

AR App for Visualizing Interior Design Changes In A Real-World Environment

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report “**AR App for Visualizing Interior Design Changes In A Real-World Environment**” is the bonafide work of Gargi Ghosh, Muskan and Sudip who carried out the project work under my/our supervision.

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We would like to express our sincere gratitude to all those who have contributed to the development and success of this AR App for Visualizing Interior Design Changes in a Real-World Environment.

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ABSTRACT

This study introduces an augmented reality application for interior design. The field of architecture requires virtual information techniques with the expansion of digital technology. People these days are too busy at work to take the time to visit different stores and purchase furnishings for their daily needs. It is challenging to satisfy client desires for a room they have decorated without providing them with an accurate virtual representation of the space. A printed furniture catalog is a paper-based resource that contains text and photographs without any user input. We have used a new interior design methodology using marker-based augmented reality. Users can select furniture options in an AR environment and view them projected in a real-world setting. To save consumers time and effort, this will streamline the interior design process and offer a better view of furniture arrangement.

GRAPHICAL ABSTRACT

The AR App for Visualizing Interior Design Changes in a Real-World Environment revolutionizes the interior design process by seamlessly integrating augmented reality technology into the design workflow. Leveraging the power of smartphones or tablets, this innovative application allows users to envision and experiment with potential design alterations directly within their physical living spaces. By superimposing virtual furniture, decor elements, and layout configurations onto real-world environments in real-time, the app empowers users to explore different design options, evaluate aesthetic choices, and make informed decisions about their interior spaces. With its intuitive user interface and extensive library of design assets, including furniture styles, color palettes, and architectural elements, the app caters to both design professionals and homeowners alike, facilitating collaborative design processes and enhancing the overall experience of interior design.

ABBREVIATIONS

1. AR: Augmented Reality
2. App: Application
3. Vis: Visualization
4. ID: Interior Design
5. RW: Real-World
6. Env: Environment
7. UI: User Interface
8. UX: User Experience
9. CAD: Computer-Aided Design
10. 3D: Three-Dimensional
11. VR: Virtual Reality
12. ML: Machine Learning
13. AI: Artificial Intelligence
14. HCI: Human-Computer Interaction
15. SDK: Software Development Kit
16. API: Application Programming Interface
17. GUI: Graphical User Interface
18. CRUD: Create, Read, Update, Delete (database operations)
19. RF: Random Forest (potentially used for predictive modeling)
20. DT: Decision Tree (another potential modeling technique)

SYMBOLS

The AR App for Visualizing Interior Design Changes in a Real-World Environment is a groundbreaking tool that redefines the interior design experience. Leveraging cutting-edge augmented reality technology, this innovative application allows users to seamlessly overlay virtual design elements onto their physical surroundings in real-time. With a user-friendly interface and an extensive library of furniture, decor, and color options, the app empowers users to explore endless design possibilities and visualize their dream spaces with unparalleled accuracy and precision. Whether renovating a living room, planning a kitchen remodel, or simply experimenting with new decor styles, the AR app provides a dynamic platform for creativity and inspiration. By bridging the gap between imagination and reality, it revolutionizes the way interior design concepts are conceptualized, communicated, and realized, making it an indispensable tool for design professionals and homeowners alike.

CHAPTER 1

INTRODUCTION

1.1 Identification of Client/ Need/ Relevant Contemporary Issue

- Visualization: Many clients struggle to visualize how proposed interior design changes will look in their actual space.
- Decision-making: Clients often find it difficult to make decisions about furniture placement, color schemes, and other design elements without being able to see them in context.
- Efficiency: Traditional methods of interior design visualization, such as physical mock-ups or 2D renderings, can be time-consuming and costly.
- Remote Work and Virtual Collaboration: With the rise of remote work and virtual collaboration, there's a growing need for tools that allow designers and clients to collaborate effectively from different locations. An AR app that enables clients to visualize and interact with interior design changes in real-world environments addresses this issue by bridging the gap between physical and digital spaces.
- Technological Advancements: With advancements in augmented reality technology, including improved device capabilities and more sophisticated AR development tools, the feasibility and usability of AR apps for interior design visualization have greatly increased. This makes it a relevant contemporary issue as it leverages the latest technological innovations to solve real-world problems in interior design.

1.2 Identification of Problem

An important stage in the creation of an Augmented Reality (AR) software that helps visualise interior design modifications in real-world settings is requirement analysis. Fundamentally, this phase entails a thorough investigation of the client's requirements, goals, and intended audience. Developers may learn a great deal about the general objectives of the project and the particular features that the customer wants by having meaningful conversations. In addition to identifying crucial components that are necessary for the app's operation, this process also involves creating user-friendly interactions for the selection, customisation, and placement of these virtual elements. Examples of these features include the ability to seamlessly integrate virtual furniture and decor items into real spaces. To ensure effective implementation, it is important to define the project's scope and set specific goals. These are crucial elements in the process. Developers may guarantee that the augmented reality application (AR app) fulfils client requirements and provides an engaging and immersive user experience by means of meticulous planning and goal alignment.

1.3 Identification of Tasks

Requirement Gathering:

- Meet with clients to understand their specific needs and requirements.
- Identify the target audience and their preferences.
- Determine the scope of the app and its features.

Research and Conceptualization:

- Research existing AR apps and technologies related to interior design visualization.
- Brainstorm ideas for features and functionalities that would provide value to users.
- Develop a conceptual framework for the app's user interface and user experience.

Design and Prototyping:

- Create wireframes and mock-ups of the app's interface.
- Design the visual elements, including 3D models of furniture and decor items.
- Develop prototypes to test the app's usability and functionality.

Development:

- Set up the development environment for AR app development.
- Implement the core functionalities of the app, such as AR rendering, object placement, and interaction.

- Integrate features for capturing and importing real-world room data, such as dimensions and lighting conditions.
- Develop features for selecting and placing virtual furniture and design elements.

Testing and Quality Assurance:

- Conduct thorough testing of the app on various devices and platforms.
- Identify and fix bugs and performance issues.
- Gather feedback from users and stakeholders to make necessary improvements.

Deployment and Distribution:

- Prepare the app for deployment to app stores or distribution platforms.
- Create marketing materials and promotional content to attract users.
- Publish the app and monitor its performance and user feedback.

Maintenance and Updates:

- Provide ongoing support and maintenance for the app.
- Monitor user feedback and address any issues or feature requests.
- Release updates and enhancements to improve the app's functionality and user experience over time.

