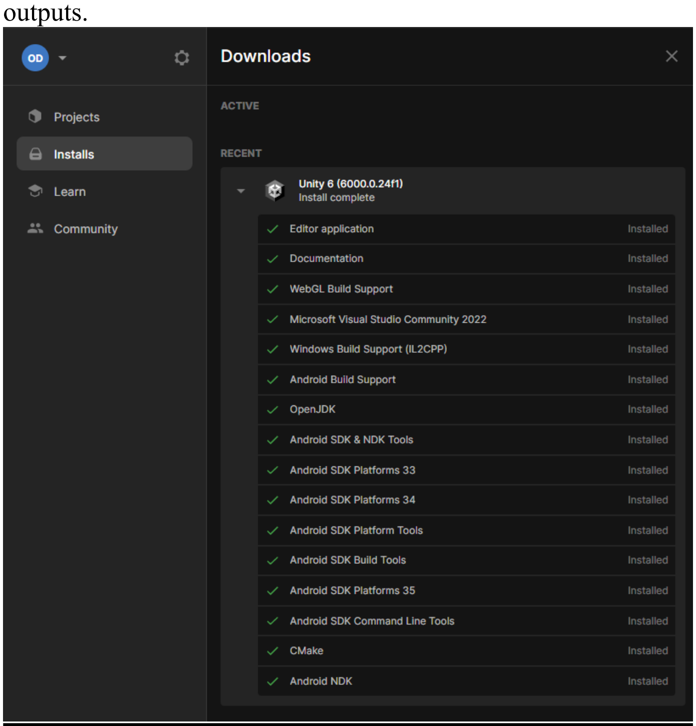


Figure 1.1: Installed required files and extensions for android based SDK project

