
**INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING
TECHNOLOGY AND APPLIED SCIENCES (IJETAS)****Integrating Spatial Computing for Next-Generation Game
Experiences****Dheerendra Pratap¹, Subrata Sahana² [0000-0002-9183-2237]**^{1,2}Department of Computer Science and Engineering School of Engineering and Technology
Sharda University, Greater Noida-201308, India**ABSTRACT**

Spatial computing is a rapid development of technology in recent years. The term spatial computing means interaction between an individual and 3D-environment. It overlaps with the concepts of Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR). Important features of spatial computing consist of - spatial mapping, gesture and motion tracking, human computer interaction. This abstract highlights spatial computing's promising future in the technological field. This technology is used in a wide range of industries, including manufacturing, architecture, construction, gaming, healthcare, and education, retail, E-commerce and Automotive industry. This study aims to explore the potential of spatial computing. In recent years lot of companies implemented this technology in their products like - Meta Quest 2, Apple Vision Pro, Microsoft HoloLens.

Keywords: Spatial Computing, Augmented Reality, Virtual Reality, Mixed Reality

DOI:

1 Introduction

Spatial computing uses advanced software and hardware to create a smoother interaction between virtual and physical environment. It creates virtual world in 3D space with which user can interact. It requires advanced cameras, chipset, sensors and complex algorithm to determine object recognition with the help of artificial intelligence. It smoothly breaks the barriers by merging digital elements into our three-dimensional physical space. Ground-breaking applications and cutting-edge technology are built using the tech giants use this technology to build their software and products.

In 2003, Simon Greenwold used the term 'Spatial Computing' in his thesis paper for the first time. Later the term also popularized by him. Spatial computing is a system that enables users to design virtual forms and place them in the real area around them [1]. Simon Greenwold plays a significant role in establishing the term 'Spatial Computing'. In recent times tech giants like - Apple, Microsoft, Google and Meta significantly use the term to define their products such as Apple Vision Pro, Microsoft Holo Lens and Meta Quest. These companies adopt the fundamental and core concept of spatial computing and they implemented it to their wide range of applications, software and games.

II. LITERATURE REVIEW

3D technologies like - augmented reality (AR), virtual reality (VR) and mixed reality (MR) are evolving quickly in today's society. A complete spatial gaming environment can create virtual, immersive and loyal environment for users. Game developers can create immersive 3D environments with the help of spatial computing in their games.

THE DEVELOPMENT HISTORY OF SPATIAL COMPUTING

Spatial computing has a notable history. The origin of this computing lies in the development of virtual reality. Virtual reality plays a impactful role in the early advancement of spatial computing. Spatial computing and virtual reality have become a cutting edge and fascinating technology now a days. Also in the educational field it provides immersive and interactive educational experiences [2]. VR technology gradually become a new field of science and technology and it created magnificent progress [3]. VR technology is not limited to mobile devices but also for other industries [4]. In 1980s VR technology is used in military to train soldiers. Also aerospace sectors used

it to train astronauts. This is the first period of spatial computing. The second period has begun in 1992. Two aerospace researchers named Tom Caudell and David Mizell first use the term 'Augmented Reality'. They are the pioneers of usage of augmented reality in industries. The rise of mixed reality took place in the third period. Paul Milgram and Fumio Kishno introduced the term 'Mixed Reality' in 1994 in their research paper [5]. This term become more popular when Microsoft introduced their first mixed reality based product - 'The HoloLens'. This type of devices merges the physical and digital elements in real-time. Tech giants like - Facebook invested billions in the development of spatial computing or creating it's operating system and eco-system. The fourth stage is the further improvement and application of spatial computing from 1980 to now. A new era of spatial computing begins when Apple launched Apple Vision Pro. It merges augmented reality (AR) and virtual reality (VR). For spatial awareness it uses LiDAR sensors. Vision Pro is driven by Apple M2 chip and its co-processor known as Apple R1.

THE CHARACTERISTICS OF SPATIAL COMPUTING

The first characteristic is interaction. Interaction between user and 3D-space is made possible by spatial computing. It allows user to feel and touch the content in three dimension. It provides seamless and immersive experience. Gestures, voice commands and haptic feedback make it easy for user to interact with spatial environment.

The second feature is design. The spatial environment is designed to provide immersive experience that merges augmented reality (AR) and virtual reality (VR). Small monitors like LCD or OLED are used to render visuals in a three dimensional virtual environment [6]. Applications and games are designed to perform seamlessly in spatial computing.

