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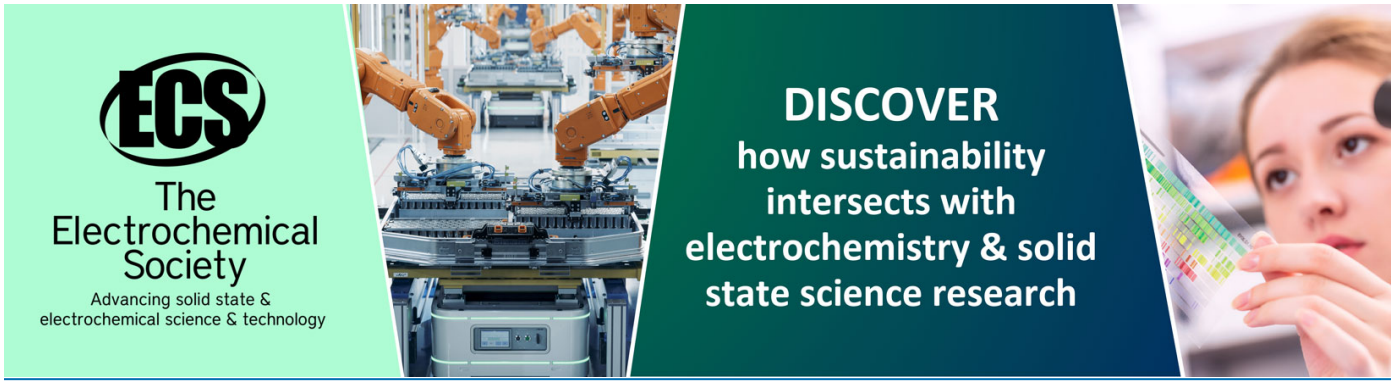

3D rooms map concept based augmented reality for green library

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Abstract. Green libraries are an exciting topic for creating environmentally friendly buildings. Libraries are synonymous with book lending services and comfortable reading rooms. The green library concept will be in line with increasing the comfort of library visitors. Libraries with large buildings need room maps for visitors to find room information. This research aims to create a room map with the concept of Augmented Reality (AR). Room maps generally use 2D images that provide information or instructions for all rooms in a building. The Augmented Reality approach as a 3D-based room map will undoubtedly provide a different experience to library visitors. Creating an AR room map will apply the Multimedia Development Life Cycle (MDLC) method. This method is suitable for application in multimedia product development. However, the resulting product is not only used as room map information but can also be used as a library promotional tool.

Keyword: augmented reality, green library, rooms map

1. Introduction

The library is a crucial gateway to knowledge contributing to society. As an organization, the library has a role in meeting the information and knowledge needs of the community [1], including contributing to environmental sustainability. Over the past few decades, libraries have engaged in various activities aimed at minimizing the negative impact on the environment, closely related to the concept of the green library [2]. The green library represents a tangible effort to support environmental sustainability. It carries out various initiatives to reduce ecological impact and promote environmental awareness among the community.

The green concept in libraries encompasses various activities to promote environmental friendliness. By introducing changes to the library's day-to-day activities, it is possible to integrate environmentally friendly practices [3]. A green library also includes using eco-friendly technology, strategic planning, and implementing environmentally friendly practices, contributing to sustainability in libraries. The concept of a green library needs to be developed to support environmental conservation efforts. One of the most prominent features of a library is its book collection. However, ensuring the comfort of library visitors is also a factor that should be considered.

The green library is one of the concepts that aims to provide a unique experience to library visitors. Libraries are expected to be ready for change, transitioning from traditional to hybrid, then from hybrid to virtual, and finally from virtual to green libraries [4]. There are various forms and activities, including guidance services using maps. People who visit the library only sometimes know where certain rooms are located. In this regard, maps become a necessity in the library. In this aspect, the green library concept incorporates the creation of 3D maps. 3D technology is widely used for various purposes, including interactive media [5], educational materials [6], introducing tangible cultural heritages[7], and the development of serious games with varying levels of difficulty [8].

This paper will discuss the concept of a green library with a 3D design, where the 3D design of the library will be connected to a map that will ultimately produce an Augmented Reality-based spatial map product. The 3D design is constructed using Blender, a prominent open-source application for creating 3D products [9]. The interface design requires adjustments [10], including organizing objects exported from Blender within the Unity software.

2. Method

Two methods are used in this research, first using the Multimedia Development Life Cycle (MDLC) [11] to create a 3D space design, then a statistical analysis method to see user responses. The MDLC method, which consists of six main stages, can be seen in Figure 1. The first stage is “Concept”, where the basic concept is formulated. The second stage is “Design”, which details the design of the spatial map. The third stage is “Materials Collection”, where the necessary data and materials are collected. The fourth stage is "Assembly", where all the elements of the 3D library are assembled. The fifth stage is “Testing”, where the 3D spatial map is tested to ensure its quality and performance. Finally, in the last stage, "Distribution", the spatial map created is disseminated.

