Review on 3D scanners for head and face modeling

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Abstract. There is a need of accurate anthropometric data of human head and face for both research and product designing. In past conventional measurements techniques were used to acquire anthropometric measurements for designing of products using scales, calipers, tapes which were less accurate and reliable, but with the advent of 3D scanner it has become very convenient for the researchers to acquire accurate 3D anthropometric head and face measurement. In the last three decades there has been a constant effort in optimizing the 3D scanners for improving its accurate and making it more user-friendly. This study discusses three different types of 3D scanners used for scanning head and face and tries to analyze their performance. The scanners included in the study are: Cyberware 3030 color scanner, Artec Eva 3D scanner and Structure sensor ST01 mode. The study provides an overview of possible advantages and limitations of all the three scanners.

Keywords: 3D scanners, human head and face, 3D modelling, ergonomics, product design

1 Introduction

There is a need of accurate anthropometric data of human head and face for both research and product designing. The products to be used for head and face are designed for one of the following purpose: protective, healthcare, aesthetic. For this they require a good close fit to provide a high level of user comfort. The conventional techniques used in past to acquire anthropometric head data included use of measuring equipments like flexible scales, measuring tapes or calipers to acquire data[1-3]. These techniques were not reliable and did not provide highly accurate anthropometric data [4]. Many researchers have tried to use multiple images taken from different projections to develop 3D models but it is time consuming and cannot provide a highly accurate 3D head and face model due to its complex shape and contour [5-6]. Medical imaging data like the one from Computerized Tomography (CT) [7] and Magnetic Resonance Imaging (MRI) [8] have been successfully used to develop accurate head and face models but due to its high cost and involvement of use of ionization radiation in CT they are not used that prominently for research and designing.

With the emergence of 3D scanning technique it has been made possible to overcome the limitations of the above techniques and acquire accurate 3D head and face data. 3D scanners have been extensively used from then for wide range of applications from product designing [9-11], apparel designing [12] to healthcare applications [7, 13]. Also 3D head anthropometric data can be used in research purpose like to study shape variance amongst people belonging to same ethnic group or location [14]. It can also help in understanding the anatomical differences in people belonging to different ethnic groups or locations [15].

There are wide ranges of 3D scanners available today with different specifications. Some are based on the laser scanning techniques where as some use structured light for 3D scanning. The cost of the scanner varies depending on the scanner accuracy and scanner resolution. This study discusses three different types of 3D scanners used for scanning head and face and tries to analyze their performance. The scanners included in the study are: Cyberware 3030 color scanner, Artec Eva 3D scanner and Structure sensor ST01 mode. The comparison provides an overview of possible advantages and limitations of all the three scanners.

2 Methods

2.1 Subjects

10 participants (5 males and 5 females) voluntarily participated in the study. They were informed about the scanning procedure and a written consent was obtained from them. Only participants with no facial deformities were considered for the study.

2.2 Equipment

Three different scanners were used for the study: Cyberware 3030 color 3D scanner, Artec Eva 3D scanner, Occipital Structure sensor model ST01. Fig. 1 depicts all the three selected scanners.

(a) (b)

(c)

Fig. 1. 3D scanners selected for the study. (a) Cyberware 3030 color 3D scanner, (b) Artec Eva, (c) Occipital Structure sensor model ST01

Cyberware 3030 color 3D scanner

Cyberware 300 color 3D scanner is one of the first scanners which were designed to scan human head and face. It creates a lighted profile of head by impounding a low-intensity laser. This profile is captured by a video sensor from two different angles. Multiple such lighted profiles are used to reconstruct a head and face model. Texture is recorder by a second video sensor.

Artec Eva 3D scanner

Artec Eva 3D scanner uses structured light 3D scanning technique. It is an easy to use hand held 3D scanner which can be used for a wide range of applications. It can be used for partial as well as full body scanning applications. It has high accuracy (0.05mm) and high resolution. It is a light weight portable and fast scanning device. It can provide good texture details too.

