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APPROACHES TO 3D SCANNING OF TRANSPARENT OBJECTS WITH MOBILE APPLICATIONS

Gergely KOCSIS [7] – Ondrej TAKÁČ, PhD.[8] – Bence PÁSZTOR[9] – László HALÁSZ[10]

ABSTRACT

In our study, we investigated the performance of various photogrammetry-based mobile applications in scanning transparent objects. (We tested the following popular 3D scanner apps by name: Luma AI, Polycam, KIRI Engine, 3D Scanner App) To broaden the comparison, we also utilized the LiDAR scanner available on Apple Pro devices, examining whether applications that leverage this technology outperform standard 3D scanning apps. The resulting 3D models were evaluated and compared in terms of their usability and overall quality. Based on the user experience and the results obtained, we also examined the usability of the applications in education.

KEYWORDS

photogrammetry, artificial intelligence, 3d scanning, lidar, polycam, luma ai, kiri engine, education

INTRODUCTION

As an introduction, let's briefly look at what photogrammetry is, where it is used, and how it can be connected to education.

Photogrammetry and 3D modeling are rapidly evolving technologies that have a significant impact on several industries, such as geographic information systems, education, construction, heritage preservation, medicine, video games, and the film industry. The core principle of these technologies is to transform images and data from other sensors into three-dimensional models that digitally reconstruct real objects and environments. This method enables a richer and more accurate presentation of visual information, thereby elevating the possibilities for analysis and visualization to a new level. (Rongjun and Armin, 2020; Steve et al., 2020)

The basis of photogrammetry is the (geometric) analysis of visual information, which enables the creation of digital surface models (DSM), orthophotos, and three-dimensional meshes (3D mesh). In the photogrammetry process, spatial information is extracted by analyzing and comparing photographs taken from different angles. In modern photogrammetry, this process

[7] Mgr. Gergely Kocsis, J. Selye University, Faculty of Economics and Informatics, Department of Informatics, 106319@student.ujs.sk
[8] Ing. Ondrej Takáč, PhD., J. Selye University, Faculty of Economics and Informatics, Department of Informatics, takaco@ujs.sk
[9] PaedDr. Bence Pásztor, J. Selye University, Faculty of Economics and Informatics, Department of Informatics, 121638@student.ujs.sk
[10] Mgr. László Halász, J. Selye University, Faculty of Economics and Informatics, Department of Informatics, 124706@student.ujs.sk

can also be carried out using video files. The algorithms are capable of accurately identifying connection points between images, determining the position and shape of objects, as well as the textures necessary for realistic 3D modeling. (Euan et al., 2019; Steve et al., 2020)
Modern photogrammetry is becoming increasingly automated - and simpler, through the use of artificial intelligence (AI) and machine learning. These algorithms not only improve processing speed but also enhance data accuracy and reduce the need for human intervention. Machine learning supports the identification of usable points, geometric reconstruction, and the analysis of correlations between images, particularly in the case of large datasets. (Rongjun and Armin, 2020; Steve et al., 2020)

Mobile devices, such as conventional smartphones and tablets, also play a key role in the widespread adoption of photogrammetry. AR applications like EM3D or Polycam enable users to create 3D models easily at low cost or completely free of charge. These applications can be widely applied not only in professional industries but also in education, creative projects, and personal archiving. (Euan et al., 2019; Wernhuar et al., 2024)

The applications of photogrammetry and 3D modeling are highly diverse. In the construction industry, for example, three-dimensional models assist in planning and maintenance, while in archaeology and cultural heritage preservation they enable the digital documentation and conservation of monuments. In medicine, such technologies support the development of accurate diagnoses and treatment plans, particularly in the field of facial and maxillofacial surgery. (Rongjun and Armin, 2020; Euan et al., 2019; Steve et al., 2020)

In the field of education, photorealistic 3D models (PR3DMs) not only provide a visually rich learning experience but also offer new methodological opportunities for improving the teaching process. These models allow students to gain a deeper understanding of complex topics, such as mathematical, scientific, and geographical concepts. With the help of 3D models, learners can be actively engaged in the learning process, as the interactive manipulation of models, such as rotation, zooming, or displaying layers - can facilitate the understanding of the connection between theoretical knowledge and practical applications.

