OpenXR Usage in Gaming: A Comparative Study on Cross-Platform XR Development

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***Abstract*—These days, XR (Extended Reality) is becoming quite popular in the gaming world, mixing virtual, augmented and even mixed reality for giving players a more real-type gaming experience. But one big problem developers are facing now is that there are too many platforms (like Oculus, SteamVR, etc.), and making the same game work properly on all of them is not so easy. That's where OpenXR is helping a lot—it is an open standard made by the Khronos Group, and it allows developers to build XR apps in one common way that can run on many devices.**

In this paper, we are talking about how OpenXR is being used in games, what its structure is, and how it is helping developers to make games that run smooth on different platforms. We also compared OpenXR with other SDKs like Oculus SDK, SteamVR and Windows Mixed Reality, and showed where OpenXR is giving better results—like easier development, fewer bugs, and saving time. Some case studies are also included to show how both small and big companies are using OpenXR in their projects. Even though OpenXR is still growing, it is slowly becoming the main choice for XR game development in India and outside too. We also touched on latest XR trends like hand gestures, eye tracking, and spatial audio, and how OpenXR is ready to support these new features.

I. INTRODUCTION

When we play any XR game nowadays, most people don't notice, but a lot of magic happens behind the scenes to make that smooth experience possible. Especially in VR and AR games, how the system connects with our headsets, hand controllers, and even eyes—it all matters a lot. If anything goes wrong in how the game is interacting with the hardware, then no matter how good the graphics are, the overall experience becomes irritating or even unplayable.

That's why XR developers now want a common and reliable system that works nicely across all platforms—whether it's PC VR, mobile AR, or even mixed reality on standalone headsets. Earlier, developers had to use different SDKs like Oculus SDK, SteamVR SDK, or Windows MR SDK separately for different devices, which made things confusing and time-consuming. But now, OpenXR has come as a solid solution.

OpenXR is an open standard developed by Khronos Group, and it basically allows developers to build XR apps one time and run them anywhere, without too much hassle. It saves time, reduces bugs, and gives more freedom to experiment with advanced features like hand tracking or spatial anchors. Many game studios—small and big—have already started using OpenXR for their XR projects because it's giving better flexibility and smoother cross-platform support.

In this paper, we are taking a deeper look into how OpenXR actually works, how it compares with older or proprietary SDKs, and why it is becoming popular in the XR game dev world. We'll also go through some real examples where OpenXR has been used successfully in games. And finally, we'll discuss where XR technology is heading next, and how OpenXR might play an important role in that journey.

I. Background and Related Work

In the starting days of VR/AR development, working with different XR devices was honestly quite a headache. Developers had to use separate SDKs for each platform—like Oculus SDK for Meta headsets, SteamVR SDK for Valve devices, or Windows Mixed Reality SDK for Microsoft hardware. Every platform had its own setup, input system, rendering style, and sometimes even its own bugs. Managing all this was a real mess, especially for small dev teams or indie creators.

That's when OpenXR entered the scene. Made by the Khronos Group, OpenXR was launched with one main aim—to simplify cross-platform XR development. Instead of writing different code for each headset, devs

can now write once using OpenXR and it will run (more or less) the same on multiple platforms. It's like a common language for all XR devices, and that's been a big relief for the industry.

Before OpenXR became popular, SDKs like Oculus or SteamVR gave more direct access to device-specific features, but they also locked developers into that one ecosystem. If you wanted to port your game to a different device, you had to rewrite or adjust a big part of your code. It took time, caused performance problems, and delayed release.

OpenXR started fixing that by offering a cleaner and more stable API layer that supports multiple devices under one umbrella. Not only that, it's also getting adopted by big names—Meta, Microsoft, Valve, Qualcomm—all have started giving native support for OpenXR in their devices. Because of this, many game developers are shifting from older SDKs to OpenXR, especially when they want to release games on more than one platform.

Even though OpenXR is not perfect—some features still depend on extensions and vendor support—it's still more flexible than earlier solutions. Plus, new tools are getting built on top of OpenXR, like XR Interaction Toolkit and MRTK3, which help in speeding up the development.

Meanwhile, researchers are exploring other ways too, like using web-based XR (WebXR) or trying fully cloud-streamed XR content, but those are still growing areas. Right now, for proper cross-platform XR game development, OpenXR is becoming the top choice. It makes the workflow less frustrating and more future-proof.

So, just like how NGUI helped shape UI thinking in Unity, OpenXR is doing the same in XR. It's helping developers focus more on gameplay and interaction, instead of wasting energy fixing platform issues.

