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AI-Assisted Room Redesign and Spatial Optimization Using Augmented Reality for Interior Visualization

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Abstract

Interior space design remains a challenge for many individuals due to limited access to professional services and difficulty in visualizing layout changes before implementation. This study presents Space Alignment, an AI-assisted mobile application that integrates artificial intelligence (AI), augmented reality (AR), and cloud-based technologies to support interior space visualization and optimization. The system allows users to upload room images for AI-based redesign, scan physical environments for real-time AR furniture placement, and analyze room layouts to generate ratings, suggestions, and optimized arrangements. The application is developed using Unity with C# as the programming language, while Replicate AI is utilized for image generation and image recognition, and Cloudinary is used for image storage and retrieval. The development follows the Agile Software Development Life Cycle (SDLC), enabling iterative testing and continuous improvement of system features. Results show that the integration of AI and AR enhances users' ability to visualize and plan interior layouts more effectively, reducing reliance on trial-and-error methods. The system provides an accessible and practical solution for homeowners, students, and individuals seeking affordable interior design assistance.

Keywords: Artificial Intelligence, Augmented Reality, Interior Design, Spatial Optimization, Mobile Application, Room Optimization

INTRODUCTION

Interior space design remains a challenge for many individuals, particularly for those who lack technical knowledge, design experience, or financial resources to hire professional interior designers. In many households, furniture arrangement and room redesign are commonly performed through trial and error, requiring the physical movement of furniture and repeated adjustments before achieving a preferred layout. This traditional approach is time-consuming, physically demanding, and often results in inefficient use of available space. In smaller residential environments, improper furniture placement may reduce room functionality, limit movement efficiency, and negatively affect the overall appearance of the space.

The continuous advancement of digital technology has introduced new methods for improving how individuals interact with and organize their living environments. Artificial Intelligence (AI) has become increasingly significant in image processing, pattern recognition, and automated content generation. AI-based systems are capable of analyzing room layouts and generating redesign suggestions based on visual patterns, design styles, and user preferences. Through machine learning and generative image technologies, users are now able to visualize possible room improvements without physically modifying their environment. At the same time, Augmented Reality (AR) technology has transformed visualization by allowing virtual objects to be placed and viewed within real-world environments in real time. AR enables users to interact with digital furniture models and room elements through mobile devices, helping them better understand spatial arrangements, object dimensions, and layout compatibility before making actual changes. This technology improves decision-making by reducing uncertainty in furniture placement and interior planning.

In the Philippine setting, many households live in limited residential spaces where efficient space utilization is important. However, access to professional interior design services remains limited because of high consultation and implementation costs. As a result, many individuals rely solely on personal judgment when arranging their rooms, which may lead to poor space organization and ineffective layouts. The increasing popularity of online furniture shopping also contributes to visualization difficulties since users cannot accurately determine whether furniture items will match the dimensions and appearance of their rooms before purchasing them. Several mobile applications related to interior design and room visualization already exist, but many of these systems provide only isolated functionalities. Some applications focus solely on furniture visualization through augmented reality, while others only provide inspiration images or manual room editing tools. Few systems integrate AI-generated redesign, AR-based interaction, and intelligent room analysis within a single mobile platform. Because of these limitations, users still experience difficulty in visualizing room layouts and design changes before making physical adjustments. Interior design assistance also remains inaccessible to many individuals because of the high cost of professional services. In addition, there is still a lack of unified mobile applications capable of combining AI-based room redesign, AR-based visualization, and intelligent room analysis within one system for improved space planning.

In response to these challenges, *Space Alignment* was developed as an AI-assisted Android mobile application designed to support users in visualizing, redesigning, and optimizing their living spaces. The application integrates Artificial Intelligence for room redesign and analysis, Augmented Reality for real-time furniture placement and visualization, and cloud-based technologies for image processing and storage. Through these features, the system aims to provide users with a practical and accessible tool that can assist in improving room layouts and spatial organization without requiring professional interior design expertise.

The study aims to:

1. Develop an AI-based room visualization feature that allows users to upload room images, select design themes, and generate redesigned outputs using cloud-based artificial intelligence.
2. Implement an augmented reality feature that enables users to place, resize, and manipulate virtual furniture within their physical environment in real time.
3. Design an AI-driven room analysis feature that evaluates room layouts and provides ratings, suggestions, and optimized arrangements for improved space utilization.

The study focuses on the design, development, and evaluation of *Space Alignment*, an AI-assisted Android mobile application that integrates Artificial Intelligence and Augmented Reality for room visualization and space optimization. The system includes three primary features: AI-based room redesign, AR-based room scanning and furniture placement, and AI-driven room analysis.

The application allows users to upload room images, select design themes, and generate redesigned room outputs using cloud-based AI processing. The system also enables real-time augmented reality visualization where users can place and manipulate virtual furniture within their physical environment. Additionally, the Analyze Room feature evaluates room layouts and generates suggestions and optimized arrangements intended to improve space utilization and visual organization.

The study is limited to Android devices only and does not include support for iOS platforms because of development constraints and hardware compatibility considerations. The system also requires a stable internet connection since AI processing and cloud storage operations rely on external online services such as Cloudinary and Replicate AI.

The performance of augmented reality features depends on device specifications, including camera quality, processing capability, and sensor support. Lower-end devices may experience reduced AR accuracy, slower response time, or limited functionality. In addition, AI-generated outputs may not always perfectly preserve the original visual attributes of the room, such as furniture colors, wall textures, and material appearance, because of the inherent behavior of generative AI models.

The development of *Space Alignment* is expected to provide benefits to different groups involved in interior space planning, mobile technology, and software development. Homeowners and renters may use the system as an accessible tool for exploring room redesign and layout optimization without requiring professional interior design services. Students and individuals living in smaller residential spaces may benefit from the application by experimenting with furniture placement and space optimization techniques. The application may also serve as a creative platform for interior design enthusiasts interested in exploring different room styles and arrangements.

The study also contributes to the field of Information Technology by demonstrating the integration of Artificial Intelligence, Augmented Reality, cloud computing, and mobile application development within a unified system. Furthermore, the study may serve as a reference for future researchers interested in AI-assisted visualization systems, AR applications, and intelligent decision-support technologies related to interior design and space optimization.

REVIEW OF RELATED LITERATURE AND STUDIES

Artificial Intelligence and Computer Vision in Interior Design

Artificial Intelligence (AI) has significantly transformed the field of visual computing, particularly in tasks involving image analysis, spatial understanding, and automated content generation. Modern AI systems are capable of interpreting complex visual environments and producing meaningful outputs based on learned patterns from large datasets. Zhao et al. (2021) explained that AI-based models can analyze spatial layouts and generate optimized design suggestions by learning from existing room structures and design patterns. This capability is highly relevant to interior design applications, where efficient space utilization and aesthetic arrangement are important factors. In relation to this, the Space Alignment system applies AI to interpret uploaded room images and generate improved layout suggestions, demonstrating how machine learning can be applied to real-world design problems.

