Revolutionary Hologram Systems: Pioneering a New Frontier in Visual Technology

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New technologies are enabling the development of consolidated, portable holographic displays that can be utilized in a variety of settings, making holographic content more accessible and shareable. Holographic displays represent objects in three dimensions, providing a more pragmatic and immersive viewing experience. This is particularly important in sectors such as architecture, design, and medical imaging, where the representation of depth can aid in comprehension and decision-making. This study presents a revolutionary and efficient method for converting 2D images into immersive 3D holograms using Blender software and a holographic FP. The process begins with Blender, an open-source 3D creative software that transforms 2D photographs into dynamic 3D models to add depth and realism. These transformed images are then uploaded to a user-friendly mobile app, which acts as an intermediary for seamless transfer to a holographic display. The smartphone app offers an intuitive interface for image customization and management. This study contributes to the understanding and practical application of 3D holographic displays by addressing key challenges and outlining the development process, resulting in a versatile tool. These recent breakthroughs in holography are expanding its potential applications and enhancing user experiences, making holographic technology increasingly significant in industries such as healthcare, education, entertainment, and data visualization.

3D Holographic Technology	3DHT
Digital Micro-mirror Device	DMD
Spatial Light Modulator	SLM
Computer-Generated Holograms	CGHs
Head-Up Displays	HUDs
Fan Projector	FP
Virtual Reality	VR
Visual Technology	VT

Keywords: Holography; 2D Images; 3D Models 3; (FP), (VR); VT.

Introduction:

Holography has made significant advancements in VT, with the potential to revolutionize how we perceive reality and present information. Barcello et al. [1] discovered that holographic systems are now an important part of modern technology. Many researches explored their creation, applications, and future impact across industries. From its early conception by D. Gabor et al. [2], holography has evolved into a multidimensional technology. J. Barabas [3] examined its development, tracing the shift from simple intervention patterns to the complex 3D holographic displays we see today.

It is increasingly used in the medical field for imaging, diagnostics, surgical planning, and a better understanding of internal organs. It acquires detailed images of tissues, aiding the surgical process. Y. Gao et al. [4] proposed augmented reality for preoperative planning, allowing surgeons to use holographic CT or MRI data to determine optimal surgical paths. J. Hatzl et al. [5] noted the growing use of 3D holographic imaging in vascular surgery for precise evaluation of arteries, stenosis, and calcification. Advances by B. Fida et al. [6] have enabled surgeons to use this technology intraoperatively, improving surgical outcomes.

The intent of utilizing 3D holographic images during a procedure is to facilitate faster and safer tissue dissection while preventing the possibility of iatrogenic injury. During endovascular repair, this technique, in conjunction with two-dimensional angiographic images, may facilitate the navigation of endovascular instruments, most likely with less radiation and contrast exposure.

All vascular segments, as well as any nearby tissues or organs, can be instantly recognized during open surgeries, as proposed by K. West et al. [7]. Virtual 3D holograms can be used to aid precision in dissection and the performance of all phases involved in open vascular surgery, particularly those procedures related to peripheral or aortic artery disease. These holograms have the potential to become a new, next-generation tool that supports operations in terms of simplicity, sharing, and spatial awareness.

Practical Implication:

Holography has made significant advancements in VT, with the potential to revolutionize how we perceive reality and present information. Barcello et al. [1] discovered that holographic systems are now an important part of modern technology. Benton [18] explored their creation, applications, and future impact across industries. From its early conception by D. Gabor et al. [2], holography has evolved into a multidimensional technology. J. Barabas [3] examined its development, tracing the shift from simple intervention patterns to the complex 3D holographic displays we see today.

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Research Objectives:

The aims of the current study are as follows:

- To investigate the fundamental principles of holography to recreate three-dimensional scenes from human and construction model holograms using a holographic fan.
- To develop innovative human holographic displays that convert 2D images into 3D visuals, with applications in product visualization and branding.

Research Scope:

Development of the innovative tool:

The creation of holographic systems has drawn significant attention recently due to their potential applications across a variety of industries, including entertainment, healthcare, education, and others. Recent technological developments have made it possible for users to interact with virtual objects in a three-dimensional world, creating holographic experiences that are more realistic and engaging. This study elucidates the process for developing human holographic displays, making it a useful tool for future research related to holographic systems.

The real-time visualization:

Through the development of holographic systems, the real-time visualization process would become much easier and more engaging, as these human holographic displays involve the conversion of 2D images into 3D visuals. This technology could be implemented in education, the media industry, security, branding, and the medical field, particularly in medical imaging.

