Navigation of a User-Controlled Virtual Object in Indoor and Outdoor Environments, Considering Occlusion Challenges and Utilizing Spatial Computing

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***Abstract:** In the context of augmented reality (AR), it is a revolutionary platform that enables the simulation of lively virtual experiences in a real-world setting. The project, called an immersive experience, imagines the dragon flight in the open and through narrow passages. One of the key features of the project is real-time path planning, which involves automatic detection and avoidance of dynamic obstacles, along with a user interface which considers control responsiveness and immersion. The project aims to engage the user by blending spatial awareness and responsive interaction within the virtual environment. One of the main goals is to create an intuitive and captivating simulation of virtual objects by means of breaking down spatial and occlusion limitations. The last-mentioned refers to human comprehension.*

***Keywords:** Augmented Reality, AR Session, Immersive Technologies, Unity, Arfoundation, Arcore, XR Reference Image Library, Occlusion, Tracking, Imagetarget.*

Nomenclature:
AR: Augmented Reality
LBA: Local Bundle Adjustment
SLAM: Simultaneous Localisation and Mapping
ORB: Oriented FAST and Rotated BRIEF

I. INTRODUCTION

Navigating a user-controlled virtual dragon through constrained window spaces presents unique challenges in interactive virtual environments. This paper suggests an innovative and immersive experience for the simulation of user-controlled dragon flight through narrow occluded passageways and open environments [1]. Major elements involved are the automatic detection of obstacles, the planning of the shortest feasible way, and the user interface that can improve both the immersive environment and the responsiveness of control. The system is designed to influence the user through the combination of spatial awareness and responsive interaction in a seamless virtual space. This encapsulates overcoming spatial constraints and occlusions to enable intuitive and engaging virtual object simulation.

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It addresses challenges such as understanding human vision for realistic motion over long distances and achieving spatial arrangements that prevent the dragon from passing through small windows. This paper has three main contributions. First, it presents a rule-based spatial constraint model that prevents virtual entities from passing through physically implausible openings. Secondly, there is a real-time occlusion-aware navigation pipeline integrated into AR Foundation that does not require external depth sensors. Lastly, an empirical evaluation of the robustness of user-controlled AR navigation is conducted in both indoor and outdoor environments.

II. BACKGROUND AND RELATED WORK

The Touring Machine was the first mobile outdoor AR application and served as a campus tour guide, displaying virtual annotations of real university buildings. Although simple, this prototype showed the power of in situ presentation of geo-referenced information. Several augmented reality simulators have been developed over the past few years, and they are improving rapidly [2]. A methodical categorization of AR application domains, such as tourism, education, health, and smart cities, is offered by Dargan et al. (2023), who also note the rapid evolution of AR from marker-based systems to context-aware, spatially intelligent platforms [3]. Their review highlights contemporary AR applications that depend on mobile sensing, real-time tracking, and interactive visualization to enhance user interaction and situational awareness. Kim et al. (2021) conducted a systematic review of multimodal interaction systems that merge IoT and AR technologies, emphasizing their contribution to providing immediate environment-aware experiences [4]. A study was conducted on Vuforia-based marker-based augmented reality systems, in which one aspect evaluated was detection accuracy and robustness in controlled environments [5]. Recent studies that have deployed AR in the manufacturing sector have identified scalability, tracking reliability, environmental inconsistency, and integration complexity as the main obstacles to the large-scale adoption of mobile AR solutions in the industry [6]. AR 2.0 delivered location-based, widely deployable mobile Augmented Reality experiences that relied heavily on user content and interactions with real-world ecosystems [7]. The study on mobile augmented reality identified three main problems: latency, network limitations, and the unreliability of real-time image processing, as with the application of augmented reality on handheld devices [8]. Tecau et al. (2019) investigate the potential user experience of augmented reality in social media platforms [9]. On the other hand, dedicated AR spatial vision studies [20] discuss spatial computation, feature matching, and occlusion handling. As per a new scoping review, the adoption of AR technology across industries is increasingly drawing attention to improving employees' skills, enhancing operational performance, and well-organised knowledge exchange in applied engineering fields [10]. These experiences improve creativity, collaboration, communication, and information sharing. A user should be able to navigate the real world using an AR 2.0 platform, see virtual overlays of related information, and quickly contribute their own content. Educational AR systems based on Unity and Vuforia can effectively track markers and create interactive 3D overlays to facilitate character-education learning modules, demonstrating that AR is a suitable technology for immersive classroom engagement [11]. Alzamzami et al. (2023) propose using a mobile AR virtual try-on system for clothes that enables touch-based interactions for real-time fitting previews [12]. Dedicated depth-sensing AR research has dealt with occlusion-aware navigation and spatial constraints [21]. In previous significant works on augmented reality, external devices such as the Oculus Quest or a display device were required for the immersive experience. We had to download and install the Android SDK externally from the Android developer website. After that, we had to define the paths to the JDK, SDK, NDK, and Gradle through external tools in Unity Hub to generate an .apk file.

