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Scientific Research

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3D Scanning accuracy of mobile devices

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Activities report

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Abstract

3D scanning is an established technology that has seen significant improvements over recent years. Modern smartphones, equipped with powerful processors, 4K cameras, and LiDAR sensors, can now function as personal 3D scanners. This research evaluates various 3D scanning applications available for smartphones, which differ in performance due to their unique scanning technologies and reconstruction algorithms. The study involves testing a range of 3D printed models in different conditions to assess the accuracy and efficiency of these applications.

Contents

1. Introduction

The field of 3D scanning has experienced rapid advancements over the past few years, transforming from a niche technology into a widely accessible tool due to significant improvements in hardware and software. Traditionally, 3D scanning was limited to specialized equipment and professional applications. However, the advent of modern smartphones, equipped with powerful processors, high-resolution cameras, and LiDAR sensors, has democratized access to 3D scanning technology. These advancements enable everyday users to create detailed 3D models using devices they carry in their pockets.

The increasing popularity of smartphone-based 3D scanning has led to the development of a multitude of applications, each employing different scanning technologies and reconstruction algorithms. While some applications deliver high accuracy and detail, others may fall short in certain aspects. Understanding the capabilities and limitations of these various applications is essential for both casual users and professionals who rely on 3D scanning for tasks such as reverse engineering, game development, augmented reality and much more.

This research aims to evaluate the performance of 7 smartphone-based 3D scanning applications and one specialized equipment called FastSCAN by Polhemus. By testing a series of 3D printed models under various conditions, I seek to assess the accuracy, efficiency, and overall effectiveness of these applications. The study will focus on identifying the strengths and weaknesses of each application, providing a comprehensive comparison to guide users in selecting the most suitable tool for their specific needs.

Furthermore, this research will explore the implications of these findings for the broader field of 3D scanning. By highlighting best practices and recommending the most effective applications, I aim to contribute to the ongoing development and optimization of smartphone-based 3D scanning technology.

2. Goals

In this research, the main goals are to:

1. **Identify User-Friendly Applications:** To determine the most accessible and user-friendly 3D scanning applications available for smartphones, ensuring they can be easily utilized for the research.

2. **Determine Optimal Scanning Methods:** To identify the best methods for 3D scanning, including the requirements and conditions necessary to achieve high-quality scans.

3. **Compare Scanned Models to Ground Truth:** To scan various 3D printed models and compare the resulting scans to the ground truth, assessing the accuracy of each application.

4. **Evaluate Application Performance**: To evaluate which applications perform better at scanning different types of models, identifying strengths and weaknesses specific to each application.

3. Activities

3.1. Research into the existing 3D scanner applications

As the phone that will be used for scanning is an Apple IPhone 13 Pro Max, I have begun searching for the scanner apps in Apple's App Store by searching "3D Scanner App" and downloading all promising apps for a rough test to evaluate their functionality, user-friendliness, pricing plans, export file type limitations, and the SDKs they are based on, ensuring a diverse selection of applications utilizing different algorithms.

The main requirements to the applications were that they must:

1. **Ease of Use**: The applications must be easy to use for both novice and experienced users.
2. **Cost Efficiency**: The applications must provide results throughout the research period at no additional cost.
3. **Technological Relevance**: The applications must be up to date with current technology and receive regular updates.

3.1.1. Results

By the end of this small research into existing 3D scanners 7 applications have been chosen for this research:

1. **Polycam:** This app uses Photogrammetry, LiDAR scanning and Gaussian Splatter. Photogrammetry is limited to 150 pictures per scan (which is enough to create a good scan of a relatively small object), gaussian splatters are fully limited to their paid subscription of 17.99$ per month. Another limitation is that export of the 3D model is limited to GLTF file type.

2. **Kiri Engine:** This app has all up to date technologies but at the same time it is the most limited application from this list: Photogrammetry is limited to 70 pictures per scan (very difficult to create a good scan with such a small number of pictures), NeRF (Neural Radiance Fields) and Gaussian Splatters are limited to their paid subscription of 17.99 € per month. Another limitation is that it can export only 3 models every week with an ability to earn extra exports by doing various tasks in the app.