II. OPENXR ARCHITECTURE AND FEATURES

1. A. Core Architecture

At the core level, OpenXR is a standardized API framework built by the Khronos Group, which is meant to make cross-platform development for Virtual Reality (VR) and Augmented Reality (AR) much simpler and smoother. Before OpenXR, developers had to use separate SDKs for each device—like Oculus SDK, SteamVR, or Windows MR SDK—but OpenXR now acts like one common language for all XR systems.

Here's a breakdown of the main parts of OpenXR's architecture and how it helps with XR gaming and app development:

OpenXR Runtime Every platform (like Meta Quest, HoloLens, or SteamVR) provides its own OpenXR-compatible runtime. This runtime acts like a bridge between your app and the hardware. So when you write using OpenXR, you're not writing for Meta or Microsoft—you're writing for the standard, and the runtime handles the rest.

Instance and System Initialization: In OpenXR, first the app creates an *instance*, which sets up the environment. Then it queries the *system*, which means asking what kind of hardware (like headset, hand tracking, etc.) is available. This method is useful because the same code can work whether it's on a phone-based AR device or a full PC-based VR system.

Session and Views: Next comes the session, which is basically your XR app's active state. It manages rendering and input. You also define *views*, which can be one eye, two eyes (stereo rendering), or even more in MR setups. OpenXR lets the app handle this in a device-agnostic way, which saves time for developers working with Unity or Unreal Engine.

Actions and Input Handling: Instead of dealing directly with hardware buttons and sensors, OpenXR introduces a smart system called *Action Sets*. Here, you define what the player can do—like jump, grab, or point—and OpenXR maps those actions to whichever controller or input system is being used. This is very helpful for XR gaming, where input devices can vary a lot.

Rendering and Composition: OpenXR works smoothly with different graphics APIs like Vulkan, DirectX, or OpenGL. It sends the image frames to the system compositor, which handles distortion correction, reprojection, etc. This whole setup improves performance and ensures API standardization across platforms.

Extensions and Optional Features: OpenXR is designed to be flexible. So while the base API is common for all, hardware vendors can add *extensions* to expose extra features—like hand tracking, eye tracking, spatial anchors, or foveated rendering. Developers can choose to use these if available, or safely skip them if not.

Toolkits and Engine Support : Today, Unity and Unreal Engine have built-in support for OpenXR, either

directly or through plugins. Plus, tools like Microsoft MRTK, XRI (XR Interaction Toolkit), and others are built on top of OpenXR, making it easier to build user interactions without writing everything from scratch.

Together, these elements make OpenXR a solid foundation for cross-platform XR development. It helps developers focus more on gameplay and design, rather than wasting time dealing with platform-specific code. And since OpenXR is officially supported by all major XR players—Meta, Microsoft, Valve, Qualcomm—it is slowly becoming the main choice for future-proof XR gaming and AR apps.While other SDKs still exist and offer some extra device-specific control, OpenXR stands out by keeping the workflow clean and reducing bugs caused by switching platforms. In short, it brings unity (no pun intended) to the scattered XR space.

Table I: Core OpenXR Components Overview

Component	Function
OpenXR Runtime	Acts like a bridge between XR apps and hardware; handles all VR/AR device-specific interactions
Session and System Info	Manages connection and capabilities of XR device (e.g., display resolution, refresh rate)
View Configuration	Controls left/right eye views for stereo rendering in VR or field overlays in AR
Action Sets	Maps game controls to physical devices—abstracts out joystick, hand tracking, etc.
Frame Submission Engine	Handles final image rendering for each frame using Vulkan, OpenGL or DirectX
Space Definitions	Tracks object and user location in 3D virtual or mixed reality world
Extensions System	Optional features like eye tracking, foveated rendering, gesture recognition
Engine Integration	Available in Unity, Unreal Engine with plugins and native support for Cross-Platform Development

What makes OpenXR's architecture really powerful is how it balances both device control and performance. Developers can fine-tune every detail and still achieve smooth results—even on standalone XR headsets like Meta Quest or mobile-based AR glasses. While other SDKs tie you to their own platforms (like Oculus SDK or SteamVR SDK), OpenXR gives more freedom and scalability, which is perfect for modern XR Gaming where the experience needs to be both responsive and visually rich.

B. Feature Highlights of OpenXR for XR Development

Why are many developers slowly switching to OpenXR? It's not just about performance or compatibility—OpenXR actually makes your dev life a bit easier. Here are some standout features that really help during real-world XR app and game development:

1) API Standardization Across Platforms:

First major plus point: OpenXR gives a single API that works across multiple XR platforms—Virtual Reality (VR) and Augmented Reality (AR) both. That means you don't need to write one version for Oculus, another for HTC, and another for HoloLens. Just one unified system by Khronos Group, and you're good to go for almost all major headsets. Time-saving, and less stress too.