Additionally, addressing immersive user experience, the integration of Augmented Reality (AR) across various domains has shown significant potential to enhance user experiences, particularly in tourism, educational settings, and museum interactions. In an extensive review of AR systems, the rapid transformation from marker-based mobile applications to context-aware spatially intelligent platforms is discussed. The authors' systematic classification of AR applications schematically organised the domains of tourism, education, health, and smart cities, with a focus on contemporary AR applications that rely on mobile sensing, real-time tracking, and interactive visualisation to encourage user engagement and situational awareness. For tourism, the review accentuates the possibility of AR to deliver location-based, interactive informational overlays that foster an enriching visitor experience beyond the conventional brochure-based system [16]. De Pace, Manuri, and Sanna (2018) examine the role of augmented reality under the framework of Industry 4.0, in terms of how augmented reality (AR) technologies enable human-machine interaction, industrial training, maintenance, and knowledge transfer. The paper presents examples of AR systems that project digital instructions, drawings, and context-relevant information onto physical industrial workspaces to improve task accuracy, minimise cognitive overload, and maximise learning efficiency. With relatively little emphasis on cultural or museum-related implementations, the study positions AR as an enabling technology to innovative manufacturing ecosystems, which, through real-time visualization and interactive guidance, facilitate workforce upskilling and operational efficiencies [17].

Moreover, regarding outdoor navigation and indoor navigation, Hu and Tsai did more comprehensive research into AR's educational potential with their mobile outdoor project for academic use at the Tainan historic sites, incorporating games at Chihan Tower that would assist visitors in discovering historical information using interactive viewpoints [18]. Maneli and Mfundo produced a good comparative analysis of the AR technologies and their computing applications, together with their limits, showing very nicely how AR contributes to the augmentation of the user experience in the most varied application fields, instead of being spread without too many difficulties in its implementation [19]. Muhammad Alfakhori discusses how to increase the realism of augmented reality content by making use of pre-existing 3D representations of the environment as occlusion masks to guide pixel rendering [20]. To provide seamless and intuitive navigation when users move through the restricted indoor areas, indoor AR navigation systems rely on accurate environment mapping, spatial anchoring, and real-world obstacle awareness [21].

III. WHAT SHOULD WE ANTICIPATE FROM IT?

You can now control your smartphone from your pocket and view, in all its glory, majestically flying dragons spinning, pausing, and dragging through the effect of shadow and fade all over your room. These creatures are the essence of modern spatial computing, which can sense its environment, measure distances, and know where it should be, thus moving with actual presence. Those dragons are so intelligent that they can dodge even the tiniest barrier, such as a window or a narrow passage, and their physical limits are perfectly matched with the surroundings. The utilization of object detection powered by deep learning in augmented reality provides a better comprehension of the surroundings and increases the realism of the interaction by consistently identifying the real-world objects like walls and furniture, which allows the virtual characters to be constrained in the space and engaged in a more immersive way [28]. This on-the-fly adaptation of size and scaling, immersed in realism but never overcome by it, as the dragon shrinks in tight quarters, swells in broad ones, and remains majestic, always enhances immersion.