3. **Luma:** This app only uses NeRF technology to process it's scans with an ability to transform the model into a mesh or a gaussian splat. This app is filled with extra functionality that some might find useful like an AI that will create models from text. Luma AI is completely free and has no limitations.

4. **Scaniverse:** This app at the start of the research has been purely Photogrammetry app that has implemented LiDAR into photogrammetry scanning to improve scan quality by manually selecting the distance to mask the object from the background. During the research, the app has added the functionality of NeRF and gaussian splatters. Scaniverse is completely free and has no limitations.

5. **3D Scanner App:** This app uses many different technologies like Photogrammetry, LiDAR and TrueDepth. This app can use LiDAR for scanning as a traditional mesh or change it to a point cloud, both have a limited distance between each point as these modes are meant for large scale scanning, it can also create automatically a room plan out of the data it gets from LiDAR. Photogrammetry is limited to 10 total uses of the cloud processing with ability to purchase more, it also provides alternatives as to use a Mac Desktop to process the images or the device itself at a

lower mesh quality than cloud processing. 3D Scanner App is completely free and has no additional limitations.

6. **Metascan:** This app only uses Photogrammetry and LiDAR, photo scans are limited to 5 per month at medium quality option while LiDAR scans are unlimited as they are processed locally on the device. The export file type is limited to USDZ type. Better quality, 150 photo scans and other file type exports are available for their paid subscription of 6.99$ per month.

7. **RealityScan:** This app only uses Photogrammetry, but it is the most user-friendly for beginners to 3D scanning as it shows where and what pictures has been taken of the object, this app also aligns the pictures while the user is still in process of taking them to report back if it has been successful at automatically aligning the pictures and if some areas of the object need more pictures taken (if this will be ignored it will not use the unaligned pictures for the reconstruction). RealityScan is limited to 50 scans per month and is completely free with no additional limitations.

3.2. Determine Optimal Scanning Method

Most 3D scanning applications include tutorials that recommend moving in a steady circular motion around the object to cover all 360 degrees at a specific height, pointing towards the centre of the object. This process is then repeated from different angles. While easy to understand, this method is not always reliable because some applications process the images in the chronological sequence they were taken, rather than an unordered sequence. This can cause the model to overlay on itself, creating artifacts.

Image 1- Top view

Image 2- Middle view

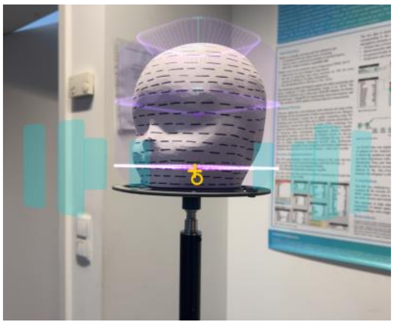

Image 3- Bottom view

This method can lead to issues where images taken from the same angle, but different heights are treated as new parts of the object by some algorithms. This results in multiple meshes at the same location instead of a unified mesh.

3.2.1. Developing a new method of scanning

After extensive testing with different scanning styles, a new method was developed to address these issues. The problem with the traditional method was that images taken from the same angle, but different heights would create separate meshes instead of combining into one. The new method requires taking pictures in a sequence that avoids capturing the same angle in future images.

The new method involves:

Starting from the bottom of the object,

1. Take pictures close to previously taken pictures while moving the camera higher until it is above the object.

2. Turn the camera 45 degrees to the side (left or right) relative to the object.

3. Take pictures in a downward motion.

4. Repeat steps 1-3 eight times until the camera returns at the starting position.

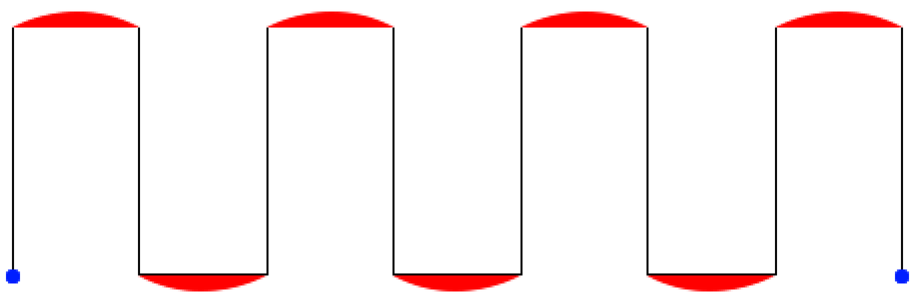

Image 4- *2D Representation of new camera movement*

In *Image* 4 the blue dot represents the beginning and end of the scan in a 3-dimensional space, indicating the same position and angle, the red curved figure represents a 45-degree angle turn to the left or right.

Image 5- *AR Representation of new camera movement*

Image 6- *Different perspective of image 5*

This new method proved to be suitable for every app tested, providing consistent and reliable scanning results across different applications due to the uniformity of the scanning process.

3.3. Process of scanning

For a successful scan, the object must be clearly visible from all sides. Some applications require physically moving around the object to take pictures, rather than rotating the object or changing the height. Therefore, a tripod was used to position the object at a comfortable height for scanning while taking up minimal space. To securely place the model on the tripod, a special plate was developed, providing a stable and flat surface for the objects.

3.3.1. Stage 1 of Scanning

The first model is a small, featureless spherical object (an infant head model) printed with dark grey filament. This posed a problem for some applications, as parts of the object were too dim to identify its shape accurately. Proper lighting is crucial for a good scan; objects should be well-lit from all sides to avoid shadows and overexposure, which can decrease scan quality.

The ideal lighting setup for 3D scanning would be to use cross-polarization, using a polarized filter on the light and a polarizing filter on the camera to eliminate reflections. However, this setup is not feasible in this research due to the use of a smartphone instead of a professional camera. Therefore, standard ambient lighting was used, ensuring not to block any light during the scanning process.

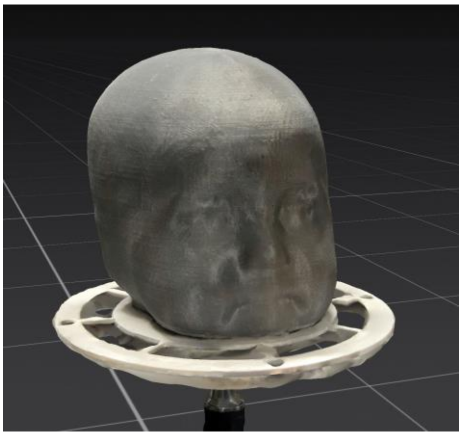

Image 7- Featureless Model

Key steps for setting up the scan:

1. **Object Visibility**: Ensure the object is clearly visible from all sides.
2. **Setup**: Use a tripod to position the object at a comfortable height, with a specially developed plate for stability. In some cases, a string can be used to suspend the object in the air for a full scan from each side.
3. **Lighting**: Properly light the object from each side to avoid shadows and overexposure. Use ambient light and avoid direct reflections.

This method ensures a stable and well-lit environment for scanning, which is critical for achieving high-quality results with smartphone-based 3D scanning applications.

3.3.2. Stage 2 of Scanning

For the second stage, two additional infant head models were printed using white filament to improve visibility. A slot was added to the bottom of each object to facilitate alignment with the plate on the tripod.

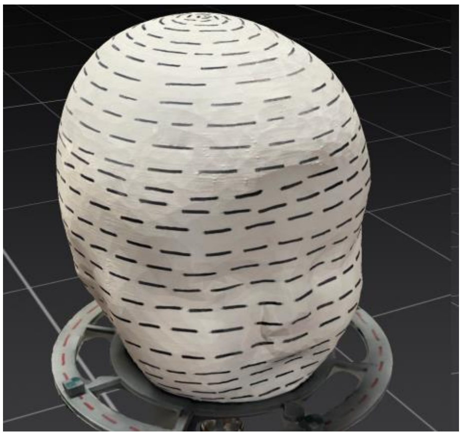

Image 7- Marked model

To enhance the scanning process, the models were marked with a water marker in a continuous pattern. This added feature points, which are essential for better tracking of individual pictures and improved visualization of the object's shape. These markings significantly improved the scan quality, as expected. Photogrammetry, the process used by many 3D scanning applications, performs best when the object has numerous unique feature points distributed across its surface.