Occipital Structure sensor model ST01

Occipital structure sensor is a first 3D scanner for mobile device. It uses a fixed wavelength of safe infra-red light for scanning an object. It is completely software controlled scanner with no buttons and can be used either as a hand held scanner or it can be mounted on an ipad or a tablet on its customized bracket. It has a lower precision (0.5mm) and works on a rechargeable battery.

Cyberware 3030 color 3D scanner has a designated raised platform where a chair is placed for the participant to sit. The scanner is adjusted such that the scanning field covers the head of the participant. Artec Eva and Structural sensor are both hand-held scanners which were used by an expert technician to acquire scans. All the three scanners have a designated software for data acquisition and processing provided by the supplier.

2.3 Procedure

Head measurements of all the participants involved in the studies were acquired to select a cap to be worn by them during the scanning process because 3D scanners cannot acquire the data of human hair. Participants were scanned using all the three 3D scanners. The order of scanning was randomly decided. Participants were informed not to move or speak during the scanning process. They were informed to sit tight and keep their eyes open and chin at a fixed angle for all the three scans so that all the scans are acquired in uniform posture.

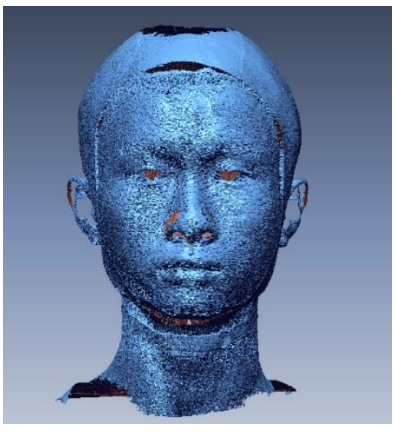
Participant were made to sit on a chair on the platform of the Cyberware 3030 scanner. The scanner was arranged in such a way that the head of the participant to be scanned fits in the scanners field of scan. Before every scan was performed, homing settings were carried out for more reliable scanned output. After which the arm of the scanner moves 360 degrees to acquire a complete 3D scan of the participant's head and face.

While scanning using Artec Eva and Structural sensor the participants were made to sit on a stool and a technician with expertise in using the scanners moved around the participant acquiring the 3D scanning.

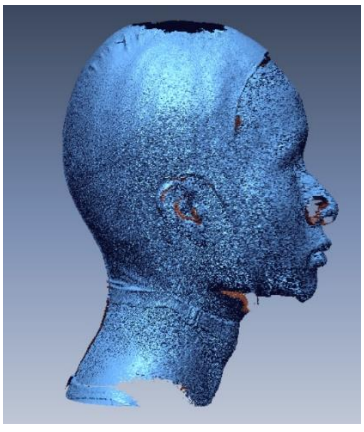
The opinion about the scanning comfort during the three scans was also studied. The technicians involved in scanning were interviewed about their comfort and issues during the scan.

3 Results

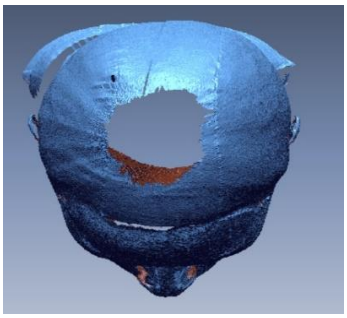
The raw data acquired from all the 3D scanners was processed using software. A stereolithographic format (STL file format) was developed for the head models developed using the scanners. Fig. 2, Fig. 3 and Fig. 4 depict results of the scanned output for a single participant in three different views i.e. front view, side view and top view.



(a)



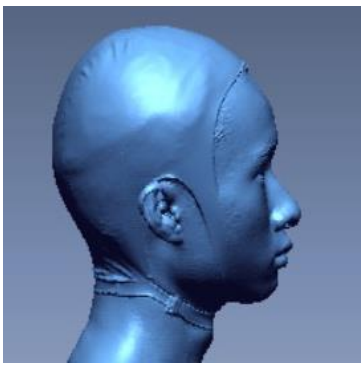
(b)