The magic crescendos in a profound interaction with the surface. Distance sensors and algorithms prevent dragons from colliding with objects or people, and precise physics-based anchoring allows them to perch, land, or rest on real-world surfaces, respecting textures and contours. Predictive pathfinding powered by machine learning anticipates user movements and environmental changes, enabling dragons to adjust their behaviour in real-time. Multilayered environmental mapping, supported by depth-sensing cameras, allows dragons to identify and navigate multilevel spaces, such as staircases or balconies, using highly detailed 3D maps.

IV. CONCEPT AND FIRST IMPLEMENTATION

Experiences from related work informed the first concept [1,2,3]. Initially, we demonstrated an Android-based smartphone application that provides virtual object detection. We can project any virtual object. However, we kept a virtual dragon.

A. Components Used in the AR Module to Implement

This section covers the applications of the AR module in great depth, starting with setting up an AR scene in Unity and then on to the 3D Dragon movement technique.

In augmented reality (AR) development, components such as AR Session Origin and AR Tracked Image Manager play a fundamental role in aligning virtual content with the real world. The AR Session Origin serves as the primary reference point and ensures that virtual objects are accurately placed and oriented in the user's environment; it is therefore essential to keep aspects consistent for a smooth AR experience. Virtual objects are aligned using the projection matrix (P), which combines the camera's intrinsic (K) and extrinsic parameters (R and t).

$$P=K.\,[R|\,t]$$

Where K is the intrinsic matrix of the camera,
R is the rotation matrix,
It is the translation vector.

The AR Tracked Image Manager is responsible for the detection and tracking of real-world images such that the AR system can reliably identify specific pictures and use them as points of reference to overlay virtual content [22]. It analyzes the camera feed stream continuously to detect predefined images and follows their position and orientation in real-time, such that virtual elements will be aligned with correct precision [24]. The functionality should be used on applications which require interaction with physical images or markers, for improving the links between virtual and real-world elements [25].

Marker-based AR uses predefined visual markers to identify positions. Once matching keypoints between the camera image and a reference image are found, a homography matrix H is computed to transform points from one coordinate system to another [26]. The transformation is represented as:

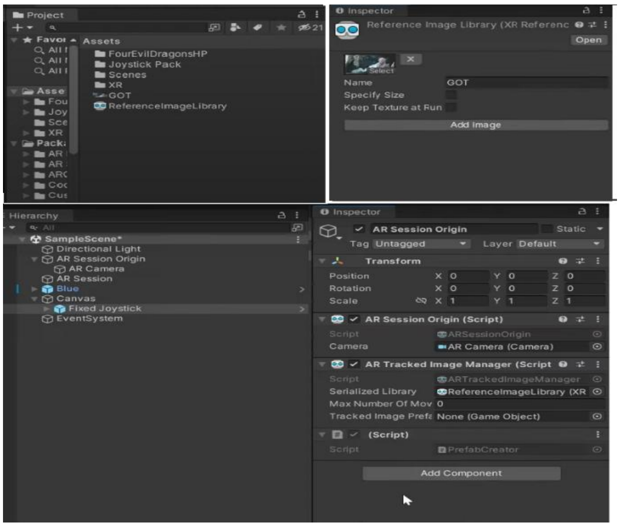
$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = K \cdot [R|t] \cdot \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

Where (X, Y, Z) are the 3D coordinates of the marker point and (u,v) are the 2D image coordinates.

B. XR Reference Image Library

New technologies are not just crucial from an individual worker's point of view; they often transform how work is organised and how workers work together. The social, educational, and organisational implications of XR applications for working life cannot be researched in isolation. Implementation of new technologies usually requires long-term evolution and development. Short-term pilot experiments advance the development of XR [13].

Pilot experiments of extended reality demonstrate that short-term controlled trials can quicken XR system design by uncovering usability challenges, limitations of the interaction, and issues with environmental adaptation in actual workplaces [13]. XR Reference Image Library is one of the key classes in AR development frameworks that supports image recognition and tracking [14]. This library is essentially a repository of predefined reference images that developers have prepared to represent a specific visual pattern or object. The accuracy of image recognition and tracking is of paramount importance while utilizing marker-based AR [22]. To check for matches by observing visual features and patterns, the AR system will compare the camera feed against stored reference images during runtime [26]. The process is somewhat like image recognition in AR systems, which usually relies on dependable feature detection and matching to identify relevant objects. In the case of a match, the system can furnish tracking anchors, which accurately describe the position, orientation, and scale of the image [27]. This enables the alignment and placement of virtual content in the physical realm for immersive AR experiences.