Literature Review:

Haleem et al. [8] explored the role of holography in the Industrial Revolution. Holography has a wide range of applications in medicine, the military, weather forecasting, VR, digital art, and security. This technology is used for quality control in manufacturing products and provides services in other technology sectors, such as architecture, 3D modeling, mechatronics, and robotics. Unlike other 3D projection technologies, holograms can be viewed with the naked eye. They are excellent for conveying complicated technological topics and displaying aesthetically appealing items. Because holograms are complicated and challenging to create, they have a significant advantage in commercial security. However, digital holographic instruments and screens are quite expensive, and when using holography for 3D imaging techniques, substantial quantities of processing power, memory, and storage are necessary to compute holographic reconstructions.

Another study by J. Kim et al. [9] investigated predictions for potential application scenarios and interaction principles of holographic displays in future automotive cockpits. Moreover, for the evaluation and testing methods of holographic technology, the VCAP model is utilized. From the perspective of interaction models, holographic displays play an essential role in the evolution of vehicle displays by providing VR experiences, and great potential scenarios can be explored through this technique. However, current holographic displays are not mature enough to appear in mass-production vehicles; this may be due to optical equipment limitations or the high demand for cockpit power.

The study by H. Wei [10] highlighted the role of holographic projection technology in the field of digital media. The main applications of this technique include film production, digital media art exhibitions, and game development. The technique proposed for projecting holographic images is the Fresnel diffraction method, and a computer digital holographic projection system is used to drive the procedure of recording and recreating the holographic image of the art. Computer image processing technology is used to process the experimental simulation holographic projection image and generate the processed image after digital image transformation. However, according to the research, the construction of the optical physical environment for holographic projection is limited by economic conditions and knowledge reserves, which makes it relatively crude. This causes large errors in the experimental results, and the immature operation of the holographic projection process may also result in a decrease in the quality of the experimental results.

The study by Y. Liu et al. [11] explored the value of 3DHT in the field of engineering education, particularly in mechanical engineering. The authors aim to understand the significance of 3DHT in learning and teaching environments, identify its strengths and weaknesses as a teaching tool, and explore the obstacles to its integration into learning environments. The study emphasizes how 3DHT can enhance engineering education, particularly in subjects like Engineering Graphics, Engineering Drawing, and CAD/CAM. It provides examples of how 3D holographic projection can assist in visualizing and understanding complex engineering concepts. The paper also acknowledges some challenges associated with 3DHT, including its high installation cost and the requirement for a high-speed internet connection. The need for specialized screening rooms and compatible lighting and video technology is also mentioned.

The study by N. Li et al. [12] implemented the Teaching Factory concept to enhance education by connecting engineering teams with students for collaborative manufacturing projects. The research focuses on delivering educational content through hologram technology. A prototype has been developed, incorporating mobile devices and gesture recognition for improved collaboration. The holographic system allows real-time visualization of complex 3D models in full size, facilitating effective learning. Unlike other VR settings, multiple users can simultaneously access the same 3D content. The proposed experimental arrangement will be evaluated in a laboratory with engineering staff and learners. Overall, this approach has the potential to revolutionize content delivery in education and enhance collaborative learning experiences.

In this work proposed by D. Blinder et al. [13], the issue raised was that previous holographic systems' displays were flat-panel-type systems with narrow viewing angles, which did not meet expectations for high-quality holographic displays. To meet such expectations, an electronic tabletop holographic display was proposed, showing full-perspective views of the model and providing a better understanding of the model's volume, shapes, and relationships among parts, visible to multiple viewers at the same time. The tabletop technique was successfully implemented with a commercially available DMD for the SLM device, along with a data server consisting of pre-calculated and stored hologram data for different viewing directions. The resolution and quality of the reconstructed hologram image were measured and analyzed in terms of 3D-MTF. However, this system still has some issues that degrade the quality, including binary amplitude encoding of the fringe and mechanical movement during image rendering time.

Novelty of Work:

The novelty of this research is significant because holographic systems have the potential to change the way we interact with information and our surroundings. Holograms can transform our reality through lifelike medical imaging, immersive educational experiences, breathtaking entertainment, and cutting-edge security measures.