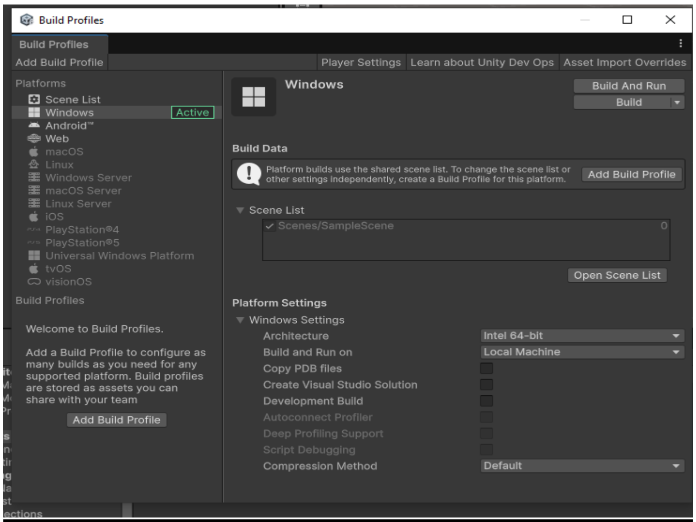


Figure 1.2: Building the Profile Setup

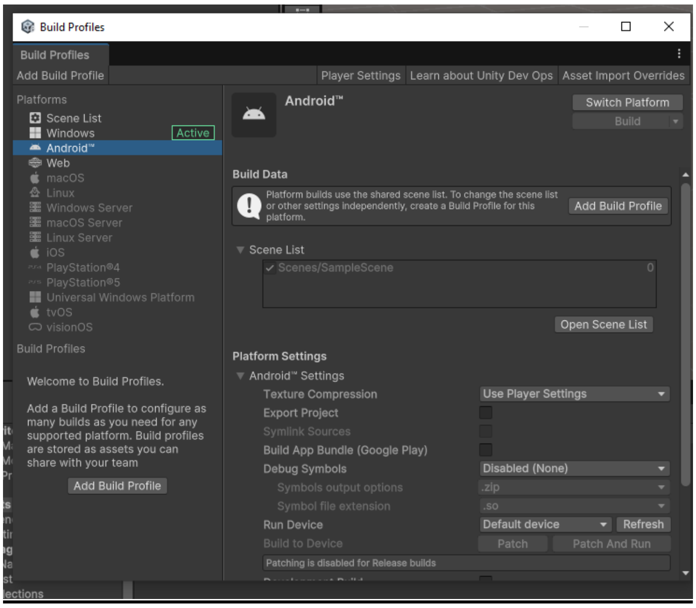


Figure 1.2: Setup for the android & XR applications

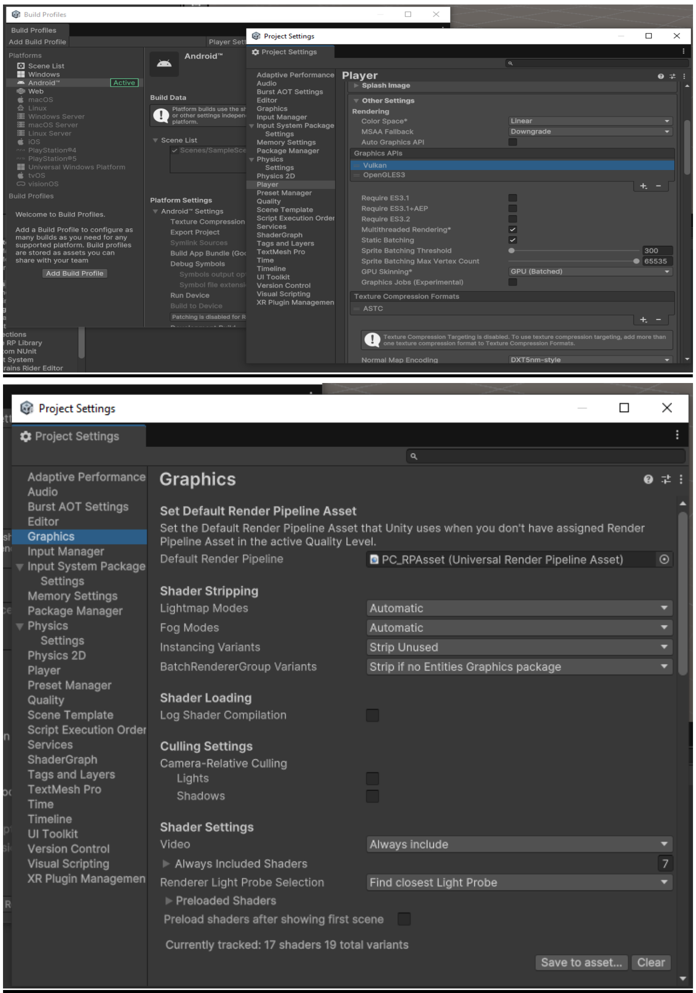


Figure 1.2: Modifications and Specifications for Project Settings

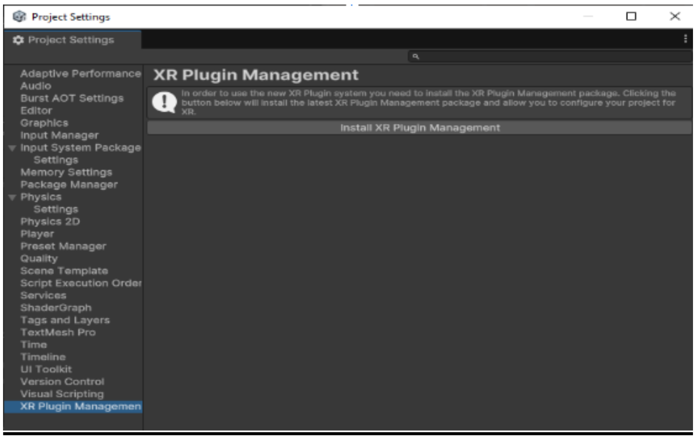


Figure 2.1: Installation for XR Plugin Management

Figure 2.2: Additional necessary packages installed

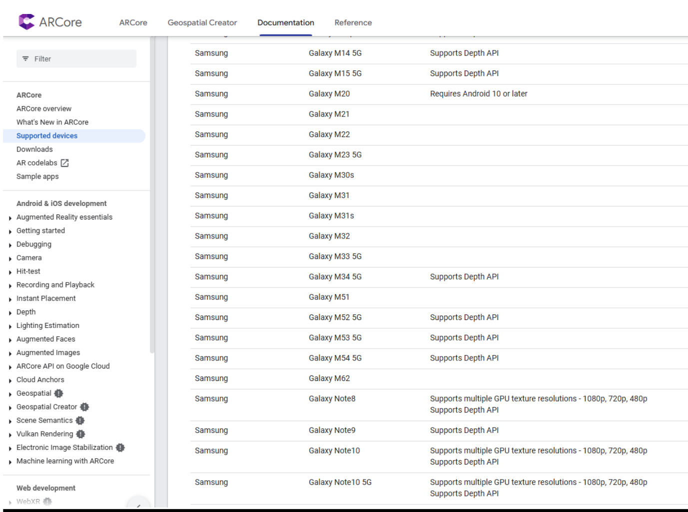


Figure 3.1: ARCore Documentation

Create a scene:

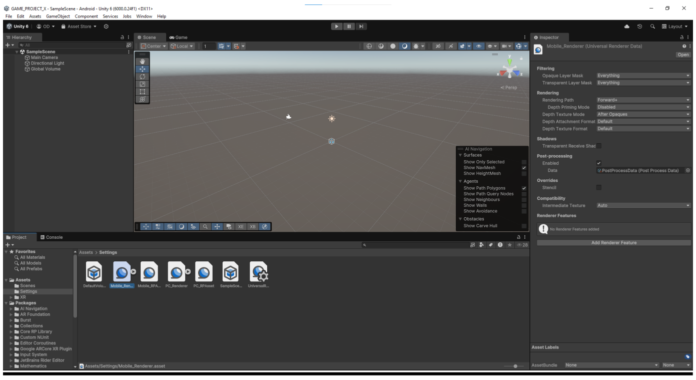


Figure 3.1: Scene Creation in Unity

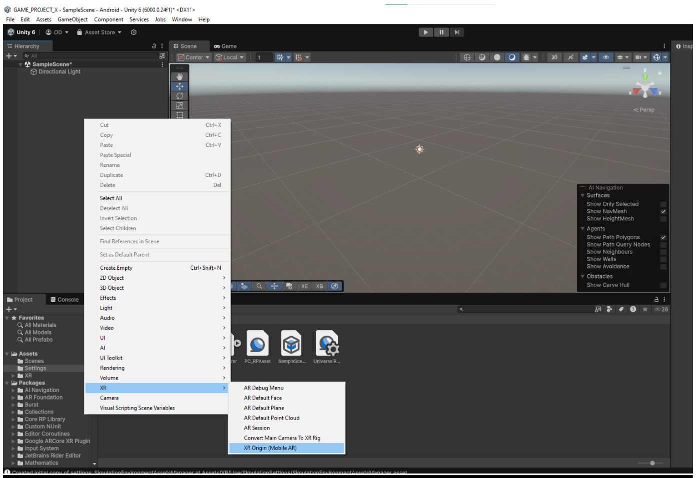


Figure 3.2 Delete Main Camera and Global Volume
Removing the main camera and global volume from the default setup is essential to avoid conflicts with the AR Camera that will be added later. The AR Camera will handle all rendering requirements, enabling a seamless overlay of AR components onto the device's display.

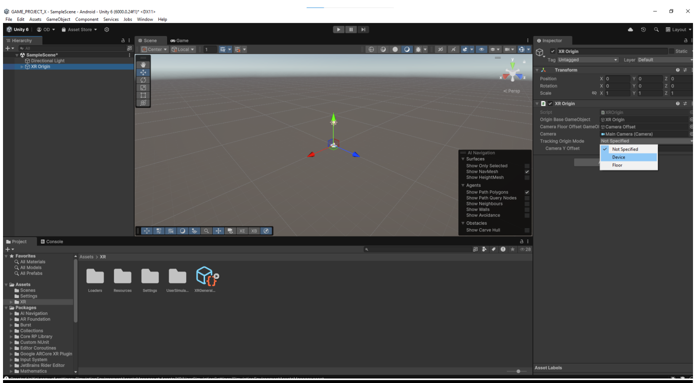


Figure 3.3 Setting from 'Not Specified' to 'Device'
In the Unity editor, changing the setup specification from 'Not Specified' to 'Device' configures the environment for AR functionality. This setting ensures that Unity will use device-specific rendering and tracking options necessary for an AR application.

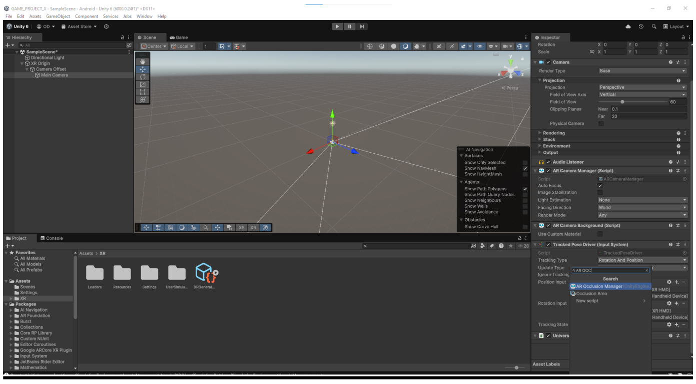


Figure 3.4: Adjust Camera Y Offset to '0'
Resetting the camera's Y offset to zero aligns it with the ground level in AR, ensuring that all virtual elements, such as markers and pathways, are grounded accurately in relation to real-world objects.