1.4 Timeline



Figure 1

1.5 Organization of the Report

Chapter 1 : Problem Identification - This chapter introduces the project and describes the problem statement discussed earlier in the report.

Chapter 2: Literature Review - This chapter presents the review of various research papers which helps us to understand the problem in a better way. It also defines what has been done to already solve the problem and what can be further done.

Chapter 3: Design Flow/ Process - This chapter presents the need and significance of the proposed work based on a literature review. The proposed objectives and methodology are explained. This presents the relevance of the problem. It also represents a logical and schematic plan to resolve the research problem.

Chapter 4: Result Analysis And Validation - This chapter explains various performance parameters used in the implementation. Experimental results are shown in this chapter. It explains the meaning of the results and why they matter.

Chapter 5: Conclusion and Future scope - This chapter concludes the results and explains the best method to perform this research to get the best results and defines the future scope of study that explains the extent to which the research area will be explored in the work

CHAPTER 2

LITERATURE REVIEW / BACKGROUND STUDY

2.1 Timeline of the Reported Problem

The timeline of the reported problem with the AR App for Visualizing Interior Design Changes in a Real-World Environment spans several months, beginning with the identification of a recurring issue affecting app performance. In the initial stages, the development team conducts thorough investigations to understand the root cause of the problem, examining factors such as rendering pipelines and hardware compatibility. Over the course of the following months, extensive data gathering, collaboration with experts, and prototype development take place to explore potential solutions and optimizations. By the sixth month, prototype solutions are tested and validated, leading to the implementation and deployment of optimized performance fixes. Ongoing monitoring and iteration ensure that the performance improvements are sustained and further refined to maintain optimal functionality over time.

2.2 Existing Solutions

Since many details are left up to the imagination of the user, it can be challenging to picture how any piece of furniture would appear in space. The technology known as augmented reality allows computer-generated pictures to be superimposed over the actual world. It has been used in engineering and architecture to solve real-world problems. Thanks to advancements in technology, people can now perceive reality more accurately. Previously known as "mediated reality," augmented reality alters one's vision of reality by using a computer. Head-mounted displays (HMDs), eyeglasses, contact optics, and trackers are some of the devices that have built-in augmented reality, which professionals use frequently. Non-professionals or regular individuals can also use elements of augmented reality to solve problems in their daily lives. The size, color, and degree of harmony with the environment are some of the factors to consider when using augmented reality. The accurate visualization of furniture in a space is made possible by augmented reality, which projects computergenerated visuals onto the actual world. By modifying what we see, it improves our understanding of reality. Professionals employ augmented reality in many different ways through devices like head-mounted displays, contact lenses, eyeglasses, and monitors. Yet augmented reality can help regular people too, by providing solutions to common issues. Currently, available augmented reality (AR) systems for interior design often utilize AR frameworks, 3D model tools, and mobile applications.

2.3 Bibliometric analysis

Augmented Reality (AR) is a cutting-edge field that combines the real and virtual world to create a revolutionary way to imagine changes to interior design. This introduction explores the development of conventional design methods, emphasizes the role of augmented reality(AR) technology, and describes the goal and possible outcomes of an AR application that is specifically designed to visualize changes in interior design in a real-world setting. The intended AR app aims to reinvent interior design by putting the user at the center of creative discovery and decision-making. The application seeks to go above the limitations of conventional design representations by providing a three-dimensional, enhanced view of suggested modifications in the user's actual surroundings. Users may see spatial changes, try out different color schemes, and arrange furniture virtually- all streamlined by this revolutionary experience, which also gives users more confidence in the selected design because they can see its effects immediately. The introduction of an augmented reality application, that allows users to visualize changes to interior design in a physical setting, has transformed the way people approach the process of creating their own homes. This revolutionary technology not only bridges the gap between idea and reality, but it also democratizes the design process by empowering people to make precise and confident changes to their surroundings. As we embark on this journey at the intersection of design and technology, our living spaces become infinitely more innovative and creative.

2.4 Review Summary

The field of architectural interior design is experiencing a gradual shift towards the use of virtual tools, mainly due to the rapid advancement of virtual technology. This paper aims to focus on how the interior design industry is adapting to these technological changes, particularly to use the augmented reality (AR) applications in the real world. The field of architectural interior design is experiencing a gradual shift towards the use of virtual tools, mainly due to the rapid advancement of virtual technology. This paper aims to focus on how the interior design industry is adapting to these technological changes, particularly in the use of augmented reality (AR) applications in the real world. The modeling process is streamlined to a great extent by using semantically annotated 3D models instead of generalpurpose tools, which greatly reduces the time needed to construct the first room model[1].

In a poll, 81% of participants said AR helped streamline the design process, especially when it came to creating spatial layouts. Most of the students who took part reported that by improving both 2D and 3D perception, utilizing the AR program improved their capacity to optimize spatial arrangements[2].

The foundation of their automated interior design system relied on a hierarchical implementation of procedural rules governing object placement. To introduce variability in the designs generated, the execution tree offered multiple pathways to reach endpoints. This means that a given rule may have multiple child rules, which can be executed either concurrently or individually. Concurrent execution in their approach adhered to three primary principles: To clarify the rules, if two rules are on the same level and have the same parent, they cannot be executed together unless

they belong to a concurrency group. However, if the rules are present in the same concurrent, they can be executed together, except if they are part of the same avoidance group. The last principle involved using avoidance groups to prevent the simultaneous execution of rules, regardless of whether belonging to the same concurrency group. This principle aims to prevent an excessive proliferation of concurrency groups. To develop augmented reality applications in interior design, it is crucial to understand user perception [3][4].

The use of virtual reality provides a deeply immersive experience, but it often falls short in terms of realism as it mainly consists of digital data intended to simulate the real world. On the other hand, augmented reality (AR) has the potential to deliver a more realistic experience by integrating digital elements into a built-in background. Current AR HMD devices face limits in delivering immersive experiences because of elements like limited field of view (FoV) or reliance on specific locations for optimal functionality. These limitations can hinder the ability of AR HMDs to deliver a truly realistic experience[5].

During the final phase of the assessment, the ability to complete each task was measured by determining the time-on-task. It was performed during the COVID-19 time period so few people were tested remotely, while others underwent in-person evaluations. Remote persons had to submit screen recordings to analyze the time taken to complete every task. After the testing phase, participants made several suggestions to improve the user experience of the application. Many of them recommended adding extra options also buttons on the main user interface screen. While a certain party recommended creating a clickable button, another suggested integrating an undo option. This study designed and examined a system for AR 3D/virtual furniture interior design using two user studies. Metrics like the System Usability Scale (SUS), Handheld Augmented Reality Usability Scale (HARUS), job

finish time, and the frequency of blunders were taken into consideration while determining the preliminary iteration of the solution across five tasks [6][7][8].

