# Multipurpose Augmented Reality Visualizer aided with hand tracking and networking API for cross platform interaction.

**Monthly Project report submitted in partial fulfillment of the Requirements for the Award of the Degree of**

**BACHELOR OF TECHNOLOGY**

In

**COMPUTER SCIENCE AND ENGINEERING**

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## CERTIFICATE OF APPROVAL

Certified that the project report entitled "**Multipurpose Augmented Reality Visualizer aided networking API for cross platform interaction."** is a bonafide work carried out jointly by **Kipa Nitin (D/19/CS/208) and Lusang P Issac (D/19/CS/204).** The project report embodies the original work done by them towards partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** at **North Eastern Regional Institute of Science and Technology, Arunachal Pradesh**. It is understood by this approval that the undersigned do not endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project report only for the purpose for which it has been submitted.

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# INDEX

## Introduction

Augmented reality (AR) is a digitally augmented representation of the real physical environment produced via the use of digital visual components, music, or other sensory stimulation provided through technology. It is a developing trend among firms working in mobile computing and, in particular, commercial apps.

Augmented Reality (AR) is on the rise and is expected to reach 2.4 billion users by 2023. However, in 2015, there were barely 200 million people using the service. Numbers are increasing at a rapid pace that cannot be ignored. In this project, we are more interested in the applications in education and eLearning than anything else.

One of the major aims of augmented reality, in the midst of the development of data gathering and analysis, is to emphasise certain aspects of the physical environment, enhance knowledge of those qualities, and generate clever and accessible information that can be used to real-world applications. Big data may help firms make better decisions and get insight into customer purchasing habits, among other things.

# Literature Review

**1. A Review of Research on Augmented Reality in Education: Advantages and Applications June 2015International Education Studies 8(13)**

Overview:

- It has been shown that using technology in the classroom may encourage students to participate in active learning, which leads to an effective learning process.
- Applying technology will lead to learning information even if it does not encourage critical thinking, elucidation, or comprehension.
- Potential to enhance learning by making it more efficient, and attractive.
- Due to its capacity to include students in real-world experiences, combining AR with education has lately received scientific interest.
- As the reality of the unpopularity of taxpayers we see as a new technology, this concept paper analyzes research on its application in a variety of disciplines, including geography, chemistry, medicine, and mathematical and physical sciences.
- The benefits e-learning and courseware, and conventional teaching methods are also explored in this study.
- The report also identifies a number of AR weaknesses that may be remedied in future studies.

Other:

**1. A Systematic Literature Review towards the Research of Game-Based Learning with Augmented Reality**

- Empowering the physical world with virtual information.
- The impact of uncertainty and scientific advances in the field of application has modified the definition of "AR Technology" to "AR Environments".
- Scanned from scientific journals published in Turkey and abroad between 2016 and 2020, were analyzed using the systematic literature review method.
- Help the gaps in AR studies and students' learning processes in terms of potential study.

**2. Advanced Medical Displays: A Literature Review of Augmented Reality**

- Provided physicians with an increasing amount of patient specific anatomical and functional data.
- Allowing physicians to take full advantage of rich sources of heterogeneous preoperative and intraoperative data.
- Establishes the relationship between subsets of this body of work in medical augmented reality.

3. **A research agenda for augmented and virtual reality in architecture, engineering and construction**

• Six use-cases for augmented reality and virtual reality were identified based on the information gathered from the workshops: stakeholder engagement, design support, design review, construction support, operations and management support, and training.
• Three key types of study have been proposed for a future research agenda, namely:
(I) Engineering-grade gadgets, which cover research that results in reliable, practicable devices.
(II) Data and workflow management, in order to efficiently handle the data and procedures that AR and VR technologies demand.
(III) New capabilities, which include the need for new research that will add new features required for the unique demands of the construction business

4. **The Impact of an Augmented Reality Application on Learning Motivation of Students.**

• To assess and comprehend how an augmented reality mobile application affects undergraduate health science students' desire to learn.
• To explain motivation in the context of learning, the intrinsic motivation theory was applied.
• Researchers looked at the variations in students' motivation for learning both before and after using the augmented reality smartphone application.
• The use of an augmented reality mobile application enhanced pupils' motivation to learn, according to the results.

**5. An overview of augmented reality technology**

• Introduces the essential technologies, development tools, and applications of augmented reality in several disciplines. Discusses the research and development of augmented reality at home and abroad.
• Anticipates the future trend in augmented reality technology development, such as AR cloud.

6. **Trends in Virtual and Augmented Reality Research: A Review of Latest Eye Tracking Research Papers and Beyond**

• Focuses on the latest research progress in ACM Symposium on Eye Tracking Research & Applications (ETRA) 2019
• Aims to figure out the influence of deep learning techniques on latest VR/AR research.
• New issues have popped up with the development of VR and AR technology, such as privacy and computation efficiency.
• Investigates on the effect of latest VR and AR techniques on people.