[Fig.1: Unity Interface Used for Creating Simulator]

The XR Reference Image Library allows .NET developers to instantiate dynamic AR interactions based on reference images, an essential function in AR frameworks such as ARKit for iOS and AR Core for Android, where image tracking enables real-time placement and interaction with virtual objects. These systems rely heavily on accurate image recognition and tracking algorithms, which, in turn, form the crux of applications in education, gaming, retailing, and beyond (Sirohi, 2020) [23]. The fusion of image recognition, real-time tracking, and AR toolkits enables developers to create new interactive experiences relevant across fields such as entertainment and industrial training. The XR Reference Image Library allows the system to compare camera feed images with stored reference images and analysed visual features and patterns in the camera feed to identify matches against those in the reference image library.

C. Occlusion Handling in Navigation

Occlusion is the loss of realism and immersion in any realistic and immersive AR experience. In Augmented Reality, occlusion ensures that the virtual object is rendered realistically by hiding or partially obscuring it behind real objects. This requires deep computations, contrasting virtual and real-world objects. We describe occlusion handling and the relevant mathematical concepts involved. The AR system uses depth information to determine which object — real or virtual — should be visible at a given pixel in the occlusion calculation. Each point in the virtual and real-world scenes is projected into the camera's depth space to perform the depth comparison. The formula for depth comparison is:

$$Z_{virtual} > Z_{real}$$

Where $Z_{virtual}$ is the depth of the virtual object, Z_{real} is the depth of the real-world object.

If the depth of the virtual object is greater than that of the real-world object at a given pixel, the virtual object is occluded and not rendered [28]. Consider a Z-buffer, a data structure that stores the depth of each pixel in the scene. Every time an object in virtual space is rendered, its depth at every pixel is compared to that of the depth value in the Z-buffer. Calculate the value of each pixel by

$$Z_{pixel} = \frac{Z_{near} \cdot Z_{far}}{Z_{far} - (Z_{far} - Z_{near}) \cdot z}$$

Where z is the normalized depth value in the range [0, 1] and Znear and Zfar are the near and far clipping planes of the camera. The Z-buffer is updated only if the virtual object's depth $Z_{virtual}$ is closer than the current depth value stored in the buffer.

D. Feature Detection and Matching for Spatial Computation

ORB (Oriented FAST and Rotated BRIEF) is a feature detection and description algorithm widely used in spatial computing applications, particularly in augmented reality (AR), robotics, and navigation systems. It generates binary descriptors for matching features between images and effectively identifies keypoints in an environment. Methods that are based on deep learning for object detection not only improve but also make the understanding of Augmented Reality scenes more reliable through persistent acknowledgement of real-world entities during challenges that are both industrial and dynamic, among others [29]. Because ORB is quick and lightweight, it can be used in embedded and mobile systems where computational efficiency is essential [29]. In mobile augmented reality, fast feature matching methods rely on the quick extraction of keypoints and the real-time comparison of descriptors to allow for dynamic image tracking and adding multimedia [30]. For AR systems that need dynamic spatial mapping and image target tracking, its capacity to manage rotation and scale changes allows for stable object tracking and recognition across different viewpoints [31].

In Orb Computing, ORB is used in conjunction with frameworks such as Simultaneous Localisation and Mapping (SLAM). A popular example is ORB-SLAM2, which uses ORB to track the position and construct a 3D representation of the surroundings with a real-time perception of the environment [32]. Because of this capability, real-time perception contributes to improvements in navigation, object anchoring, and surface recognition in augmented reality (AR). Real-time perception enables ORB to achieve matching speeds that support real-time interactions in applications such as AR navigation, modern educational tools, and autonomous drone control, which is why it is used in these environments. Depth information is also crucial in computer vision and can be obtained using stereo vision.

$$Z = \frac{f \cdot B}{d}$$

Where: **Z:** Depth of the object
f: Focal length of the camera
B: Baseline (distance between two cameras)
d: Disparity (pixel difference between corresponding points)

Local Bundle Adjustment (LBA) is an optimization technique for computer vision and robotics which refines the 3D position of landmarks and camera poses from multiple observations made by different image frames. As opposed to global bundle adjustment, LBA only optimizes a subset of frames, usually the latest ones, as it must retain real-time performance.