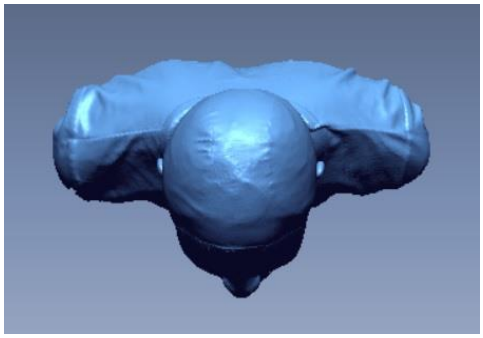
(c)

Fig. 2. Scanned output from Cyberware 3030 scanner(a) Front view (b) Side view (c) Top view

(a)

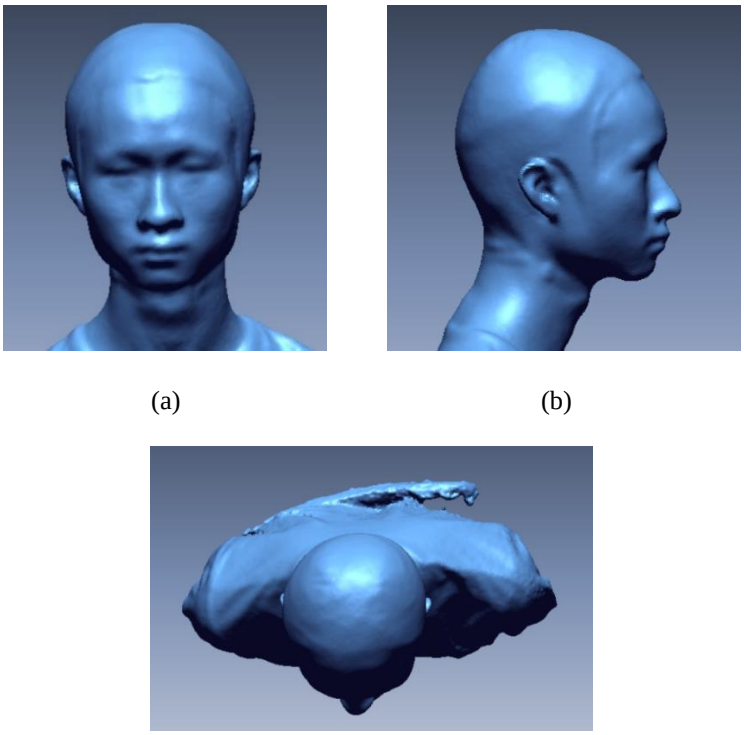


(b)



(c)

Fig. 3. Scanned output from Artec Eva 3D scanner (a) Front view (b) Side view (c) Top view



(a) (b)

(c)

Fig. 4. Scanned output from Structure sensor (a) Front view (b) Side view (c) Top view

4 Discussion

Based on the acquired scan results the three scanners were evaluated. The factors considered for the comparison were scanner accuracy, time and process of data acquisition and processing, the advantages and the limitations of the scanner and possible applications of the scanners and the user friendliness. Table 1. provides a brief detail of all the evaluation based on the observations during the study and based on the scanned output.

Table 1. Over-view of the scanner properties

Properties	Cyberware 3030	Artec Eva	Structure Sensor
Size (cm)	182.5x192.5x122.5	26.15x15.82x6.37	11.92x2.8x2.9
Weight (Kg)	332	0.85	0.095
Frame rate	-	16 Frames/second	30-60 Frames/second
Cost	High	High	Low
Homing required	Yes	No	No
Time for scanning	High	Low	Low
Time for data processing	Low	High	Low
Point cloud density	High	High	Low
Accuracy of data	High	High	Low
Comfort to person being scanned	More	Less	Less
Comfort to technician	More	Less	Less
Need for technician expertise	No	Yes	Yes
Portability	No	Yes	Yes
Missing data	Yes	No	No
Heating problem	No	Yes	Yes

Cyberware 3030 is one of the very first generation scanners developed for 3D scanning of human head and face. Many researchers have used Cyberware 3030 scanner in their studies [16-18] to develop 3D head models and design products based on the acquired data. Many initial database and surveys of 3D head models were developed using Cyberware 3030 color scanner.

The scanned data acquired from the Cyberware 3030 scanner had a lot of missing data. The scanner is unable to scan data in the shadowed regions (regions behind ear, below the chin, nostrils). Also in cases of wrinkles data was lost. The ear data is not acquired and hence the scan cannot be helpful in designing any ear based product. The data of head scalp is also lost as the scanner can only scan the areas parallel to its field of view.