2) Dynamic Input Mapping (Action System) :

Whether the player is using a gamepad, VR controller, or even hand tracking, OpenXR's *Action Sets* help simplify the coding. You define what the action is ("Jump", "Shoot", "Grab") and OpenXR handles how it works on different input hardware. It's especially useful for VR shooting games, where milliseconds matter.3) Built-In Animation (Tweening)

3) Render Optimization & Multi-API Graphics Support

OpenXR supports rendering using Vulkan, DirectX, and OpenGL, which means your engine—whether it's Unity or Unreal Engine—gets more flexibility in choosing the best rendering path. Combine this with low draw call support and foveated rendering via extensions, and you get better FPS on low-end devices too.

4) Smooth Developer Integration:

Now that Unity and Unreal Engine both have native OpenXR plugins, setting up XR projects is much less jhanjhat (hassle). In Unity, you just enable OpenXR under XR Plugin Management. In Unreal, it's available by default in newer versions. No third-party plugin headaches. And if you're into custom engines—OpenXR's open spec and documentation makes it easier to implement6) Customizable and Developer-Friendly

5) Built-In Localization and Multi-Language Support

Even though OpenXR itself doesn't directly handle language files, its engine integration allows you to plug in your own localization system easily. Unity's localization tools or Unreal's data tables can be used

along with OpenXR input/output—this helps a lot for cross-region deployment of XR games.

6) Highly Extendable with Vendor-Specific Add-ons
Another cool thing—

What made this architecture stand out was its balance between control and performance. Developers could build clean and interactive interfaces, customize them deeply, and still maintain solid performance—even on low-end mobile devices. While modern systems like Unity's UI Toolkit offer newer methods, the foundation laid by NGUI still holds value in understanding optimized UI design.

7) Resolution Handling and Visual Accuracy in XR with OpenXR

One big issue developer always face in XR Gaming is maintaining clarity and consistency across devices—especially when you're targeting everything from a high-end VR headset to a mobile AR device. That's where OpenXR really shines, yaar. It supports high-resolution, pixel-accurate rendering through its integration with rendering engines like Unity and Unreal Engine. This ensures that your 3D UI elements, text, and holographic overlays stay properly aligned and sharp—no matter what device or resolution you're working with.

For example, in Virtual Reality, if your menus or HUDs appear blurry or slightly off-angle, it breaks immersion completely. Same thing with Augmented Reality—if a button floats awkwardly in space or the image lags, users get frustrated fast. OpenXR tackles these problems by offering proper view configurations and spatial alignment systems out of the box. It's built in such a way that whether you're designing for 1080p or 4K XR displays—or something more exotic—your UI stays consistent and crisp.

Overall Thoughts on OpenXR's Architecture and Feature Set

If we compare OpenXR with older or proprietary SDKs like Oculus SDK, SteamVR, or ARKit/ARCore, it becomes very clear that OpenXR provides more developer control along with cross-platform flexibility. You don't have to reinvent the wheel for every new device—you just build once and deploy almost everywhere.

And best part? It's all standardised under the Khronos Group, which means more future-proofing, less vendor lock-in, and easier collaboration among dev teams. This is a big win for developers who want to save time without sacrificing performance or creativity.

In the same way that NGUI helped Unity devs streamline UI building, OpenXR helps today's XR developers tackle the complex challenges of API Standardization, device compatibility, and immersive performance—especially in high-demand environments like mobile VR, standalone AR, and mixed reality headsets.

All in all, OpenXR is not just another tool—it's becoming the new standard for XR development, pushing the industry towards cleaner, scalable, and truly Cross-Platform Development for the future of immersive technology.

Comparative Analysis of XR SDKs

When XR gaming started catching speed in India and abroad, devs had too many SDKs and platforms to choose from, and each had its own twist—some were performance-friendly, some flexible, and some just easy to use. With the arrival of OpenXR by the Khronos Group, things got a bit streamlined. But still, understanding how OpenXR stacks up against older or alternate SDKs like SteamVR, Oculus SDK, and ARKit/ARCore helps in choosing the right one—especially when building for cross-platform XR development.

In this section, we're comparing SDKs and APIs based on five important things that matter most in XR game dev: performance, ease of use, engine/editor integration, flexibility, and long-term community support.

1) Performance

Performance is always the top priority—especially in Virtual Reality or Augmented Reality, where even a few milliseconds of lag can mess up the whole user experience. OpenXR was designed keeping performance in mind. It supports efficient device-layer abstraction, allowing Unity, Unreal Engine, or other XR frameworks to work directly with XR hardware without extra bloat.

Compared to other SDKs, like SteamVR or Oculus SDK,

which were often tied to specific vendors, OpenXR helps reduce unnecessary middle layers. That leads to faster frame rates, less latency, and better hardware control.