The authors' system offered many tools for managing photos, scaling models, and adjusting threshold values and marker attributes for object manipulation. From the item list on the left, the user may pick various virtual furniture items, change, remove, or modify their attributes, and then conceal them as needed. Every picture and virtual model is continuously added to the system. Additionally, if the user chooses to continue working on their design, they may store their virtual furniture design in a project file and import it at a later time[9].

The main goal of the paper was to address the shortcomings of traditional systems and provide a solution that encourages the innovation of a 3D model of a room that can be used repeatedly by both interior designers and customers[10].

The outcome of the application design explained how the augmented reality (AR) software was created, which included designing the front page of the home screen and determining how those 3D objects would appear. Additionally, technical testing was conducted to ensure the application can be installed and used seamlessly on various smartphone devices. This was all part of the application design result[11].

This project aimed to reduce the time and effort required for the interior design of homes. They created an augmented reality catalog that showcased a variety of home design products. Moreover, they allowed customers to customize the listed products in the catalog according to their preferences. These changes could be made to the size, texture, color, or orientation of the product. The expected cost of product setup was also calculated to ensure that users stayed within their budget. Previously, customers had to wait until interior designers arrived at the location to provide product samples, among other issues related to interior design[12].

The article explored augmented reality technologies and 3D interior models for various interior designs. A framework for hard decoration modeling has been created to help users perceive each aspect of the design project, to achieve the balance between geometry and function. Specialized stereoscopic technology was simulated for content and sensory information about various furnishings, appliances, and ornamental materials for soft décor to improve clients' understanding and involvement with personalized interior design projects. In the ARID framework, this generates an AR3D interior prototype [13].

The article proposes an improved user experience and perception of objects using marker-less augmented reality. They used a marker-less tracking technique that tracked an object's position and orientation by utilizing positional tracking[14].

2.5 Problem Definition

Introducing our advanced augmented reality app that enables you to visualize changes to interior design in real spaces. This cutting-edge solution ensures seamless integration with design services by offering personalized design options and sophisticated tracking capabilities without the need for markers. With the help of cloud storage services, customers can view their designs from anywhere, and the offline mode ensures that the functionality will continue to work even when there is no internet connection. Our technology is optimized for performance and provides a user-friendly interface that revolutionizes how people interact with interior design.

2.6 Goals/ Objectives

Our experience creating augmented reality software that enables users to visualize interior design in real-world settings shows that the app is adaptable to a wide range of age groups and professional backgrounds. The inclusion of a sign-up page that requires a login and password for authentication not only increases user engagement and accessibility but also underscores the importance of safeguarding user privacy and data within AR application ecosystems.

Moreover, accessibility, collaboration, and personalization in interior design visualization have improved significantly with the integration of cloud storage and online store collaboration into the AR app ecosystem. These features enable users to create immersive and customized creative experiences, foster teamwork, and streamline the procurement process by providing easy access to design files and product catalogs.

CHAPTER 3

DESIGN FLOW/ PROCESS

The design flow for the development of the AR App for Visualizing Interior Design Changes in a Real-World Environment begins with a thorough requirement gathering phase, where the needs and preferences of both design professionals and homeowners are carefully assessed. This is followed by a conceptualization stage, where the overall vision and goals of the app are outlined, and use cases are developed to understand user interactions. Subsequently, the focus shifts to user interface (UI) design, aiming to create intuitive interfaces that facilitate easy navigation and customization of interior design elements. Concurrently, efforts are made to collect and prepare a comprehensive database of furniture models, decor items, and color palettes to be integrated into the app. The core of the development process revolves around implementing augmented reality functionalities, including real-time object recognition and spatial mapping, to enable users to visualize virtual design changes within their physical environment. Throughout the development lifecycle, rigorous testing and quality assurance measures are employed to ensure functionality, performance, and stability across different devices and environments. Upon completion, the app is deployed to app stores and promoted through various channels to reach its target audience. Post-launch, ongoing maintenance and updates are carried out to address any issues and incorporate new features based on user feedback and emerging technologies.

3.1 Evaluations & Selection of Specifications/Features

The evaluation and selection of specifications and features for the AR App for Visualizing Interior Design Changes in a Real-World Environment are crucial steps in ensuring the app's effectiveness and usability. This process begins with a comprehensive analysis of user requirements, market trends, and technological capabilities to identify the most relevant and impactful features. Stakeholder input, including feedback from design professionals and potential users, is solicited and incorporated to prioritize features that align with user needs and preferences. Additionally, usability testing and prototyping are conducted to assess the feasibility and usability of proposed features and iterate on design decisions. Factors such as ease of use, visual fidelity, performance, and compatibility across different devices are carefully evaluated to determine the specifications and features that will offer the most value to users. Throughout the evaluation process, a balance between innovation and practicality is maintained to ensure that the selected features enhance the app's functionality while remaining accessible and intuitive to a broad audience of users.



Figure 2



Figure 3

3.2 Design Constraints

Several design constraints must be considered during the development of the AR App for Visualizing Interior Design Changes in a Real-World Environment to ensure its functionality, usability, and effectiveness. One significant constraint is the hardware compatibility of the application, as it must be compatible with a wide range of smartphones and tablets equipped with augmented reality capabilities. Additionally, the app must adhere to performance constraints, ensuring smooth and responsive rendering of virtual design elements within the real-world environment, even on devices with limited processing power. Another critical constraint is the accuracy and reliability of the app's spatial mapping and object recognition algorithms, which are essential for accurately overlaying virtual design changes onto physical spaces. Moreover, considerations such as data privacy, security, and regulatory compliance impose constraints on the collection, storage, and handling of user data within the app. Finally, constraints related to time and budget must be taken into account, requiring efficient project management and resource allocation to meet development deadlines and budgetary constraints.

1. User Experience Constraints:

The app must provide an intuitive and user-friendly interface for users to interact with virtual design elements and make changes easily.

Accessibility considerations should be taken into account to ensure that the app is usable by individuals with disabilities, such as providing options for voice commands or screen reader compatibility.

2. Content Constraints:

The app must have a library of high-quality 3D models and textures for furniture, decor, and architectural elements to offer users a variety of design options.

Content licensing and copyright considerations must be addressed to ensure that all virtual design elements are legally used and distributed within the app.