Methodology:

Experimental Setup:

Outlining standards for selecting illustrative photos and settings, and ensuring regulated environments for precise evaluation, is essential. It also involves ensuring data privacy and obtaining participant consent, after which images should be chosen and presented in a way that complies with ethical standards. Finally, any conflicts of interest or potential biases must be disclosed

Manual 2D to 3D Conversion using Blender: Selecting representative 2D images for conversion and manually converting these images into 3D scenes using Blender's tools, while ensuring that visual quality and depth perception are consistent, is crucial. These 3D scenes are then exported from Blender to a mobile-compatible format, after which a specific mobile application is used to import and render the 3D content. Compatibility is checked, and parameters are fine-tuned for flawless mobile viewing. Finally, it is ensured that the 3D scene's rotation, intensity, and start and stop functions can all be controlled via the mobile app.

Mobile to 3D Hologram Fan Projection:

Setting up a Wi-Fi connection between the 2D Hologram FP and the mobile device, as well as configuring the mobile device's 3D Hologram FP app, is essential. It is important to ensure that there is fast and reliable data transfer so that real-time rendering is possible. Moreover, controls are added to the app to govern the holographic 3D scene's rotation, intensity adjustments, and start/stop functions. The holographic FP used in this study is shown in Figure 1. Table 1 provides essential details about the structure of the FP, highlighting its key features and specifications. Figure 2 illustrates the workflow of our study.

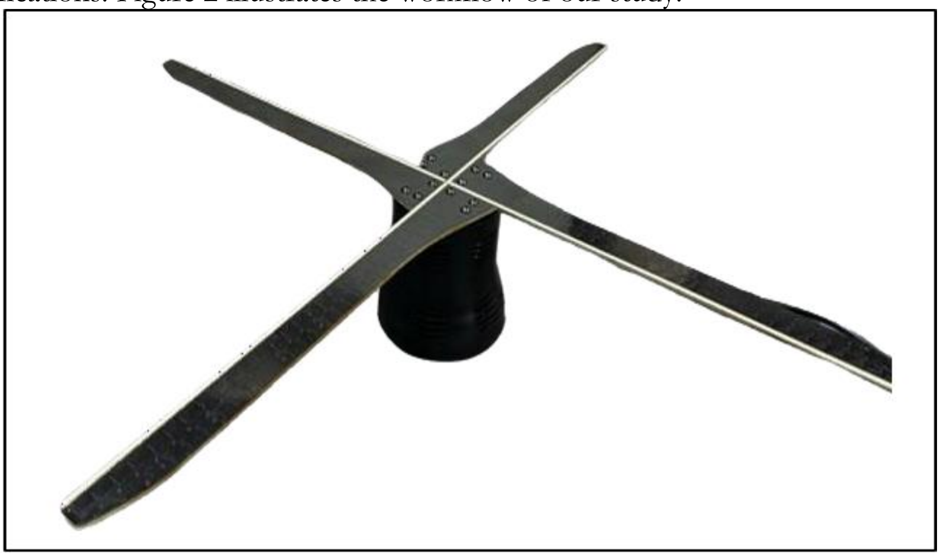

Figure 1: 3D Holographic FP [14]