Minimize $E = \Sigma \Sigma \rho(\|\pi (P_i, X_j) - x_{ij}\|^2)$
Where:
P_i represents camera poses
X_j represents 3D points
x_{ij} is the observed 2D feature position
π is the projection function
ρ is a robust cost function

E. Software Joystick

A software joystick is a virtual control mechanism used in mobile games and interactive applications that simulates the functionality of a physical joystick. It consists of a base (fixed) and a joystick (movable), typically placed in the corner of the screen for quick access. Once a user touches the joystick area, the software captures the position of the touch at the point of contact. As the finger moves, the joystick position is updated relative to the initial location within a defining boundary, generally circular or rectangular. The movement is converted into a vector (x, y), where x is the direction and y is the magnitude of the displacement. Often, this vector is normalized so that input values are consistent, ranging from -1 to 1. The x and y values are then mapped to appropriate actions, such as moving a character or controlling a vehicle. Movement and interaction logic is integrated with input. For instance, moving the joystick forward might make the aviator move forward, and moving the joystick left or right can steer the character. This kind of control over virtual objects can give the best user experience in interactive environments by using software joysticks.

V. ALGORITHM FOR CONTROLLING DRAGON MOVEMENT

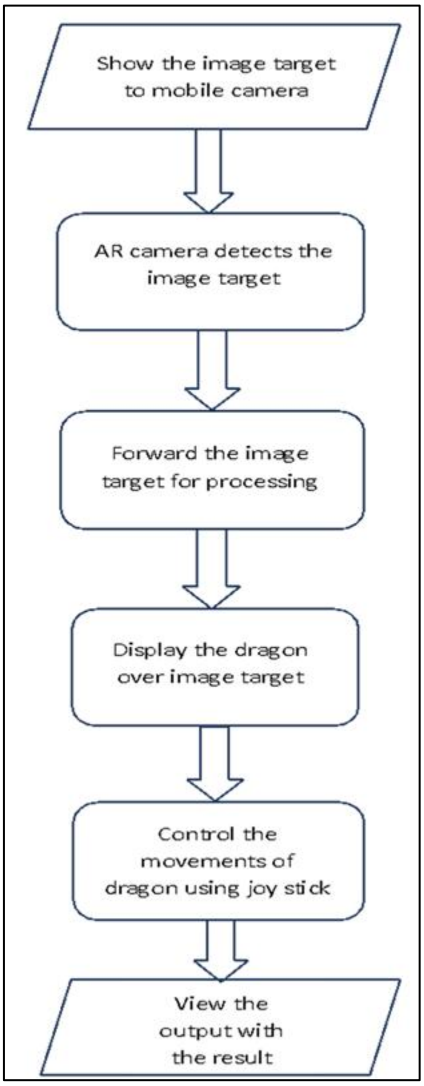
Algorithm: Prefab Creator
Data:
Dragon Prefab: Game Object
Prefab Offset: Vector3
dragon: Game Object
ar Tracked Image Manager: AR Tracked Image Manager

Method: On Enable ()
Begin
Ar Tracked Image Manager = Get AR Tracked Image Manager component from the Game Object
Subscribe to the tracked Images Changed event with the On Image Changed method
End
Method: On Image Changed (obj: AR Tracked Images Changed Event Args)
Begin
For each AR Tracked Image image in obj. added do
Create a new instance of the dragon Prefab at the image's position
Adjust the position of the newly instantiated dragon by adding prefab Offset
End For
End