Computer vision also plays a critical role in enabling machines to understand visual environments. Li and Wang (2020) emphasized that computer vision techniques allow systems to detect objects, recognize boundaries, and interpret spatial relationships within images. These functions are essential for applications that aim to analyze room structures and furniture placement. Through image processing and object detection, systems can identify key elements in a room such as walls, furniture, and empty spaces, which can later be used for redesign or optimization. This supports the development of intelligent systems like Space Alignment, where uploaded images are analyzed to understand room composition before generating redesigned outputs. Machine learning algorithms have also been widely used to improve spatial optimization and layout generation. Kim and Park (2021) found that machine learning models can analyze room dimensions, object sizes, and user preferences to generate efficient furniture arrangements. This helps users maximize available space while maintaining aesthetic balance. Similarly, Johnson and Lee (2022) explored generative AI models and found that they are capable of producing realistic and visually appealing interior design outputs. These findings support the use of AI in generating redesigned room images within the Space Alignment system.

AI-based recommendation systems have also been shown to enhance personalization in digital applications. Brown et al. (2023) explained that these systems analyze user behavior and preferences to generate tailored suggestions that match user needs. In the context of interior design, this allows systems to produce room layouts that align with user-selected themes and preferences, improving overall satisfaction and usability. Previous studies further support the use of AI in interior design systems. Liu et al. (2021) developed an AI-based interior design system capable of generating room layouts based on user preferences and spatial constraints, showing that automated design systems can reduce manual effort. Zhang and Kim (2022) also found that deep learning models can generate room layouts with efficiency comparable to human-designed spaces. These studies demonstrate the growing capability of AI in automating design processes and improving spatial planning.

Augmented Reality for Visualization and Interaction

Augmented Reality (AR) has emerged as a powerful technology for enhancing user interaction and visualization. Chen et al. (2022) stated that AR improves decision-making by allowing users to view digital objects within real-world environments in real time. This reduces uncertainty when evaluating design options, as users can immediately see how virtual furniture or design changes would appear in their actual space. In mobile development, AR technologies such as Google ARCore and Apple ARKit provide essential features including surface detection, motion tracking, and environmental understanding. These technologies make it possible to accurately place virtual objects within physical environments, which is a core function of the Scan Room feature in the Space Alignment system.

Studies related to AR-based furniture placement systems also highlight the effectiveness of this technology in interior design applications. Patel et al. (2020) and Wang et al. (2020) demonstrated that AR-based furniture placement systems improve user confidence and engagement by allowing real-time visualization of virtual objects in physical spaces. These systems help users make better design decisions by removing guesswork from spatial planning. Hybrid systems that combine AI and AR have also shown promising results. Garcia et al. (2021) and Cruz et al. (2022) found that integrating both technologies improves visualization and spatial understanding, making design systems more effective and interactive. These findings support the development of Space Alignment, where AI-generated redesigns are combined with AR-based visualization to create a more immersive user experience.

Mobile Application Development and System Technologies

Unity Technologies serves as one of the most widely used platforms for developing real-time 3D and AR applications. According to Unity Technologies (2021), the engine supports interactive simulation, rendering, and cross-platform deployment, making it suitable for mobile applications that require real-time visualization. In systems that combine AI and AR, Unity acts as the central development environment where user interaction, scene rendering, and system logic are integrated. This makes it an appropriate tool for building applications like Space Alignment, which require both graphical rendering and external API integration. Cloud-based technologies are also essential in supporting AI-driven applications. Miller et al. (2023) emphasized that cloud computing provides scalable storage and processing power required for handling large amounts of image data and AI computation. This is particularly important for systems like Space Alignment, where user-uploaded images are processed externally through AI services and then returned as redesigned outputs. Cloud storage services such as Cloudinary enable efficient image management and fast retrieval, ensuring smooth system performance.

These technologies are commonly used together in modern interior design applications, where each one contributes to improving how users visualize and plan spaces. AI handles analysis and generation of design outputs, AR provides real-time visualization within physical environments, and cloud systems support the processing and storage of data needed for these features. When combined in a single system, they make it possible to create more practical tools that assist users in understanding and improving room layouts in a more efficient way.

RESEARCH GAP AND STUDY RELEVANCE

Despite the advancements in Artificial Intelligence, Augmented Reality, and cloud-based technologies, many existing interior design applications still provide limited functionality and isolated features. Some systems focus only on AI-generated room redesign, while others primarily emphasize augmented reality furniture placement without intelligent room analysis or optimization. In addition, several existing applications require expensive subscriptions, professional design knowledge, or high-end hardware, limiting accessibility for ordinary users. Previous studies have demonstrated the effectiveness of AI in generating room layouts and the usefulness of AR in improving visualization and user interaction. However, limited studies have explored the integration of AI-based redesign, AR visualization, and intelligent room analysis within a single mobile application designed specifically for accessible interior space planning. Most existing systems also focus heavily on visualization while providing minimal support for practical room optimization and design evaluation.

Because of these limitations, there remains a need for a unified and accessible mobile application that combines AI-assisted redesign, augmented reality visualization, and room analysis features into one platform. The development of Space Alignment addresses this gap by integrating these technologies within a single Android-based application that allows users to redesign, visualize, and optimize their living spaces in a more practical and interactive manner.

METHODOLOGY

RESEARCH DESIGN

This study employed a Developmental Research Design in the development of Space Alignment, an AI-assisted Android mobile application designed for room redesign, optimization, and visualization. Developmental research design is appropriate for studies that focus on the creation, improvement, and evaluation of systems, applications, or technological solutions intended to address existing problems or user needs. The study focused on designing and developing a mobile application capable of assisting users in visualizing and improving their living spaces through the integration of Artificial Intelligence (AI), Augmented Reality (AR), and cloud-based technologies. The application allows users to upload room images, generate AI-based redesigns using selected interior design themes, receive room optimization suggestions, and visualize conceptual room improvements.

The researchers utilized various software development tools and technologies in building the system, including Unity for Android application development, PHP and SQL for cloud-based functionalities and database management, Cloudinary for image storage, and Replicate API services for AI-generated image processing and visualization. These technologies were integrated to provide users with an interactive and intelligent room design experience. The study also involved testing and evaluation procedures to assess the functionality, usability, and overall performance of the developed application. Feedback and observations gathered during testing were used to identify necessary improvements and ensure that the system met the objectives of the study. Through the use of developmental research design, the researchers were able to systematically create, refine, and evaluate the proposed system to provide a functional and user-centered AI-assisted interior design application.