The third feature is real time data processing. Real time data processing is very crucial for spatial computing because it should react instantly according to the user actions. This characteristic plays a crucial role in gaming and navigation.

The fourth feature is seamless integration. Spatial computing combines the physical space and digital content seamlessly (**Figure 1**).

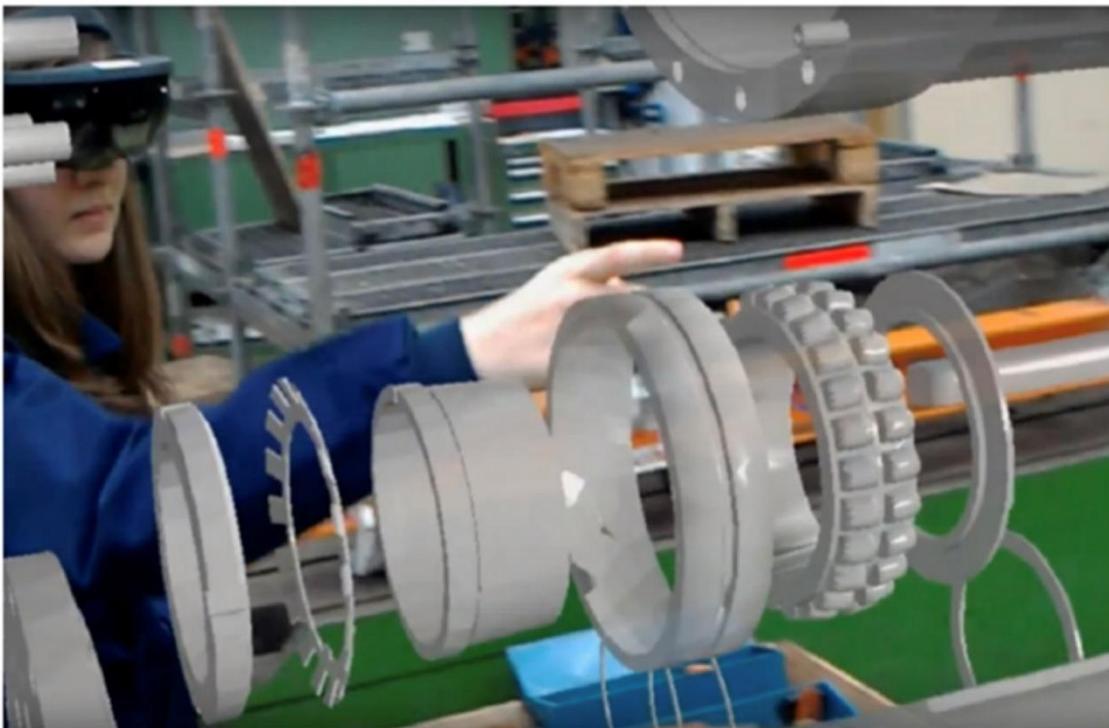


Figure 1. Seamless integration through HoloLens [14]

The last feature is Multi-User collaboration. In traditional games players are less involved in the game because they interact with the character through mouse and keyboard. But on the other hand, in VR games players can interact with character through joysticks and virtual headsets [7]. A lot of applications are developed based on the core concept of spatial computing provides multi-user interactions. This feature enhances collaboration and teamwork.

In recent years game industry has major growth. Lot of technologies are used to make game realistic. Spatial computing is one of them. This developing field merges multiple technologies like artificial intelligence, computer graphics, augmented reality, virtual reality and display technology [8]. Spatial computing merges the physical environment with digital content . User can interact with it using gestures and actions. Hand gestures plays a significant role for engaging user in virtual environment [9]. Eye tracking and motion tracking play significant role in to this. Accelerometers and Gyroscopes are used to track the motion. LiDAR is used to track objects in real-time. LiDAR play's a significant role to detect objects and shapes [10]. 3D rendering engines are used to create immersive experience. Powerful processor like R1 chip and M2 chip are used to render virtual content. For traveling the sound in three-dimension spatial audio technology is used. It improves the realism of virtual environments. Artificial intelligence (AI) methods are used for 3D-object detection and natural language processing. Various sensors and data capturing technologies are also involved to detect and track 3D-objects [11]. Game developers implement AI in their games with which players can interact with Non-Player Character (NPC) [12] .

