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MOBILIAR: AN FURNITURE BUYING ENVIRONMENT WITH THE HELP OF AUGMENTED REALITY AND 3D VISUALIZATION

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ABSTRACT
Every household has a need of furniture, to make the house utilitarian and make living easier. In India, we still depend heavily on the traditional furniture buying methods i.e., going to furniture marts, looking for the furniture we like, estimating if the furniture would fit in the desired spot, and buying the furniture solely based on a hunch of whether it would fit and match the rest of the house's interior design. This proves to be a big problem when the furniture has already been bought and it doesn't fit or look good in the desired spot. Taking the fact that buying without trying is a difficult choice to make, we decided to develop a system that would help the user visualise the furniture, and get an ease in buying the desired furniture. The system is implemented as a mobile application. The technology used behind this is Augmented reality (AR), which is an advanced and efficient solution for connecting and visualizing the 3d models in any own environment. This is possible by using Unity gaming engine with the blender 3d software for building the models and a google provided package AR Foundation for android tools. We hope to create a better environment of AR technology platforms for everyday users and sellers. We are able to achieve the goal of saving time and hassles by the use of AR.

Keywords: augmented reality, ArCore, camera application, Virtual reality, E-Shopping.

INTRODUCTION
For ages, shoppers have been faced with a dilemma for their shopping needs, that is "will the commodity we intend to buy, actually be appropriate in our needs?". In this case, "will the furniture we intend to buy fit in our home's desired space?" This question is very hard to answer based solely on the buyers memory of their space. This especially gets harder when the dimensions of that space are misinterpreted by huge margins. The solution to this is simple e-commerce mixed with newer technologies. E-commerce is the online purchasing and selling of products and services [1]. AR is a technology that can add digital elements like pictures, sounds, and other sensory experiences to the real world to make it more interesting or informative [2,11]. The use of augmented reality has increased, with virtual "try-before-you-buy" gestures ranging from evaluating things in the house. With the widespread of internet and the ease of life that comes with internet applications, more people have been turning towards this try and buy ideology. This ideology becomes very easy to implement in the furniture buying environment with the help of augmented reality. Augmented reality acts as a bridge between the 'try and buy' ideology and the newer e-commerce shopping convenience. The aim of this system is to bring the convenience of online shopping to the traditional consumers who believe in the 'try and buy' ideology, by giving them a virtual trial of the furniture that they intend to buy.

It is observed that while using e-commerce, and shopping for products online it is very difficult to visualize the products in real life. The pictures listed on the website are often not very useful. These pictures can easily prove to be deceiving and the customer can end up with the wrong product. It is also observed the difficulty a consumer faces while buying furniture offline. It either becomes a very tedious process where a carpenter has to come visit the house and take measurements of the actual space, before custom making furniture for that space. The customers directly go to physical stores to buy the furniture and later realise that the furniture doesn't exactly fit the space as they'd hoped or the color don't blend as well as they wished. Shopping for furniture online or offline has its own pros and cons but a common issue in both is that the buyer's can't see how the piece of furniture would look in the shopper's home before buying. To overcome this issue, the proposal to build an AR based try

and buy application that allows shoppers to see products in their homes before buying them. Objectives of this project are as follows: AR technology can provide customers with more information about a product compared to just a picture or video. It allows them to see the product in 3D and even visualize how it would look in their own space. This can help prevent disappointment when the product arrives and doesn't meet their expectations. AR technology is easier and safer to use because it doesn't require a lot of equipment or special safety measures. It's also more convenient to maintain. Unlike other types of technology, AR doesn't require for the user to clear a space or take any other special precautions to use it. To make a trial of furniture product available virtually in 3D using AR

LITERATURE SURVEY

Throughout the boom of internet and technology in general, there is a growth of life changing technologies. One of which is augmented reality [8]. The real environment and computer-generated content are combined in augmented reality (AR), an interactive experience. The use of augmented reality allows individuals to see things they previously couldn't. With an example of furniture, furniture could only be visualized in a place with the actual furniture being present there, but with augmented reality, the furniture doesn't have to be physically present in the room. It can be virtually visualised in a given space with the use of augmented reality. Augmented reality has a wide variety of applications.