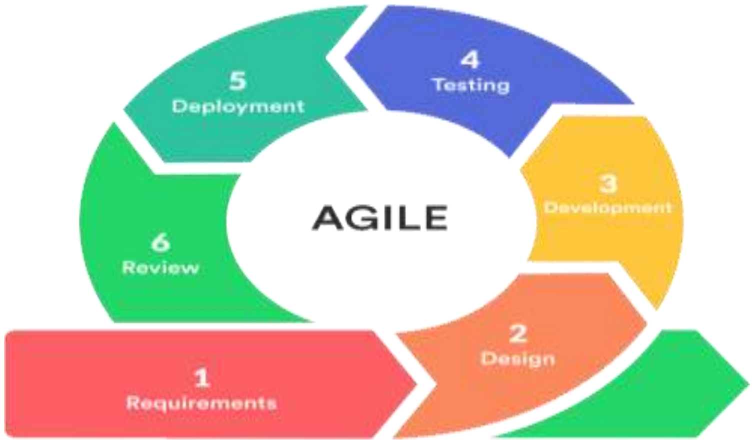


Figure 3.1 Agile Software Development Life Cycle Model

REQUIREMENT ANALYSIS PHASE

During the Requirement Analysis phase, the researchers identified the problems and challenges related to room visualization and interior design planning. The researchers analyzed common difficulties experienced by users when redesigning or optimizing room spaces, such as the inability to visualize room improvements, limited access to professional design tools, and lack of interior design knowledge. The researchers determined the functional and technical requirements needed for the proposed system, including room image uploading, AI-generated room redesign, room optimization analysis, augmented reality visualization, and cloud-based image handling. Necessary software tools, APIs, development platforms, and programming technologies were also identified during this phase. Additionally, the researchers analyzed the needs of the target users and determined the required system functionalities, interface components, and application features necessary to achieve the objectives of the study.

DESIGN PHASE

During the Design phase, the researchers created the graphical user interface (GUI), application layouts, navigation flow, and system structure of the proposed mobile application. The researchers designed the upload panels, theme selection panels, optimization panels, result panels, and augmented reality interfaces to ensure user-friendly interaction and accessibility. The researchers also prepared system diagrams such as flowcharts, data flow diagrams, use case diagrams, and entity relationship diagrams to visually represent the processes, workflows, and functionalities of the application. The user interface was designed to provide a clean, organized, and accessible experience for users with minimal technical knowledge.

Additionally, the researchers designed the flow of AI processing, image uploading, cloud communication, and result generation processes within the system.

DEVELOPMENT PHASE

During the Development phase, the researchers implemented the actual coding and creation of the application components. Unity was utilized as the primary platform for developing the Android mobile application, while C# scripting was used to manage system functionalities, user interface interactions, and API communication processes. The researchers developed various system features including image uploading, AI-generated room redesign based on selected interior design themes, AI-generated room optimization analysis, conceptual room optimization visualization, and augmented reality viewing functionalities. Cloudinary was utilized for cloud-based image uploading and storage, while PHP and SQL were used for backend functionalities and database-related processes. The researchers continuously modified and refined the application features during development to improve system performance, usability, and functionality.

INTEGRATION PHASE

During the Integration phase, the researchers combined and connected the different components, technologies, and functionalities of the system to ensure smooth communication and operation between all modules. Various APIs, cloud services, databases, and user interface components were integrated into the mobile application. The researchers integrated Replicate AI APIs for AI-generated room redesign and optimization visualization, Cloudinary for cloud-based image uploading and storage, and PHP and SQL for backend processes and data management.

The augmented reality functionality and user interface navigation were also integrated within the Unity development environment.

Additionally, the researchers ensured that the system components, including image uploading, AI processing, room visualization, and result generation, functioned properly as a unified system. Necessary adjustments and refinements were conducted during the integration process to improve compatibility, responsiveness, and overall system performance.

TESTING AND VALIDATION PHASE

During the Testing and Validation phase, the researchers conducted various tests to evaluate the functionality, usability, and overall performance of the developed prototype. The system was tested to ensure that its major features, including room image uploading, AI-generated room redesign, room optimization analysis, conceptual visualization, and augmented reality viewing, were functioning properly.

The researchers performed functionality testing to identify possible errors, bugs, and system issues that could affect the application's performance. User interface testing was also conducted to evaluate the responsiveness, accessibility, and consistency of the application's navigation and design components. Additionally, validation of the system was conducted through observations and user feedback to determine whether the developed prototype successfully met the objectives of the study.

The researchers assessed the effectiveness of the AI-generated outputs, system usability, and user interaction experience. The results gathered during testing and validation were used to refine and improve the application's overall functionality and performance.

REVIEW PHASE

During the Review phase, the researchers evaluated the overall effectiveness, usability, and performance of the developed system based on testing results, observations, and user feedback. The researchers reviewed whether the objectives of the study were successfully achieved and identified areas requiring further improvement.

The strengths and limitations of the system were also analyzed, particularly regarding the AI-generated visualization outputs and the limitations of current AI image-generation technologies in preserving exact room structure, furniture arrangement, and room details during optimization processes. Feedback and observations gathered during the review process were utilized to identify recommendations and possible improvements for future development and enhancement of the proposed system.