3.3.3. Stage 3 of Scanning

A matte, highly detailed object with dense colour variety is ideal for 3D scanning, with trees being a natural example of such features. For the next model, a tree stump was chosen to be printed and scanned. However, since the model is printed in PLA, it lacks the matte quality and colour variety. To provide a contrasting scenario, a small, low-detail hollow globe was also selected for scanning to test the importance of detail density.

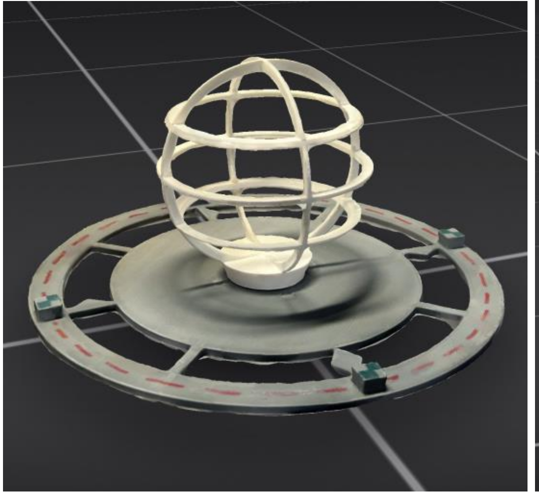

Image 8- *Unmarked globe model*

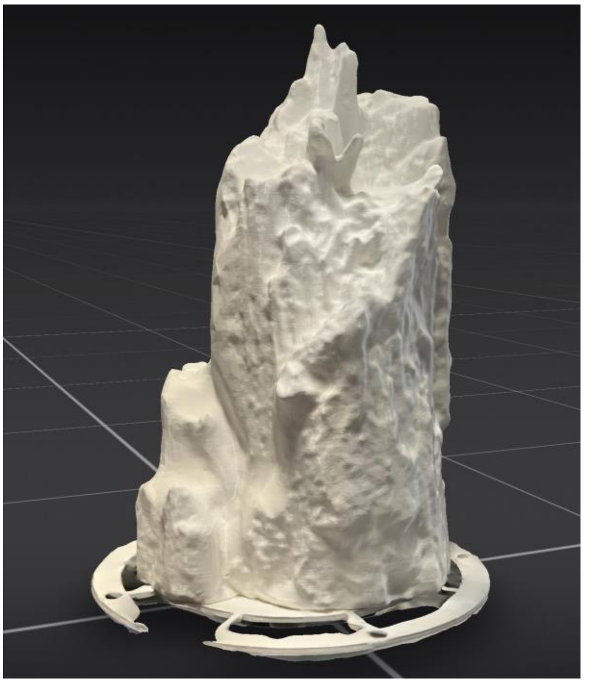

Image 9- *Unmarked tree stump model*

Both objects were initially scanned without any markings to establish a baseline. After collecting the initial data, the objects were densely marked with a water marker and scanned again to compare the results with the unmarked versions.