From a methodological perspective, such models are particularly useful in interactive learning environments, where students can explore geometric elements and complex structures at their own pace. For example, in a virtual classroom, students can use 3D models to examine the structure of geological layers, the organization of molecules, or the details of architectural designs. This form of interactive learning supports deeper cognitive processing, as students participate in the learning process not only as passive recipients but also as active explorers.

USED MATERIALS AND RESEARCH PROCESS

Our research was conducted indoors, under good lighting conditions, in a controlled environment.
We chose an everyday object, a transparent glass bottle, as the subject of 3D scanning. This is relevant due to the educational connection, as it is easier to obtain everyday objects for 3D scanning there.
During our research, we examined the differences among the applications used, their handling and the resulting 3D models.

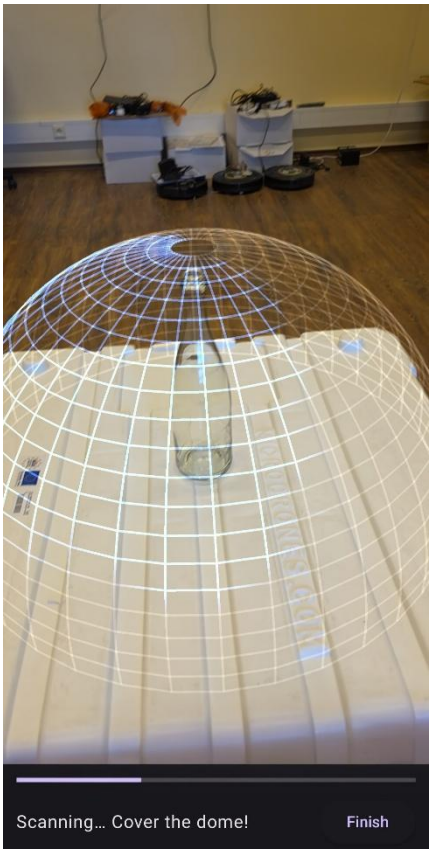
Used devices and materials:

- Samsung Galaxy S25 Ultra 256
- iPad Pro 12.9 2020 256
- transparent, clear glass bottle
- Luma AI: 3D Capture (android), (Google Play, Luma AI, 2025)
- Polycam 3D Scanner & Editor (android), (Google Play, Polycam, 2025)
- KIRI Engine (android), (Google Play, KIRI Engine, 2025)
- 3D Scanner App (iOS – iPadOS), (App Store, 3D Scanner App, 2025)

Three of the applications used (Luma AI, Polycam, KIRI Engine) were tested on an Android device, and the fourth application (3D Scanner App) was tested on an Apple iPad Pro, as it also utilizes the LiDAR sensor on the device. At the beginning of our research, we assumed that the application using LiDAR technology would give the worst results, as the laser beams would penetrate the transparent glass surface, thus destroying the 3D model. We also examined how the artificial intelligence application (Luma AI) performed compared to other applications used.

The first scan – Luma AI: 3D Capture (android)

The application uses artificial intelligence to create a 3D model. To enhance both accuracy and user experience during scanning, the software generates a virtual dome around the target object, guiding the user through an intuitive capture process in which the device, in our case, an S25 Ultra, must be moved around the object in a controlled path. This interactive feature ensures that images are collected from a wide range of angles, thereby improving the coverage of the object's geometry. There was no special sensor usage during its operation, it only used the camera of our device.