AR Technologies for Interior Design Planning using a Simultaneous Localization and Mapping Method-M F Syahputra M R Aulia , Dedi Arisandy 2020[3] This research paper discusses the use of AR technology for Simultaneous Localization and Mapping (SLAM)-based interior design planning. The authors describe the technical details of the AR system, which includes using AR markers and a SLAM algorithm to track and map the physical environment. The study concludes by highlighting the potential of AR technology in enhancing the interior design process.

Pattern-based AR Application for the Dissemination of Cultural HeritageA.-M. Boutsi*, S. Verykokou, S. Soile, C. Ioannidis 2021[4] The research paper focuses on the development of a pattern-based AR application for the promotion of cultural heritage. To achieve this, the application uses image recognition technology that is based on the Oriented FAST and Rotated BRIEF (ORB) feature detection and matching algorithm. The paper describes the technical details of the development process, which includes using Unity for the AR interface and Vuforia for image recognition. The research also discusses the challenges involved in developing an AR application, such as achieving accurate object recognition and optimizing the algorithm for mobile devices. The study concludes by highlighting the potential impact of the application in promoting cultural heritage and the need for further research to improve its effectiveness.

Interior design using Augmented Reality - Ms. Tanmayi Samant, Ms. Shreya Vartak [5] this research paper explores the use of (AR) technology in interior design. The authors describe a system that utilizes AR to create a virtual environment in which users can visualize furniture and decor in real-time. The system uses FAST corner detection to track and map the physical environment without requiring identification markers. The study concludes by highlighting the advantages of using AR in interior design, including improved visualization, reduced costs, and increased customer satisfaction.

Feature-Based Tracking via SURF Detector and BRISK Descriptor-Sangeen Khan and Sehat Ullah 2019[6] It discusses the use of the SURF detector and BRISK descriptor for feature-based tracking in augmented reality applications. The paper aims to improve the accuracy and speed of feature detection and tracking in AR by comparing the performance of these two methods. The results show that the combination of SURF and BRISK can achieve high accuracy and fast performance, making it a promising approach for feature-based AR tracking.

Capabilities of ARCore and ARKit Platforms for AR/VR Applications, Pawel J. Nowacki and Marek Woda,2019[7] The paper discusses the capabilities of the ARCore and ARKit platforms for AR/VR applications. It explores the differences between the two technologies in terms of features and performance. The study found that ARCore had several advantages, including better compatibility with different devices, faster processing

speed, and improved tracking accuracy. Additionally, ARCore had better support for cloud anchors, which enable shared AR experiences across different devices and users.

Ananda P. and Omar A. (2018), "Interior Design with Augmented reality", Department of Computer Science and Information Technology, Saint Cloud State University[8] The research paper proposes an AR-based interior design system that uses marker-based tracking with the ARToolkit library and OpenCV libraries for feature detection and matching. The system also utilizes the Canny edge detection algorithm for image segmentation and the Delaunay Triangulation algorithm for creating a 3D mesh of the room.

Study of applications Ikea Place AR-Kit Augmented Reality: This application allows users to place, move and rotate furniture items as per their room layout and available space. It uses 3D models which are built to scale. Houzz App: This application uses 2D imaging to place furniture overlays over real-life spaces. Arloopa: It detects flat surface and places 3D object on it. It allows the placed object's rotation and resizing. Their view changes based on relative distance and angle from the phone. It can utilize marker based, markerless and location based AR Pokemon go: It shows the character on screen using AR. The application allows to take pictures with 2D characters. The table 1 below give an overall summary of all the research papers discussed in survey of existing systems.

Table 1. Literature Survey Summary

Papers	Algorithm Used	Advantages	Disadvantages
Augmented Reality Technologies for Interior Design Planning using a Simultaneous Localization and Mapping Method-M F Syahputra M R Aulia , Dedi Arisandy 2020[3]	SLAM	The application is capable of displaying multiple 3D objects	The object or ground will no longer be seen if the camera is tilted over 45 degrees.
Pattern-based augmented reality Application for the Dissemination of Cultural HeritageA.-M. Boutsi*, S. Verykokou, S. Soile, C. Ioannidis 2021[4]	ORB, RANSAC algorithm	In comparison to other applications in cultural	The application performs pattern object recognition successfully only if the pattern is around the same scale as pattern image
Interior design using Augmented Reality - Ms. Tanmayi Samant, Ms. Shreya Vartak[5]	FAST(Features from Accelerated Segment Test) corner detection.	Features from Accelerated Segment Test (FAST) corner detection, which allows real-time tracking of furniture items without the need for identification markers. This can simplify the user	The system has limited testing or validation of the system described, which makes it difficult to assess the effectiveness and reliability of the system in real world setting