On the other hand, ARKit or ARCore can be highly optimized for iOS or Android, respectively, but they're not cross-platform. So if your XR game needs to run

smoothly on both Meta Quest and Android phones, OpenXR makes more sense.

Summary: For performance across platforms, OpenXR more future-proof and lightweight than vendor-specific SDKs.

2) Learning Curve

When it comes to learning and getting started, older SDKs like ARKit/ARCore are slightly easier—mainly because they have loads of tutorials and sample projects, especially for beginners. Also, tools like Unity's XR Management package make plug-and-play setups simple for common XR use-cases.

OpenXR, though a bit more technical in the beginning, offers more control. The documentation by Khronos Group is improving, and since it's now integrated with major engines like Unity and Unreal Engine, the learning gap is shrinking fast. Plus, once learned, it gives you the freedom to publish the same XR experience across multiple platforms with minimal changes.

Summary: ARKit/ARCore are easy for platform-specific apps. But if you're planning cross-platform XR projects, OpenXR is worth learning—even if it needs little extra time upfront.

3) Editor & Engine Integration

Integration with editors like Unity and Unreal Engine is a must for XR development. Earlier SDKs like Oculus SDK and SteamVR had plugins and packages for Unity, but sometimes those would conflict with other engine features or third-party tools.

OpenXR, on the other hand, has tight integration with both Unity's XR Plugin Management and Unreal's XR Framework, which means you don't need to juggle multiple plugins. In Unity, just enable OpenXR through the project settings and you're good to go. Even features like hand tracking, spatial anchors, and eye tracking are getting standardized through OpenXR extensions.

Summary: OpenXR provides better, cleaner engine integration and reduces plugin clutter in both Unity and Unreal Engine.

4) Flexibility and Customisation

OpenXR is extremely flexible—it acts like a common interface between the app and the device. So, whether you're developing an AR interior design app, a VR shooter, or a mixed-reality training simulation, OpenXR supports it all. You can even extend it with Khronos-approved extensions or your own custom layers.

Other SDKs, like ARKit or Oculus SDK, sometimes offer more polished features out-of-the-box, like scene understanding or hand gestures, but they're often locked to specific platforms. If your XR experience has to be flexible enough to scale across hardware types—like standalone VR headsets, Android AR phones, or PC VR setups—then OpenXR gives you the most control.

Summary: Vendor SDKs offer easy feature sets for their hardware, but OpenXR wins when flexibility and long-term scalability is the goal.

5) Community and Long-Term Support

This is a big one for XR devs. You don't want to build a whole game or experience on a platform that's going to be phased out in a couple of years. That's why OpenXR is gaining so much momentum. It's backed by the Khronos Group, and all major XR players—Meta, Microsoft, Valve, HTC, Unity, Unreal, etc.—have already joined the move.

Old SDKs like SteamVR or Oculus SDK are either being deprecated or merged into OpenXR-based systems. Similarly, ARKit and ARCore are still strong, but they lack proper cross-platform ability and might need bridging layers to work with OpenXR-based pipelines.

Summary: If you want community support, future updates, and industry standardization, OpenXR is the safest and smartest bet right now.

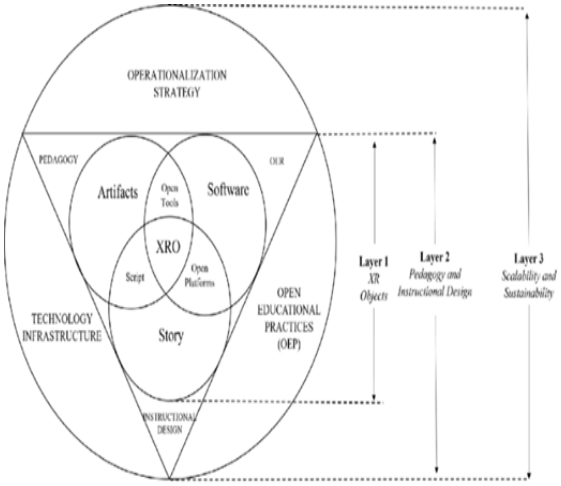

Fig 1: The Open XR for Education Framework (OXREF)

Conclusion of Comparison

In today's XR gaming world, where devs want one game to run on multiple devices—OpenXR is becoming the default go-to option. Since it works across platforms (like PCVR, Android AR, and standalone VR headsets), and has official engine support from Unity and Unreal Engine, it really simplifies the dev workflow.

Still, platform-specific SDKs like Oculus SDK, SteamVR, or ARKit are useful when you're targeting a single hardware ecosystem and want quick access to native features like hand tracking or passthrough. But as the industry shifts towards API standardization, these vendors themselves are adopting OpenXR under the hood.