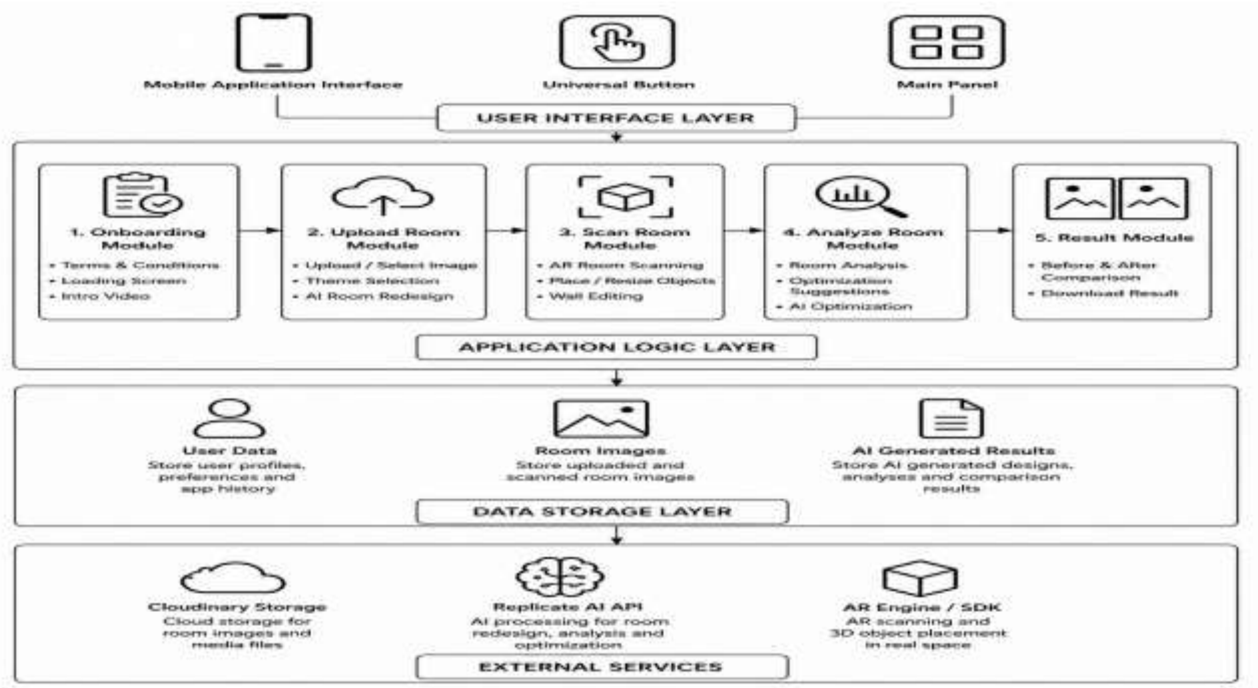


Figure 3.2 Proposed Space Alignment System Architecture

The proposed AI-powered room redesign system follows an Input–Process–Output (IPO) model to efficiently transform user room images into optimized interior design recommendations. In the input stage, the system gathers data from users through the mobile application interface, including uploaded room images, user preferences, selected design themes, and AR room scan data. Additional inputs are also obtained from external services such as cloud storage, AI APIs, and AR engine tools that support room scanning and object detection.

During the processing stage, the system handles the collected information through several application modules. First, the onboarding module manages user registration, terms and conditions, and introductory guidance. Next, the upload room module processes room image uploads and theme selections. The scan room module uses augmented reality technology to scan the room, detect dimensions, and allow object placement or wall editing. After scanning, the analyze room module performs AI-driven room analysis, optimization, and redesign generation based on the user's preferences and room structure. Finally, the result module prepares the redesigned outputs, including before-and-after comparisons and downloadable design results.

In the output stage, the system generates AI-enhanced room redesigns, optimized layouts, interior design suggestions, and visual comparisons of the original and redesigned spaces. The system also stores user profiles, uploaded room images, and generated AI results in the data storage layer for future access and continuous improvement. Through the integration of AI technology, cloud storage, and AR functionality, the system provides users with an interactive and intelligent room redesign experience.

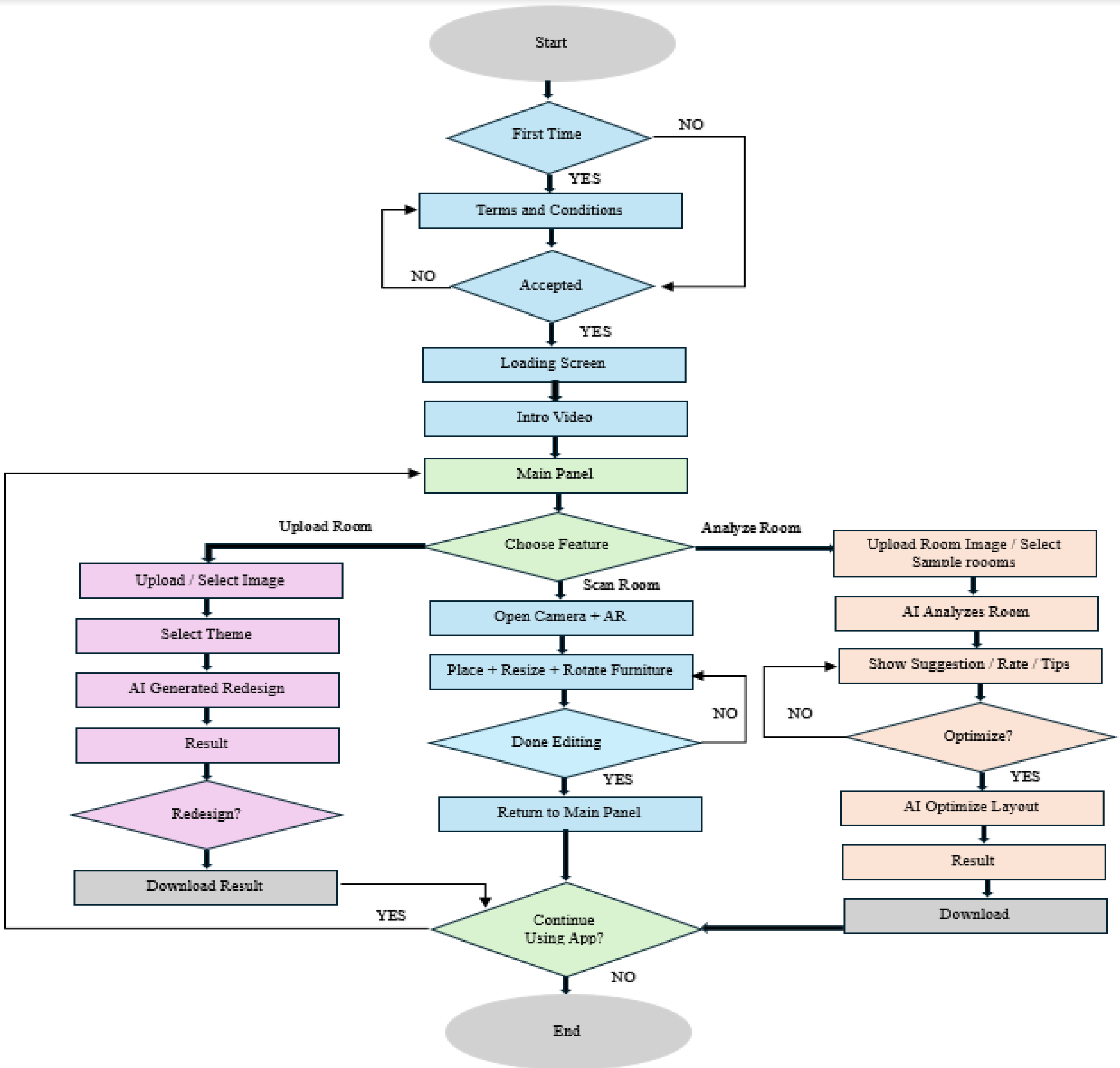


Figure 3.3 Flow Chart Diagram of the Proposed Space Alignment System

The flowchart illustrates the overall process flow of the AI-powered room redesign system. The process begins when the user opens the application. If the user is accessing the system for the first time, they are required to read and accept the terms and conditions before proceeding to the loading screen, intro video, and main panel. From the main panel, the user can choose among three main features: Upload Room, Scan Room, and Analyze Room. In the Upload Room feature, users upload or select a room image, choose a preferred design theme, and receive an AI-generated redesign result which can later be downloaded. In the Scan Room feature, the system uses augmented reality (AR) technology to scan the room and allow users to place, resize, or rotate furniture before saving the edited layout. In the Analyze Room feature, users upload room images for AI analysis, where the system provides suggestions, ratings, and optimization tips to improve the room layout. After completing any feature, users may either continue using the application or exit the system. The flowchart demonstrates how the application integrates AI and AR technologies to provide an interactive and intelligent room redesign experience.