		experience and make it easier for users to visualize furniture items in their real world environment.	
Feature-Based Tracking via SURF Detector and BRISK Descriptor-Sangeen Khan and Sehat Ullah2019[6]	SURF and BRISK	BRISK generates and matches descriptors much quicker thus reducing running time.	The method's performance and compatibility with smartphones and tablets have not been evaluated.
Capabilities of ARCore and ARKit Platforms for AR/VR Applications, Pawel J. Nowacki and Marek Woda,2019[7]	Gives an extensive comparison between ARcore and ARKit capabilities. Helps in choosing the correct platform and framework to work on.	ARCore is fully documented for application in UNITY. Faster in mapping larger surfaces such as empty room	ARCore has 3 times more memory usage than ARKit. Frames per second is limited to 60 fp
Ananda P. and Omar A. (2018), "Interior Design with Augmented Reality", Department of Computer Science and Information Technology, Saint Cloud State University[8]	Implemented an app with the help of MarkerLess AR. Started off with a marker based approach due to the lack of markerless AR support of their system	Does not require static images and in turn markers. Once the content is placed in a room, it is more flexible than marker-based alternatives	Only provides support for android. It is required that the surface has a texture for computer vision to recognize it.

There are certain limitations with all the existing systems as no system is a hundred percent accurate. Following are certain things that each of these lack: Pokemon Go has very limited AR functionality. While Pokemon Go's AR mode adds an extra layer of immersion to the game, its use may be limited. The 3D character models cannot be moved or resized. Arloopa lacks behind in its pricing. While Arloopa offers a free trial, some of the platform's features are only available with paid plans Ikea place and the Houzz app have limited compatibility and limited availability. Both apps are only available on latest versions of iOS. These apps do not have the AR features available in India. Houzz specifically lacks intuitiveness and doesn't give a realistic feel of the items. The literature surveyed in terms of research papers have some drawbacks of their own. Applications based papers showcase the limitations with their applications, such as not being able to identify the ground or the object, when the camera is shifted above a defined 45°.The applications not being optimized for the real-world use cases. Applications not being reliable enough with pattern recognition and the speed at which the environment is detected. Some papers have limited testing, and limited generalizability. These papers are very application oriented and can't be widely used for general purpose use, or even general understanding of the concepts. While the research work gives an extensive comparison between ARCore and ARkit platforms, it fails to recommend one better platform that can be claimed as better. Depending on the use case and application that is sought to be built, the better platform differs. While ARCore is better with developing android-based applications, ARKit prevails in building iOS-based applications.

PROPOSED WORK

Shopping for furniture online or offline has its own pros and cons but a common issue in both is that the shopper can't see how the piece of furniture would fit in the buyers home before buying. To overcome this issue, an AR based try and buy application that allows shoppers to see products in their homes before buying them, is proposed. AR allows its customers to preview the products or experience services in their own environment and on their own time, before making a choice of purchase.

Here is a brief overview of what the AR Placement algorithm: The script defines a public GameObject variable arObjectToSpawn, which is the object that will be placed in the AR environment. It also defines a GameObject variable placementIndicator, which is an object that provides a visual representation of the position where the object will be placed. In Start(), the script finds the ARRaycastManager in the scene. In Update(), the script checks if the user has touched the screen and there is no spawnedObject already in the scene. If both of these conditions are met, ARPlaceObject() is called, which instantiates the arObjectToSpawn at the PlacementPose position and rotation. Update PlacementPose() updates the PlacementPose of the placemen tIndicator based on the ARRaycastManager's Raycast. UpdatePlacementIndicator() sets the position and rotation of the placementIndicator based on the PlacementPose, and sets it active or inactive based on whether or not there is a spawnedObject already in the scene. ARPlaceObject() instantiates the arObjectToSpawn at the PlacementPose position and rotation, and disables all the planes in the scene using the ARPlaneManager component. Finally, it disables the ARPlaneManager and ARPlane components on this script to prevent any further planes from being detected. This script can be attached to an empty game object in a Unity scene that has an ARSessionOrigin component, an ARPlaneManager component, and an ARSession component. The user can then drag an object prefab into the arObjectToSpawn field in the Inspector window, and drag a placement indicator object into the placementIndicator field. When the scene is run on an AR-capable device, the user can touch the screen to place the object at the desired location.