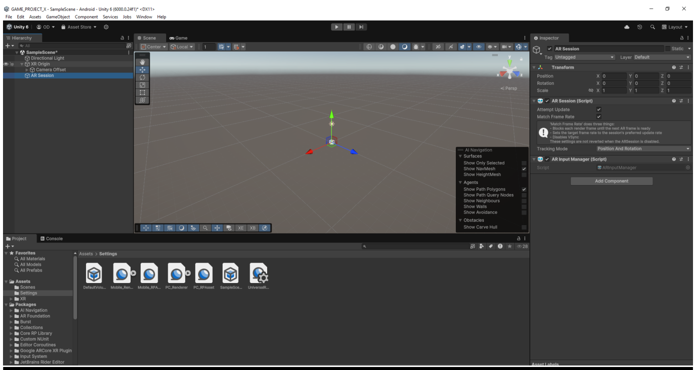


Figure 3.5: Modify the features in inspector as per requirements

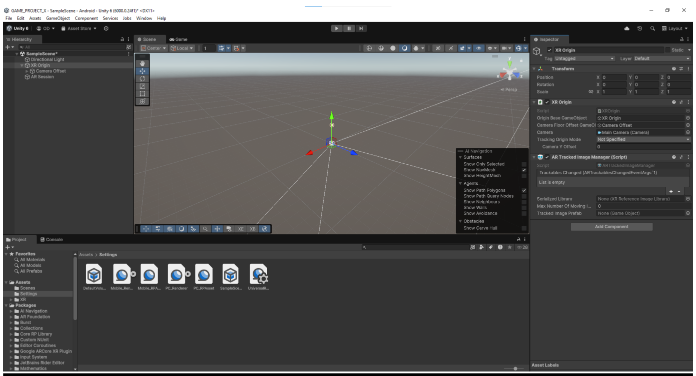


Figure 3.6 Addition of AR Tracked Image Manager under AR Session
The AR Tracked Image Manager component is added to handle image-based tracking, allowing the application to recognize specific images and associate them with virtual objects or instructions. This is a crucial component for dynamic navigation cues.

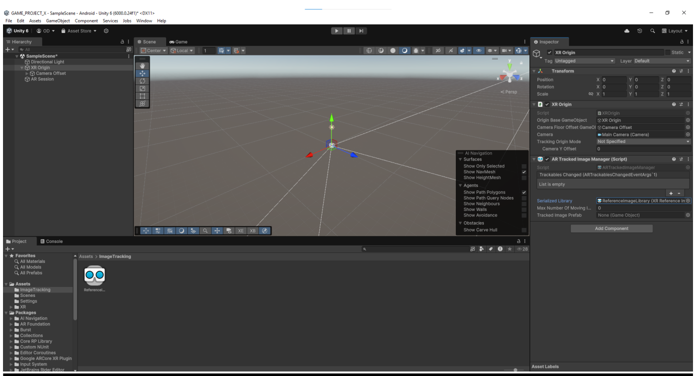


Figure 3.7: Select Serialized Library as the Reference Image Library

Assign the previously created reference image library under XR Origin. This library contains images that the application will recognize and track, triggering corresponding actions, such as showing directions or pulling up relevant information about locations on campus.

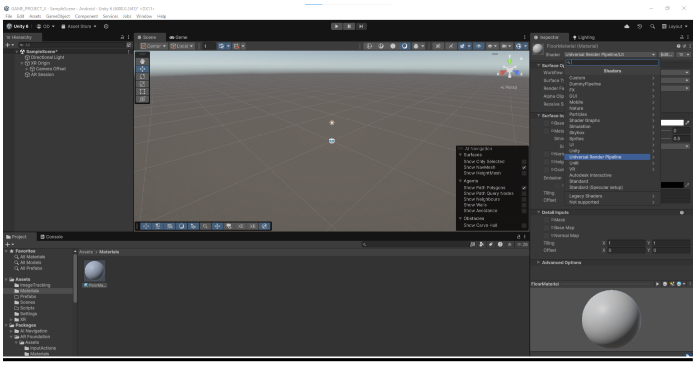


Figure 3.8 Change Material to Universal Render Pipeline/Unlit
To optimize graphics for an AR experience, change the material's shader to the Unlit variant under the Universal Render Pipeline. This ensures that the AR objects remain visible and do not interact with lighting conditions in unintended ways.

Set Surface Type to Transparent:
Changing the surface type to transparent helps to overlay digital elements over the real-world feed without obscuring it, allowing for a clearer AR experience where objects or markers are visible without obstructing the user's view of the campus.