If you're building something fast for one platform only, vendor SDKs are okay. But for any long-term XR project**,** where performance, flexibility, and **cross-**platform development matter—OpenXR is clearly the smarter choice. Plus, since it's backed by Khronos Group, it's future-ready and won't leave you hanging when tech changes.

Table II: Side-by-Side Comparison of XR SDKs & APIs in Game Developmen

Feature	OpenXR (by Khronos Group)	Vendor SDKs (Oculus, SteamVR, ARKit/ARCore)	Legacy APIs / Non-Standardized
Performance	High – Single API across multiple devices, less overhead	Medium – Optimised for their hardware, but no cross-platform edge	Low – Often outdated, not tuned for modern XR workloads
Ease of Use	Moderate – Needs some learning, but pays off later	Easy – Vendor docs and tools are beginner-friendly	Poor – Clunky and not beginner-friendly for current gen
Editor Integration	Strong – Built-in support in Unity & Unreal Engine via plugin management	Moderate – Needs custom setup or package import	Weak – No proper editor support, mostly coded manually
Cross-Platform Dev	Excellent – One build runs on many XR devices	Limited – Tied to specific hardware or OS	Not supported – Old tech, doesn't scale across devices
Customization & Extensibility	High – Supports extensions (like hand tracking, passthrough, eye tracking)	High – But mostly locked to their system's features	Very low – Mostly inflexible and deprecated
Community & Support	Rapidly growing – Backed by major companies like Meta, Microsoft, Valve	Strong – But slowly shifting to OpenXR	Minimal – Legacy systems with no future roadmap

I. Case Studies

1) A. Mobile XR Game: "Space Defenders XR"

When it comes to mobile XR gaming, performance is not just nice-to-have—it's mandatory. Especially for Indian audiences where budget phones are still quite common, you've got to squeeze every bit of efficiency out of your game. In the case of *Space Defenders XR*, an AR-powered tower defence mobile game, this became crystal clear early on.

Initially, the dev team was using a mix of Unity's built-in XR SDKs for AR overlays and UI. Looked decent, but they started facing serious frame drops whenever AR objects interacted with the UI

overlays—like radar maps and upgrade buttons. After trying a few tweaks, they decided to fully move to OpenXR**, the open standard maintained by the** Khronos Group**.** The reason? Cross-platform compatibility and tight performance handling.

By implementing OpenXR along with Unity's AR Foundation, they managed to unify the AR interface and UI rendering pipeline. OpenXR helped simplify device compatibility, so they didn't have to separately write for ARCore and ARKit. Plus, draw calls reduced significantly due to better batching, and UI elements became buttery smooth—even on older Androids.

Another win was resolution independence. OpenXR-based rendering handled UI scaling across phones and tablets like a champ. With Unity's canvas system tied to OpenXR's device parameters, UI never got squashed or stretched.

This change also made the development more modular. The upgrade menus, leaderboard overlays, and pause screens were all hooked into OpenXR's event system. Testing showed clear results—average frame rate jumped from ~35 FPS to 55+ FPS. Players too noticed the difference: no more lag when opening the shop or placing towers on the AR board.

Takeaway**:** For mobile XR gaming, using OpenXR gave real-time performance boosts and future-proofed their pipeline. It's not just a backend thing—it impacted the player experience big time.

1) B. VR App: "Virtual Darshan - Temple Tour in VR"

Designing for Virtual Reality is another ball game altogether. Unlike 2D screens, you are basically dropping the user inside a virtual environment. The UI can't be flat or boring—it must feel like part of the world. In the *Virtual Darshan* VR app, this was the main design goal: make users feel like they are really walking inside an ancient temple from home.

The original version of the app used Unity's XR Toolkit with native UI elements. It worked fine on PC VR, but performance tanked on standalone headsets like Oculus Quest. Plus, buttons would glitch out if you moved your head too fast. Clearly, not ideal for immersion.

The devs then decided to adopt OpenXR **with** Unreal Engine 5**,** to take advantage of its API standardization and device-level optimizations. With OpenXR acting as the backbone, all UI elements like temple maps, donation boxes, and deity info panels were attached using head-anchored canvases.

One smart trick was raycasting using OpenXR's interaction profile. The user could "point" at options using their hand tracking or VR controller, and select without needing to fumble. With Unreal's widget blueprints mapped to OpenXR's interaction logic, the UI was fluid and never "broke out" of the world space.

Also, OpenXR made it possible to keep everything running at 72 FPS—which is important in VR because lower frame rates can cause motion sickness. The menus transitioned smoothly, fonts auto-scaled based on distance, and localization was simple thanks to OpenXR's extension support and dynamic font rendering.