***Proposed Methodology/Techniques*:** The proposal is to build an android application for using the augmented reality based application. Following are more details about the same

1. UNITY: A cross-platform engine used for game development, augmented reality and virtual reality based applications.

2. Working cross-platform with augmented reality platforms within Unity is made possible by the AR Foundation. Unity developers can use an interface that is provided by the AR Foundation package., but does not contain AR functionality itself. Additionally, using AR Foundation on certain devices requires additional packages designed for Unity's officially supported target platforms. The purpose of AR Foundation is to define an API that is compatible with multiple platforms and allows developers to access common functionality.

3. AR Subsystems: AR Foundation is based on subsystems. Subsystems are platform independent interfaces for providing several kinds of information. AR-related subsystems use the Unity Engine and are defined in the AR Subsystems package. XRnamespace. AR subsystem. Each subsystem is in charge of a distinct task. For instance, XRPlane Subsystem has an interface for aircraft detection.

4. XR Core Plugin for AR To enable ARCore compatibility using Unity's cross-platform XR API, use the ARCore XR plugin pack. The ARCore XR plugin uses Unity's cross-platform XR API to implement the native endpoints needed to create handheld AR apps that target Google's ARCore platform. This package, however, does not offer a standalone public scripting interface. Most of the time, a portable AR program should be built using the scripts, prefabs, and materials offered by the AR Foundation. Additionally, source files, static libraries, shader files, and plugin information are included when including an ARCore XR plugin.

5. To create a scaling algorithm for determining the right scale factor for objects it considers factors like distance and perspective. Once the scale factor is calculated, the object's transformation is adjusted accordingly. A proximity-based algorithm might involve: Calculate the average distance between the object and its surroundings.

Decide on a scaling factor based on this average distance. For instance:

- Smaller average distance implies a larger object scale.
- Larger average distance implies a smaller object scale.

Implement the calculated scale factor in the object's transformation. This approach assumes that the object should appear larger when it's closer to other objects and smaller when farther away. Finding the right scaling values may require some trial and error to achieve the desired visual impact.

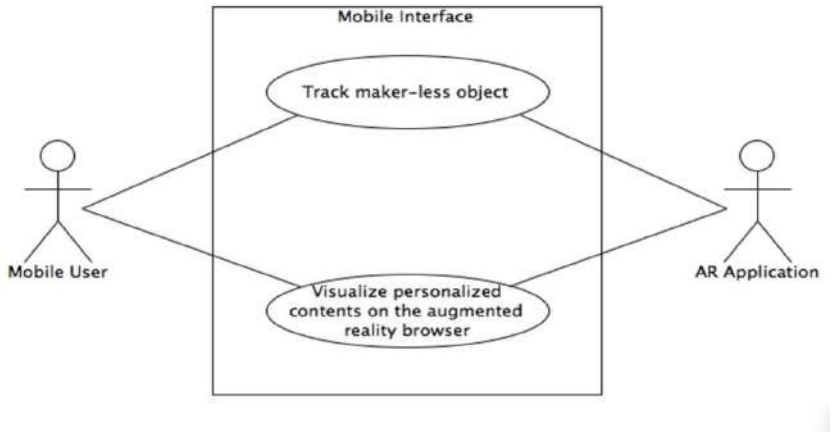

Fig. 1. Use case Diagram for application

The above use case diagram shows that there will be 2 acting agents, i.e., a mobile user, a human user who will have the mobile application, and who wants to use the AR application to visualise the furniture virtually, and secondly the AR application itself. The mobile application would serve 2 main purposes, one, of tracking marker less objects, and two, of visualising the personalised content on the mobile application