Adjust Base Map Intensity:
By modifying the Base Map intensity from 255 to 0, the opacity and brightness levels can be controlled, making digital elements blend naturally with real-world surroundings while being easily distinguishable.

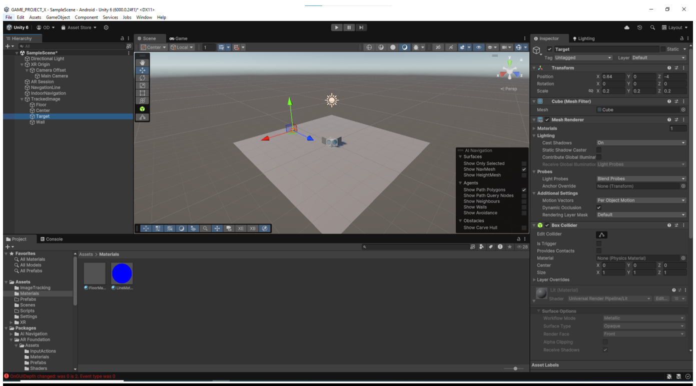
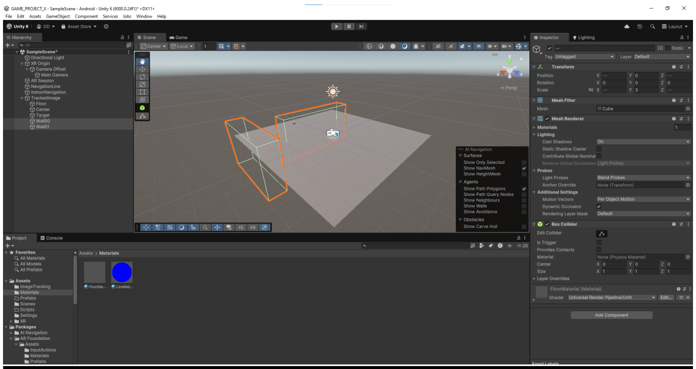


Figure 4.1: Scene Configuration to Arrange Objects in the Scene (Walls, Targets, Center)

Each object, such as walls and navigation targets, is positioned accurately within the virtual campus model. This includes walls, targets, and other elements like paths that guide users through the AR navigation interface. Rearranging coordinates of all objects accordingly in the scene of Wall00,Wall01 and other cubes respectively.



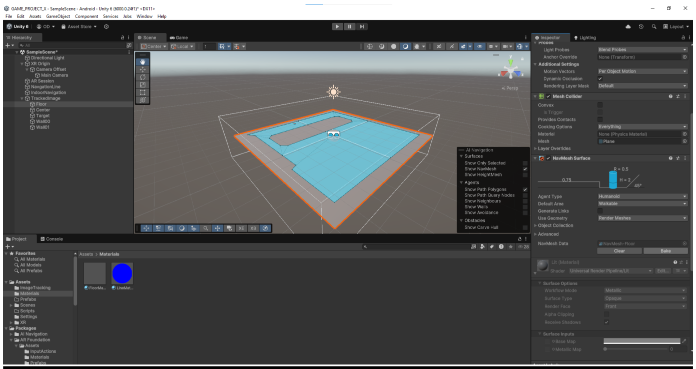


Figure 4.2: Bake Lighting Settings

Baking light and shadow data helps in rendering static lighting more efficiently, enhancing the realism of the virtual objects. This step is crucial for AR environments as it improves visual consistency, especially when virtual objects are overlaid on real-world elements.

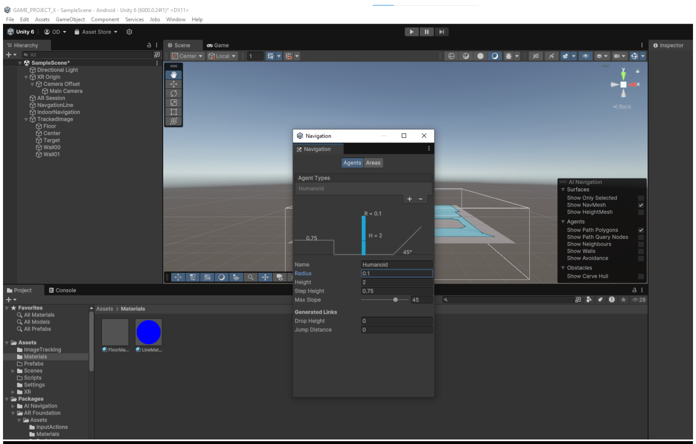


Figure 4.3: hanging radius from 0.5 to 0.1.