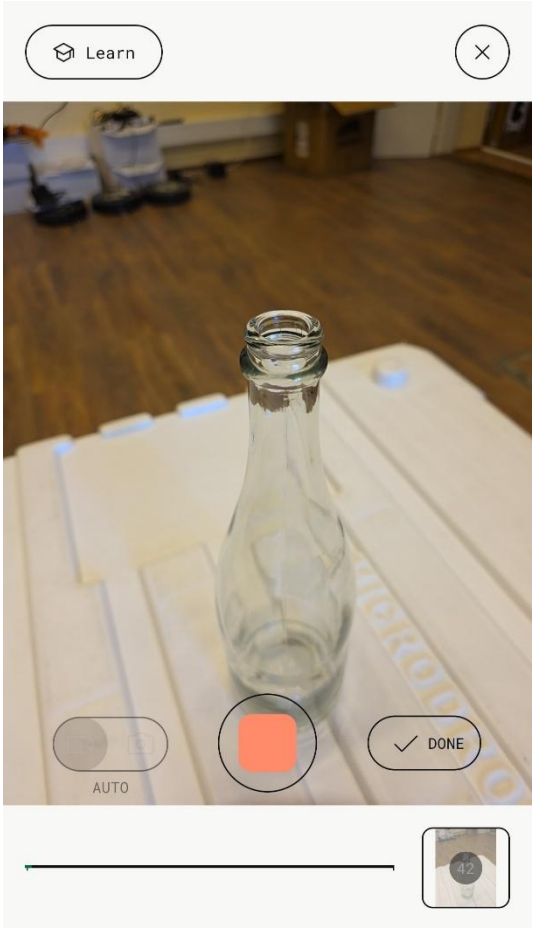
1. *Figure: Scanned object in the field of view of the Luma AI App*

The second scan – Polycam 3D Scanner & Editor (android)

The application operates without the support of any specialized sensors, relying exclusively on the built-in camera of our Android device (S25 Ultra) to perform the 3D scanning process.

To ensure comprehensive data capture, we had to physically move around the target object, allowing the software to record it from multiple perspectives and angles. This method enables the reconstruction of surface geometry by combining overlapping photographic inputs, although its effectiveness is highly dependent on the user's movement precision and the consistency of the captured images.

Such an approach highlights both the accessibility and the limitations of sensor-free mobile photogrammetry: while it broadens availability by functioning on standard smartphones, the accuracy and completeness of the resulting 3D models may vary significantly when compared with applications that utilize depth sensors or LiDAR technology.



2. *Figure: During the scanning process – Polycam app*

The third scan – KIRI Engine (android)

This application incorporates artificial intelligence only partially within its 3D reconstruction workflow, which limits its capabilities compared to more advanced solutions such as the Luma AI app, where AI plays a central and comprehensive role throughout the entire modeling process.

Unlike applications that leverage additional hardware features, this app does not employ any specialized sensors; instead, it relies exclusively on the camera of our Android device (S25 Ultra) to capture the necessary visual data.

In order to ensure that the object was documented from multiple perspectives, the scanning procedure required us to physically walk around the target, thereby allowing the software to detect and process as many geometric and textural details as possible. While this method supports the creation of a basic three-dimensional representation, the partial reliance on AI may result in lower reconstruction accuracy and quality when compared to fully AI-driven applications, particularly in handling challenging surfaces such as transparent or reflective materials.



3. Figure: During the scanning process – KIRI Engine

The fourth scan – 3D Scanner App (iOS)

This application integrates a specialized sensor in addition to the standard camera system, namely the LiDAR scanner available on our Apple device, to enhance the 3D reconstruction process.

During scanning, the procedure required us to physically walk around the target object to provide the application with sufficient data from multiple perspectives. However, it quickly became evident that the transparent glass bottle selected as the test object was not detected by the system, while the surrounding environment was successfully captured and modeled with precision. This outcome highlights a key limitation of LiDAR technology when applied to transparent or translucent materials, as the sensor is unable to accurately interpret surfaces that transmit or refract light.

Despite this shortcoming in object detection, the application demonstrated a high standard of usability, offering a streamlined interface and smooth user experience that would be advantageous in a variety of practical scenarios, particularly when scanning opaque objects and environmental structures.



4. Figure: During the scanning process – 3D Scanner App. The LiDAR only detects the environment, not the bottle.

RESULTS

The Luma AI: 3D Capture app generated the three-dimensional model within approximately three minutes. Following the scanning process, the captured data was automatically uploaded to the platform's cloud infrastructure, where advanced artificial intelligence algorithms processed the information and reconstructed the 3D model. Once the model generation was completed, the final output was transmitted back to our device for further use.