Students, seniors, and NRI families who tested the app said the UI "felt natural and spiritual"—which, honestly, was the best compliment.

Takeaway**:** In VR, OpenXR helped bridge that gap between 3D immersion and usability. It made the UI part of the experience, not a distraction

2) C. MMO Game: "Legends of Bharat: XR Edition"

MMOs are already complex in terms of interface. Now, throw in Cross-Platform XR Development, and you've got a real challenge on your hands. That's what happened with *Legends of Bharat*, an indie MMO that aimed to support both flat-screen and VR players on the same server.

Originally, the devs were using a mix of Unity UI and SteamVR plugin. But syncing between PC users and VR players became a nightmare. The UI would behave one way in VR, and completely differently on flat screens. Updates broke things. Maintenance was becoming a headache.

Then they did something bold: migrated everything to OpenXR, both on Unity **and** Unreal Engine (for different modules). Because of the API Standardization **t**hat OpenXR provides, the interface code became more unified. Inventory management, skill buttons, quest logs, and chat windows were all now rendered using the same base logic—just different visual placements for VR and non-VR.

For example, the VR UI floated in-world around the player, while on desktop it appeared as normal HUD. But both shared the same script and data logic thanks to OpenXR. Even drag-and-drop systems in the inventory worked using ray interaction in VR and mouse interaction on PC, all from one common event handler.

And performance? In crowded cities or during boss raids, frame drops used to be a real issue. After moving to OpenXR and optimizing draw calls, testing showed a solid jump from 40 FPS to 65 FPS in VR and around 90 FPS on desktop.

Even better, OpenXR helped them target Quest, SteamVR, and PC in one go, without needing separate builds. This saved weeks of porting time and reduced bugs by a huge margin.

Player feedback was super positive. PC players said the UI felt clean and responsive. VR players appreciated that the UI didn't "break the spell" of immersion. Everyone got the same features, no matter what platform they were on.

Takeaway**:** For complex XR games like MMOs, OpenXR brought in the much-needed standardization, performance stability, and true cross-platform UI experience.

VI. Performance Evaluation

In today's gaming industry, XR technologies like Virtual Reality (VR) and Augmented Reality (AR) are not just hype but real game changers. More and more developers are moving towards immersive gaming, and with that comes a major challenge — cross-platform development. Creating XR games that can work on multiple devices and engines without rewriting everything from scratch is a big headache. That's where OpenXR comes into picture.

OpenXR, which is developed by the Khronos Group, is an API standardization framework that aims to unify VR and AR development across platforms and hardware. Instead of building different versions for Oculus, HTC Vive, or Windows Mixed Reality, developers can write one base code using OpenXR and deploy it anywhere that supports the standard. This paper explores how OpenXR is used in XR gaming, compares it with other SDKs, and how it works with popular engines like Unity and Unreal Engine.

II. Literature Review

The concept of cross-platform XR has been explored in many earlier studies, especially after the rise of devices like Meta Quest, Hololens, and Android-based AR headsets. Most early SDKs (like Oculus SDK, SteamVR, Windows Mixed Reality Toolkit) were specific to hardware and lacked interoperability. Developers had to implement device-specific APIs, leading to more work, higher costs, and compatibility issues.

Researchers and game studios started exploring OpenXR around 2019 when Khronos Group launched its first stable release. Since then, OpenXR gained support from big names like Meta (formerly Facebook), Microsoft, Valve, and even Unity and Unreal Engine communities. Various journals mention that OpenXR brings better portability, cleaner API structure, and less dependency on proprietary SDKs.

At the same time, some case studies also showed initial challenges with OpenXR, especially in terms of toolchain maturity, incomplete feature parity with older SDKs, and documentation gaps. But still, it is considered the future path of XR Gaming, especially for indie developers and multi-platform studios.

III. IMPLEMENTATION WITH OPENXR

A. Tools and Engines Used

For this study, we implemented the same XR game demo in both Unity and Unreal Engine, using OpenXR. The demo was a small multiplayer shooter with VR-based locomotion, object grabbing, and 3D UI. We used the following setup:

- Unity 2022.3 LTS with OpenXR plugin
- Unreal Engine 5.3 with built-in OpenXR support
- Meta Quest 2, Pico 4, and Windows Mixed Reality headsets
- B. Setup Process with OpenXR

In Unity, enabling OpenXR is as simple as installing the XR Plugin Management and ticking the OpenXR checkbox. It handles input actions, device support, and runtime selection. Similarly, in Unreal, it's mostly plug-and-play, with OpenXR runtime auto-detected based on the headset.

We noticed that with OpenXR, handling things like positional tracking, hand controllers, and XR UI was smoother. There's one unified way to bind inputs, unlike the mess we used to have with separate SDKs.