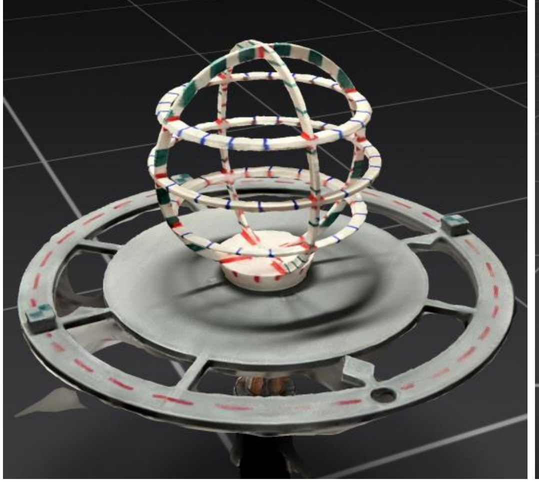

Image 10- *Marked globe model*

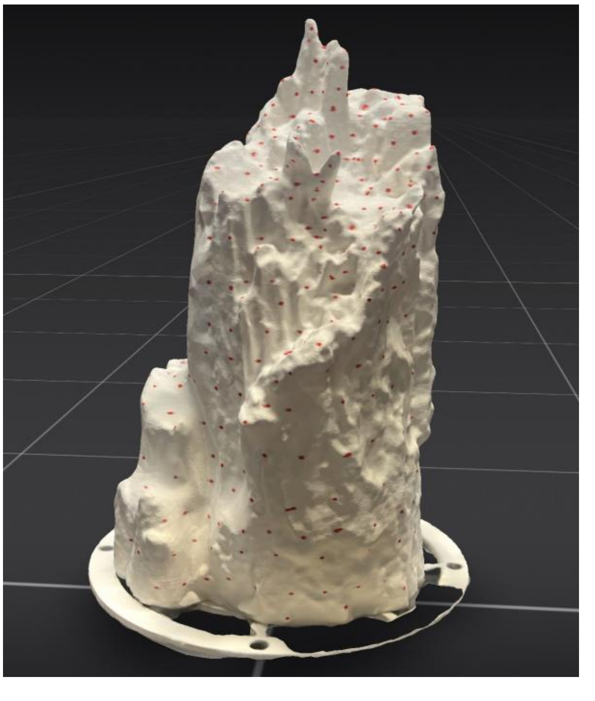

Image 11- *Marked tree stump model*

3.3.4. Polhemus FastSCAN

The Polhemus FastSCAN is specialized equipment used for professional 3D scanning, comprising a laser scanner, an electromagnetic sensor, and a processing unit. The sensor must be attached to the object being scanned. Instead of attaching the sensor directly to the object, I decided to attach it to the plate that the object is firmly fixed to. This setup allows the scanner to remain stationary while the plate, along with the object and sensor, rotates on the tripod.

FastSCAN application is prone to crashing and may fail to recognize the scanner, complicating its use. The sensor is highly sensitive to any metal that can be magnetized, such as structural beams in walls, metal desks, and even the tripod itself, which can cause inaccuracies in the scan. While the walls and desks can be avoided by maintaining distance, the tripod cannot, as it is integral to the scanning setup.

The FastSCAN produces a set of sweeps that should ideally be aligned with each other. However, misalignment can occur, especially with a high number of sweeps, leading to a deformed end model. To achieve the best results, it is crucial to minimize the number of sweeps per location. This can be done in two ways: Make fewer sweeps during scanning or manually remove sweeps that lack sufficient detail. I opted for the manual removal method to ensure all parts of the object are scanned in good detail. After scanning, extensive manual processing is required to choose which sweeps to keep, set appropriate parameters for post-processing, and execute the final processing.

When analysing the results, I observed that the black marker used on the objects, which proved useful in photogrammetry, was causing small indentations in the final model. This deformation is due to the black marker absorbing the laser, being less reflective than the white colour of the PLA.

3.3.5. Synthetic process

To ensure a fair comparison of the various 3D scanning applications, I decided to create a structure that would allow me to scan objects in the exact same way for every application.

This approach ensures that each application receives the same set of images taken from the same locations, facilitating a reliable comparison of their performance.

To achieve this consistency, I designed, printed, and constructed a structure that securely holds the phone in a fixed position at a suitable distance from the object. This structure is not intended to improve the scanning process itself but to create a stable and controlled environment for comparison. For the infant head models and the globe, the structure captures 40 images per scan and for the tree stump model due to its greater height, the structure captures 48 images, adding an extra layer of images to account for its vertical dimension.

By using this structured approach, I ensure that all scanning applications are tested under identical conditions, providing a fair and consistent basis for evaluating their performance.

3.4. Comparing Scanned Models to Ground Truth

After collecting all the 3D scans, I imported them into CloudCompare. The models were cleaned of artifacts, aligned, and trimmed to ensure maximum similarity. However, since CloudCompare lacks a metric scale, it is not possible to obtain numerical results directly from the comparisons. Therefore, I decided to perform the calculations using MATLAB.