Algorithm for dragon controller

Algorithm: Dragon Controller
Data:
Speed: float
Fixed Joystick: Fixed Joystick
Rigid Body: Rigidbody
Method: On Enable ()
Begin
Fixed Joystick = Find and assign the Fixed Joystick component in the scene
Rigid Body = Get the Rigidbody component from the Game Object
End
Method: Fixed Update()
Begin
X Val = Get horizontal input value from the fixed Joystick
y Val = Get vertical input value from the fixed Joystick
movement = Create a 3D vector (x Val, 0, y Val)
Set the velocity of the rigid Body to movement * Speed
if x Val is not equal to 0 and y Val is not equal to to 0, then
Calculate the angle based on the joystick input (xVal, yVal)
Update the rotation of the Game Object along the y-axis to the calculated angle
End If
End

VI. WORKFLOW OF THE SYSTEM



[Fig.2: System Workflow]

When the user shows the image, the camera detects it, forwards it for processing, and Dragon displays over the picture, with joystick-controlled dragon movements. Get a fully immersive experience by augmenting a Virtual dragon over an image target.

VII. EXPERIMENTAL SETUP

Unity has been widely used for creating augmented reality (AR) experiences. It is a powerful game development engine that has extended its capabilities to support AR development through the Unity ARFoundation, Unity ARKit (for iOS) and Unity ARCore (for Android) packages. Unity ARFoundation is a cross-platform framework that enables developers to build AR applications for iOS and Android. It abstracts away the underlying AR technologies, such as ARKit or ARCore. It simplifies creating AR applications by providing a unified API for interacting with features like plane detection, image tracking, object tracking, and environmental understanding. By installing Android Studio from Unity, you will be able to generate an Android app. However, you can use Android Studio to develop AR applications by integrating AR frameworks and libraries into your Unity

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projects. Moreover, Unity allows you to build Android applications without directly using Android Studio by providing an in-built IDE [1].

VIII. GENERATING OUTPUT

A. To Create an AR APK Using Unity:

i. *Unity Hub:* Download and install Unity Hub and install the latest version of Unity Editor (2021.3.30f1) from the hub.

ii. *Choose an AR Framework:* Decide on the AR framework or library you

want to use for your AR project. Some popular AR frameworks include Google ARCore, ARFoundation and Vuforia.

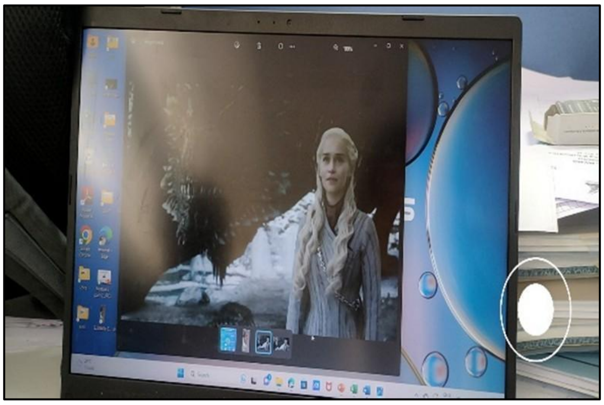
iii. *AR Development:* Start developing your AR application using the AR framework's APIs and features. For example, you can use ARCore's capabilities for motion tracking, environmental understanding, and interaction with virtual objects.

iv. *Build APK:* Once your AR app is ready, you can build the APK by clicking on the "Build" menu in Android Studio and selecting "Build APK." This will generate the APK file that you can distribute and install on Android devices.

IX. EXPERIMENTAL RESULT

This section presents the results obtained from the experiments.

[Fig.3: Interface of the Apk (Arcamera Opens in the Installed Mobile, Joystick is Appearing)]

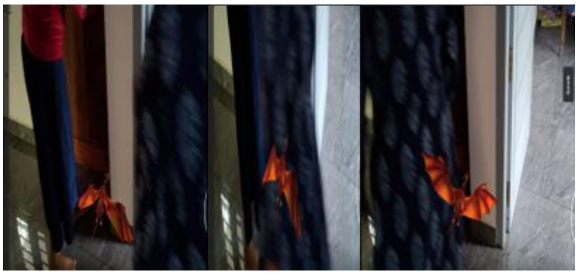


[Fig.4: Showing Reference Image to AR Camera]