7. **Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade**

• Analyzed through searching in three interdisciplinary databases: Scopus, Web of Science, and Springer link.
• Possible to demonstrate that the use of AR for inclusive education in the field of sciences is where more studies have been conducted.
• The studies generally included students with different impairments (hearing, visual, motor or cognitive), minorities (ethnic, vulnerable), etc.
• Identified open issues that could give rise to new research in the subject of using AR to favor the creation of inclusive learning scenarios.

8. **Trends of Augmented Reality Applications and Research throughout the World: Meta-Analysis of Theses, Articles and Papers between 2001-2019 Years**

- Meta-analysis of studies on the use of augmented reality in applications and research throughout the world.
- Thirteen criteria were used to assess global trends in augmented reality research and applications.
- Frequency and percentage were used to interpret the data.
- Used in a variety of disciplines, including special education, engineering arts, and education in the visual arts.

**9. AREdu 2019 – How augmented reality transforms to augmented learning**
**Authors: Arnold E. Kiv**

- AREdu 2019: The 2nd International Workshop on Augmented Reality in Education
- Includes a brief introduction, a review of the papers, and some thoughts on the event's present and potential future.
- AREdu topics of interest:
  - Virtualization of learning: principles, technologies, tools
  - Augmented reality gamification
  - Design and implementation of augmented reality learning environments
  - Mobile technology of augmented reality
  - Aspects of environmental augmented reality security and ethics
  - Augmented reality in science education
  - Augmented reality in professional training and retraining

## Problems & Solutions

1. In education, concepts which needs multidimensional understanding are hard to achieve using traditional tools such as a Black Board. AR can solve this problem by a 3d representation with multiple layers and angles.
2. AR in Professional Training

Aerospace, aviation, hospitality, military, and other industries must invest a significant amount of money and equipment in military training. AR may decrease costs while also making training more engaging.

3. AR can also help with:

a) See inside the living human body: from animal dissection to demonstration of how the heart pumps blood to the rest of the body, anything can be visualized virtually.

b) Bring the solar system into the classroom.

c) Interactive geometry.

d) Turn art into an interactive animation.

## Deliverables and Success Criteria

The project intends to deliver a a Multipurpose Augmented Reality Visualizer app aided with Multi Targets detection and Networking framework for real-time cross platform interactions. Following are the features intended to be implemented in a polished final version:

1. The app will function as an AR app which can use a phone's camera to place educational and interactable 3d or 2d object into the real world.

2. In order to further simplify the process, we are going to add Multi-Target Tracking of geometric arrangement such as boxes Or use google' cloud anchor in order to interact with the objects in real-time using only the camera.

3. Finally, we will use a networking framework for the spectator/student to view what the host user is doing using the app on their own personal phones.

4. Furthermore, Hand tracking can be used to use for inputs.

**Cost and Time:**

While cost has been non-existent or minimal as the engine, assets or API are either free or opensource. And it took multiple months to implement all of this.

**Methodology**

| | |
|---|---|
| ➔ Engine | ➔ Unity Engine |
| ➔ 3D Modelling | ➔ Blender, MagicaCSG etc. |
| ➔ 2D sprites | ➔ GIMP, Krita |
| ➔ AR | ➔ Vuforia Engine (Primary), ARCore by google, AR Foundation, ARCore XR Plugin and ARKit XR Plugin |
| ➔ Networking | ➔ Photon(Primary), Cloud Anchors by ARCore, Mirror etc. |
| ➔ Coding IDE/Editor | ➔ Microsoft Visual Studio |
| ➔ Hand Tracking SDK | ➔ Manomotion |

# Working of the components:

**Networking:**

**1. PUN 2:**

**Introduction**

A quick, efficient, and adaptable real-time networking development framework is called Photon. A server and several client SDKs for popular platforms make up Photon.

Our approach to a high-level, Unity-specific solution is called Photon Unity Network (PUN): A nice place to start is with matchmaking, user-friendly callbacks, components to synchronise items, Remote Procedure Calls (RPCs), and comparable functionality. A strong, comprehensive API follows that for control at a higher level.

Some features:

- Easy to use API
- Availability of Offline mode.
- Lots of demos and an extensive PUN Basics Tutorial
- Server available as hosted service (free for development) or as "On Premise"
- Load-balanced! Scales across servers (with no extra effort)
- Photon Server's performance is noted to be exceptional.
- Dedicated servers.
- Punch-through NAT is not required.

**PUN's Structure**

The highest level is the PUN code, which implements Unity-specific features like networked objects, RPCs and so on.

The second level contains the logic to work with Photon servers, do matchmaking, callbacks and such. This is the Realtime API. This can be used on it's own already. You will notice a lot of overlap of topics between PUN and the Realtime API (a.k.a. LoadBalancing API) but that's fine.

The lowest level is made up of DLL files, which contain the de/serialization, protocols and such.

**Connect And Callbacks**

ConnectUsingSettings gets you online in no time: It grabs all important settings from the PhotonServerSettings asset and off you go.

*PhotonNetwork.ConnectUsingSettings();*

PUN uses callbacks to let you know when the client established the connection, joined a room, etc..

For example: *IConnectionCallbacks.OnConnectedToMaster*.