3.4.1. Manual test results

Fred				
Original vs Unmarked	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
3DScannerApp'	0.0173829	0.02014199	0.085173718	0.038253953
'LumaAI'	0.0186153	0.03167388	0.490339603	0.040595508
'Metascan'	0.0164081	0.02062215	0.138054156	0.036786922
'Polhemus'	0.0162564	0.02197946	0.089033299	0.038103327
'Polycam'	0.0171978	0.02063948	0.14557158	0.038914856
'RealityScan'	0.0194935	0.02647459	0.483792082	0.042626122

3DScannerApp: Best for detailed accuracy and maximum deviation measures.
Polhemus: Best for overall similarity with the original model.
Metascan: Best for robust similarity measure.

Considering all metrics, **3DScannerApp** seems to be the overall best performer due to its strong performance in multiple metrics, specifically rmsSSD and hausdorffSSD, which are critical for assessing detailed accuracy and maximum deviations.

Barney				
Original vs Marked	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
3DScannerApp Barney'	0.0127086	0.01369935	0.024768215	0.019302206
'KiriEngine Barney'	0.0363567	0.07912946	0.456309067	0.14946127
'Metascan Barney'	0.0521347	0.10564947	0.453015863	0.273130418
'Polhemus Barney'	0.0548078	0.10992375	0.457445761	0.292506039
'Polycam Barney'	0.0463245	0.0931751	0.457259542	0.261209377
'RealityScan Barney'	0.055932	0.10520618	0.456980666	0.294865836
Scaniverse Barney'	0.0120484	0.0130073	0.034117084	0.019419054

Scaniverse has the best averSSD and rmsSSD, suggesting it has the highest overall accuracy. **3DScannerApp** has the best hausdorffSSD and hausdorffSSD95, indicating it handles maximum deviations well.

Both **Scaniverse** and **3DScannerApp** are strong performers, with Scaniverse being slightly better overall due to lower average and root mean square differences.

Maurice				
Original vs Marked	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3DScannerApp Maurice'	0.026279	0.044775	0.645446199	0.05693316
'KiriEngine Maurice'	0.020214	0.024265	0.150098841	0.04537794
'LumaAI Maurice'	0.021854	0.026588	0.27175287	0.046465815
'Metascan Maurice'	0.020511	0.026044	0.448597623	0.045537924
'Polhemus Maurice'	0.021958	0.026024	0.390039457	0.045432348
'Polycam Maurice'	0.022893	0.028135	0.422639753	0.047805996
'RealityScan Maurice'	0.027164	0.043103	0.646755082	0.055629389
'Scaniverse Maurice'	0.022118	0.026624	0.462078507	0.047788325

KiriEngine has the best results across all metrics, indicating it has the highest overall accuracy and handles maximum deviations well.

Globe				
Original vs Marked	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Globe Marked'	0.063428	0.090147	0.347118243	0.214331155
'KiriEngine Globe Marked'	0.076933	0.103409	0.344997113	0.221303502

'LumaAI Globe Marked'	0.070049	0.095	0.347118243	0.203948314
'Metascan Globe Marked'	0.0596	0.088045	0.341465706	0.222357298
'Polycam Globe Marked'	0.076353	0.101183	0.347118243	0.21189544
'RealityScan Globe Marked'	0.081516	0.106642	0.346782332	0.222346823
'Scaniverse Globe Marked'	0.088904	0.115146	0.34744598	0.23865854

Metascan has the best results for averSSD, rmsSSD, and hausdorffSSD, indicating it is the most accurate and consistent.
LumaAI has the best hausdorffSSD95, suggesting good handling of deviations.

Metascan is the best overall performer for the globe model, with consistently low scores in multiple metrics.