3. Integration Constraints:

The app may need to integrate with existing interior design software or platforms to import design data or collaborate with other professionals.

Compatibility with third-party services or APIs for additional features, such as e-commerce integration for purchasing design elements, may be necessary.

4. Localization Constraints:

The app may need to support multiple languages and cultural preferences to cater to users worldwide.

Considerations for different measurement systems, design aesthetics, and cultural norms may also need to be addressed for a global audience.

5. Performance Constraints:

The app should optimize resource usage to minimize battery consumption and prevent overheating of devices during prolonged use.

Real-time rendering of virtual design elements must maintain a consistent frame rate and visual quality across different devices and environments.

6. Testing and Quality Assurance Constraints:

Rigorous testing procedures should be in place to identify and address any bugs, glitches, or compatibility issues across different devices and operating systems.

User feedback and usability testing should be conducted throughout the development process to ensure that the app meets the needs and expectations of its target audience.

7. Scalability Constraints:

The app should be designed to accommodate future updates, additions, and enhancements, such as new features or expanded content libraries, without compromising performance or usability.

Scalability considerations should also include the ability to handle increased user traffic and data storage requirements as the app gains popularity.

- Several design constraints must be considered during the development of the AR App for Visualizing Interior Design Changes in a Real-World Environment to ensure its functionality, usability, and effectiveness.

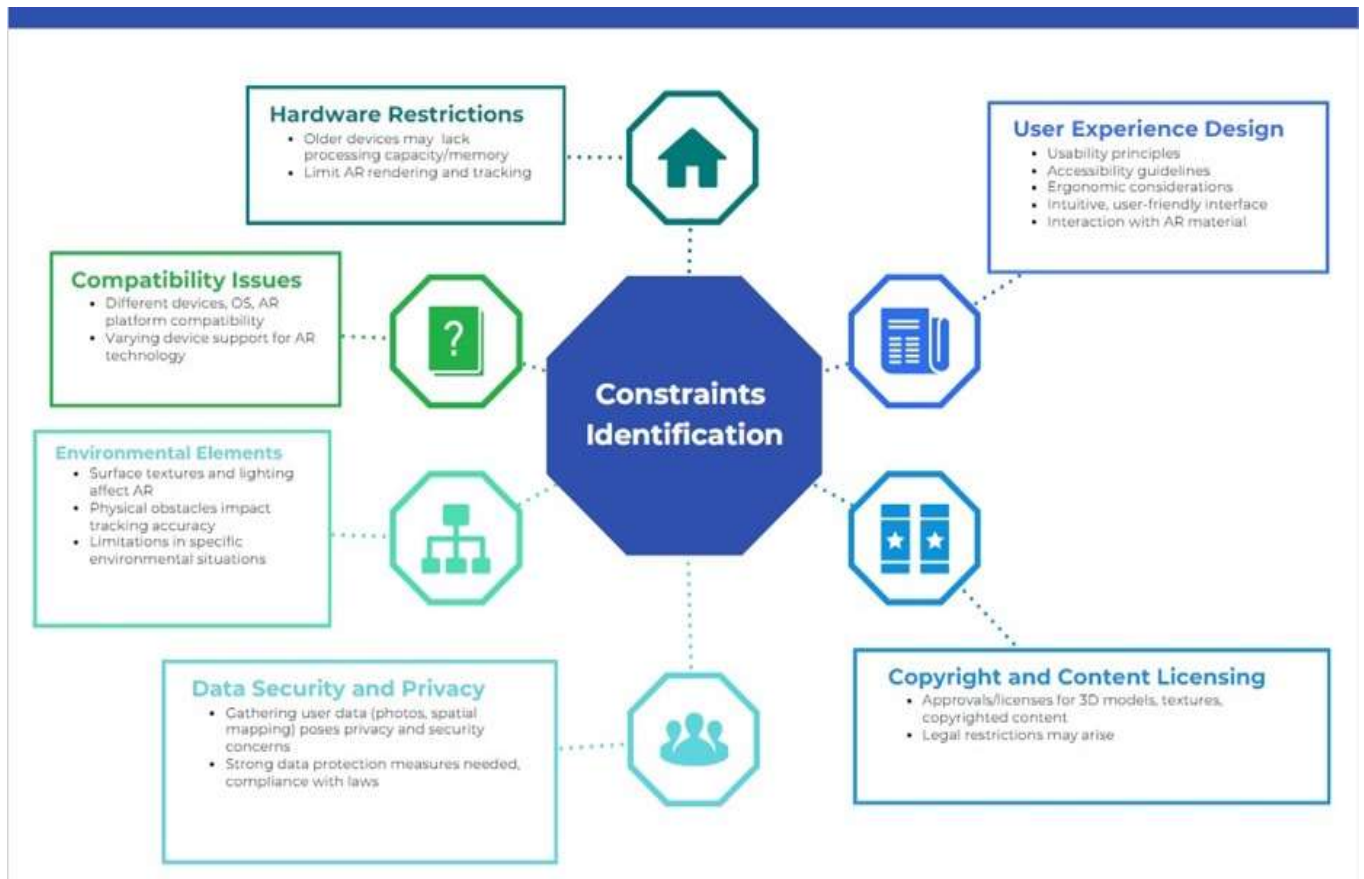


Figure 4

3.3 Analysis of Features and finalization subject to constraints

The analysis of features and finalization subject to constraints for the AR App for Visualizing Interior Design Changes in a Real-World Environment involves a meticulous process of evaluating potential functionalities against various constraints to ensure the app's functionality, usability, and feasibility. Features are analyzed based on factors such as user needs, market demands, technical feasibility, and resource constraints. Stakeholder input and feedback, including input from design professionals and potential users, play a critical role in prioritizing features that offer the most value and align with user expectations. Concurrently, constraints such as hardware compatibility, performance limitations, and regulatory requirements are carefully considered to determine the feasibility of implementing specific features within the app. Iterative prototyping and usability testing are conducted to assess the usability and effectiveness of proposed features in real-world scenarios and identify any potential issues or limitations. Through this iterative process, features are refined, adjusted, and finalized to strike a balance between innovation, usability, and practicality, ensuring that the AR app meets user needs and regulatory standards while delivering a compelling and intuitive user experience.