For convenience, PUN has the MonoBehaviourPunCallbacks MonoBehaviour. It implements important callback-interfaces and registers itself automatically, so you can inherit it and just override specific callback-methods.

```
// ...
public class YourClass : MonoBehaviourPunCallbacks
{
   // ...
   public override void OnConnectedToMaster()
   {
      Debug.Log("OnConnectedToMaster() was called by PUN.");
      PhotonNetwork.JoinRandomRoom();
   }
   // ...
}
// ...
```

Alternatively implement IConnectionCallbacks in any class and register instances for callbacks via PhotonNetwork.AddCallbackTarget.

**Matchmaking**

Within OnConnectedToMaster you could try to join an existing room or create your own. The following code snippets show possible method calls to start or join.

```
// Join room "someRoom"
PhotonNetwork.JoinRoom("someRoom");
//Fails if "someRoom" is not existing, closed or full. Error callback:
IMatchmakingCallbacks.OnJoinRoomFailed
// Tries to join any random Room:
PhotonNetwork.JoinRandomRoom();
//Fails if there are no open room. Error callback:
IMatchmakingCallbacks.OnJoinRandomFailed
// Create this room.
PhotonNetwork.CreateRoom("MyMatch");
// Fails if "MyMatch" room already exists and calls:
IMatchmakingCallbacks.OnCreateRoomFailed
```

When friends want to play together and have a way to communicate outside of PUN (e.g. with Photon Chat, Facebook), they can make up a room name and use JoinOrCreateRoom. If nobody else should be matched into this room, make it invisible for matchmaking:

```
RoomOptions roomOptions = new RoomOptions();
roomOptions.IsVisible = false;
roomOptions.MaxPlayers = 4;
PhotonNetwork.JoinOrCreateRoom(nameEveryFriendKnows, roomOptions,
TypedLobby.Default);
```

With JoinOrCreateRoom, the room gets created on demand, so it doesn't matter who is first. If it's full, IMatchmakingCallbacks.OnJoinRoomFailed gets called (if you implemented and registered it somewhere).

# 2. GOOGLE CLOUD ANCHORS:

A Cloud Anchor is a special type of anchor that can be used to persist AR experiences in the real world. With the ARCore Cloud Anchor API, or ARCore Cloud Anchor service, you can create interactive layers of digital information and anchor them to actual locations, designing experiences that can be shared over time by multiple people across many different devices. Cloud Anchors connect real world locations with digital content that anyone can access from compatible mobile devices. Both Android and iOS users can participate in the same experience and return to them again and again, even weeks or months later.

**How Cloud Anchors work:**

ARCore connects to the ARCore Cloud Anchor API to host and resolve Cloud Anchors, thereby enabling these shared experiences. This requires a working Internet connection.

In their environment, the user establishes a local anchor.

1. The anchor is hosted

ARCore uploads that local anchor's data to the ARCore Cloud Anchor API, and the ARCore Cloud Anchor API returns a unique ID for that anchor.

2. The ID can be forwarded to users who wants to access.
3. The anchor is resolved

Using the ID we can recreate the same anchor using the ARCore Cloud Anchor API.

**Hosting**

To establish and host an anchor, ARCore uses a 3D feature map of the space surrounding that anchor. To obtain this feature map, the device's rear camera must map the environment in and around the center of interest from different viewing angles and positions before the host call. The ARCore Cloud Anchor API then creates a 3D feature map of the space, and returns a unique Cloud Anchor ID to the device.

**Resolving**

When another user in the same environment points their device's camera at the area where the Cloud Anchor was hosted, a resolve request causes the ARCore Cloud Anchor API to periodically compare visual features from the scene against the 3D feature map that was created. ARCore uses these comparisons to pinpoint the user's position, orientation, and pose relative to the Cloud Anchor.

# 3. AR:

**1. AR Foundation and ARCore Extensions for Unity capabilities and features**

AR Foundation is a cross-platform framework that allows you to build augmented reality experiences once, then build for either Android or iOS devices. ARCore Extensions for AR Foundation enables additional ARCore functionality and features that are not (yet) exposed through AR Foundation and the ARCore XR plugin on Android and the ARKit XR plugin on iOS.