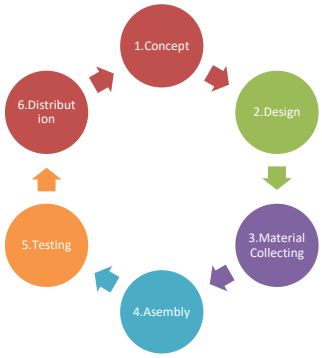

Figure 1. Multimedia development life cycle (MDLC) method (Luther, 1994).

The final stage in this process involves distributing the completed 3D library spatial map design and collecting evaluation data from users [12]. The method used for data collection is the Likert scale through a questionnaire. The completed design is submitted to the college library for user evaluation according to the research's objectives. This process allows for user assessments that can provide valuable input and feedback related to the 3D library spatial map design based on Augmented Reality.

3. Results and Discussions

3.1 Concept

The concept of Green Building, or environmentally friendly buildings, involves various criteria for assessing a structure's sustainability and environmental impact. There are at least 14 knowledge categories related to Green Building [13]. However, in the context of this research, not all Green Building concepts can be implemented in the planning and design of library spaces. In this study, the primary focus is on space limitations using plants and windows as a substitute for lighting fixtures.

3.2 Design

In the design phase, the next step is to illustrate the concept established in the previous stage by creating a spatial map image, as seen in Figure 2. In this process, the spatial map design is created using the Drawio application, producing 2D images that will be used as markers. The Vuforia application is then utilized to activate these markers, subsequently used to display 3D objects. Vuforia is a commonly used application for creating markers for Augmented Reality-based applications, primarily due to its compatibility with mobile devices [14].

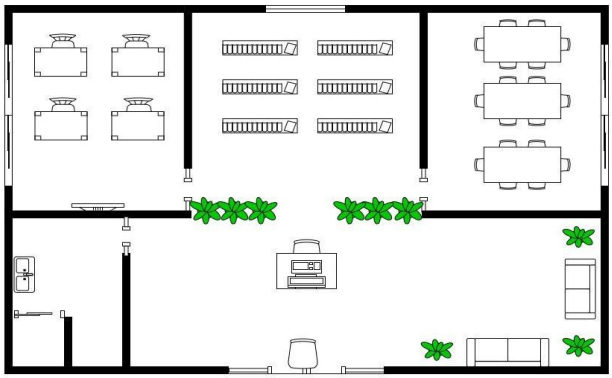

Figure 2. Design of 2D map

3.3 Material Collection

In the stage of designing the 3D Augmented Reality library space, the next step involves gathering 3D objects to complete the furnishings in the library space. As seen in Table 1, these objects are sourced from the Blender Kit resources, providing various types of 3D objects that can be utilized in this research. It is important to note that the objects used in this design are freely available, minimizing costs in implementing the Augmented Reality-based green library design concept.

Table 1. Blenderkit Assets

Asset	Name	By
	Sunday Sofa	Abdelrahman Mohamed
	Pot Bush	Rex Hans
	Door	Jan Holinka
	Office Desk 1200 * 600mm	The Doctor
	Led Tv	ArtAmin
	Office Chair	Rex Hans
	Wood Vase With Grass	Rex Hans
	Low Poly Grass Mix 01	Rex Hans
	Loft Coffee Table	Patryk Zemsta
	Chair	ShareTextures Textures
	Window Al Double Short	Parametr Studio
	Procedural Bookshelf Stylized For Cartoons	Tobias Pisarovic
	Monitor 3D Model	Mohammadreza Farhadfar
	Shower Door	Mesk911

	Bath Spout Shower Tap Double Bathroom Sink	Cezary ArtAmin Mesk911

In addition to using 3D objects from the Blender Kit, in the room design, walls and floors are created using materials in the form of images sourced from freepik.com. A list material image can be see in Table 2.

Table 2. Material Image

Asset	Name	Creator
	Free vector wood planks texture background parquet flooring	kjpargeter
	Free vector damask seamless pattern background	GarryKillian

3.4 Asembly

The next step in designing 3D space for the Augmented Reality-based library is to design 3D objects using Blender software. Figure 3 shows five space designs in a blender: waiting room, collection room, reading room, meeting room, and bathroom. Creating realistic 3D objects is one of the critical processes in 3D design [14].

Figure 3. Space Design in Blender

The next step is to export the designed 3D objects from Blender software into a .fbx file format. This is necessary to open and integrate these objects into the Unity application. Based Figure 4 can explain that five model 3D placed on the marker. Unity plays a crucial role in controlling how 3D objects are displayed when used in conjunction with markers. This process is crucial to developing the Augmented Reality-based 3D library spatial map, allowing these objects to interact with the natural environment through Augmented Reality technology [15].