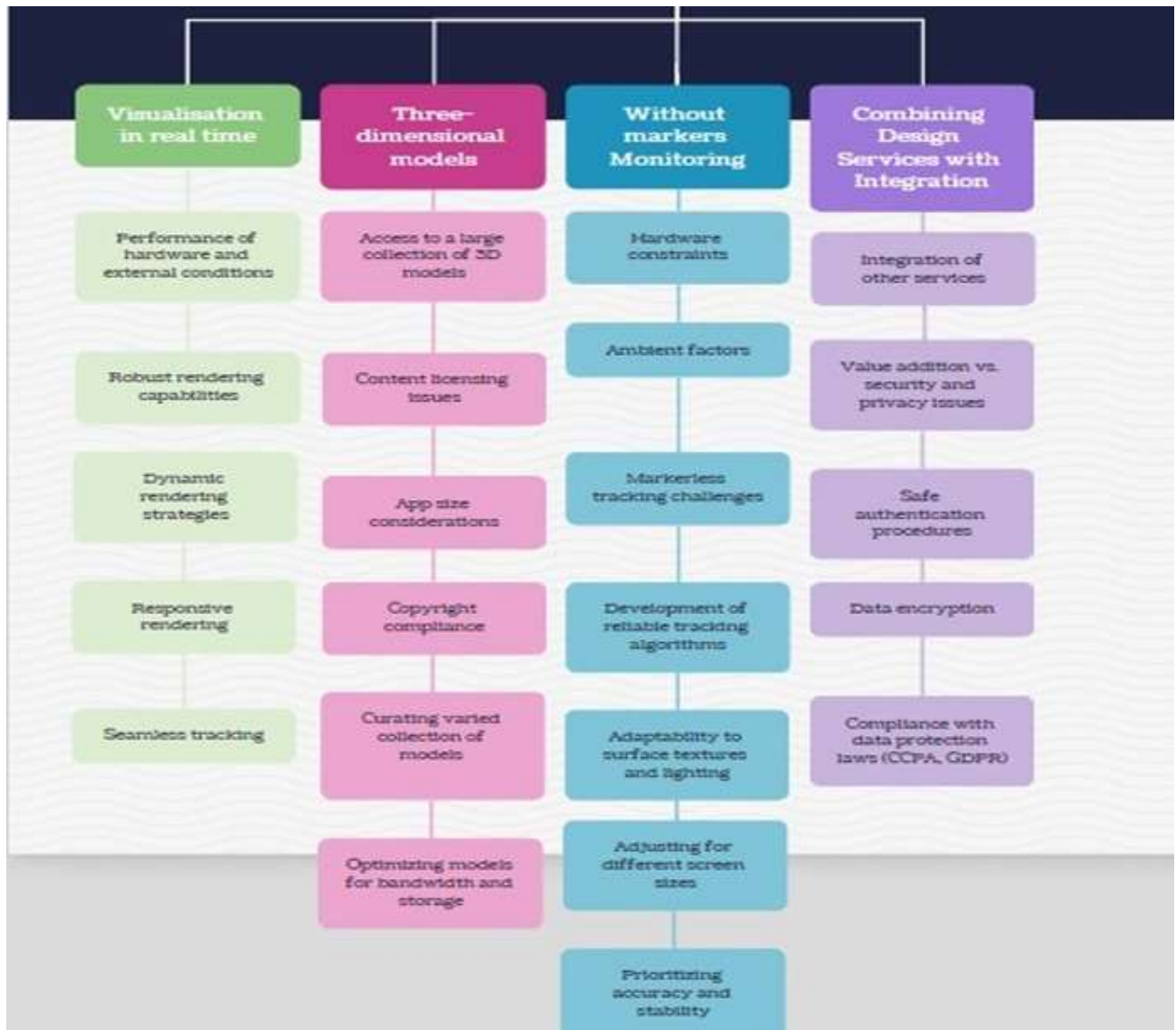


Figure 5

3.4 Design Flow

The design flow for the development of the AR App for Visualizing Interior Design Changes in a Real-World Environment encompasses several key stages aimed at conceptualizing, designing, implementing, and refining the application. It begins with the identification of user requirements and market demands, followed by a comprehensive analysis of the app's objectives, target audience, and technical feasibility. Subsequently, the focus shifts to conceptualization and ideation, where the overall vision and goals of the app are outlined, and use cases are developed to guide the design process. User interface (UI) and user experience (UX) design come next, focusing on creating intuitive interfaces and seamless interactions that facilitate easy navigation and customization of interior design elements within the AR environment. Concurrently, efforts are made to collect and prepare a diverse database of furniture models, decor items, and color palettes to be integrated into the app. The development phase involves implementing augmented reality functionalities, including real-time object recognition, spatial mapping, and virtual design visualization. Throughout the development process, rigorous testing and quality assurance measures are employed to ensure functionality, performance, and stability across different devices and environments. Post-launch, ongoing maintenance, updates, and user feedback are incorporated to refine and enhance the app's features and usability continually.

3.5 Design Selection

1. PERSONALISATION CHOICES

- Offer users a range of customization options to personalize their design experience, such as choosing furniture styles, color schemes, and layout configurations.
- Implement user profiles or preferences settings to save and recall personalized design choices for future sessions.
- Provide recommendations and suggestions based on user preferences and previous design selections to enhance the personalization experience.

2. TRACING WITHOUT MARKERS

- Develop AR algorithms that enable object recognition and tracking without the need for physical markers or tags, allowing users to place virtual furniture and decor elements directly onto surfaces in the real-world environment.
- Utilize computer vision techniques such as feature detection and matching to identify and track surfaces, furniture, and architectural features within the camera view.

3. COMBINING DESIGN SERVICES WITH INTEGRATION

- Integrate the AR app with existing design services and platforms to streamline the design process and facilitate collaboration between users and design professionals.

- Enable seamless import/export functionality to transfer design projects between the AR app and other design software or services.
- Incorporate features such as real-time collaboration tools, project sharing, and feedback mechanisms to enhance teamwork and communication among users and design stakeholders.

4. OFFLINE MODE

- Implement offline functionality that allows users to access and use the AR app's core features without an internet connection.
- Enable offline caching of design assets, furniture models, and other resources to ensure uninterrupted usability and performance in offline mode.
- Provide users with the ability to save and export design projects locally for offline viewing and editing.

5. OPTIMISING PERFORMANCE

- Employ optimization techniques such as occlusion culling, level of detail (LOD) rendering, and texture compression to optimize rendering performance and minimize latency.
- Implement efficient memory management strategies to reduce memory usage and ensure smooth operation on devices with varying hardware capabilities.
- Continuously monitor and fine-tune performance metrics through profiling and testing to identify and address performance bottlenecks and improve overall app responsiveness.