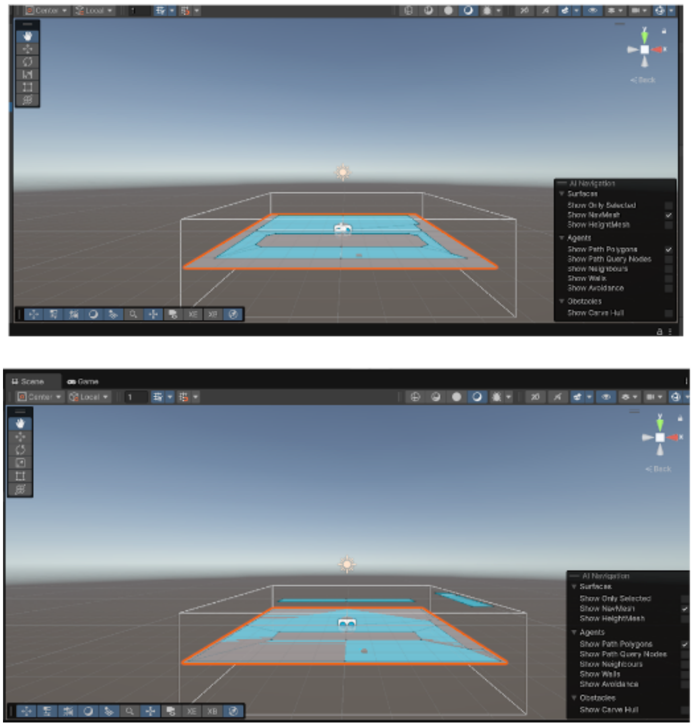


Figure 4.4: Before and after Baking 0.1 radius.

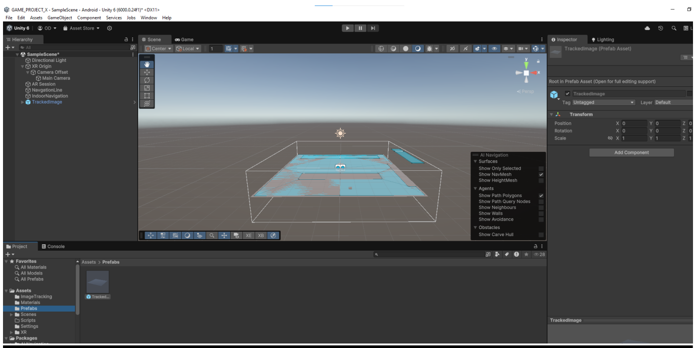


Figure 4.5: Moved Tracked Image Data to Prefabs

Prefabs are reusable objects in Unity, making it easier to manage multiple tracked images within the AR environment. Transferring tracked image data to Prefabs streamlines the development and makes updates more manageable.

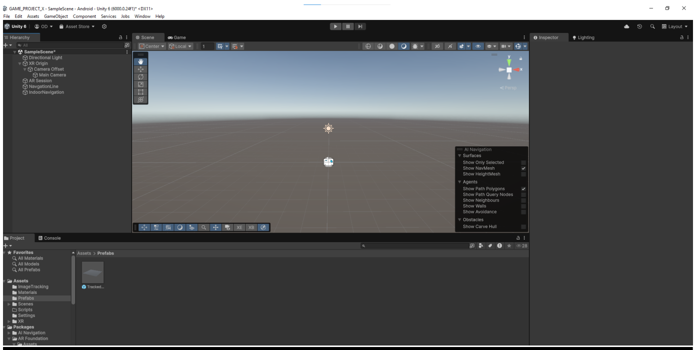


Figure 4.6: Deleting Tracked Image from Sample Scene

Once the Prefab setup is completed, the TrackedImage object in the SampleScene is removed to avoid duplication, ensuring a more organized and efficient project hierarchy.

Scripting and Code Integration

Open TrackedImage Prefab and Attach Navigation Script
Opening the TrackedImage Prefab and attaching the navigation script allows it to track images and initiate appropriate navigation actions. This script controls directional prompts and other interactions users experience in the app.

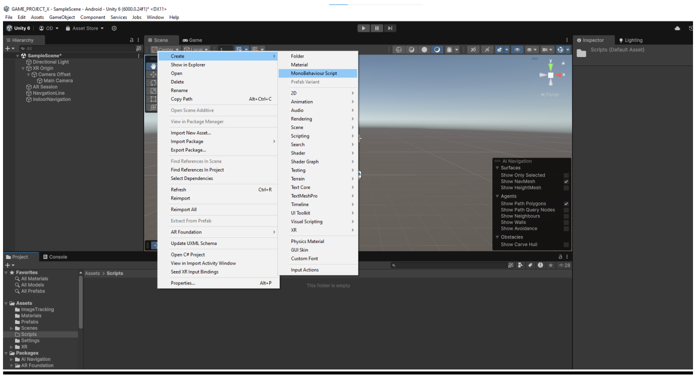


Figure 5.1: Update and Move NewIndoorNav.cs Script

The NewIndoorNav.cs script is customized to handle AR navigation logic, integrating pathfinding, user position updates, and directional cues within the AR experience. Relocating this script under IndoorNavigation helps keep the project organized.