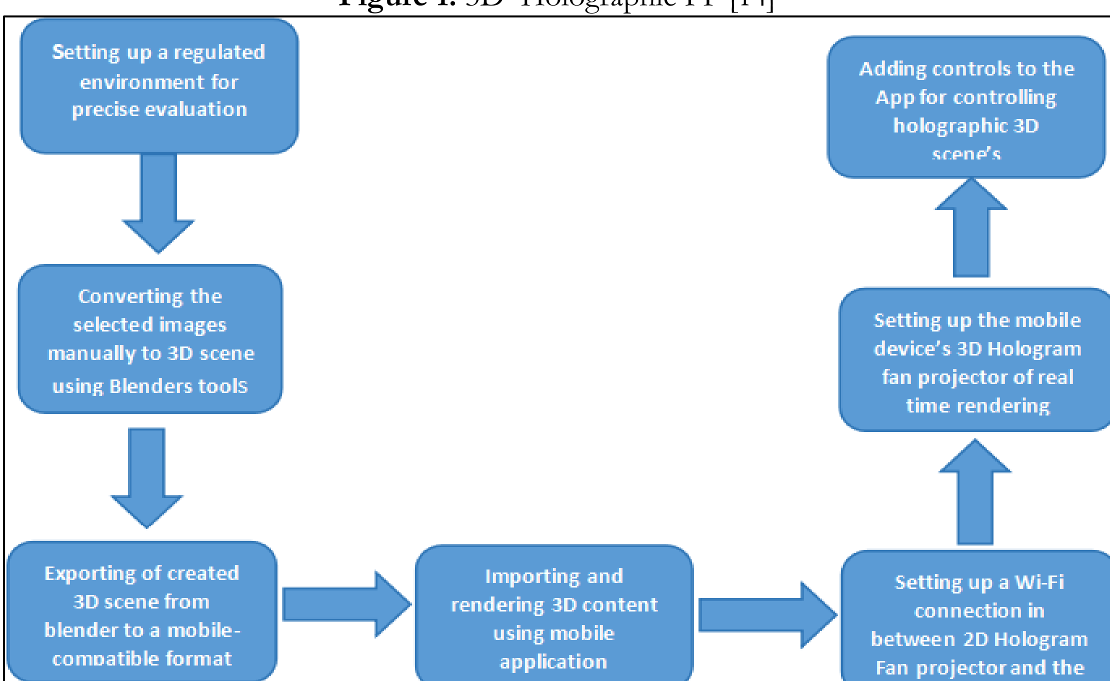

Figure 2: Workflow of Generating a Holographic Image

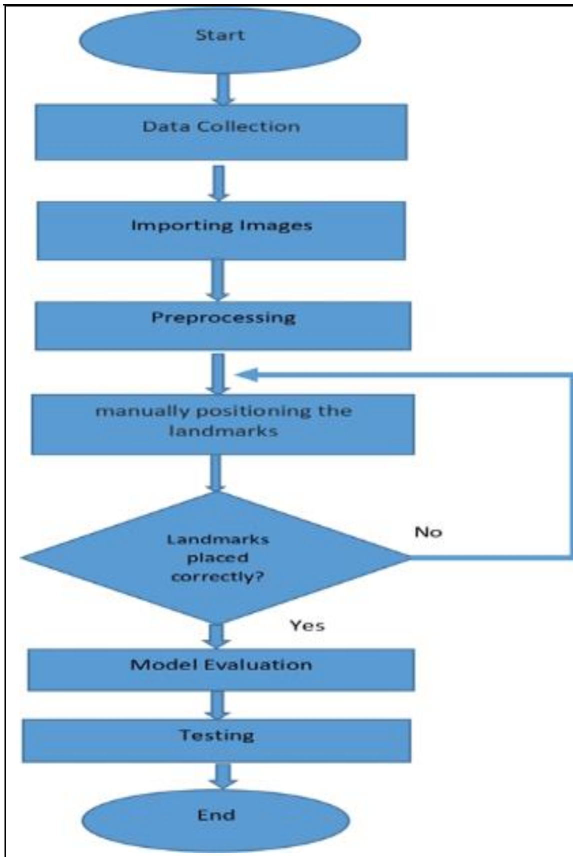

Figure 3: Flow diagram of the proposed study

Table1: Holographic FP Specifications

Brand	PROOLIN
Model	FA60N
Blade	4
Input	AC 100~240V 50/60Hz
Rated Power	70W
Resolution (Pixel)	512*512
Visual Angle	176O
Lamp Beads Life Time	500,000 Hours
Brightness	4000 cd/m2
Content Format	MP4, AVI, RM-VB, MKV, GIF, JPG, PNG
CPU	Quad-core Cortex TM-A7
Shell Material	ABS + PC / SECC
Work Temperature	-20 OC ~ 50 OC
PC Operation System	Window XP, Win7, Win 8, Win10
Diameter	56 cm
Box Size	480 mm x 150 mm x 130mm
Installation Mode	Wall Hanging, Landing and Carrying On

