The affordances of 3D imaging modalities for forensic facial identification

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INTRODUCTION:

The ear can be used as a biometric for identification when the face is obscured. Ear comparison can be unsuccessful in forensic scenarios if images are not captured in the same pose, angle and lighting. This study involves digitising ears with low-cost 3D photogrammetry app (Metascan), Agisoft Metashape software, and LiDAR scanning app (Scaniverse). These 3D models are then compared to a high-cost structured light model (Artec) to evaluate the accuracy of the low-cost modalities.

WHAT ARE THE AIMS OF THIS INVESTIGATION?

This study is not only to contribute to the forensic practice of forensic identification through facial comparison, but to also develop a cost effective standard for more accurate comparisons of the ear in unconstrained images.

We hope to answer the following questions:

- Will low-cost scanning technology produce an effective 3D surface of the ear compared to high-cost scanning technology (Artec benchmark)?
- What is the accuracy of the low-cost 3D models when compared to the Artec benchmark?

HIGH-COST MODALITY; ARTEC:

The Artec Space Scanner as seen in Figure 1a is a high-resolution 3D structured blue light scanner. It has a 3D point accuracy of up to 0.05mm and 3D resolution of up to 0.1mm (Artec3D.com, 2022), allowing for complex geometry to be captured. It is perfect for creating accurate 3D models but is high-cost retailing for approximately £17,000 excluding software subscriptions/purchase.

THE GOLD STANDARD OF 3D SCANNING:

With accompanied Artec Studio software, the user has control over brightness of emitted light, frames per second of scans and the extremity of the scanner's sensitivity. A live feed of the captured data can be visualized on a connected monitor in the software, allowing for gaps in collected data to be rectified.

MODEL BUILDING PROCESS:

As seen in Figure 1b-f, structured light scans can be processed to produce detailed and geometrically accurate 3D models with texture in Artec Studio software. The process from alignment of scans to texture building can be conducted manually or can be run through an autopilot algorithm for efficiency.

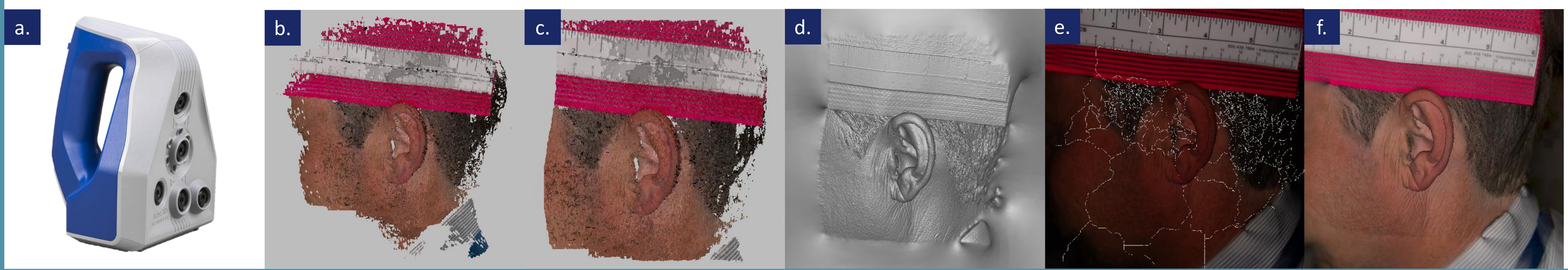

Figure 1: The process of building a 3D model from Artec scans in Artec Studio 15;
a. the Artec space scanner;
b. raw Artec scans;
c. Artec scans after alignment;
d. fusion model of scan layers after hole filling and brush editing;
e. model after mesh simplification and texture building;
f. final model with optimized texture

LOW-COST MODALITIES:

AGISOFT METASHAPE SOFTWARE:

Photogrammetry is a low-cost method for building 3D models. DSLR camera prices can range from £300-£4,000, with Agisoft Metashape Standard software costing £148.84 , which increases to £2,909.45 with Metashape Professional.

Figure 2a depicts the camera used in this investigation, and Figures 2b-f display the process of building a 3D model from photographs.