| **ARCore feature** | **AR Foundation with ARCore Extensions** |
|---|---|
| Supported Unity versions | Unity 2019.4.3f1 or later |
| Unity XR support | Install the AR Foundation and ARCore XR Plugin packages, and enable ARCore plug-in provider under Project Settings > XR Plug-in Management (Android) |
| GitHub repo(s) (SDK / samples) | google-ar/arcore-unity-extensions<br>Unity-Technologies/arfoundation-samples |
| In-editor development workflow | AR Remoting & Simulation |
| Pause the AR Session | Disable the ARSession object |
| Detect tracking issues | Use notTrackingReason provided by ARSession and returning a NotTrackingReason |
| Select camera config | See Configuring the camera for ARCore Extensions |
| Plane finding | Use Plane Detection provided by ARPlaneManager |
| Local anchors | Use Anchors provided by ARAnchorManager |
| Cloud Anchors | Provided by ARCore Extensions |
| Basic light estimation | Use *Ambient Intensity* Light Estimation mode provided by ARCameraManager |
| Environmental HDR light estimation | Automatically enabled when a compatible camera config is selected and one or more Environmental HDR settings are selected:<br>• *Ambient Spherical Harmonics*, *Main Light Direction*, *Main Light Intensity* in the Light Estimation mode provided by ARCameraManager<br>• Environmental Probes are enabled in an AREnvironmentProbeManager |
| Augmented Images | Use (2D) Image Tracking provided by ARTrackedImageManager |
| Augmented Faces | Use Face Tracking provided by ARFaceManager |
| Depth API | Use AROcclusionManager to enable Automatic Occlusion in AR Foundation 4.1.0-preview.2 or later with ARCore XR Plugin 4.1.0-preview.2 or later |
| Raycasting | Use Raycasting provided by ARRaycastManager |
| Feature points | Use Point Clouds provided by ARPointCloudManager |
| AR camera image access | Use Pass-through video provided by ARCameraBackground |
| CPU image access | Provided by AR Foundation |
| GPU texture access | Accessible as external Texture2Ds. |
| Multithreaded rendering | Supported in Android Player Settings in AR Foundation 2.1.0 or later. |

# 4. Custom Code:

Following are some of our custom codes:

### #1: Connecting to server and changing scenes:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using Photon.Pun;
using UnityEngine.SceneManagement;

public class ConnectToServer : MonoBehaviourPunCallbacks
{
    void Start()
    {
        PhotonNetwork.ConnectUsingSettings();
    }

    public override void OnConnectedToMaster()
    {
        PhotonNetwork.JoinLobby();
    }

    public override void OnJoinedLobby()
    {
        SceneManager.LoadScene("Lobby");  //"Lobby" is the name of the scene I assigned
for Lobby;
    }
}
```

### #2: Creating and joining room:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using Photon.Pun;
using TMPro;
using namespace Google.XR.ARCoreExtensions.Samples.PersistentCloudAnchors;

public class CreateAndJoinRooms : MonoBehaviourPunCallbacks
{
    public TMP_InputField createInput;
    public TMP_InputField joinInput;
    public void CreateRoom()
    {
        PhotonNetwork.CreateRoom(createInput.text);
    }
    public void JoinRoom()
    {
        PhotonNetwork.JoinRoom(joinInput.text);
    }
    public override void OnJoinedRoom()
    {
        PhotonNetwork.LoadLevel("Play");
```

```
    }
}
```

### #3: Sharing the code via whatsapp:

```
using UnityEngine;
using System.Collections;
using System.IO;
using System.Runtime.InteropServices;


public class Sharing : MonoBehaviour
{
    string subject = "Code To Connect With Project";
    string body = _hostedCloudAnchor.Id;

#if UNITY_IPHONE

 [DllImport("__Internal")]
 private static extern void sampleMethod (string iosPath, string message);

 [DllImport("__Internal")]
 private static extern void sampleTextMethod (string message);

#endif

    public void OnAndroidTextSharingClick()
    {

        StartCoroutine(ShareAndroidText());

    }
    IEnumerator ShareAndroidText()
    {
        yield return new WaitForEndOfFrame();
        //execute the below lines if being run on a Android device
#if UNITY_ANDROID
  //Reference of AndroidJavaClass class for intent
  AndroidJavaClass intentClass = new AndroidJavaClass ("android.content.Intent");
  //Reference of AndroidJavaObject class for intent
  AndroidJavaObject intentObject = new AndroidJavaObject ("android.content.Intent");
  //call setAction method of the Intent object created
  intentObject.Call<AndroidJavaObject>("setAction",
intentClass.GetStatic<string>("ACTION_SEND"));
  //set the type of sharing that is happening
  intentObject.Call<AndroidJavaObject>("setType", "text/plain");
  //add data to be passed to the other activity i.e., the data to be sent
  intentObject.Call<AndroidJavaObject>("putExtra",
intentClass.GetStatic<string>("EXTRA_SUBJECT"), subject);
  //intentObject.Call<AndroidJavaObject>("putExtra",
intentClass.GetStatic<string>("EXTRA_TITLE"), "Text Sharing ");
  intentObject.Call<AndroidJavaObject>("putExtra",
intentClass.GetStatic<string>("EXTRA_TEXT"), body);
  //get the current activity
  AndroidJavaClass unity = new AndroidJavaClass ("com.unity3d.player.UnityPlayer");
  AndroidJavaObject currentActivity =
unity.GetStatic<AndroidJavaObject>("currentActivity");
```

```
  //start the activity by sending the intent data
  AndroidJavaObject jChooser = intentClass.CallStatic<AndroidJavaObject>("createChooser",
intentObject, "Share Via");
  currentActivity.Call("startActivity", jChooser);
#endif
    }


    public void OniOSTextSharingClick()
    {

#if UNITY_IPHONE || UNITY_IPAD
  string shareMessage = " Code To Connect With Project ";
  sampleTextMethod (_hostedCloudAnchor.Id);

#endif
    }

}
```

## Purpose of the app:

As interactive classroom are becoming evermore popular, our app will allow every students to view the AR showcases using their own phones from their own POV. This gives a next layer of interactivity.