D. CHALLENGES IN SPATIAL COMPUTING IN GAMES

Spatial Computing for game development is an advanced technology which requires complex hardware. So that limited companies make hardware for this. So limitations of hardware is significant challenge for this computing. When it comes to render 3D graphics, data blending, data processing and analysis, hardware plays significant role. Hardware constraints like cost and size should be handle carefully to achieve the highest possible efficiency of the device. The display quality and resolution have a significant impact on the performance of spatial computing devices. Accurate navigation in virtual world is very complicated process. That needs high resolution and efficient monitor to manipulate, move and remove the object in the virtual environment. User comfort is one of the most important aspects of spatial devices. In recent times AR &VR devices are heavy and bulky so that they are poorly balanced. At this user find discomfort after a long use. User can face strain and fatigue. When the weight distribution is balanced poorly, it cannot be adopted by a large range of head sizes. Staying in the virtual environment for a long time causes a major disconnection between eye and body. This leads to motion sickness and major discomfort. When we wear spatial devices, the screen is quite close to our eyes. Watching the screen for a long period of time can causes headache, dry eyes and eye strain. In virtual environment user mainly focuses on objects and contents. This constant refocusing leads to focus and depth issues. Also it can be happened using low contrast and highly brightened virtual environment. Other significant challenge in spatial computing is unfamiliar user interface. User interface and interaction is very complex and difficult to learn because of the complex technology of this computing. Gesture controls, eye tracking and interaction with objects in virtual environment can be difficult for new users. Spatial devices collect and store data of users like - biometric data, gestures, body movements, eye tracking and voice commands and user's location. This raises the bar of privacy concerns and data security. In today' s world data privacy is vital for the user.

III. RELATED WORK

Spatial games utilize augmented reality (AR), virtual reality (VR) and mixed reality (MR) to design games for various platforms like - android, iOS, VR headsets and MR headsets.

Pokémon Go is one of the most popular augmented reality (AR) game. In this game Pokémon are virtual creatures and they are trained by the user. The game brings Pokémon in to the real world with help of spatial computing. It allows users to interact with the virtual creatures. Minecraft Earth is a virtual reality (VR) game where players used to build structures with the help of block-building mechanics. Using AR, players can place their block anywhere.

Microsoft built some spatial games for Holo Lens 2 which is a mixed reality headset with transparent lenses [13]. Fragments is one of them. Fragments is an interactive and immersive storytelling game. In this game holographic figures talk, respond and move with your surroundings (Figure 3). To place characters and clues in real environment, the game uses spatial technology. Land of Dinosaurs developed for Holo Lens 2 transport users in the age of dinosaurs. In this game users can interact with real-life sized dinosaurs.



Figure 3. Hologram Projection in VR device [3]

Tech giant Facebook also built some spatial games for Meta Quest and Meta Quest 2. Resident Evil 4VR is survival horror game for Meta Quest. This game includes intense action and horror in a immersive way. Beat Saber is a rhythm game developed for Meta Quest. In this game users use virtual lightsabres to cut blocks to the beat of the song. Vadar Immortal is a Star Wars- themed VR game. Players can explore the Star Wars universe through this game. Players can fight with enemies using lightsabres.

Another tech company Apple invested billions in spatial games. Lego Builder’s Journey is a puzzle spatial game for Apple Vision Pro (Figure 2). User can interact and solve the puzzles in real time in three dimensional space. The game maintains its minimalist art style for AR gaming. Synth Rider is rhythm-based VR game. This game allows players to move in three dimensions. Players must hit notes and dodge obstacles to keep up with a diverse range of music tracks. Game Room is spatial board game and card game that is developed for Vision Pro. This games include - Chess, Solitaire, Hearts, Yacht, Flipit, Sea Battle and Checkers. This game can be played in online multiplayer with AI opponents.