Figure 4. Augmented Reality Design in Unity

3.5 Testing

The testing phase involves experimenting with printed markers or 2D maps. The testing is successful if the marker can display 3D objects when the camera is directed towards it. Testing is successful when the created marker can display the 3D room objects as a whole, and this function can be deemed effective [16]. The testing results indicate that the Augmented Reality system can effectively recognize and display 3D objects when the marker is detected. Figure 5 illustrates that the marker can display the 3D design virtually.

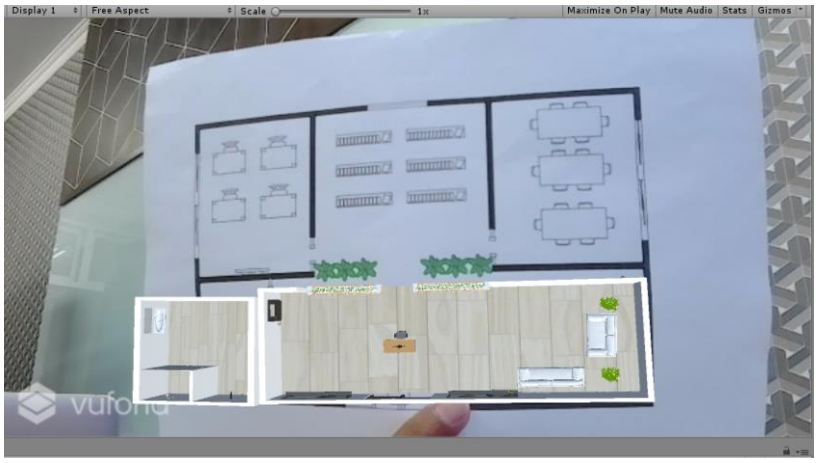

Figure 5. Testing the marker on the camera

3.6 Distribution

The next stage in the research is distributing the Augmented Reality-based 3D library spatial map design to users for evaluation to determine whether this concept is well-received. This evaluation is conducted by gathering user feedback through a questionnaire that employs a 5-level Likert scale. After collecting the response data from college library users who have interacted with the 3D Augmented Reality-based map design, the next step is calculating the average of the user responses. This process provides valuable insights into how users respond to and perceive the 3D library spatial map design based on Augmented Reality that has been developed. The results of this evaluation serve as a basis for improvements and refinements to the design according to user needs and preferences.

Table 3. Likert Scale

Scale Measurement	Score Value
Highly Agree (HA)	5
Agree (A)	4

Neutral	3
Disagree (D)	2
Strongly Disagree (SD)	1

The formula to calculate the mean or average from a set of data is as follows:

$$\textbf{Mean} = (\Sigma x) / n \quad (1)$$

Mean : Represents the average.
Σx : Stands for the sum of all values in the sample or population.
N : Represents the total number of values in the sample or population.

Calculating the mean or average is an essential step in statistical analysis. In this context, the mean is used to obtain the central or average value from a data set in a sample or population. The result of calculating the mean provides a statistical representation of the central tendency of the data. The results of the design calculations, which were distributed to 100 respondents, obtained the results as below:

Table 4 . Results of Respondents' Answers

Answer	Score Value	Frequency (N)	Mark Questionnaire (∑x)	Percentage
Strongly Disagree (SD)	1	0	0	0%
Disagree (D)	2	2	4	2%
Neutral (N)	3	24	72	24%
Agree (A)	4	38	152	38%
Highly Agree (HA)	5	36	180	36%
Total		100	408	100%
Mean			4,08	

From the data obtained, it is evident that most respondents responded positively to the 3D Augmented Reality-based library spatial map design. About 36% of the respondents strongly agreed with the design, while another 38% agreed. Approximately 24% of the respondents responded neutrally to the design, with only 2% expressing disagreement. The resulting mean score of 4.08 falls into the "strongly agree" category. These findings reflect strong acceptance of the 3D Augmented Reality-based library spatial map concept, with the majority of respondents expressing a high level of approval for the design. This data provides a positive outlook regarding the potential implementation of this concept within a university library environment.

4. Conclusion

The concept of Green Buildings or environmentally friendly buildings involves assessing various criteria. In this research, the library design with the green library concept uses plants as a substitute for space partitions. Although not all aspects of Green Building are implemented, this approach can be used as a first step in utilizing green library principles. Testing aims to ensure that the marker can display 3D objects, and user evaluation using a Likert scale results in positive responses to the design. The average score from user responses is 4.08, reflecting positive acceptance of this design and indicating good potential for implementation in a university library environment. The research results show that AR space maps can be developed in university libraries that have or are currently developing the green library concept**.**

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