For added security against misuse, the host can only control it. Also its possible to add the functionality for the clients to ask permission to the host for control which is very easy as all the building blocks are setup.

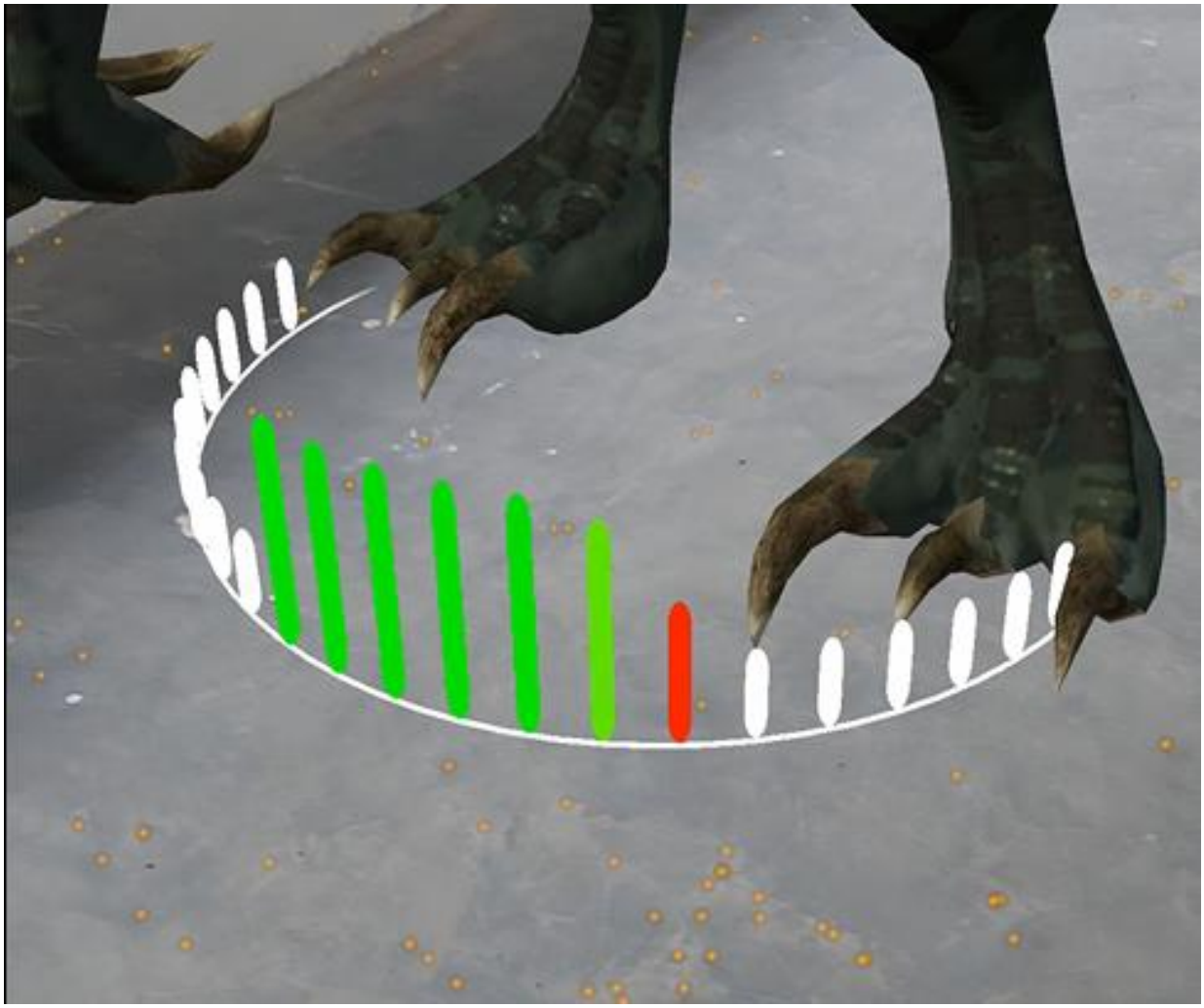
With this we aspire to achieve easy to use AR boosted educational framework which can easily explain concepts that the limiting aspects of 2-dimensional chalk and blackboard cannot achieve.