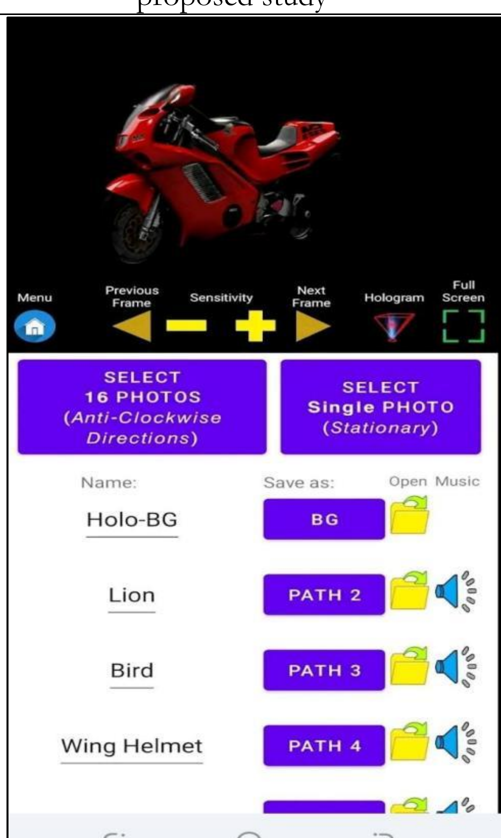

Figure 3a: Select image

Figure 3b: Image customization

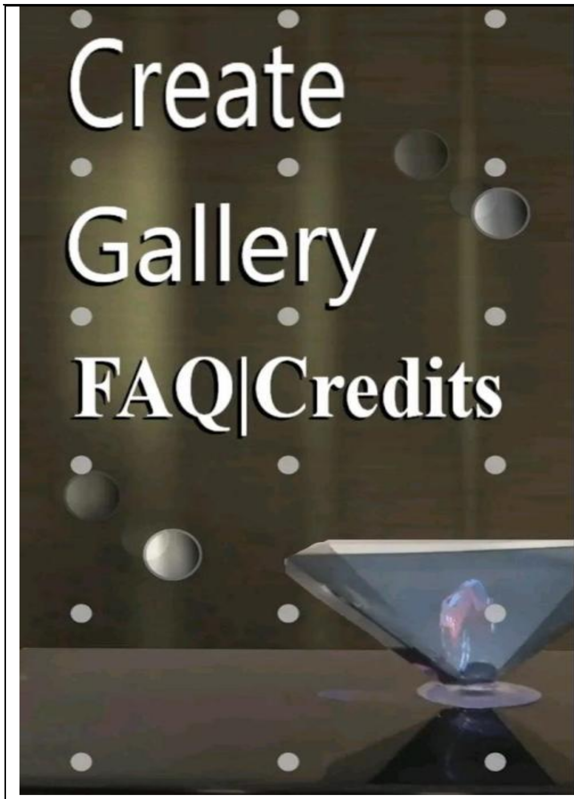

Figure 3c: Create gallery

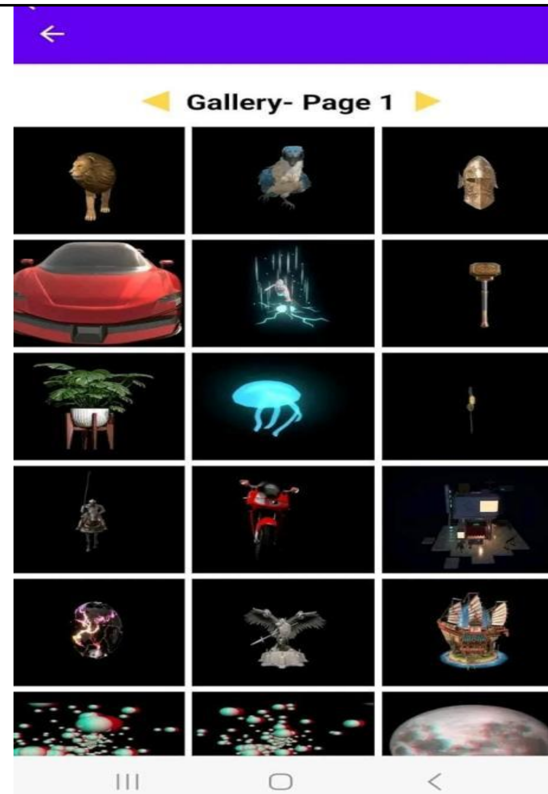

Figure 3d: Gallery page

Algorithm: Creating Face Models with the Keen Tools Face Builder Plugin

Input:

Creating face models using the Keen Tools Face Builder plugin.

- Data collection: Collecting four images that depict the front, left, right, and back views.
- Importing the 2D images: Import the selected two-dimensional images into the Blender workspace.

Preprocessing:

- Activating the Face Builder plugin: Activate the Face Builder plugin and click on the tool to start it.
- Familiarizing yourself with the plugin: Familiarize yourself with the UI and tool elements.
- Manually positioning face landmarks: Manually position the important facial landmarks on each photo using the Face Builder tools.
- Depicting landmarks: Process the eyes, nose, mouth, and other distinguishing features of the face.

Model Evaluate:

- Process of generating 3D models: Begin the creation of a 3D model.
- Streamlining and modification: Examine the 3D model from the front, left, right, and back. Adjust it to improve accuracy. Using the Face Builder plugin's elements, fine-tune the facial components. Adjust the proportions and overall quality for each view.