Tree Stump				
Original vs Marked	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Tree Stump Marked'	0.0072371	0.01073733	0.113849733	0.009305828
'KiriEngine Tree Stump Marked'	0.00411	0.00614775	0.1167217	0.009300995
'LumaAI Tree Stump Marked'	0.0049111	0.00735487	0.197019505	0.009084973
'Metascan Tree Stump Marked'	0.009776	0.01506623	0.072313302	0.009352891
'Polycam Tree Stump Marked'	0.0039521	0.00652505	0.118034261	0.009269592
'RealityScan Tree Stump Marked'	0.0044298	0.0080755	0.209586032	0.011983068
'Scaniverse Tree Stump Marked'	0.0044573	0.00682476	0.143723636	0.009330184

For this model KiriEngine, Luma AI, Metascan and Polycam have best results in their own categories.

Polycam is the overall best performer for the Tree Stump results, as it has the lowest averSSD and competitive scores across other metrics.

3.4.2. Synthetic test results

Due to lack of detail and colour of the object, the model named “Fred” has failed to be scanned by any of the applications successfully, due to that it is missing from any of the results. In addition to that 3D Scanner app and Metascan were the only apps that were able to successfully create an acceptable result for the Globe and the Tree Stump.

Barney				
Original vs Synthetic	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Robo Barney'	0.0165811	0.02275341	0.366123924	0.041593506
'Kiri Engine Robo Barney'	0.0163075	0.02044226	0.337997028	0.036936654
'Metascan Robo Barney'	0.0163435	0.02182532	0.285763412	0.03887308
'Polycam Robo Barney'	0.0161163	0.02074097	0.334110135	0.036844671

Polycam has the best averSSD and hausdorffSSD95, indicating high overall accuracy and robustness.
Kiri Engine has the best rmsSSD, showing good overall fit.
Metascan has the best hausdorffSSD, indicating the least deviation in maximum distance.

Polycam is the overall best performer due to its low average and robust similarity scores.

Maurice				
Original vs Synthetic	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Robo Maurice'	0.0237306	0.03459973	0.65056577	0.049986764
'Kiri Engine Robo Maurice'	0.0229626	0.02689398	0.294353954	0.046262184
'Metascan Robo Maurice'	0.0201212	0.02424926	0.366457809	0.043897888
'Polycam Robo Maurice'	0.0231434	0.02952324	0.457572728	0.048416042

Metascan has the best averSSD, rmsSSD, and hausdorffSSD95, indicating high overall accuracy and robustness.
Kiri Engine has the best hausdorffSSD, showing the least deviation in maximum distance.

Metascan is the overall best performer due to its consistently low scores across multiple metrics.

Globe				
Original vs Synthetic	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Robo Globe'	0.0655285	0.09223679	0.344296011	0.214593423
'Metascan Robo Globe'	0.0575938	0.08556858	0.343351918	0.223316128

Metascan has the best averSSD, rmsSSD, and hausdorffSSD, indicating it is the most accurate and consistent.

Tree Stump				
Original vs Synthetic	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
'3D Scanner App Robo Tree Stump'	0.0064442	0.00959743	0.120210221	0.009637561

'Metascan Robo Tree Stump'	0.0093278	0.01381177	0.07592162	0.009367494

3D Scanner App has the best averSSD and rmsSSD, indicating high overall accuracy. **Metascan** has the best hausdorffSSD and hausdorffSSD95, indicating it handles deviations well.

3D Scanner App is the best overall performer for the tree stump model due to its low average and root mean square differences.

3.5. Evaluate Application Performance

RealityScan may not be at the top of the leaderboards due to the high mesh density it outputs. This high density can lead to more significant inaccuracies in MATLAB's edge-to-edge distance calculations compared to other apps with lower mesh density. However, RealityScan is ideal for beginners because it provides real-time feedback on which pictures are good and aligned during the scanning process.

3D Scanner App is impressive, delivering excellent results and remarkable texturing capabilities. While I haven't fully utilized all its features due to time constraints in this research, its extensive functionality merits further exploration. It certainly deserves more attention for a deeper understanding.

Scaniverse is an exceptionally user-friendly scanner with limitless applications. Its processing is done locally on the phone, ensuring fast and efficient scans. It’s particularly forgiving, making it perfect for users who simply need to move the camera around the object. Enthusiasts might find it a great alternative to the standard photos app due to its speed. In less than a minute, you can scan and process an object, making it ideal for capturing complex shapes that a single picture can't convey. So it’s perfect for personal use.