## SUPPORTING SCREENSHOTS AND EXPLANATIONS:

**a) Host and Resolve Screen:** Here, we need to choose if we are going to be hosting or resolving

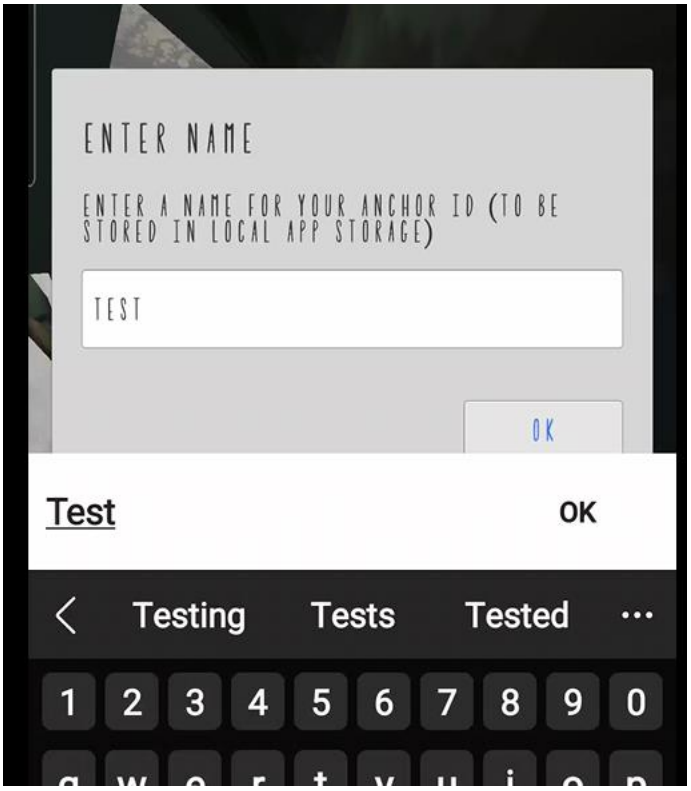
**b) Plane Detection:** On clicking “Begin Hosting”, plane detection starts. After plane is detected we can click on the generated area to place our object.

**c) Nitin's POV of Dinosaur Sample:** After Placing the object we need to save the object by mapping it from different side. A visual aid is provided to show where to point the camera and the level of mapping done.