Based on this current experiment, we recommend a minimum of 30 photographs from differing angles around the ear ensure all images align, and an accurate depth and geometry is produced in the model.

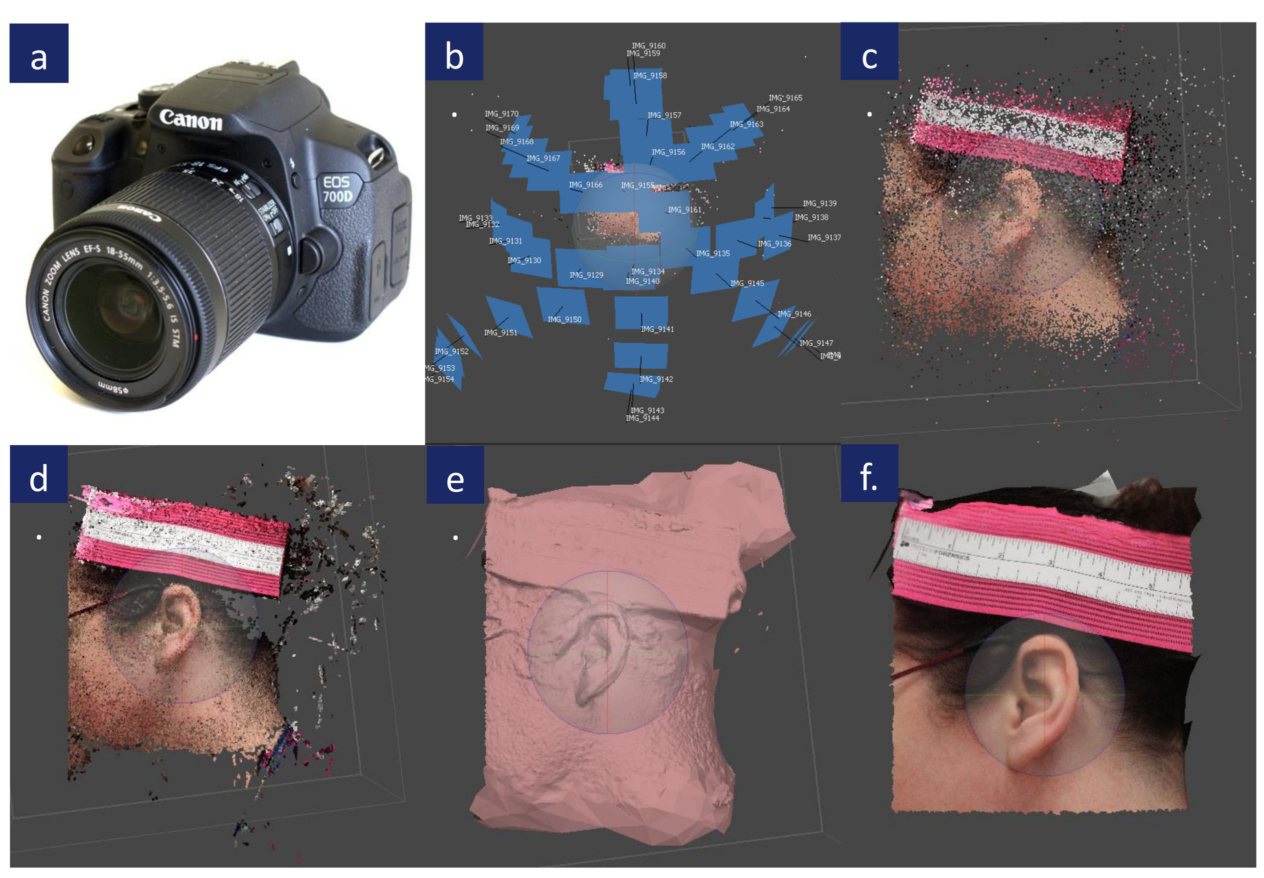

Figure 2: The process of building a 3D model from DSLR photographs in Agisoft Metashape; a. Canon EOS 700D DSLR camera; b. photographs aligned; c. point cloud built from tie points; d. dense cloud produced; e. solid mesh built; f. texture applied to give final model

METASCAN APP:

Metascan is a low-cost subscription-based app available on devices supporting iOS 14. The photogrammetry aspect of the app creates 3D models from 20 or more images by estimating distance by finding matching visual features between the photos.