The resulting model demonstrated an impressively high level of accuracy and visual fidelity, representing not only the primary object but also its surrounding environment in a photorealistic manner. The textures appeared vivid, consistent, and highly detailed, enhancing the overall realism of the reconstruction. A particularly noteworthy outcome was observed with the chosen test object - a transparent glass bottle. Despite the well-known challenges associated with capturing transparent surfaces in photogrammetry, the model successfully preserved the transparency property. When the 3D model was manipulated and rotated on-screen, the glass bottle convincingly maintained its translucent quality, highlighting the robustness of Luma AI's rendering and processing approach.



5. *Figure: The final 3D model created with the Luma AI app*

The Polycam application produced a three-dimensional model within approximately twenty seconds, which represents a remarkably short processing time compared to many other scanning solutions.

During the workflow, the raw data collected from the scan was transmitted to the provider's cloud infrastructure, where the computational processing was carried out. Upon completion, the finalized 3D model was automatically sent back to our device, ensuring a seamless and efficient data transfer process that requires minimal user intervention.

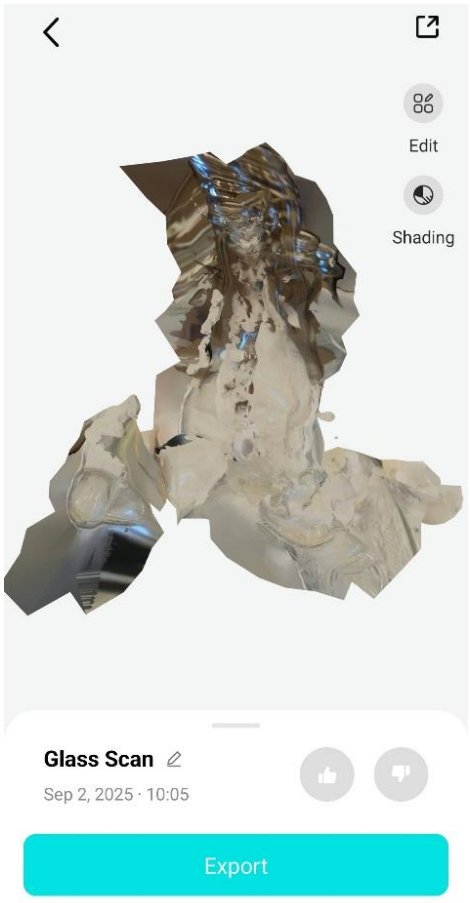
However, in contrast to applications utilizing artificial intelligence for model generation, Polycam does not employ AI-based reconstruction techniques. As a result, the software encountered significant limitations when dealing with transparent materials, such as the glass bottle used in our test. Due to optical phenomena like refraction, the application failed to reconstruct the entirety of the object's geometry, capturing only fragmented portions of the bottle's surface. Consequently, the resulting 3D model cannot be considered fully usable, as it lacks both completeness and surface detail.

Furthermore, no meaningful texture quality could be observed, which underscores the challenges Polycam faces when attempting to process transparent or reflective objects.



6. Figure: The final 3D model created with the Polycam app

The KIRI Engine application generated the three-dimensional model in approximately one minute, placing it between the faster and slower solutions examined during our study. Similar to other mobile-based scanning tools, the workflow involved uploading the captured data to the provider's cloud infrastructure, where the computational reconstruction process was executed. Once the processing was completed, the finished model was automatically transmitted back to our device, thereby ensuring a user-friendly experience with minimal manual steps required.
Despite the information that KIRI Engine partially integrates artificial intelligence techniques into its reconstruction pipeline, the application was unable to produce a usable model of the test object. Neither the surrounding environment nor the transparent glass bottle was successfully reconstructed, highlighting the significant limitations of the algorithm in handling complex optical properties such as refraction and transparency.
The resulting 3D output was essentially unusable and unrecognizable as either the target object or its context. Furthermore, no observable texture quality could be identified in the model, which further demonstrates the challenges that remain in applying photogrammetry and AI-assisted reconstruction methods to transparent objects.



7. Figure: The final 3D model created with the KIRI Engine app

The 3D Scanner App, tested on our Apple iPad Pro device, produced a three-dimensional model within approximately fifteen seconds, making it one of the fastest solutions among the applications examined in our study. Unlike several cloud-based platforms, this application performed the entire reconstruction process locally on the device, relying exclusively on the iPad's integrated processor and LiDAR sensor.