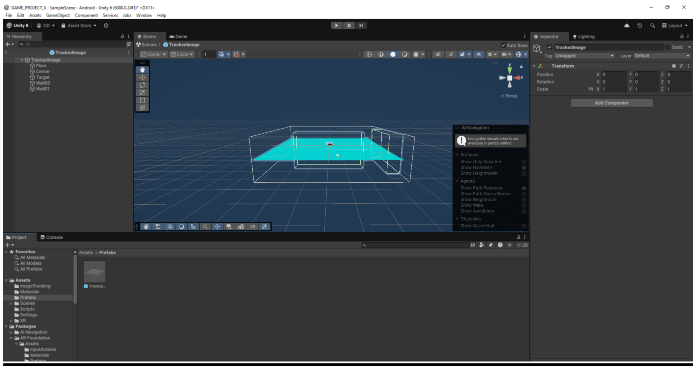


Figure 5.2: Open TrackedImage Prefab

Move Navigation Script to Target and update the code for NewIndoorNav.cs script:

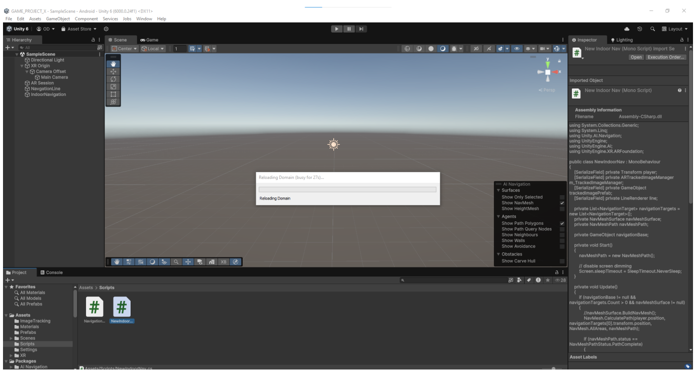


Figure 5.3: Moving NewIndoorNav script under IndoorNavigation

Final AR Navigation System Setup

1. Drag Components for AR Setup:

   For the final setup of the AR navigation system, drag the following into the New Indoor Nav script component:

- Player: The main camera, representing the user's perspective.
- Tracked Image Manager: The XR Origin, responsible for handling the entire AR setup.
- Tracked Image Prefab: The template used to instantiate recognized images within the AR scene.
- Line Renderer: Used to create a navigation line that guides users through campus.

Change the width of Line Renderer:

Modify Line Renderer Width:

Adjust the line renderer's width before and after the change, which visually impacts the clarity of navigation lines in the AR display. Fine-tuning the width ensures that the path is easily visible without obstructing the real-world view.