6. DESIGN USER EXPERIENCE

- Focus on creating an intuitive and immersive user experience that guides users through the design process seamlessly.
- Incorporate user-friendly gestures, controls, and interactions that make it easy for users to manipulate virtual design elements and navigate within the AR environment.
- Provide clear and concise instructions, tooltips, and onboarding tutorials to help users familiarize themselves with the app's features and functionalities.

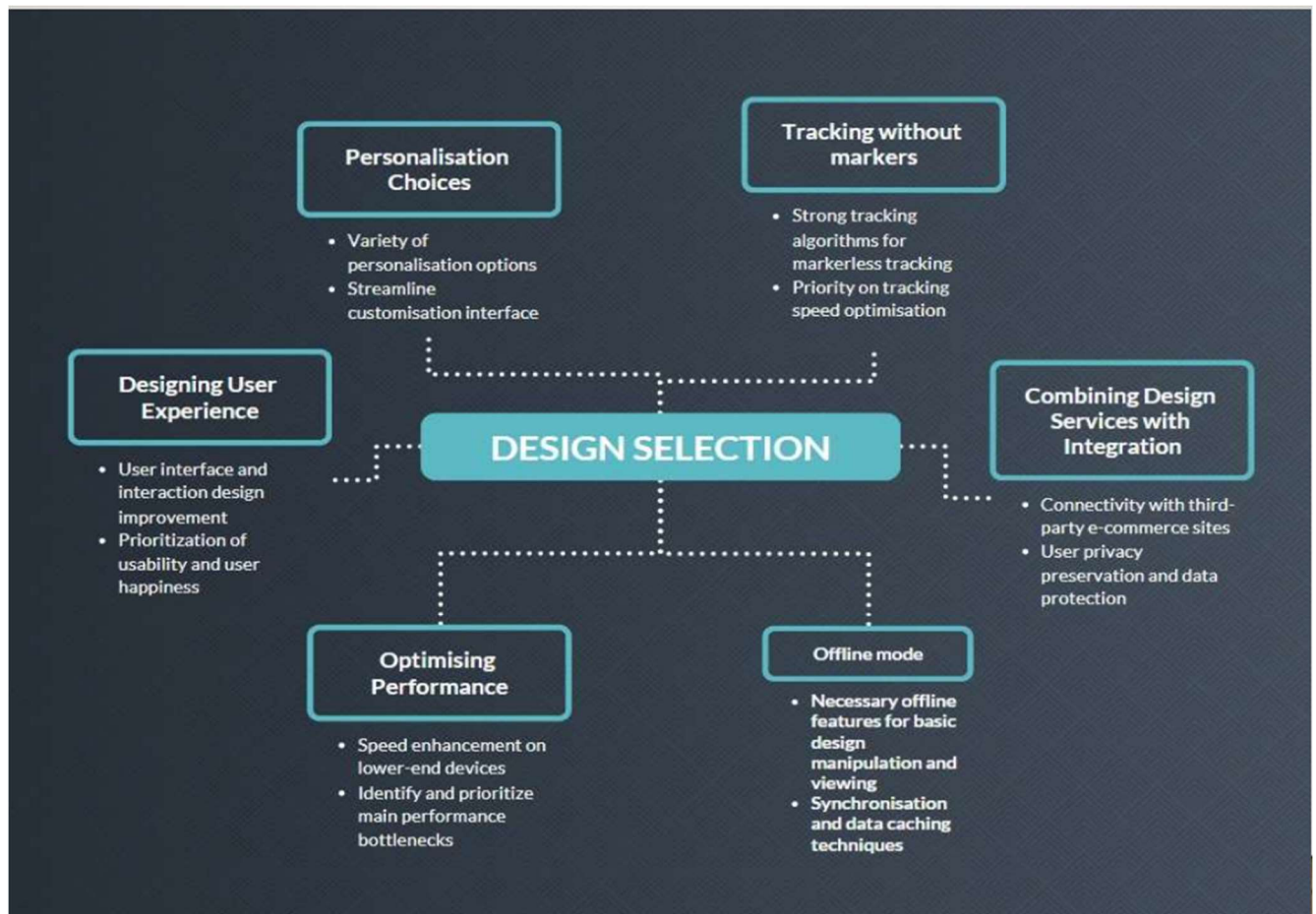


Figure 6

3.6 Implementation Plan/ Methodology

The project employs a meticulous approach to crafting Augmented Reality (AR) software for visualizing interior design modifications in real-world settings. The following attributes are included in the methodology used:

A. Requirement Analysis :

When developing Augmented Reality (AR) software for visualizing changes to interior design, it is vital to conduct a thorough requirement analysis. This involves closely examining the needs, objectives, and target audience of the client and engaging in insightful discussions to understand the project's objectives. This process helps to outline critical features and ensures intuitive interactions for selecting, adjusting, and positioning virtual elements in physical spaces. A well-defined project scope and goals are crucial for successful implementation. Careful planning and alignment of objectives ensure that the AR software meets the client's requirements and provides an engaging user experience.



Figure 7

B. Research and Inspiration :

During the research and inspiration phase, developers analyze the latest technologies and available AR interior design applications to gain insights into emerging trends and industry best practices. They dive into the world of interior design, taking cues from user interfaces and furniture catalogs to understand the tastes of their target market. To ensure the seamless integration of AR features into the app, developers also explore AR development tools such as ARKit and ARCore. By conducting thorough research and seeking inspiration, developers lay the foundation for innovative and user-focused augmented reality interior design software that exceeds customer expectations.



Figure 8

C. Conceptualization and Design :

During the design phase, developers use their creativity to imagine the user interface and experience of an augmented reality (AR) interior design app. They focus on simplicity and user involvement through brainstorming sessions. Wireframes and prototypes are used to transform ideas into visual concepts, enabling an iterative development process. The development team prioritizes AR features and gesture-based interactions, along with user-friendly controls for selecting and organizing virtual items. By keeping the user's needs in mind and utilizing modern design tools, developers create aesthetically pleasing and user-friendly AR interior design software.



Figure 9

D. Development :

Developers strive to create a fully functional AR interior design software by choosing the appropriate AR development framework such as ARKit or ARCore. They integrate essential AR features like surface mapping and object tracking for seamless interaction. To enhance user experience, they include high-quality 3D models of furniture and décor. They also enable manipulation and customization of virtual objects. By giving priority to sound development processes and leveraging advanced AR technologies, developers ensure the delivery of an exceptional AR interior design app.