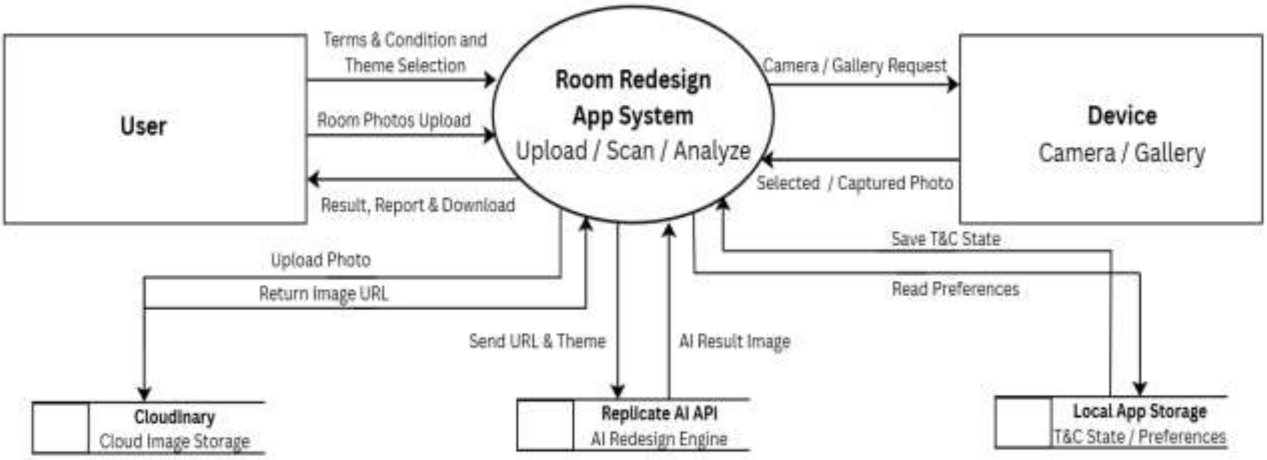


Figure 3.4 Data Flow Diagram of the Space Alignment System

The Data Flow Diagram (DFD) illustrates how data moves within the AI-powered Room Redesign App System, which consists of three major processes: upload, scan, and analyze. The process begins when the user interacts with the application by accepting the terms and conditions, selecting design themes, and uploading or capturing room images through the device camera or gallery. In the upload process, room photos are sent to Cloudinary cloud storage, where image files are stored and converted into accessible image URLs. During the scan process, the application communicates with the device camera or gallery to capture or retrieve room images for further processing. In the analyze process, the generated image URL together with the selected theme is sent to the Replicate AI API, which performs AI-based room redesign and optimization. The AI-generated result image is then returned to the application and displayed to the user. Additionally, the system stores user preferences and terms-and-conditions states in local app storage for future access. The DFD demonstrates how the user, device, cloud storage, AI engine, and local storage interact to support the intelligent room redesign functions of the application.

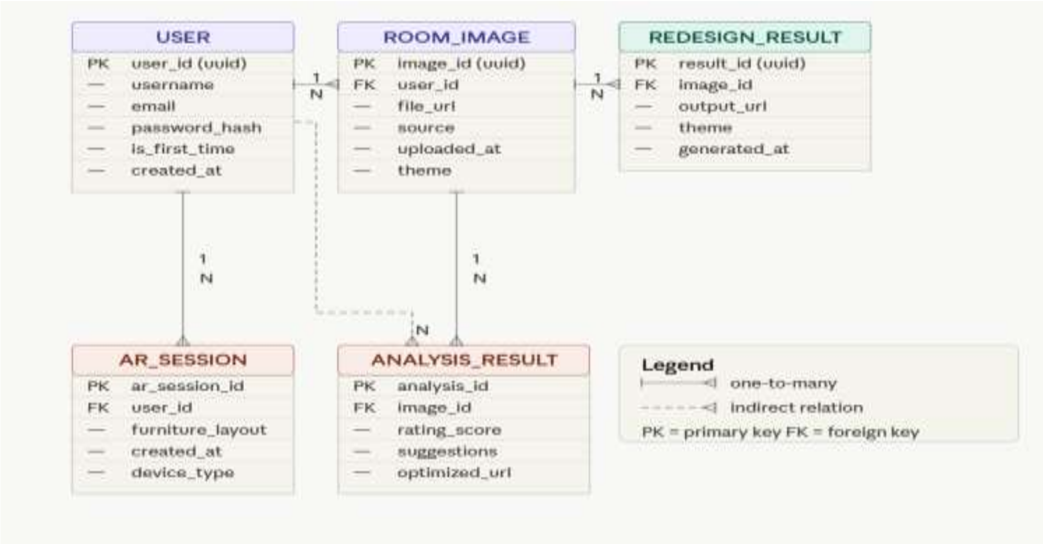
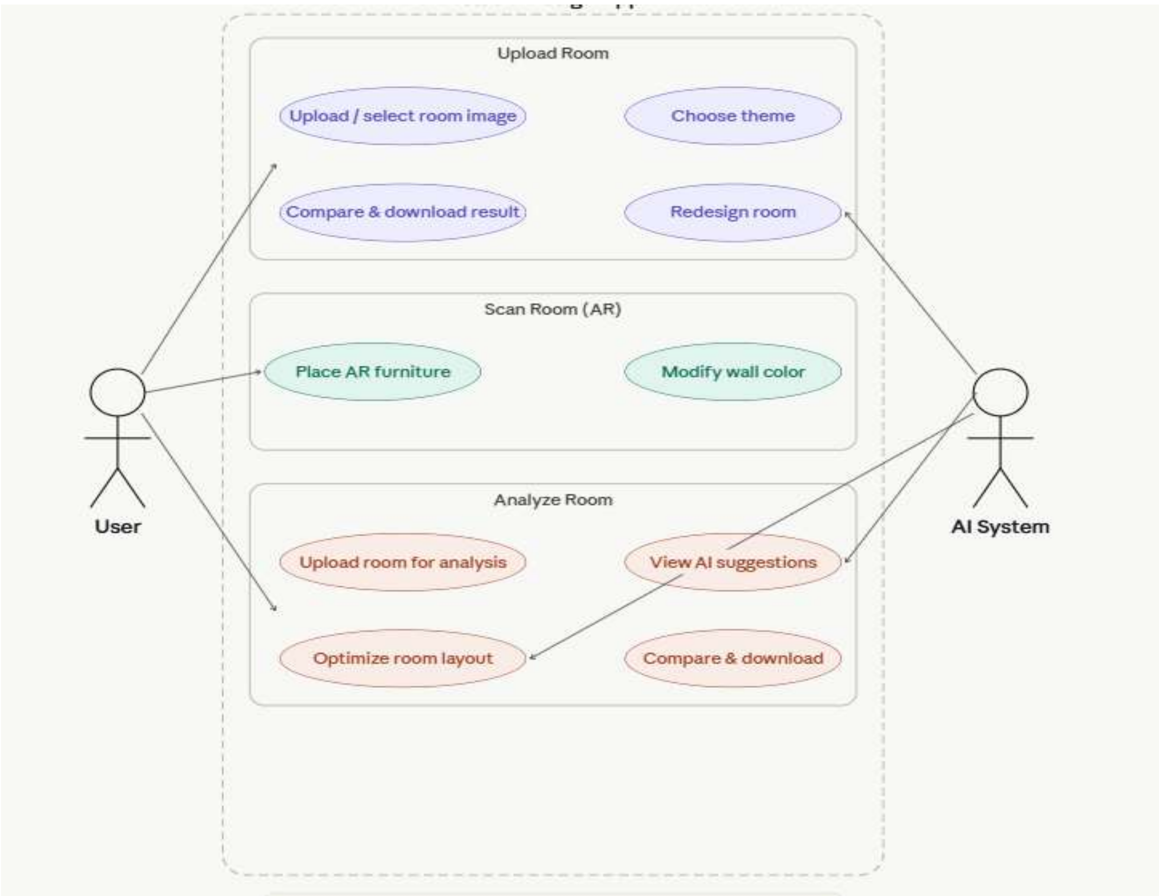