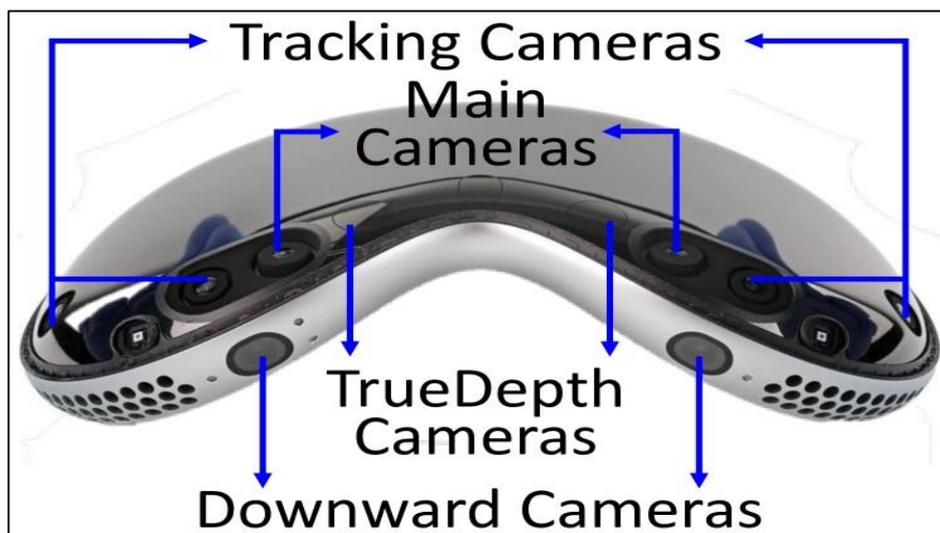


Figure 2. Apple Vision Pro cameras for Object- Detection [15]

Games like Harry Potter: Wizards Unite uses Google maps and ARCore. To build augmented reality apps for android devices, Google provides development platform which is called ARCore. Developers make apps using cameras and sensors of smartphones to blend the digital content. Jurassic World Alive is developed using AR Core. This game involves interaction with dinosaurs in real time in real environment. In AR Dragon game user can interact with a virtual dragon. User can engage with the dragon in real world by feeding and taking care of it. The game also designed and developed in Google AR Core.

IV. METHODOLOGY

A. IMPLEMENTATION

Unity is a game engine developed by Unity technologies. Unity 3D provides development environment for spatial games. C# programming language is used to develop it. Unity has drag and drop functionality. Developers can create two and three dimensional games. This engine is cross platform. There is no additional plugin needed in Unity game engine. VR devices can access directly from within projects with Unity VR. This game engine provides a set of API that are compatible with a variety of devices.

B. GAME MECHANICS

The guidelines, procedures and interactions that determine how game functions and how players interact with it are known as game mechanics. Game mechanics are crucial components in a game. User controls the character to interact quickly with the surroundings in action mechanics. Action mechanics include - running, dodging, jumping and avoiding obstacles. Strategy mechanics require decision making, problem analysis and problem solving skills. It allows players to make their own decision to move the game forward. Exploration Mechanics allows the user to explore the whole game. Explore new places. Find hidden objects.

C. GAME STORYLINE

A good game needs a proper story to connect with players. An engaging storyline and well-written narrative improves the entire gaming experience. At this player can connect emotionally and engaged with the game. Players can find purpose in a story driven game in a deeper level. Games like - God of War where the main character Kratos find purpose after the death of his beloved wife. Story give the games structure and explains or excuses any challenges that are encountered.

D. Spatial Game design

Advance technologies like eye tracking and gesture based controls are used to develop spatial game. The game should combine the physical space and digital content. To understand the spatial environment developers used depth sensors devices like - LiDAR. Sensor technologies like eye tracking and motion tracking are used to track user movements and gestures