SCANIVERSE APP:

Scaniverse is a free app available on iOS devices with a LiDAR sensor.
The app uses Apple's infrared laser technology as LiDAR for recording distance measurements from multiple angles to construct a 3D geometrical model, along with generating colour texture to project onto the model.

ANALYSIS:

MODEL COMPARISONS:

Models were compared using CloudCompare (open source software). This is done by scaling and aligning low-cost point cloud (PC) models to the Artec model, then running the 'point cloud to point cloud' comparison algorithm. Process is depicted in Figure 3.
PC to PC comparisons allows differences between models to be visualised with a colour scale, whilst producing a histogram displaying the distribution of points in the low-cost models by distance away from the reference Artec model.

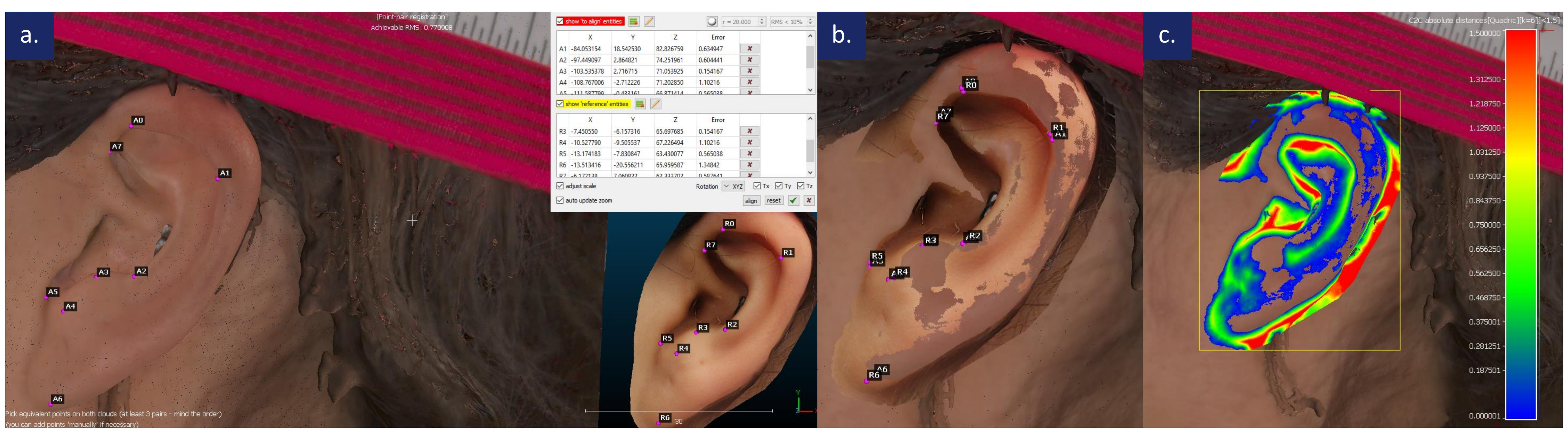

Figure 3: Process of comparing 3D models against the Artec model in CloudCompare; a. reference points added to features of the ear on the Artec model, with corresponding 'to align' points selected on the model to be compared; b. model aligned with the Artec model; c. point cloud to point cloud comparison with maximum distance set to 1.5