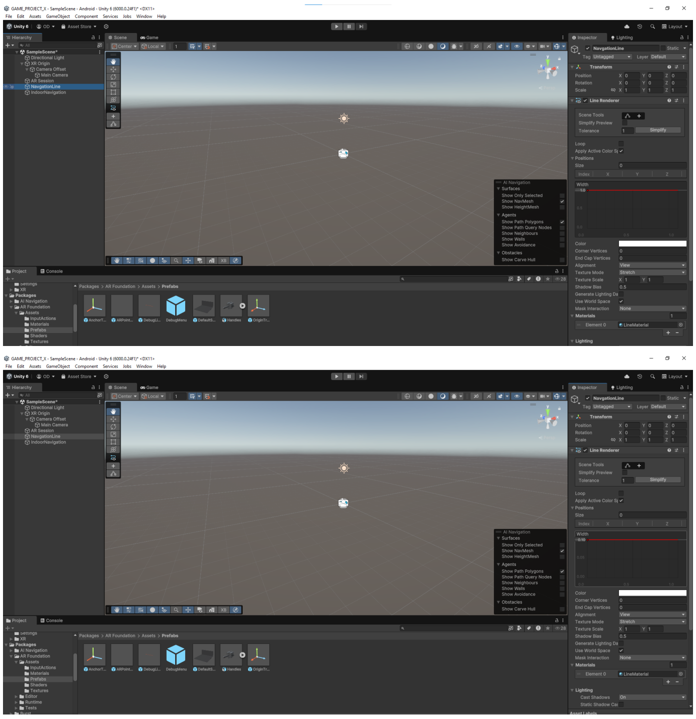


Figure 5.3: Before and after changes were made

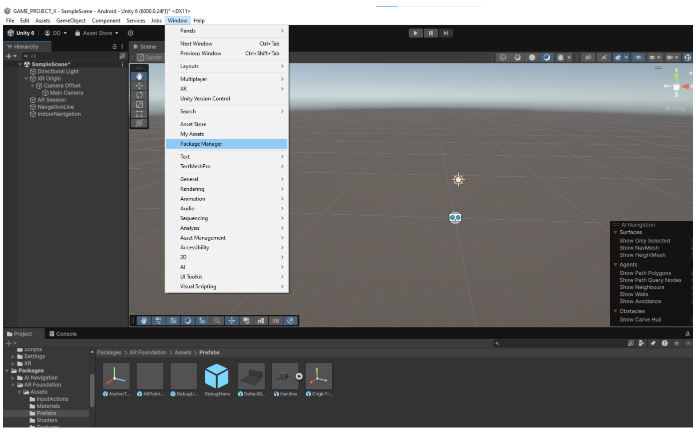
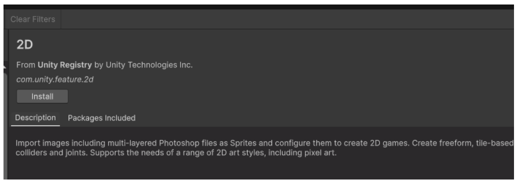


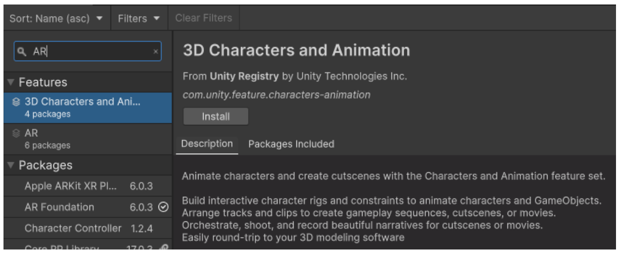
Figure 5.4: The device is to be connected.

Building and Testing

1. Unity Registry and Build Profiles:

   Navigate to the Unity Registry to configure build profiles for different devices. This includes setting target devices for compatibility and adjusting performance settings specific to AR applications.





Configure Player Settings for XR Plugin Management:

In Player Settings, enabling XR Plugin Management allows the app to connect to compatible AR devices. Select the appropriate plugins for ARCore or ARKit based on the target platform (Android or iOS).

Go to Player Settings:

In player settings-> XR Plugin Management

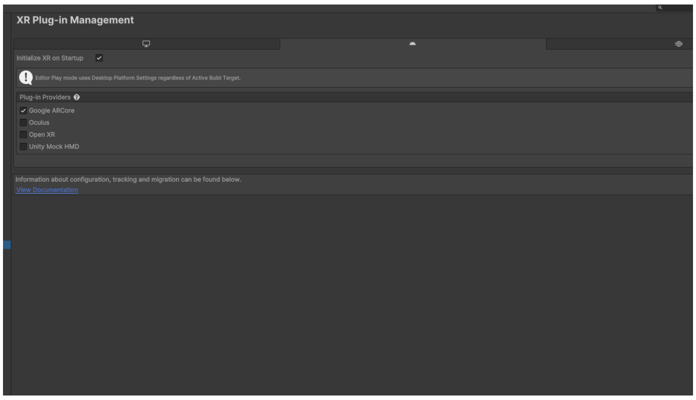


Figure 6.1: XR Plugin Management

Establish Connection with Secondary Device via IP Address. For real-time testing and debugging, connect to a secondary device using its IP address. This allows you to simulate the campus navigation experience and validate the AR interactions before final deployment.

V. CONCLUSION AND FUTURE WORK

AR Campus Navigation project is an example of how AR can be used to modernize campus experiences. This system leverages Unity's XR plugins and AR Foundation to provide users an intuitive and interactive way of navigating through complex environments. The project demonstrates how AR can be used to develop real world solutions that reduce barriers and improve user interaction. By solving problems like real time image recognition, integration of virtual elements without seams, and interoperability across platforms, the project shows that AR is not only useful for navigation, but a game changing experience for user interaction with real world. Further work could be to extend the system with voice commands, additional interactive components, and real time environmental adaptation to create a fully extended AR functional navigation integrated with a navigation software.

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