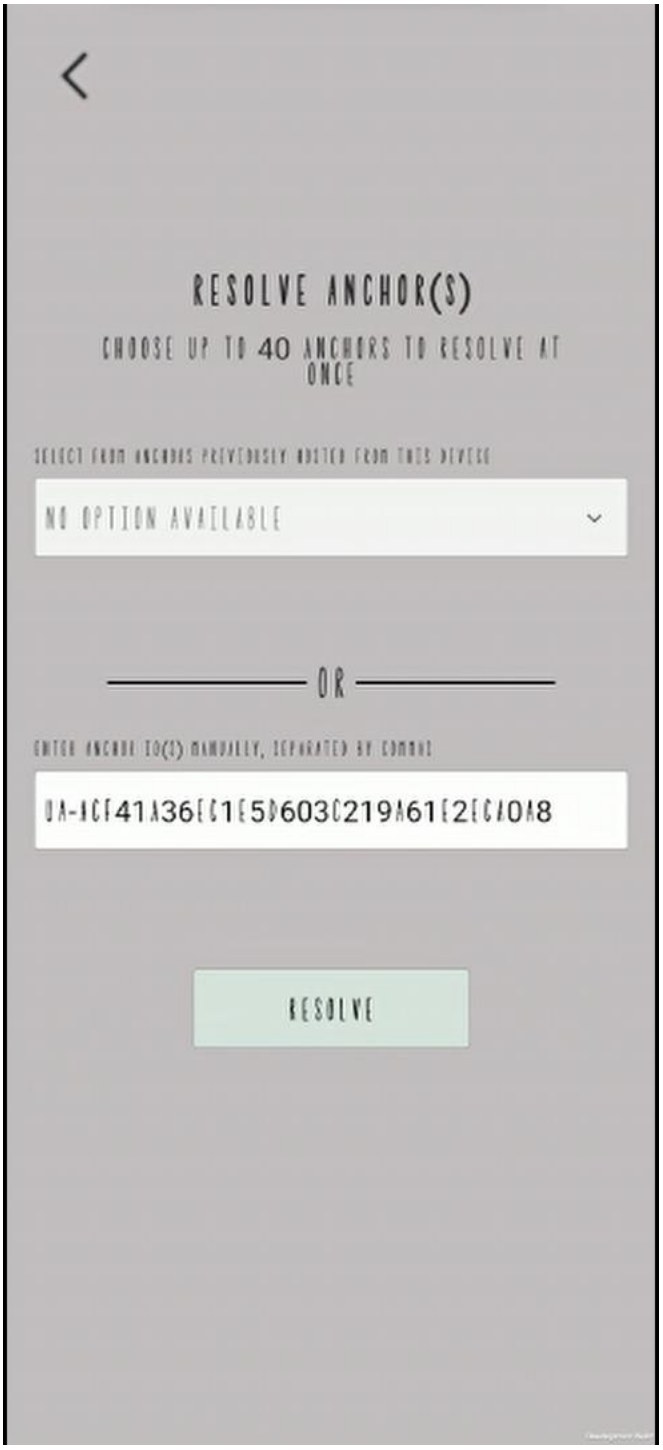
**d) Nitin’s POV of Dinosaur Sample:**

**e) Now we need to name the anchor to generate the hosted ID.**



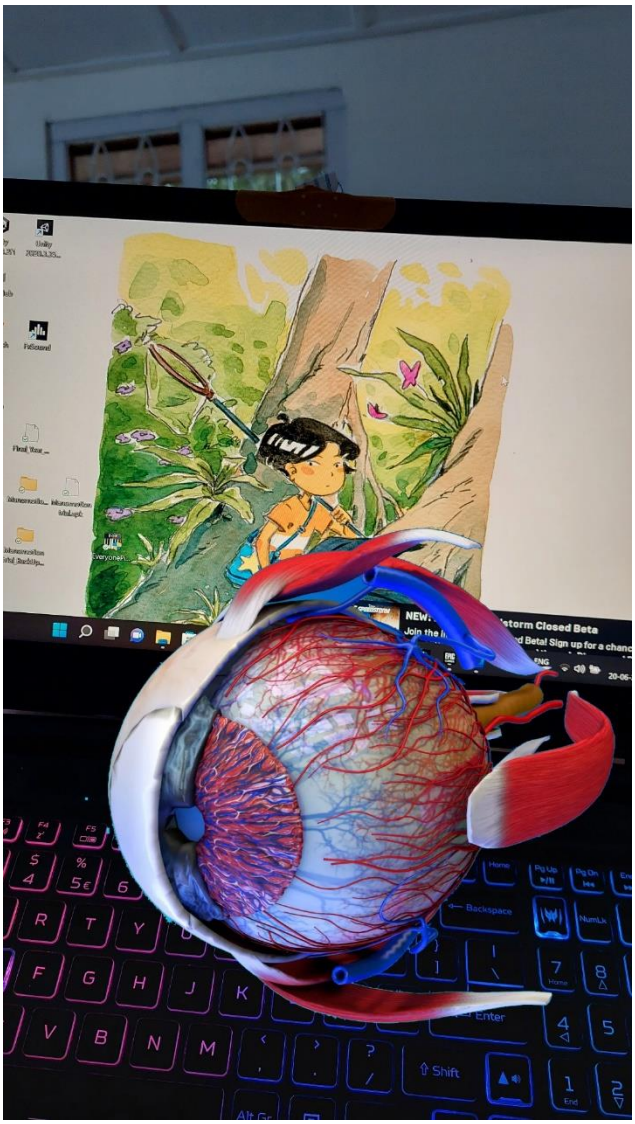

**f) Share:** The Id is generated and you can share the Id by pressing the Share button. Which takes you to sharing dialog box. It also automatically copies the id to the clipboard.

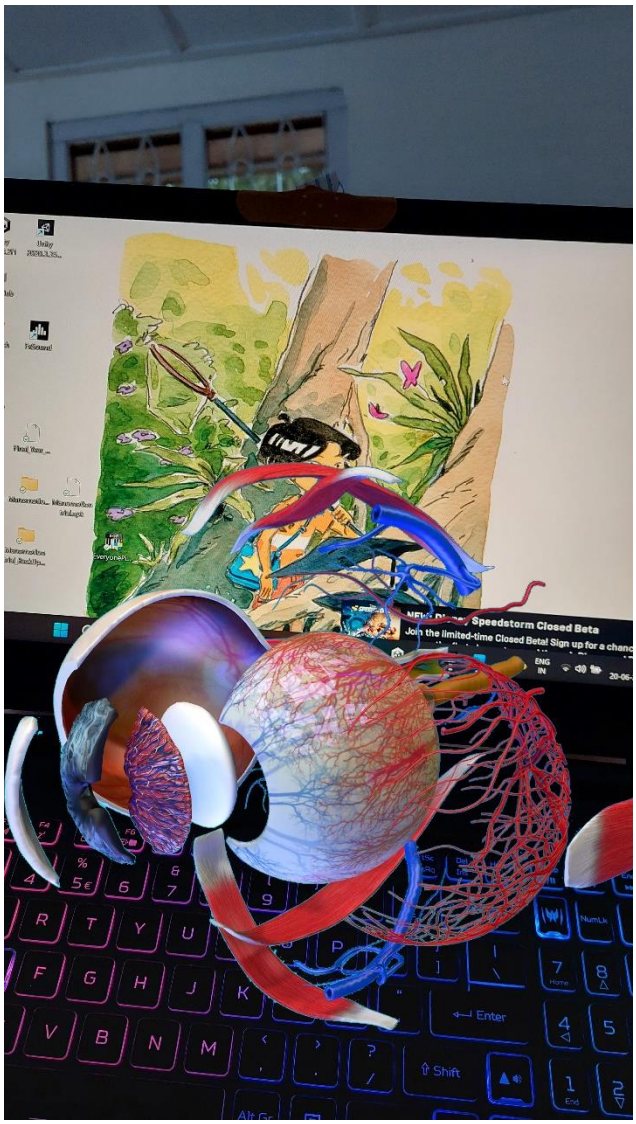
**g) Resolving Anchors:** Here paste the id and press resolve.