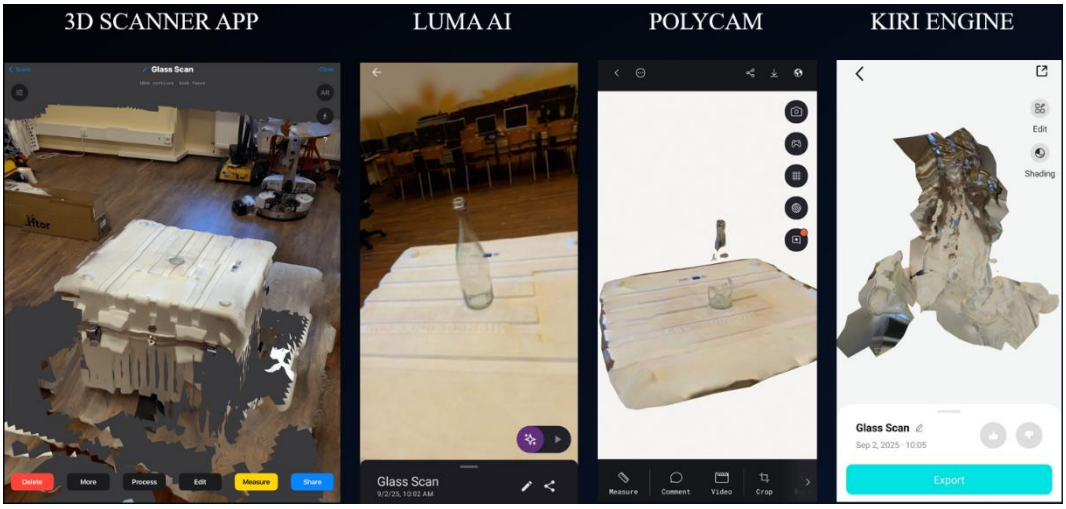
This local processing not only reduced the dependency on external infrastructure but also minimized the time required to obtain the final model, thereby enhancing efficiency and usability in scenarios where immediate results are desirable.

A particularly noteworthy aspect of the output, however, was the complete omission of the target object. The transparent glass bottle used in our test was entirely disregarded by the LiDAR sensor, and as a result, the reconstructed model contained only the surrounding environment.

While the environmental reconstruction demonstrated high quality, with sharp textures and well-defined spatial details, the application proved ineffective in handling transparent surfaces. This outcome underscores a fundamental limitation of LiDAR technology in its current mobile implementation: although highly effective for solid and opaque structures, it is incapable of capturing materials with significant light transmission properties, such as glass.



8. *Figure: The final 3D model created with the 3D Scanner App*



9. *Figure: The resulting 3D models next to each other*

CONCLUSION

Our initial hypothesis, that the 3D Scanner App utilizing LiDAR technology would yield the weakest results, was only partially confirmed. While the application failed to reconstruct the transparent target object, it successfully modelled the surrounding environment with a high degree of accuracy and sharpness. In contrast, the KIRI Engine application produced an output of significantly lower quality, as it failed to provide a recognizable reconstruction of either the

object or the environment. Consequently, among the tested solutions, KIRI Engine delivered the least satisfactory result, whereas the 3D Scanner App demonstrated notable strengths despite its limitations with transparent materials.

When evaluating usability and overall user experience, all four tested applications can be considered appropriate for integration into educational contexts. None of the solutions presented barriers in terms of complexity, as their workflows were intuitive and generally required little more than user registration to begin operation. Among them, the 3D Scanner App provided the most seamless and efficient user experience, largely due to its speed and straightforward interface.

Based on the quality of the reconstructed models, however, our recommendations for educational use differ. Luma AI emerged as the most suitable application, as it was able to handle even transparent surfaces effectively, producing photorealistic results that were both accurate and visually rich. Polycam, while unable to properly reconstruct transparency, nonetheless performed consistently well with opaque surfaces and offered reliable outputs, making it our second recommendation. Taken together, these findings suggest that both Luma AI and Polycam may represent viable and pedagogically valuable tools for incorporating 3D scanning into educational practice.

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