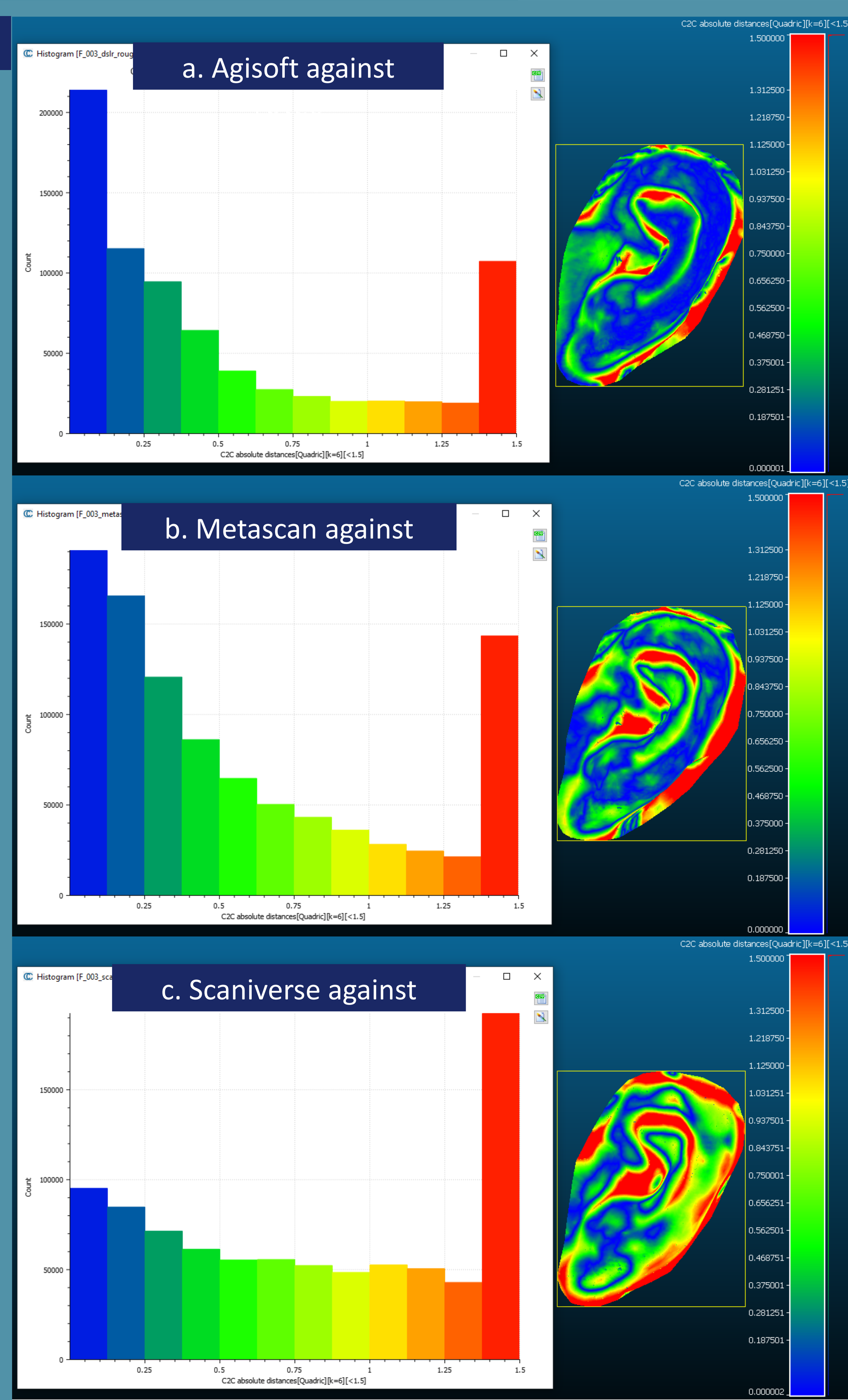

Figure 4: Point cloud to point cloud comparisons of scans (a. Agisoft model b. Metascan app model c. Scaniverse app model) of the same participant against the Artec Lidar model, along with histograms displaying the point accuracy distribution in 12 classes representing distance deviation from the Artec model

OUR FINDINGS SO FAR...

Figure 4 shows how this data is presented:

- The histogram shows the count for points within a distance range of 0-0.125 to the Artec model for the Agisoft model is over 20,000, whereas the histogram for the Scaniverse model in Figure 4b shows the count for points within the same range of the Artec model is just under 10,000.
- The Agisoft model is far closer to the Artec model, and therefore more accurate than the Scaniverse model.

These findings are consistent across our sample of 17 left ears. 76% of Agisoft models had the highest similarity when compared to the Artec model, whereas 24% of Metascan scans outperformed the Agisoft models. Scaniverse models are the least accurate in all cases. So far, low-cost photogrammetry scans appear to be more accurate than low-cost LiDAR scans.