Figure 3.5 Entity Relationship Diagram

The Entity Relationship Diagram (ERD) illustrates the database structure of the AI-powered Room Redesign Application and shows how user data, room images, AI-generated results, and AR sessions are connected within the system. The USER entity stores user account information such as user ID, username, email, password hash, first-time login status, and account creation date. A single user can upload multiple room images and create multiple AR sessions, establishing a one-to-many relationship between the USER entity and both the ROOM_IMAGE and AR_SESSION entities. The ROOM_IMAGE entity stores uploaded room images along with their file URL, image source, upload date, and selected design theme. Each room image belongs to one user but may produce multiple redesign and analysis results. This creates a one-to-many relationship between ROOM_IMAGE and both the REDESIGN_RESULT and ANALYSIS_RESULT entities. The REDESIGN_RESULT entity contains the AI-generated redesign outputs, including the result ID, image reference, generated output URL, selected theme, and generation date. This table stores the final redesigned room outputs produced by the AI engine. The ANALYSIS_RESULT entity stores room analysis data generated by the AI system, including room ratings, design suggestions, and optimized room layouts. These results are linked to the uploaded room images for evaluation and improvement purposes. Lastly, the AR_SESSION entity records augmented reality interactions such as furniture layouts, device type used, and session creation date. This allows the system to save and manage AR-based room editing activities performed by users. Overall, the ERD demonstrates how the application organizes and manages user information, uploaded room images, AI redesign outputs, room analysis data, and AR sessions to support the intelligent room redesign process.



Insert Figure 3.6 Use Case Diagram

The Use Case Diagram presents the interactions between the users and the proposed system, *Space Alignment*. It illustrates the major functionalities of the application and demonstrates how users interact with the system's features, including room redesign, augmented reality visualization, and room optimization analysis. The diagram identifies the primary actors involved in the system, namely the User and the AI System. The User is responsible for uploading room images, selecting design themes, interacting with augmented reality features, requesting room analysis, and viewing generated results. Meanwhile, the AI System processes uploaded room images, generates redesigned room visualizations, provides room optimization suggestions, and produces conceptual optimized room layouts based on user inputs. The Use Case Diagram also illustrates the major processes within the system, such as uploading room images, redesigning rooms using selected themes, comparing and downloading generated outputs, placing virtual furniture using augmented reality, modifying wall colors, analyzing room layouts, viewing AI-generated suggestions, and generating optimized room visualizations. These functionalities collectively demonstrate the overall workflow and interaction processes of the proposed application.

Use Case	Actor	Description
Upload / Select Room Image	User	Allows the user to upload or select a room image for AI processing and visualization.
Choose Theme	User	Allows the user to select an interior design theme for room redesign.

Redesign Room	User, AI	Generates a redesigned room image based on the uploaded room and selected theme.
Download Result	User	Allows the user to download the generated room result.
Place AR Furniture	User	Allows the user to place virtual furniture within the room using augmented reality.
Modify Wall Color	User	Allows the user to preview and modify wall colors using augmented reality.
Upload Room for Analysis	User	Allows the user to upload a room image for AI-based room analysis.
View AI Suggestions	User, AI	Generates room optimization suggestions and recommendations based on the uploaded room image.
Optimize Room Layout	User, AI	Generates a conceptual optimized room layout visualization based on AI analysis.

Table 3.1 Space Alignment System Use Case Diagram Summary

Table 3.1 presents a summary of the major use cases of the proposed Space Alignment system. It describes the primary functions available to users and identifies the corresponding actors involved in each process. The table highlights the interaction between the User and the AI System in performing tasks such as room image uploading, theme selection, AI-powered room redesign, augmented reality furniture placement, wall color modification, room analysis, and layout optimization. Overall, the use case summary provides a concise overview of the system's core functionalities and user interactions within the application.

RESULTS AND DISCUSSION

The developed system, *Space Alignment*, is an Android-based mobile application that integrates Artificial Intelligence (AI), Augmented Reality (AR), and cloud-based technologies to assist users in visualizing, redesigning, and improving interior spaces. The application was developed using Unity Technologies and C# programming language, while Cloudinary was utilized for image storage, Replicate AI for AI image generation and analysis, and Google ARCore for augmented reality functionalities. The system provides three major features, namely Upload Room, Scan Room, and Analyze Room, which collectively support room visualization, furniture arrangement, and space optimization.

AI-Based Room Redesign

The Upload Room feature allows users to upload room images or select sample images provided by the application in order to generate redesigned room outputs based on selected themes and prompts. During system testing, uploaded images were successfully transferred to Cloudinary and converted into accessible image URLs for AI processing.