Figure 10

E. Testing and Feedback

During the testing phase, developers assess the AR interior design app to ensure it functions properly and meets user expectations. Beta testers provide valuable feedback on navigation and usability to identify and resolve issues. The app undergoes rigorous testing to ensure consistent performance and compatibility across various devices and AR scenarios. To offer users a seamless experience, developers give priority to fixing any bugs and continuously improve the app based on user feedback. During the testing phase, developers assess the AR interior design app to ensure it functions properly and meets user expectations. Beta testers provide valuable feedback on navigation and usability to identify and resolve issues. The app undergoes rigorous testing to ensure consistent performance and compatibility across various devices and AR scenarios. To offer users a seamless experience, developers give priority to fixing any bugs and continuously improve the app based on user feedback.



Figure 11

CHAPTER 4

RESULT ANALYSIS AND VALIDATION

4.1 Implementation of solution

Our development of an augmented reality (AR) app for visualizing interior design within real-world environments highlights its effectiveness across diverse demographics and professional fields. Below are the characteristics of the AR app that we have developed:

(I) SIGN-UP PAGE INTEGRATION:

To enhance user interaction and security in AR applications, it is crucial to include a sign-up page that requires password and login authentication. By doing so, users can create personalized accounts, which fosters a sense of ownership and makes it easier for them to access unique design projects and preferences.



Figure 12

(II) VISUALIZATION FOR VARIED AGE GROUPS:

Based on our analysis, it seems that augmented reality software can be useful for users of various age groups, ranging from young adults to the elderly. The participants in our study found the interface design to be age- and gender-neutral, which improved their involvement with the interior design visualization process. Additionally, the user-friendly navigation further enhanced their experience with the software.

- **Accessibility Features:**

The augmented reality software may incorporate accessibility features such as adjustable font sizes, color contrast options, voice commands, and gesture-based controls to accommodate users with different abilities and preferences.

These accessibility features ensure that users of all ages and abilities can comfortably interact with the software and engage in the interior design visualization process without encountering barriers or difficulties.

- **Learning and Skill Development:**

The intuitive and user-friendly interface of the augmented reality software facilitates learning and skill development for users of all age groups, including young adults, seniors, and individuals with limited technological experience.

Users can quickly grasp the basic functionalities of the software and gradually explore more advanced features and capabilities, enhancing their digital literacy and proficiency in using augmented reality technology.

- Educational and Therapeutic Applications:

Augmented reality software can have educational and therapeutic applications for users across different age groups, including children, adolescents, adults, and seniors.

For children and adolescents, the interactive and immersive nature of augmented reality can foster creativity, spatial awareness, and problem-solving skills through engaging design activities and games.

For seniors and individuals with cognitive impairments or neurological conditions, augmented reality experiences can provide cognitive stimulation, memory enhancement, and therapeutic benefits through interactive and meaningful interactions with virtual environments.

- Cross-Generational Engagement:

Augmented reality software has the potential to promote cross-generational engagement and social interaction among family members, friends, and caregivers.

Users of different age groups can collaborate, share design ideas, and work together on interior design projects using the software, fostering intergenerational communication, teamwork, and bonding experiences.

- Community and Support Networks:

Augmented reality software can serve as a platform for building online communities and support networks for users of all ages who share common interests in interior design, home decor, and creative expression.

Users can connect with like-minded individuals, seek inspiration, share tips and advice, and showcase their design projects within a supportive and collaborative virtual environment, regardless of their age or background.



Figure 13

(III) USER EXPERIENCE AND ACCESSIBILITY:

We found that adding the sign-up page was positively correlated with increased user satisfaction based on qualitative feedback and usability tests. Along with the ease of accessing individual design portfolios and collaboration features, participants valued the shortened account setup procedure.



Figure 14

(IV) COMPREHENSIVE 3D LIBRARIES REALISTIC VISUALIZATION:

To enhance the realism and augmented reality immersion of interior design visualization, extensive 3D libraries are combined. With the help of an enormous library of meticulously curated high-fidelity models of clothing, furnishings, lighting, and architectural details, users of the augmented reality program can visualize their design concepts with an unparalleled level of accuracy and detail.

- Variety and Customization:

The extensive 3D libraries offer a wide variety of design elements, including furniture, decor, fixtures, appliances, and architectural details, allowing users to create diverse and personalized design concepts.

Users can customize and mix-and-match different design elements from the library to reflect their unique style preferences, aesthetic tastes, and functional requirements, resulting in highly personalized and tailored interior design visualizations.

- High-Fidelity Models:

The 3D models in the library are meticulously crafted with high-fidelity textures, materials, and finishes to accurately represent real-world objects and materials.

Detailed attention is given to the intricacies and nuances of each design element, including surface textures, patterns, reflections, and shadows, to create a lifelike and realistic representation in augmented reality.

- Realistic Lighting and Shadows:

The 3D library includes realistic lighting fixtures and environmental lighting effects that accurately simulate natural and artificial lighting conditions.

Advanced rendering techniques are used to generate dynamic shadows, reflections, and ambient occlusion, enhancing the realism and depth of the interior design visualizations in augmented reality.

- Interactive and Dynamic Elements:

Some design elements in the library may include interactive and dynamic features, such as movable furniture, adjustable lighting, and operable appliances, allowing users to experiment with different configurations and scenarios.

Users can interact with the virtual design elements in real-time, adjusting their position, orientation, scale, and properties to achieve the desired look and feel in their interior design visualizations.

- Continuous Updates and Expansion:

The 3D library is regularly updated and expanded with new additions, including the latest trends, styles, and design innovations in the interior design industry.

Users have access to a growing collection of new design elements and assets, ensuring that their design concepts remain fresh, relevant, and up-to-date with current design trends and preferences.



Figure 15

(V) COLLABORATIVE FEATURES WITH ONLINE RETAILERS:

Users can explore, choose, and see furniture, decor, and accessories from a wide range of collaborating merchants immediately within their design projects thanks to the AR application's integration of online retailer collaboration. Users can access a vast product inventory through agreements with top e-commerce platforms or individual stores, which expedites the procurement process and improves design customization.



Figure 16

(VI) SEAMLESS ACCESS TO CLOUD STORAGE:

The integration of cloud storage features in the AR application allows users to access their design files, project layouts, and customization preferences easily from different devices and locations. Our research has shown that

customers benefit greatly from the convenience of saving and retrieving their design files from online repositories such as Dropbox, Google Drive, or exclusive cloud solutions.

- Collaboration Features:

Cloud storage integration enables seamless collaboration among multiple users or team members working on the same design project. Users can share their design files with colleagues, clients, or stakeholders, allowing for real-time feedback and collaboration regardless of geographical location.