Testing:

Exporting the whole 3D model: Export or integrate the models to create a complete 3D representation.

Results & Discussion:

In this study, we successfully demonstrated how to transform 2D photographs into immersive 3D holograms using Blender software and a holographic FP. The open-source capabilities of Blender made it possible to quickly convert 2D images into dynamic, lifelike 3D models, which is a crucial function for creating eye-catching holographic displays.

The results of the experiment showed that a well-executed hair simulation could be used to construct and enhance a realistic 3D face model. The hair-specific particle technique effectively achieved the desired density and length, creating a texture that closely matched real human hair in terms of appearance. The model appeared dynamic and lifelike due to the alterations made in "Particle Edit" mode, which enabled complex styling. The "Shader Editor" allowed for adjustments to the color, shine, and transparency of the hair strands, further enhancing the overall realism of the hair material's appearance. The rendering process demonstrated how various techniques were combined to improve the model's appearance and facilitate smooth animation, proving that Blender is a powerful tool for 3D modeling. The successful rendering of the final animation highlighted the effectiveness of the methods used and their potential applications across various sectors, such as VR, gaming, and animation. The experiment also highlighted a few challenges, including the need for precise adjustments to achieve the best results and the potential for increased processing costs when creating complex scenes. These findings show that while significant progress has been made in 3D modeling approaches, further refinement and exploration of advanced features are still possible to enhance output quality and user experience.

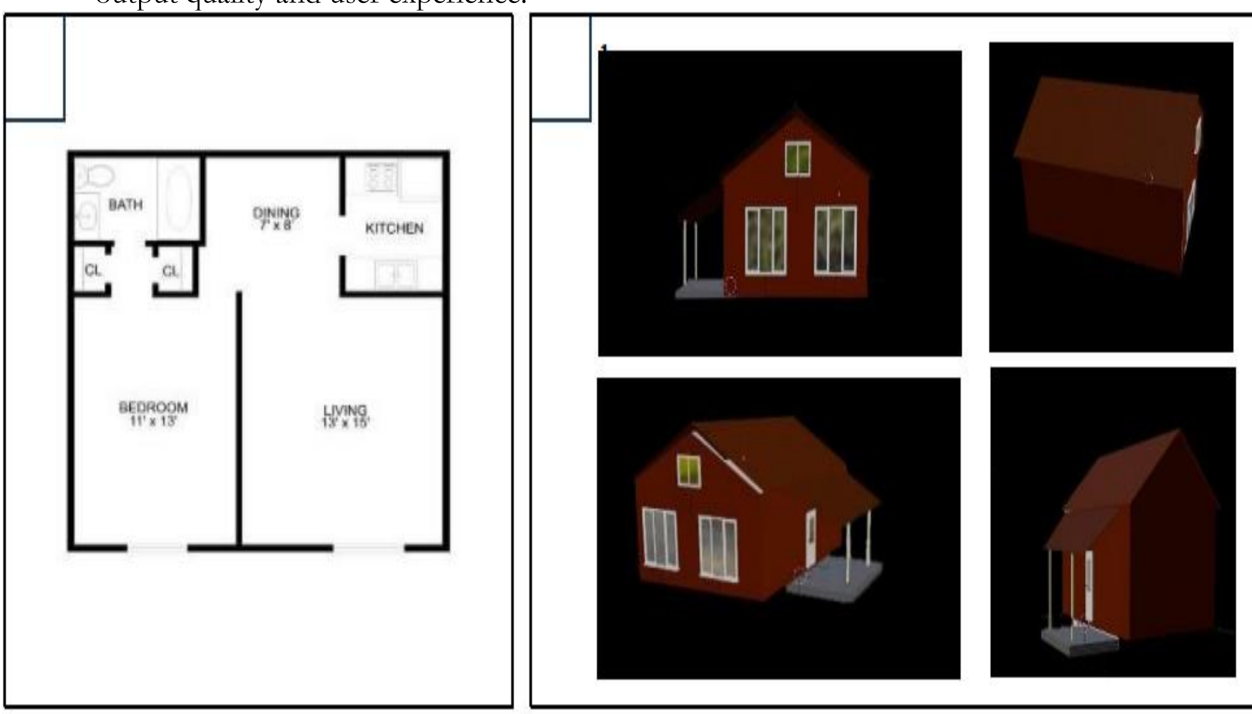

Figure 4: 2D blueprint and the 3D holographic model of a construction

The optimization led to the creation of an optimized mobile application that facilitated the management and modification of images. It served as a stable link between the 3D models and the holographic FP, making it easy to project the holograms onto the display. A wide range of users can optimize the system because, as shown in Figures 3a, 3b, 3c, and 3d, users can edit and modify the holographic content through the app without requiring technical expertise.