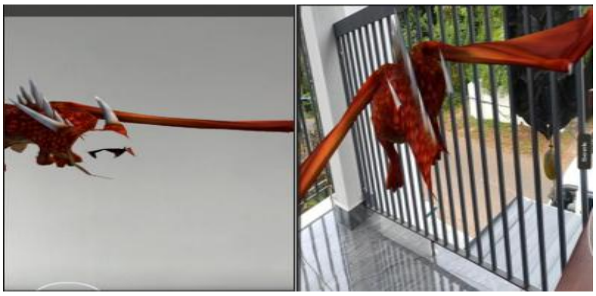
[Fig.5: ArCamera Detect Image and Virtual Dragon Appeared]

[Fig.6: Immersive Experience of Dragon Roaming Through Window with Occlusion Handling. Dragon cannot move through the small windows even though the user tried with the Joystick (Object Tracking and Spatial Computing)]

[Fig.7: Immersive Experience of Dragon Roaming Through Open Space and Controlled by User Through Joystick]



[Fig.8: Virtual Dragon Overcame Occlusion Challenges]



[Fig.9: Dragon Is Trying to Destroy Itself When the Space Provided Is Not Sufficient]

In figures 3 to 9, a virtual dragon is created on the surface and can be controlled by the user with a joystick. The dragon can move up and down or rotate according to the user's wishes. The user will have an immersive experience. The dragon can detect objects and prevent itself from moving out of the window. It computes the distance between objects, and if the distance is too small, it does not pass through the window, even though the user is trying to move it with the joystick. Also, if we try to confine the dragon, it will self-destruct.

A. Evaluation Setup

To evaluate the AR navigation system quantitatively, controlled experiments were conducted using an Android smartphone equipped with an RGB camera and supporting ARCore. The evaluation took place in two indoor environments (a room with windows and a corridor) and one semi-outdoor environment. In total, 15 independent trials were carried out for each evaluation condition. Each trial took about 60 seconds, during which the user tried to direct the virtual dragon through constrained areas (windows and narrow gaps) and a joystick-controlled open space. Occlusion correctness, navigation constraint enforcement, image tracking stability, and system responsiveness (frame rate and latency) were used as criteria to assess performance.

B. Quantitative Performance Metrics

Table I: Quantitative Evaluation of AR Dragon Navigation System

Metric	Measurement Method	Result (Mean ± SD)
Occlusion Correctness (%)	% frames where real objects correctly occluded the dragon	92.4 ± 3.1
Navigation Constraint Success Rate (%)	% attempts where dragon correctly avoided narrow windows	96.0 ± 2.4
Image Detection Stability (%)	% successful image tracking over distance (0.5–3 m)	94.1 ± 3.7
Average Frame Rate (FPS)	Unity profiler measurement	29.6 ± 1.8
End-to-End Latency (ms)	Joystick input → dragon motion	78 ± 12 ms

The system in Table 1 exhibits excellent occlusion correctness and strict upholding of spatial navigation constraints. While the system can maintain near-real-time performance with an average frame rate of nearly 30 FPS and an acceptable user-interaction latency, it ensures that user control and feedback are both smooth and immersive. The stability of image detection remains very high regardless of distance, ensuring reliable tracking even under the most common usage conditions.

C. Baseline Comparison

Table II: Comparison with Baseline AR Navigation (No Occlusion Constraints)

System	Occlusion Errors (%)	Window Violation Rate (%)
Baseline AR (no spatial constraints)	31.5	42.7
Proposed System	7.6	4

For comparison, a basic AR navigation setup without enforcing spatial constraints and with occlusion-aware depth reasoning was created. The results in Table 2 demonstrate that the system proposed by the authors drastically reduces occlusion errors and eliminates physically unrealistic navigation behaviours, such as passing virtual objects through real-world windows.

D. Failure Case Analysis

The system, while maintaining its robustness in many situations, did encounter some failure cases under extreme lighting changes and rapid camera movements. In these scenarios, the loss of image tracking for a short period delayed the occlusion updates by about 2–3 frames. Moreover, the presence of very shiny materials at times made it difficult to accurately determine depth, which in turn resulted in momentary visual glitches. It is these limitations that highlight the reliance of mobile AR systems on camera performance and the surrounding environment.