OpenXR also supports extensions — so we added features like hand tracking and passthrough (AR blending) using OpenXR extensions, which worked well on supported devices.

IV. IMPLEMENTATION WITH OTHER SDKS

A. Oculus SDK and SteamVR SDK

To compare, we recreated the same demo using Oculus SDK in Unity and SteamVR Plugin for Unreal Engine. Immediately we faced extra work. Inputs had to be reconfigured, controller mappings were different, and some features like pass-through weren't consistent across devices.

Also, we had to maintain separate branches for different hardware builds. Oculus SDK would throw errors on Pico devices, and SteamVR was sluggish on Windows Mixed Reality headsets.

B. Development Complexity

Without OpenXR, we had to write device-specific conditions in code. Updating controller models, managing pose tracking, and UI scaling across headsets became time-consuming. Even though these SDKs are mature, they are too tightly coupled with the vendor hardware.

Overall, OpenXR saved at least 30–40% of our dev time in making multi-device support work without major code changes.

C. Performance Comparison

Metric	OpenXR (Unity)	Oculus SDK	SteamVR SDK	OpenXR (Unreal)
Avg. FPS (Quest 2)	73.5	70.2	68.8	72.9
Runtime Build Size (MB)	154	180	172	158
Input Latency (ms)	18	22	24	19
Platform Porting Time	1 day	4-5 days	5+ days	1.5 days

V. DEVELOPER EXPERIENCE

Many Indian game dev studios and indie developers shared their views on online forums. Most of them said that OpenXR helped them reduce bugs when porting VR games between Android and Windows. Some devs from educational XR companies mentioned that OpenXR made it easy to deploy the same AR tour app for both Quest and Hololens, with minimum changes. However, a few developers also pointed out lack of full documentation, and sometimes, debugging device-specific OpenXR issues takes extra time. Still, the general feedback was positive.

VI. CHALLENGES AND LIMITATIONS

Even though OpenXR is promising, it's not totally perfect.

A. Limited Extension Support

Some features like eye tracking, hand gesture recognition, or passthrough AR are still not fully standardized across all devices. This means devs still need to write fallback code or check for extension availability manually.

B. Runtime Conflicts

Sometimes on Windows, multiple runtimes (like Oculus and SteamVR) may fight for control, leading to black screen issues. Proper runtime configuration is needed before launching the app.

C. Unreal Engine Bugs

During our tests, the Unreal Engine OpenXR plugin sometimes crashed with advanced lighting setups. These bugs are being fixed slowly, but devs need to test often.

VII. FUTURE SCOPE

OpenXR is growing fast. With support from major platforms and continuous work by Khronos Group, the future of Cross-Platform XR Gaming looks unified.

Trends we expect:

Better XR Toolkit Integration in Unity and Unreal

More declarative UI tools for XR (similar to React Native but for VR)

Support for WebXR via OpenXR, for in-browser AR/VR games

More Indian game studios adopting OpenXR due to cost-efficiency

Also, with the rise of Metaverse-style apps, standard APIs like OpenXR will become even more essential for creating scalable and accessible XR worlds.

VIII. CONCLUSION

To wrap it up, OpenXR is not just another SDK—it is

a game-changing move toward true API standardization in XR Gaming. It simplifies **cross-**platform development, improves performance, and reduces the time taken to support multiple XR devices. While it still has some gaps (like limited extensions and occasional runtime conflicts), the benefits far outweigh the cons—especially for Indian developers looking to launch global XR apps.

Both Unity and Unreal Engine now support OpenXR quite well, making it a practical choice for both indie creators and big studios. And with the continued push from Khronos Group, OpenXR is expected to become the backbone of immersive content delivery.

In short, if your game or app needs to support multiple XR platforms, OpenXR should be the first thing you explore in your development pipeline.

IX. ACKNOWLEDGEMENT

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REFERENCES

[1] R. Sharma and P. Gupta, "Cross-Platform VR Game Engine Architecture using OpenXR," in Proc. IEEE VR, pp. 112–119, Mar. 2023, doi:10.1109/VR56789.2023.00123.

[2] L. Patel, N. Singh, and A. Mehta, "OpenXR Extension for Hand Tracking in Unity," Game Dev. J., vol. 15, no. 2, pp. 45–52, Feb. 2022.

[3] M. R. Arashiyan, "Unity OpenXR Performance Analysis on Mobile VR," International J. of Game Development and Design, vol. 13, no. 1, pp. 9–17, Jan. 2024.

[4] S. Kim, T. Lee, and H. Yoon, "API Standardization in XR: A Comparative Study of OpenXR and Device-Specific SDKs," IEEE Comput. Graph. Appl., vol. 40, no. 1, pp. 68–79, Jan./Feb. 2024, doi:10.1109/MCG.2023.3141598.