A few crucial steps need to be taken to create a 3D animation of a construction building. First, a film depicting the building process was made, focusing on the individual components that made up the structure. Then, using Blender software, this film was converted into a dynamic 3D animation that highlighted the movement and rotation of the building pieces, allowing for sophisticated design and animation of the construction process. After that, the 3D animation was adjusted to play smoothly on a holographic fan display by determining the correct frame rate, resolution, and alignment. The next step was to connect to the holographic fan via Wi-Fi using the "3D Display" mobile application. After entering the device's credentials, the device could be successfully accessed. Finally, the mobile app was used to upload the optimized 3D animation, which produced the holographic display of the construction model and the human model, as shown in Figure 4.

The graphic depiction of a 2D building blueprint's transformation is shown in Figure 4. Vertices and edges are precisely planned and extruded to create this complex metamorphosis. Interestingly, this technique coordinates the lifting of the initially flat 2D forms, a subtle process that involves the addition of height. The precision lies in aligning these augmented dimensions meticulously with the exact specifications outlined in the original blueprint. The 3D construction model surpasses conventional approaches by improving stakeholder participation, cost-efficiency, and dynamic visualization.

In practical tests across various industries, including healthcare, architecture, and education, the 3D holograms were found to significantly enhance comprehension and decision-making by providing more immersive, realistic visualizations. For example, medical professionals found them useful for viewing complex anatomical structures, while designers benefited from the depth and spatial clarity provided by the holograms.

Analytical analysis:

The analytical analysis of the proposed study focuses on several key aspects, including time complexity, space complexity, and the overall efficiency of the process. The time taken for data collection depends on the availability and selection of images. This is generally considered a constant time operation, O(1), since it involves a predefined number of images (four).

The import operation is dependent on the size of the images and the performance of the system. However, it is also a constant operation for a fixed number of images, so it can be considered O(1). Activating the plugin and familiarization operations take negligible time, approximately O(1).

For manually positioning face landmarks, the time complexity depends on the number of landmarks to be positioned. If n represents the number of landmarks, this is O(n). Similar to the positioning of landmarks, the time complexity for processing facial features can be considered O(m), where m is the number of features being processed.

For generating 3D models, the model generation time is dependent on the complexity of the model. It is a computationally intensive task and can vary significantly based on the implementation, typically O(k), where k represents the number of operations required for the generation. Each view evaluation (front, left, right, back) adds complexity. If adjustments are required for each view, and if p represents the number of parameters being adjusted, this can be represented as O(4p), simplifying to O(p) since the constant factor does not affect big-O notation.

For the testing phase, exporting the 3D model is generally a one-time operation, but the time taken can depend on the size of the model. Therefore, it is considered O(1).

Overall Time Complexity:

$$T(n)=O(1)+O(1)+O(n)+O(m)+O(k)+O(p)+O(1)=O(n+m+k+p).$$

This reflects that the time complexity is influenced by the number of landmarks, the features processed, and the complexity of model generation.

The space required for storing the images is O(4), which is constant, assuming each image occupies a fixed amount of space. For storing plugin data, it will require space for its user interface and processing data, which can also be considered constant space, O(1). The landmarks and facial features stored in memory will consume space relative to O(n) and O(m), respectively. The 3D model representation will require additional space, which can be considerable depending on its complexity, O(k).

Overall Space Complexity: $S(n)=O(4)+O(1)+O(n)+O(m)+O(k)=O(n+m+k)$

This means that the space complexity is influenced by the number of landmarks, features, and the complexity of the model.

The algorithm is efficient in that it breaks down the complex task of creating a 3D face model into manageable steps, each with a defined purpose.

The use of a plugin like Face Builder allows for a more intuitive and user-friendly approach to 3D modeling, reducing the learning curve for users who are unfamiliar with 3D modeling software.

Manual intervention in positioning landmarks ensures that the accuracy of the model is high, which is crucial for applications such as animation or medical imaging.