The generated image URLs were then processed through Replicate AI to create redesigned room outputs. The generated outputs demonstrate that the system is capable of producing visually improved and realistic room redesigns that align with selected themes and user preferences. Users were able to compare original and generated images through the swipe comparison feature, download generated outputs, and request multiple redesign variations using different prompts and themes. The feature provided users with alternative room design ideas without requiring physical rearrangement of furniture or manual redesign efforts Variations in generated outputs were observed depending on image quality, lighting conditions, room complexity, and selected design themes. Despite these variations, the system consistently produced meaningful redesign outputs that support user decision-making in interior space planning. These findings support previous studies which indicate that artificial intelligence can effectively generate visual design outputs and spatial recommendations for interior design applications.

Figure 4.1 Upload Room – Image Selection Preview and AI Generated Redesign Output

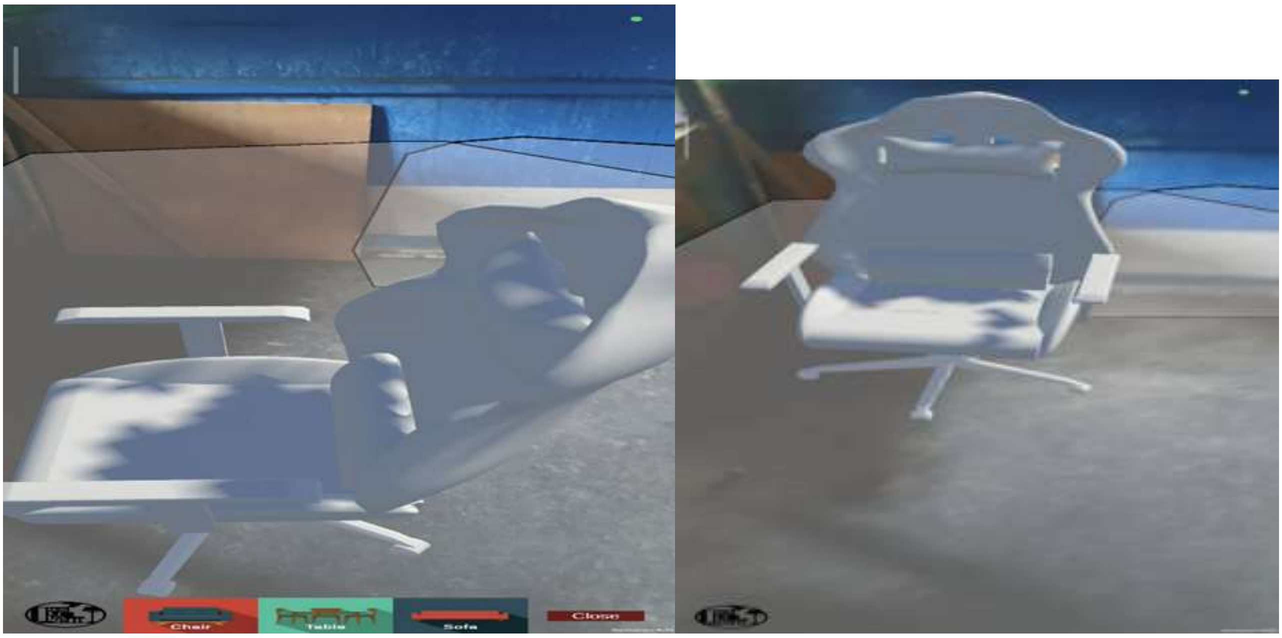
Augmented Reality Visualization

The Scan Room feature utilizes augmented reality technology to provide real-time visualization of furniture and design elements within physical environments. During testing, the system successfully detected floor and wall surfaces using ARCore and allowed users to place virtual furniture within scanned areas. Users were also able to resize, rotate, reposition, and customize placed objects according to their preferences.

The results show that the feature provides an interactive visualization experience that improves users' understanding of room layouts and spatial arrangements. Users were able to experiment with furniture placement and room organization without physically moving objects inside their environment. The application also allowed wall color visualization in real time, further improving the room planning experience.

The placement of virtual objects was generally stable and aligned properly with real-world surfaces, particularly on devices with higher hardware capabilities. However, testing showed that AR performance may vary depending on camera quality, processing power, sensor availability, and lighting conditions. Lower-end devices occasionally experienced reduced tracking stability and slower rendering performance. Despite these limitations, the feature remained functional and effective in supporting real-time room visualization and furniture placement.

The findings support previous studies emphasizing the effectiveness of augmented reality in improving spatial visualization, user interaction, and design decision-making within interior design systems.



4.2 Scan Room – Floor Plane Detection and Furniture Placement

AI-Based Room Analysis and Optimization

The Analyze Room feature was developed to evaluate room images and generate outputs that include room ratings, design suggestions, and optimized room layouts. During testing, the system successfully processed uploaded room images and generated analysis results related to space utilization, furniture arrangement, and overall design quality.

The generated optimization outputs provided users with alternative room arrangements intended to improve spatial organization and functionality. Users were able to compare original room images with AI-generated optimized outputs through the swipe comparison feature integrated within the application. The system demonstrated the ability to identify layout issues and provide suggestions that may assist users in improving room arrangement and space usage. However, it was observed that while the feature successfully improved room layouts and spatial arrangements, the AI-generated optimized outputs did not consistently preserve the original visual appearance of the room. In several outputs, changes in wall colors, furniture colors, textures, and material appearance were observed even though the implemented AI prompts contained multiple restrictive instructions intended to preserve the original room design elements. This behavior is associated with the inherent characteristics of generative AI image models. Although prompt engineering techniques were applied to minimize unnecessary visual modifications, the AI model still prioritized generating visually coherent and aesthetically enhanced outputs rather than strictly maintaining all original room attributes. As a result, certain visual elements such as colors, textures, lighting, and furniture appearance may be altered during image generation. Despite this limitation, the feature remained effective in generating improved spatial arrangements and providing users with alternative layout concepts that support room planning and interior design decision-making. The findings are consistent with existing studies involving AI-generated image systems, where generative models are effective in design generation and layout optimization but may exhibit limitations in preserving exact visual consistency from original input images.

Figure 4.3 Analyze Room – Room Evaluation and Optimization Result

System Performance

The overall performance of the system was evaluated based on functionality, responsiveness, stability, and usability across all major features of the application. The results indicate that the system operated successfully in handling image uploads, AI image processing, augmented reality interaction, and navigation between application panels.

Cloudinary integration enabled efficient image uploading and retrieval, while Replicate AI successfully generated redesign and analysis outputs within acceptable response times depending on internet connection speed. The augmented reality feature maintained stable object placement and accurate surface detection on supported devices. The user interface was also observed to be organized and easy to navigate, allowing users to access features and results without significant difficulty.

Performance differences were observed based on internet connectivity and device specifications. Devices with higher processing capabilities demonstrated faster AI processing, smoother navigation, and more accurate AR rendering. Lower-end devices occasionally experienced delays during AI processing and reduced AR stability. Internet speed also affected the response time of cloud-based AI generation and image retrieval processes.