Collaboration features such as version control, comments, and annotations can enhance teamwork and streamline the design review process, ensuring that everyone involved in the project stays updated on the latest changes and revisions.

- Backup and Recovery:

Cloud storage provides automatic backup and recovery capabilities, ensuring that users' design files and project layouts are securely stored and protected against data loss or device failure.

In the event of accidental deletion, device damage, or system crash, users can easily restore their design files from cloud backups, minimizing downtime and preserving their work.

- Cross-Platform Compatibility:

Cloud storage solutions offer cross-platform compatibility, allowing users to access their design files from various devices and operating systems, including smartphones, tablets, laptops, and desktop computers.

Whether users are working from home, the office, or on the go, they can seamlessly access and edit their design projects using the AR application across different devices, ensuring continuity and flexibility in their workflow.

- Scalability and Flexibility:

Cloud storage solutions offer scalable storage options, allowing users to adjust their storage capacity based on their evolving needs and requirements.

As users' design projects grow in complexity or size, they can easily upgrade their cloud storage plans to accommodate additional files and data, without the need for hardware upgrades or infrastructure changes.

- Security and Privacy:

Cloud storage providers implement robust security measures and encryption protocols to protect users' data against unauthorized access, data breaches, or cyberattacks.

Users can have peace of mind knowing that their design files and project layouts are stored in secure, encrypted cloud repositories, with access controls and permissions to safeguard sensitive information and intellectual property.



Figure 17

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

Our experience creating augmented reality software that enables users to visualize interior design in real-world settings shows that the app is adaptable to a wide range of age groups and professional backgrounds. The inclusion of a sign-up page that requires a login and password for authentication not only increases user engagement and accessibility but also underscores the importance of safeguarding user privacy and data within AR application ecosystems.

Moreover, accessibility, collaboration, and personalization in interior design visualization have improved significantly with the integration of cloud storage and online store collaboration into the AR app ecosystem. These features enable users to create immersive and customized creative experiences, foster teamwork, and streamline the procurement process by providing easy access to design files and product catalogs.

5.2 Future Work

Future work in the advancement of the AR App for Visualizing Interior Design Changes in a Real-World Environment could explore several avenues to further enhance its functionality and usability. One potential direction is the integration of advanced machine learning algorithms to provide personalized design recommendations based on user preferences, spatial constraints, and historical design data. Additionally, the incorporation of virtual reality (VR) capabilities could enable users to immerse themselves in fully immersive virtual environments and experience their design concepts from different perspectives. Furthermore, the expansion of the app's database with a wider range of furniture styles, decor elements, and architectural features could offer users greater flexibility and customization options in their design projects. Moreover, research into enhancing the app's real-time rendering capabilities and optimization for different hardware platforms could improve performance and user experience. Lastly, collaboration with interior design professionals and industry experts to gather feedback and insights could inform iterative updates and refinements to the app, ensuring its continued relevance and effectiveness in meeting the evolving needs of users in the field of interior design.

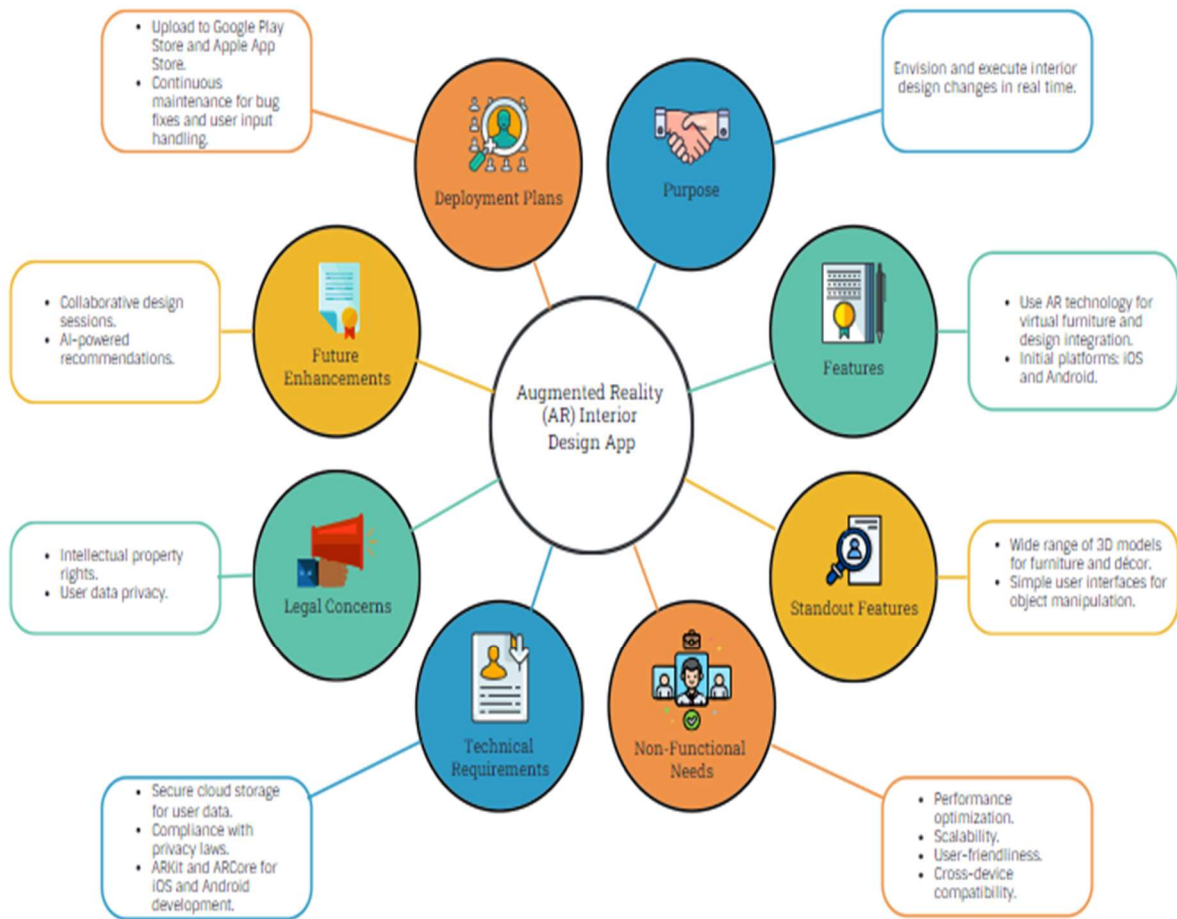


Figure 18

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