Limitations:

Its extensive use may be restricted by power requirements, the resolution limitations of the fan projection display, and increased costs. Some users experienced limitations based on hardware capabilities, which affected the performance and rendering quality of the models. Additionally, while the plugin is user-friendly, some users still require further training to fully utilize its features, particularly in the manual placement of landmarks. The success of the modeling process heavily depended on the quality of the input images. Poor-quality images resulted in suboptimal 3D models.

Using Blender and a holographic fan projection (FP), this study investigates the creation of portable holographic displays; however, it may encounter various obstacles. There may be a loss of clarity and detail while converting 2D photos into 3D holograms. The high resolution may need to be within a certain range to see the entire effect; this restriction could affect the immersive experience. This may not be feasible in many situations, particularly in environments with larger groups, as the output required for sectors like medical imaging and architectural design, which depend on minute details, might not be supported by current holographic displays. Despite Blender's open-source nature, producing lifelike 3D models from 2D photos can still be challenging and require specific expertise. Creating high-quality holograms could be difficult for users without prior 3D modeling skills. Additionally, portable holographic displays' viewing angle and display size are often limited.

Recommendation:

The value of this technology in critical industries could be established by comparing its depth accuracy with conventional 3D displays. Assessing the feasibility and potential for adoption of this technology would also benefit from market research

Discussion:

The findings suggest that this new approach to producing 3D holograms has wide-ranging effects across several industries. The simplified procedure lowers the entry barriers for individuals who may not have extensive technical experience, thereby increasing the usability and accessibility of holographic technology for a variety of applications. By enhancing the system's usability and flexibility, the integration of a mobile app into the workflow adds significant value.

Holograms hold great potential for use in education and entertainment, as they provide an interactive and engaging way to present information or narratives. In industries such as healthcare and architecture, for example, the ability to visualize content in three dimensions improves depth perception, which in turn leads to a better understanding of complex structures and more informed decision-making.

However, the paper also highlights some areas that require further research. While basic 3D holograms can be produced quite well using the current method, more complex visualizations may necessitate more advanced software or processing power. Additionally, the mobile app may undergo further development to enable more advanced customization features, such as real-time hologram modification. A comparison of relevant studies with our study is provided in the following table.

Table 2: Comparison of existing studies and proposed methodology

Reference	Contribution
Pedersen et al.[15]	This study presents the use of a 3D holographic augmented reality interface, the TombSeer program that seeks to bring virtual historical artifacts to life in a museum environment. The application's main goal is to bring displays back to life by crafting immersive, culturally rich experiences. To engage and educate people, TombSeer combines the historical depth of the ROM with Meta's holographic AR technology.
Skirnewskaja, J., & Wilkinson, T. D.[16]	The research aims to improve road safety by exploring holographic (HUDs) as a solution to the distraction caused by in-car displays.
Tu, H., Yuan et al.[17]	The paper explores the innovative use of fem-to-second laser technology to create (3D) (CGHs) within glass substrates.
Mavrikios et al.[18]	This study identifies and assesses the potential advantages of using holographic video conferencing for delivering seminars in higher education.
Hamzeh et al.[19]	The research introduces a method to generate holographic construction information from parametric models, facilitating faster and accurate bricklaying.
Our Study	Our research attempts to create a hardware and software-based holographic advertising system. Realistic 3D animations of a construction site and a person's face must be made, then the system must be tested and optimized for holographic fan projection. The goals attained improve holographic display technology, giving industries and companies a flexible tool for efficient consumer interaction and marketing.

Conclusion:

Holography remains the pinnacle of technology for rendering all the optical cues necessary for the human visual system to perceive images in true 3D. In contrast, other technologies such as (auto) stereoscopy, light-field displays, and volumetric displays face limitations and trade-offs that hinder full 3D rendering. However, these technologies may serve as transitional solutions, improving visual comfort as we progress toward fully realized holographic displays. Several challenges still need to be addressed. The two primary hurdles are the ability to compute photorealistic 3D holograms within a practical time frame and the development of an appropriate electronic device capable of reproducing large, high-resolution holographic 3D images.

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involved in this study. Furthermore, we confirm that this manuscript has not been published or submitted to any other journals.

Author's Contribution:

Rameez Ahmed is responsible for the conception, and design of the study. Kiran Hidayat contributed to the development of the methodology and execution of experiments. Shakil Ahmed provided critical feedback on experimental design and contributed to interpreting the results and drafting the manuscript. Raees Ahmed created a Mobile App for the study.

Conflict of interest: Authors declared no conflict of interest.

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