Another problem with Cyberware scanner is the field of view is very small (30 cm x 34cm). Hence proper head scan comprising of neck region also cannot be acquired for every individual. Also based on the height of every individual the scanner has to be re-adjusted and aligned parallel to the head of the participant. It is also required to initially perform homing for the scanner every time it is used. Although it has many limitations unlike Artec Eva it does not use any flashing light source making it more comfortable for the person to be scanned.

The data acquired by the Cyberware scanner lacks a lot of information, but various CAD/CAM tools are available in 3D data processing so it is possible to interpolate the data and fill the holes. This affects the accuracy of the scan but can help develop a 3D model which can prove to be helpful in developing customized products for head face.

Even though Artec Eva 3D scanner is accurate, it has a few limitations which need to be discussed. One of the major limitations of Artec Eva is high flashing lights which at times cause some discomfort to the subjects to be scanned. For the same reason it can also not be used to scan a person with epilepsy. It can acquire an accurate scan only if the individual using it has a high level of expertise and experience in using it. If the speed of scanning is too fast or slow the track can be lost leading to a need of second scan. Also the person handling the scanner needs to hold the scanner in one hand and a tablet or a laptop in another hand while scanning, making it difficult to scanning for a long time using it.

The software for data processing for Artec scanner is user friendly and has options for editing the raw scanned data. It has options to perform global registration making sure the minor errors while scanning can be rectified. It also has features like holes filling and smoothening which can help improve the quality of head scanned data. But it takes a high data processing time. The texture data acquired is of a high quality and can help create a precise head and face model.

The scanning time for Artec Eva is less as it does not need any prior homing or calibration. The Artec Eva can be used for developing customized products where high level of accuracy is required. Many researchers have used Artec Eva to achieve a high level of accuracy in 3D head scanning [19-21].

Structure scanner is a smallest sized scanner amongst the three. It can be used as a hand held scanning device or can be mounted on a bracket with an ipad or tablet. It has no buttons on it and hence is totally controlled by the associated software, at times making it difficult for the user while not using a bracket. The scanning process is similar

to that of Artec Eva where the person to be scanned sits on a stool and the person acquiring the scan moves around. It can be used for performing a scan of a specific body part or a whole body. Scanning time is less as compared to Cyberware 3030. Like Artec Eva it does not require any calibration or prior homing.

Structure sensor is less accurate as compared to Artec Eva and Cyberware 3030. The data is not very precise but it provides a rough outline of the head and face. It cannot provide accurate facial features or ear data. It can be used for applications which require less accurate data. It is cheaper compared to both Artec Eva and Cyberware 3030 scanner. One of the major limitation of Structure scanner is the amount of heat generated is very high and hence it cannot be used for a long duration of time. But it is easier to use as compared to Artec Eva and does not require a high level of expertise and can be used for a wide range of applications.

Technicians' interview provided an insight about the comfort of use of the three scanners. According to the information provided by the technicians it was realized that Cyberware 3030 color 3D scanner was the most comfortable to use as the technician needs to just operate the device using a software from a console. While considering the other two scanners i.e. Artec Eva 3D scanner and Structure sensor, the technician needs to hold the scanners and move the scanner at a fixed rate. If the technician moves too quickly or slowly, the track of the scan is lost and the scanning process has to be repeated. The technician needs to bend and move to make sure all the regions are scanned, making it uncomfortable while performing scanning for a long time. Heating problem of structure sensor was also inferred to be a reason for the discomfort based on the technician's review.

5 Conclusion

In last few decades the accuracy and precision of the 3D scanners have improved highly. All the three models of 3D scanners examined in this chapter have their own set of advantages and limitations. The older model of 3D head scanners like Cyberware 3030 lacked the ability to scan the shadowed regions. Advanced scanners like Artec Eva and structural scanner are hand held and are user-friendly and portable. Depending on the requirement of accuracy for the application the designer can choose a 3D scanner like Artec Eva or structural scanner for head and face based scanning.

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