Despite these limitations, the system maintained overall functionality and stability throughout testing and successfully delivered the intended features of the application.

Figure 4.4 System Main Panel Interface

Discussion of Findings

The findings of the study indicate that the developed application successfully demonstrated the integration of artificial intelligence, augmented reality, and cloud-based technologies within a single mobile platform for room visualization, redesign, and space optimization. The system was able to generate AI-based room redesigns using uploaded room images and user-selected themes, allowing users to explore alternative interior layouts and design concepts without physically modifying their environment.

The Upload Room feature demonstrated the capability of AI systems to generate redesigned room outputs that support interior design planning and visual decision-making. The Scan Room feature showed that augmented reality technology can improve spatial visualization and furniture arrangement planning through interactive real-time object placement within physical environments. Meanwhile, the Analyze Room feature demonstrated the ability of AI systems to evaluate room layouts, generate design suggestions, and provide optimized room arrangements intended to improve space utilization and organization.

The study also highlighted several practical limitations associated with AI-generated image systems and mobile augmented reality technologies. In particular, AI-generated optimization outputs may alter visual room elements such as colors, textures, and furniture appearance despite the use of restrictive prompts intended to preserve the original room design. In addition, AR performance remains dependent on device hardware capabilities, environmental lighting conditions, and sensor accuracy.

The findings support previous literature emphasizing the effectiveness of artificial intelligence in image generation and spatial analysis, as well as the usefulness of augmented reality in improving visualization and user interaction. The developed application demonstrates that combining these technologies within a mobile environment can provide users with a more accessible and practical approach to interior space planning and room optimization.

CONCLUSION

The study focused on the development of *Space Alignment*, an Android-based mobile application that integrates Artificial Intelligence (AI), Augmented Reality (AR), and cloud-based technologies for room visualization, redesign, and space optimization. The application was developed using Unity Technologies and C# programming language, with Cloudinary utilized for cloud image storage, Replicate AI for AI image generation and analysis, and Google ARCore for augmented reality functionalities. The developed system demonstrated the practicality of integrating multiple emerging technologies within a single mobile platform intended for interior design assistance and spatial planning. The findings of the study showed that the application successfully provided users with tools for visualizing and improving room layouts through AI-generated redesigns, real-time augmented reality interaction, and AI-based room analysis. The AI-Based Room Redesign feature enabled users to upload room images and generate alternative room designs based on selected themes and prompts. The generated outputs provided users with visual representations of possible room arrangements and design improvements without requiring physical rearrangement of furniture or actual room modification. The feature demonstrated that AI systems can assist users in exploring alternative design concepts and improving decision-making related to interior space planning.

The Augmented Reality Visualization feature further demonstrated the effectiveness of AR technology in improving spatial understanding and user interaction. The system successfully allowed users to place, resize, rotate, reposition, and customize virtual furniture within real-world environments through real-time camera interaction. This feature provided users with a more interactive and immersive method of planning room layouts and furniture arrangements while reducing the need for physical trial-and-error adjustments. The results also showed that augmented reality can improve user visualization and room planning experiences by allowing users to immediately observe how furniture and room elements appear within actual physical spaces.

The AI-Based Room Analysis and Optimization feature successfully generated room evaluations, layout suggestions, and optimized room arrangements based on uploaded room images. The system demonstrated the capability to identify issues related to room organization, furniture placement, and space utilization while providing alternative layout recommendations intended to improve room functionality and efficiency. However, the study also identified limitations associated with generative AI image models. Although the implemented AI prompts contained multiple restrictive instructions intended to preserve the original appearance of the room, the generated optimized outputs did not consistently maintain visual elements such as wall colors, furniture colors, textures, materials, and lighting conditions. This limitation is associated with the behavior of generative AI systems, which prioritize visual coherence and aesthetic enhancement over exact preservation of original room attributes. Despite this limitation, the generated outputs remained useful in presenting improved spatial arrangements and assisting users in room planning and interior design decision-making.

The study demonstrated that the integration of artificial intelligence, augmented reality, and cloud-based technologies within a mobile application can provide users with an accessible, interactive, and practical tool for room redesign and spatial optimization. The developed system reduced the need for manual furniture rearrangement and provided users with alternative room design concepts that may assist in improving space utilization and room organization. The findings of the study also support previous research emphasizing the effectiveness of AI in image generation and spatial analysis, as well as the usefulness of augmented reality in improving visualization and interaction within interior design applications. Overall, the study showed that mobile-based AI and AR technologies can be effectively utilized to support interior space planning and provide users with more convenient and efficient room design assistance.

RECOMMENDATIONS

Based on the findings, system performance, and limitations observed during the development and testing of the application, several recommendations are proposed for future improvements and further studies related to AI-assisted interior design systems.

Future researchers who may adopt or continue this study are encouraged to explore more advanced artificial intelligence models or image editing approaches that focus on preserving the original visual appearance of room images during optimization and redesign processes. During system testing, it was observed that AI-generated outputs occasionally altered wall colors, furniture colors, textures, lighting conditions, and material details despite the implementation of restrictive prompts. Future implementations may incorporate segmentation-based processing, object-preservation techniques, or constraint-based AI models to improve visual consistency while still generating optimized room layouts and redesign suggestions.

Researchers are also encouraged to conduct additional studies involving larger groups of users in order to further evaluate system usability, functionality, user satisfaction, and effectiveness in real-world environments. User-centered testing involving homeowners, students, renters, and interior design enthusiasts may provide more detailed feedback regarding interface usability, visualization quality, and practical usefulness of the system. The inclusion of quantitative evaluation methods and usability assessment tools may also strengthen future studies related to AI-assisted room planning applications.

Future developers may improve the augmented reality functionality of the system by enhancing surface detection, object tracking stability, and rendering performance, particularly for lower-end Android devices. Since AR performance was observed to depend on camera quality, lighting conditions, processing power, and sensor availability, further optimization techniques may help improve system accessibility and consistency across a wider range of mobile devices.

Additional furniture models, design themes, and customization options may also be integrated into the application in order to provide users with more flexibility in creating room layouts and personalized interior designs. Future versions of the system may include support for multiple room categories such as bedrooms, kitchens, offices, classrooms, and commercial spaces to expand the usability of the application beyond residential environments.

Future studies may also consider integrating automated room measurement systems, budget estimation tools, furniture dimension recommendations, or material suggestion features in order to improve the practicality of the application for actual interior planning and renovation purposes. Integration with real-world furniture catalogs or online shopping platforms may further enhance the usefulness of the system by allowing users to view or purchase furniture items related to generated room designs.

Lastly, future researchers may expand the application to support additional platforms such as iOS and tablet devices to improve accessibility and reach a larger group of users. Further improvements in cloud optimization, AI processing speed, and offline functionality may also help improve overall system performance and user experience in future implementations of the study.

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