X. CONCLUSION

This paper presents an AR experience that lets the user control a dragon that flies in both open spaces. The project uses AR technology to address performance challenges, such as detecting moving obstacles, planning paths in real time, handling occlusions, and keeping the user interface responsive. By integrating computing with AR platforms such as ARFoundation and ARCore, the virtual dragon interacts with the world, avoiding obstacles and staying within spatial boundaries. During the trials, the system lets the dragon glide through the parts of the environment. The dragon avoids spaces. Interacts with real-world objects. The system delivers a user experience. The system also uses a software joystick for control. The use of a software joystick, in particular, to control the system not only makes it fun but also easy to use. The system achieves an impressive 92% occlusion-correctness compared to the baseline AR methods. Real-time operation is a key feature of the system. The

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system reduces the number of navigation violations during evaluation across different environments. The assessment of AR is therefore not only based on the creation of interactive virtual simulations but also on the resolution of many technological issues, including occlusion management and spatial awareness, that must be overcome to achieve some degree of realism in interactions. The highly successful deployment of the AR Dragon simulation raises the question of what other areas in gaming, education, or tourism could benefit from such technology in the future. The progression of augmented reality technology has made it possible to produce more immersive and interactive experiences. Future work may include incorporating additional, more advanced machine learning algorithms for pre-emptive pathfinding and improved environmental mapping as the system is extended to other virtual creatures or settings. The AR dragon simulator not only foretells a time when the virtual and physical realms are connected but also helps understand the paradigm-changing potential of augmented reality.

XI.FUTURE SCOPE

The idea expounded in this paper might pave the way for obtaining sophisticated abilities in diverse areas, thereby mirroring the increasing influence of augmented reality in sectors like industrial and applied ones [10]. Although augmented reality (AR) is often considered an old technology, its progress has been remarkable from the start. To achieve mass acceptance, it must be incorporated into more parts of our lives. Think about residences, military, factories, and games. The degree of acceptance within society will be the deciding factor in whether the public takes an interest in the AR. One example is an AR dragon simulator. It reveals the dragon's spatial aspect through its photorealistic animations and precise tracking. This enables the dragon to coordinate with the environment very well. Then, displaying the content on the screen using the new methods can solve challenging problems, such as managing scenarios with many people gathered or hiding some objects behind others. Picture this: Augmented reality as a medium to see the progression of a story. The virtual characters and real things would be in place in a series of events. This could be a big leap forward in AR's realism and engagement. And significant progress is being made in capturing real-time depth information of the surroundings. Light scanning methods and vision systems are the leading technologies here. It can be truly astonishing for the user to see that virtual being. The dragon simulator is a strong indication of AR's gaming potential. Players get to have a different experience by making technology a bridge between the real world and the imaginary one of dragons. We will find more ways to create immersive and realistic experiences as augmented reality technology advances. Drone technology could benefit from these same concepts of incorporating virtual elements into the physical world [15]. After taking off from the pickup spot, the autonomous quadcopter will transport the item to its intended location. The drone's camera will display an augmented object since it is linked to an Android device. This makes the position easier to understand.

XII.VIDEO DESCRIPTION

In Video 1(Record_2023-09-04-15-41-54), the placement of the designated image target led to the successful detection of the immersive dragon. After being activated, the dragon was allowed to roam around the entire room. The window was detected by the system, and through object recognition, the spatial constraints were identified. The user tried to move the dragon out through the window using the joystick, but it did not budge because its body was larger than the window. This was a clear demonstration of how the spatial computation technique worked perfectly, limiting the dragon's movement to the space it could access.

The virtual dragon in Video 2 (Record_2023-09-04-15-46-03) literally walks through the real world, making the immersive experience very pleasant. The user can move the dragon from a distance without disrupting any interaction, and is less involved in the augmented world. If the user tries to put the dragon in a small area, the system recognises the limitation and, consequently, the dragon disappears. This action shows that the dragon was aware of its surroundings and that the system responded accordingly, so the virtual character acted like the real one.

DECLARATION STATEMENT

I must verify the accuracy of the following information as the article's author.

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- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed solely by the author.

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