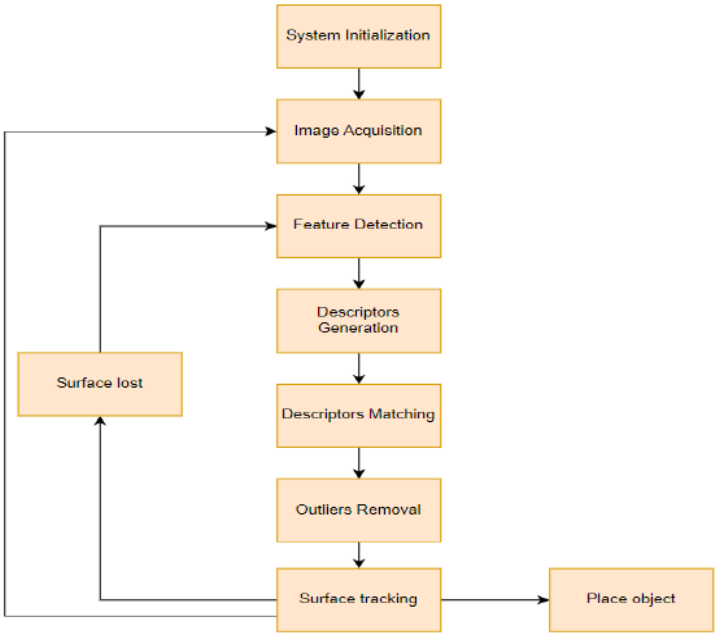

Fig. 2. ARCore Backend

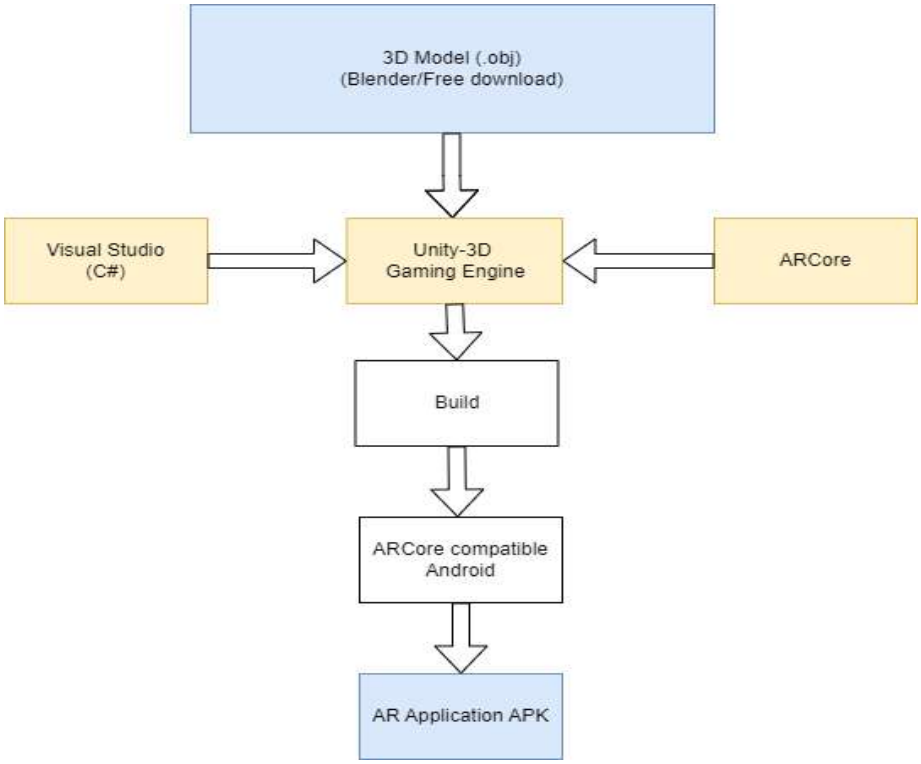

Fig. 3. System Design

Fig. 3 explains the actual working of the mobile application. Firstly, 3D models are created using free softwares such as Blender3D. These models can then be imported as .obj extensions. IDE such as visual studio was used to work with C language. All the building and actual coding part was done by using the unity 3D gaming engine. Unity 3D gaming engine was accompanied by ARCore, to import and adapt to augmented reality functionalities. Then the actual building portion was done followed by making it compatible to android. Android compatibility was achieved again with ARCore. And finally the augmented reality application's apk was created