Metascan is a decent scanning tool but lacks distinctive features to set it apart from other apps. Additionally, it only allows users to take 10 scans before requiring a subscription, which is a significant limitation.

Kiri Engine is a highly restricted app. Most of its functionality is hidden behind a paywall, offering users only the photogrammetry mode. This mode allows for 70 pictures per scan and a weekly limit of 3 scans.

Polycam is a well-designed application that offers a wealth of features for users. It includes comprehensive tutorials for various scanning types and additional tools to assist users in their 3D scanning journey. Moreover, Polycam provides its own social media platform for sharing scans among users, which can be a valuable source of inspiration.

Luma AI is an impressive app that offers a unique social media feature for sharing scans, focusing on gaussian splatter, which is its specialty. The app is intuitive and enjoyable to use. However, I've found that uploading videos to create models produces more reliable results with minimal errors compared to Luma's built-in scanning method.

4. Conclusion

Average results for all models

Application	averSSD	rmsSSD	hausdorffSSD	hausdorffSSD95
3D Scanner App	0.025408	0.035901	0.243671622	0.06722526
Kiri Engine	0.034903	0.053737	0.26703118	0.106860427
Metascan	0.031287	0.051485	0.29068933	0.117833891
Polhemus	0.031007	0.052642	0.312172172	0.125347905
Polycam	0.033344	0.049932	0.298524277	0.113819052
RealityScan	0.037708	0.0571	0.428379638	0.125090648
Scaniverse	0.012875	0.015485	0.213306409	0.025512521

Scaniverse - excels in average sum of squared differences, root mean square of squared differences, and robustness in similarity measures.

3D Scanner App - strong performer with low averages in most metrics.

The average results for all models show that the most reliable app to be scanning is **Scaniverse** but it’s not necessarily the best in each scenario. For the globe model it has showed the worst results among other apps, but its new feature “Splat” which uses NeRF technology will improve the result for such a small object with a small amount of feature points. And obviously in some specific cases a different app can have the advantage for that specific scenario but in average **Scaniverse** will be suitable for all purposes.

It is important to remember that other applications have some different features that are indirectly used for 3D scanning, but they can be extremely useful in certain scenarios:

Luma AI Dream Machine for creating artificial videos created from text and pictures, along with Genie that can create 3D models from text, it won't get the scaling right, but it will represent your idea at its best capabilities. So, it would be a good idea to keep an eye on Luma for its revolutionary technologies.

3D Scanner App's "RoomPlan" feature can be very useful for creating an easy room plan without additional work required as creating a room 3D model, importing it into a 3D modelling software, scaling the model and process it to fit your needs. Along with that 3D Scanner App can also use the TrueDepth camera on the IPhone to create highly detailed models, what is it's advantages and disadvantages is yet to be found but it would be awkward to scan as it is positioned on the screen side of the phone so the user will have to be blindly scanning.

Overall to scan a medium object, starting from $5cm^3$ and up to a $1000cm^3$, Photogrammetry would be ideal to use.

To scan small, featureless or maybe even partially transparent objects NeRF technology would be perfect for the job. It is capable of scanning objects that neither Photogrammetry and LiDAR technologies are capable of doing.

For large objects a LiDAR technology can be used but restricted to the sensor range, usually restricted up to 5 meters, but all other technologies can be used very reliably with better experience of their use.

For extra large objects like large buildings or even cities NeRF and Photogrammetry can be used. In this case a NeRF will be much easier to use as it doesn't require the precision and quality of Photogrammetry but can create a great a relatively similar results to Photogrammetry. LiDAR isn't an option as it is restricted to 5 meters on the IPhone, but it can be used when specialized LiDAR cameras are available, in which case it would be a great option for scanning a large area. To scan this large area obviously a use of a drone would be necessary.

5. References

https://poly.cam/

https://lumalabs.ai/

https://youtu.be/GJ2gtQ0WxTU?si=mUpel3iDT46JWD83