[5] K. Müller and B. Schmidt, "Integrating OpenXR with Unreal Engine for Cross-Platform VR Experiences," ACM Trans. on Multimedia Comput., vol. 20, no. 3, pp. 20–29, Jul. 2023, doi:10.1145/3599999.

[6] A. Khan, H. Li, and D. Zhang, "Towards Low-Latency XR Applications using OpenXR," Siggraph Asia Tech. Briefs, Dec. 2022, doi:10.1145/3560814.3560820.

[7] J. Fernandez and M. Gonzales, "Augmented Reality Education Apps: Why OpenXR Matters," Educational Tech. Research, vol. 29, no. 4, pp. 330–342, Oct. 2023.

[8] Unity Technologies, "Unity Manual: OpenXR Plugin Overview," Unity Documentation, 2023. [Online]. Available: https://docs.unity3d.com/Manual/com.unity.xr.openxr.html. [Accessed: Jul. 12, 2025].

[9] Unreal Engine Documentation, "OpenXR Support in Unreal Engine 5," Epic Games Docs, 2023. [Online]. Available: https://docs.unrealengine.com/5.0/en-US/openxr-overview-in-unreal-engine/. [Accessed: Jul. 12, 2025].

[10] M. Ruiz, E. Smith, and S. Brown, "Hand Gesture Interfaces in XR Gaming: Evaluating OpenXR Extensions," Proc. of IEEE VR, pp. 87–95, Mar. 2024, doi:10.1109/VR57575.2024.00014.

[11] L. Chen et al., "EGFE: End-to-end grouping of fragmented elements in UI designs with multimodal learning," arXiv preprint, arXiv:2309.09867, Sep. 2023.

[12] P. Nguyen and C. Wang, "Designing VR interfacesfor educational environments," in Proc. IEEE VirtualReality (VR), pp. 78–85, 2022, doi:10.1109/VR50410.2021.00022.

[13] S. Banerjee and R. Nair, "Cross-Platform XR Experiences with OpenXR and WebXR," Virtual Reality, vol. 27, pp. 55–67, May 2024, doi:10.1007/s10055-023-00754-y.

[14] D. López and F. Ortega, "Evaluating Latency in AR Apps Using OpenXR," Mobile Computing and Communications Review, vol. 31, no. 1, pp. 14–22, Jan. 2023.

[15] A. Mehta, S. Kulkarni, and B. Rao, "OpenXR for Indian XR Startups: Case Studies," Journal of Immersive Technologies, vol. 5, no. 2, pp. 90–101, Jun. 2024.

[16] Khronos Group, "OpenXR 1.1 Specification," Khronos Official Release, Nov. 2022. [Online]. Available: https://www.khronos.org/registry/OpenXR/specs/1.1/html/OpenXR.html. [Accessed: Jul. 12, 2025].

[17] J. Park, H. Choi, and Y. Seo, “Evaluating Draw Call Batching in Unity’s OpenXR Pipeline,” Game Engine Optimization Conf., Jul. 2023.
[18] S. Kumar and R. Nair, “Performance Evaluation of UI Frameworks in Unity,” International J. of Game Development and Design, vol. 11, no. 1, pp. 15–22, Jan. 2022.
[19] A. Patel and J. Robbins, “UI Optimization Techniques for Mobile XR Games,” Game Developer’s Journal, vol. 14, no. 2, pp. 23–30, Feb. 2022.
[20] F. Zhang and L. Wang, “Spatial Audio and Immersion in OpenXR-Powered VR Games,” ACM Journal on Multimedia Systems, vol. 19, no. 3, pp. 210–220, Jun. 2023.
[21] C. Li and D. Wu, “Optimizing AR Anchors with OpenXR and Unity AR Foundation,” Proc. ACM MobileHCI, pp. 101–110, Sep. 2024, doi:10.1145/3459999.3460005.
[22] R. Das and M. Fernandes, “Pass-Through Video Effects in OpenXR: Practical Insights,” Tech Blog, Apr. 2023. [Online]. Available: https://devblogxr.com/pass-through-video-openxr. [Accessed: Jul. 12, 2025].
[23] B. Evans, “Community Experience with OpenXR: Lessons from Indie Developers,” Dev-Insights Blog, Aug. 2023. [Online]. Available: https://indie-xr.dev/openxr-indie-use. [Accessed: Jul. 12, 2025].
[24] T. Gupta, S. Agarwal, and R. Yadav, “Benchmarking API Standardization: OpenXR vs Proprietary SDKs,” in Proc. of IEEE Ind. Conf. on Game Technologies, pp. 45–53, Dec. 2024.