RESULTS AND DISCUSSION

The 3D model software Blender, which is free, is used to create 3D models. Blender3D also allows for colouring and texture, which may then be exported in the specified file format or extension. The appropriate 3D model can be exported in the desired file format, such as .obj, .fbx, or .blend. Now the Unity 3D game engine can manage the exported assets. For augmented reality tasks, Unity 3D uses a combination of ARCore, Visual Studio, and game assets

Fig. 4, Interface of mobiliAR

Fig.1 shows a simple and user-friendly interface for the application 'mobiliAR'. The clean user experience is designed by keeping accessibility and utility in mind.

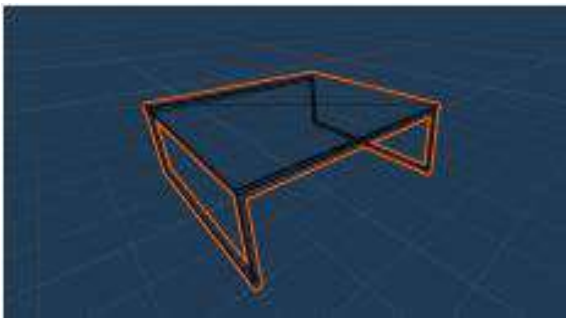

Fig. 5, Marker less AR

The Fig. 5 illustrates how marker less AR works. It creates a grid around the entire room, identifying different planes and places the object on a plane with empty space available.

Fig. 6. Table Implementation.

As seen in Fig. 6 the application shows the furniture selected, in an augmented reality. That is, it shows the 3D rendered models of furniture in the home space. These furniture models are life size models, and after buying the furniture, this is how they would fit in the designated area. Once the plane has been detected and the object given it's initial placement the object can be moved around, rotated and resized.

Fig. 6 displays the system's AUC, or area under the curve.

An Area under the curve (AUC) curve compares the ratio of genuine positives (sensitivity) to false positives(1-specificity) across various thresholds to illustrate how well a binary classifier performs. The AUC score goes from 0 to 1, with 1 denoting the best possible classifier and 0.5 denoting a random classifier. The AUC curve, in other words, summarizes the classifier's overall capacity to distinguish between positive and negative examples. A greater AUC shows that the classifier performs better at correctly predicting the class.

Result Analysis

The application provides life sized 3D models of the desired furniture. It helps in easing the online furniture buying experience, by eliminating the hassle of the measuring dimensions and the fitting process. It provides precise visualization of how the furniture would fit in a given spot in the room. The objectives stated are achieved. With this AR application, the customer is able to get a lot more information from the 3D depiction, than they would get from memorizing the furniture details, and then wondering whether the furniture fits in the desired space. With AR, fancy equipment is not required to visualize anything in a given particular space. The user is fully aware about their environment at all times, and can easily visualise the furniture models in any home space. And finally this application has made the trial of furniture easier by making it available virtually using 3D models, and with the help of augmented reality.

CONCLUSION

Practically speaking, augmented reality has a plethora of real-world applications. This technology can be used to create mobile applications for shopping, learning, healthcare, marketing, sports, gaming, entertainment, and travel. Making the most effective use of augmented reality can assist clients in selecting the right products. In-depth information, such as surveys and related materials, will also be available to customers, which is helpful for businesses looking to influence their target market .More crucially, AR in particular may allow customers to make purchases in-store, regardless of their zone of operation. By superimposing 3D objects in various locations, AR enables consumer to interact comfortably with enhanced conveyance to their home. In the current context with more goods in this business, shorter runs dramatically accelerate product diversity and heighten competition. Top-down production policy may even be defined as a heuristic about future customer wants thanks to the helpful feedback provided by data obtained from the usage of AR techniques in marketing. What makes the aforementioned AR-based marketing approach so resilient is its capacity to implant in the mind of the application user—who might not even be technically sound about how to use the product and its relationships with other elements in its vicinity after being procured—an intelligent, quick, and effective decision-making process.

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