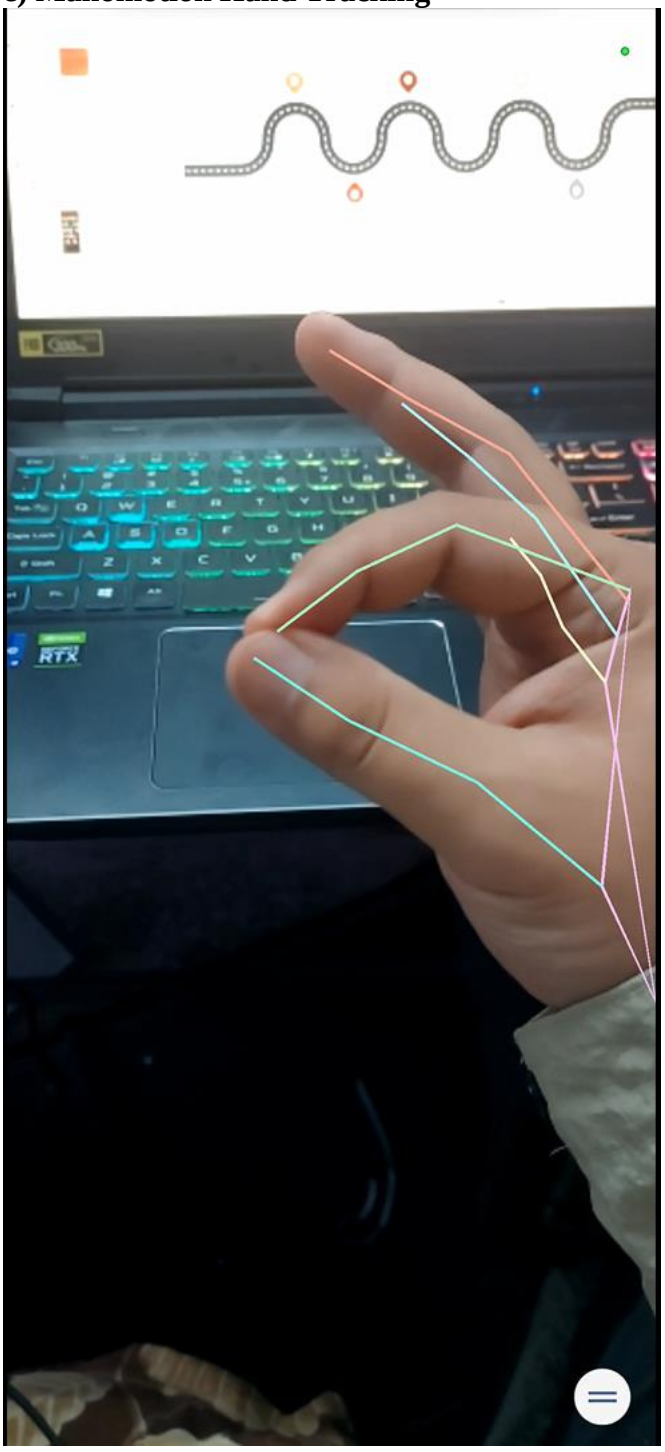
**g) Issac's POV of Dinosaur Sample:** After resolving. You can scan the same area and it will generate the model at exact same place from different angles and multiple phones.

**d) Some application: Eye dissection study.**





**e) Manomotion Hand Tracking**



**Roadmap & Progress so far:**

➔ Task 1 : Implementing AR (Completed)

1.1 Successful Implementation of AR framework in unity, with placeholder 3d objects, deployable to all AR supported devices. Screenshots in next section.

➔ Task 2 : Implementing Networking framework for real-time cross platform interactions. (Completed)

➔ Task 3 : Choosing a visualiser topic and implementation with a demo apk for testing.

➔ Task 3 : Manomotion hand tracking and a demo apk for testing. (Building blocks constructed)

➔ Task 4 : Polishing and features adding if possible. Such as hand tracking, voice commands etc.(Done)

➔ Task 5 : Final Product (Done).

## Conclusion

A new trend is augmented reality. The market for instructional tools is also fertile ground for innovations, and it quickly catches up with the latest developments. There is a tonne of untapped potential for augmented reality in teaching. AR is becoming more widely available and used as a result of the current usage of mobile technology and recent hardware advancements. So now would be an excellent moment to start moving in that direction.

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06. A research agenda for augmented and virtual reality in architecture, engineering and construction
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07. The Impact of an Augmented Reality Application on Learning Motivation of Students.
Authors: Tasneem Khan & Kevin Johnston
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Authors: Yunqiang Chen, Qing Wang, Hong Chen, Xiaoyu Song, Hui Tang, Mengxiao Tian
College of Information and Electrical Engineering, China Agricultural University, Beijing 100083, China

09. Trends in Virtual and Augmented Reality Research: A Review of Latest Eye Tracking Research Papers and Beyond
Authors: Jicheng Li &Roghayeh Barmaki
Computer & Information Sciences University of Delaware.

10. Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade
Authors: Jairo Quintero, Jhoni Cerón and Gloria Velez
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12. AREdu 2019 – How augmented reality transforms to augmented learning
Authors: Arnold E. Kiv
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