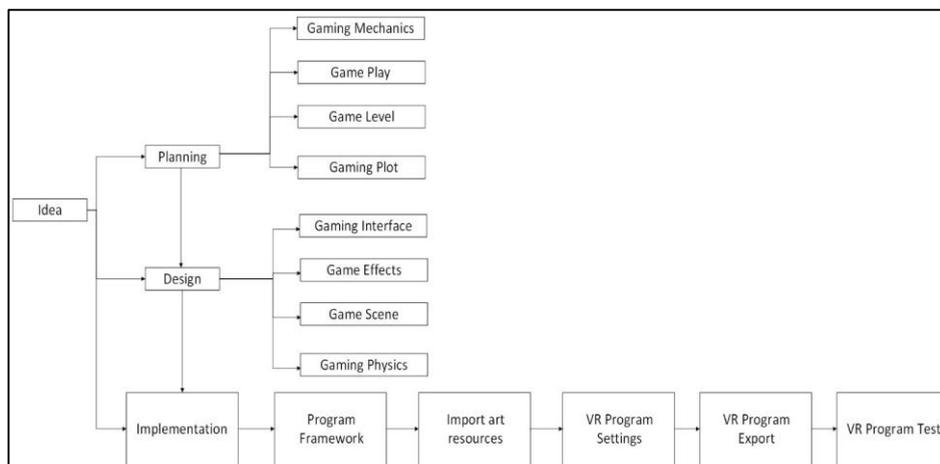


Figure 4. The Roadmap of Game Development

V.CONCLUSION

Spatial computing provides a virtual world with which user can interact. People can move and place objects in the environment with the help of AR & VR devices. Spatial computing creates immersive experience for games. Spatial computing includes AR, VR and MR. VR means a ‘virtual’ environment created by computer and ‘reality’ refers the real life environment of the world. People can create, control and manipulate object in this virtual world. On the other hand, augmented reality uses a real world where user can put, move or remove 3D object. It includes

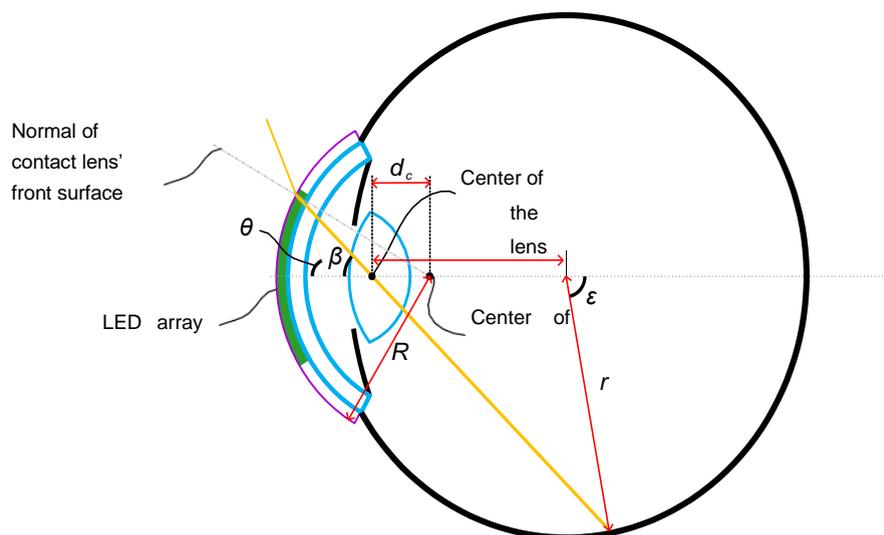
images, videos, 3D models and sounds. Mixed reality is the merging of computer generated environment and real-world environment. Digital and real-world components are combined in mixed reality.

A. ADVANTAGES OF SPATIAL COMPUTING IN GAMES

Spatial computing includes gesture, voice command which enables user to explore the game seamlessly. It has motion sensor. The sensor enables user to play as a character in spatial environment. Some of notable examples - Beat Saber (VR) and Pokémon Go (AR). Multiplayer gaming is possible in virtual space through spatial computing. Where players have the opportunity to compete and collaborate with each other. New possibilities are open for game developers through spatial computing to develop immersive and innovative experiences.

B. THE FUTURE DEVELOPMENT OF SPATIAL COMPUTING

Current hardware of spatial computing is expensive and have limitations in processing, power, battery life and display quality. But in future AR & VR headsets can be affordable easily. In future AR contact lenses could provide immersive experience without need of bulky AR & VR headsets (Figure 5). More reliable and accurate sensors can be used in spatial computing. In future more advanced technologies like artificial intelligence, Internet of Things and blockchain will be used in this computing.



C. THE POSITIVE IMPACT OF VIRTUAL SPATIAL COMPUTING ON SOCIAL INTERACTION

For a traditional computer device it is very difficult to communicate in a physical environment where digital content blends. Social interaction, collaboration and team works are made possible in spatial computing. Games like Minecraft Earth provides multiplayer features in an immersive way. In future spatial devices can be affordable, where multiple players can interact with in a same game and move, replace and manipulate objects within the gaming world. Growing technologies like – VR Chat and Altspace VR rapidly increase social interaction. Where users can socialize in a lot of ways in these technologies. Hosting events, virtual meetings and virtual multiuser chat are possible in this. Spatial computing provides this kind of interactive feature in a three-dimensional place. Now this computing starts a new era for breaking down geographical barriers.

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