Egyptian Prosthodontic Association (EPA Newsletter)

Photogrammetry Digital Scanning

Is it time for affordable digital dentistry?

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Digital incorporation into clinical practice became a key for success in modern dentistry. It improved the quality of dental practice by enhancing the predictability and shortening of the chairside time [1]. Stepping into the digital dentistry implies owning a digital scanner with high accuracy depending on one of the known technologies in digital dental scanning as confocal imaging, triangulation or active wavefront sampling [2].

However, the high price of the equipment can still be an impediment factor for dentists, restricting the digital introduction in their clinics. For this reason, it is interesting to develop low-cost techniques such as photogrammetry [3].

What is photogrammetry?

By definition Photogrammetry is a mathematical technique based on the generation of three-dimensional coordinates by identifying repeated points in multiple overlapping two dimensional images acquired at different angles for the same object [4]. (Figure 1 & 2).

This approach depends on passive light projection or simply depending on the surrounding ambient light, rather than other methods that depend on active light or laser projection of white, red, or blue structured lights on the scanned object [5]. Projected light luminous point is projected onto an object, and the distance to the object is calculated by triangulation [5].

Processing the images to produce three dimensional models.

Here comes the important question: How these images are changed into three dimensional models in one of the formats used in dental field as STL, PLY or OBJ?

At first, we have to take a look on how photogrammetry dedicated software as Zephyr 3D, Reality capture, Agisoft metashape work. The software pairs the inserted photos through detecting overlaps between images, it creates a cloud of scattered points, identifying the three-dimensional position of common points in two or more photographs. From this, a dense cloud of dots is created, which finally generates the three-dimensional mesh of the object

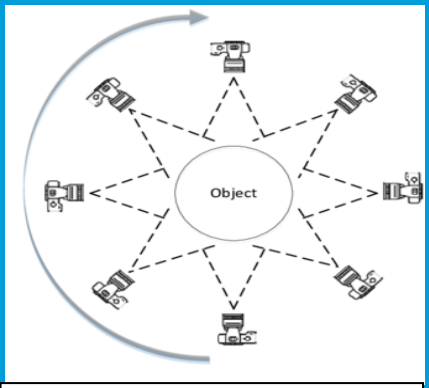

Figure 1: overlapping images required for photogrammetry imaging.

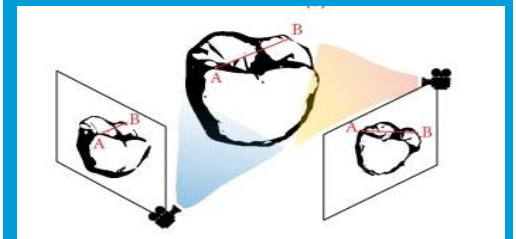

Figure 2: Stereophotogrammetry technology that generates files by algorithm by obtaining coordinates from numerous pictures. (2)

and its texture [6,7] (Figure 3).

What is the level of accuracy expected from this technique?

Photogrammetry seems to be a good and accessible method for acquiring digital dental models, with excellent quality achieved when starting from a plaster model [8].

With these findings in mind, we might assume that photogrammetry is a viable means to acquire digital models at minimal expense. This leads to the possibility of using photogrammetry based on open-source software, as doing so would be within the reach of students and young dentists not yet able to acquire expensive digital tools [8].

Levels of trueness and precision that are comparable with extraoral and intraoral scanners were recorded in studies concerned with photogrammetry scanning method [6,7,8].

Limitations and the cost of being economic.

There is always a cost for going into the economic way, despite that photogrammetry is an easier and more accessible technique, there are two major drawbacks which are:

* Time needed for rendering images inside photogrammetry software which differs according to the type of software used and number of images acquired for the object [9].

* The quality of produced model is dependant on the quality of 2D images used, regarding sharpness, focus and exposure levels of the images [7].

* The need for spraying shiny and reflective surfaces, to prevent refraction and scattering of ambient light used for photographing the object, which may result in a deficient determination of the depth of the scanned object (10). Another reason for using scanning spray is that teeth are quite uniform objects with minimal photometrical landmarks. Using a small amount of powder was intended to create a random-texture surface to aid in the image correlation process inside photogrammetry software (11).

What do you need as equipment to start with photogrammetry?

You may think it requires a lot of sophisticated equipment to start with the process of photogrammetry. On the contrary simply what you need is an efficient normal camera, better preferred to be a professional digital single reflex camera DSLR either full frame or crop sensor. These cameras provide full control on photography settings as lighting, exposure and focus. The megapixel resolution is not the determinant of the image quality as much as its sharpness, depth of field, noise reduction and proper light distribution. The lens for image capturing is better to be a macro lens with fixed focal length that provides minimum image distortion [12].

This doesn't mean that mobile phone cameras are not used for photogrammetry. In fact they can be used in the case of larger objects or human face scanning.

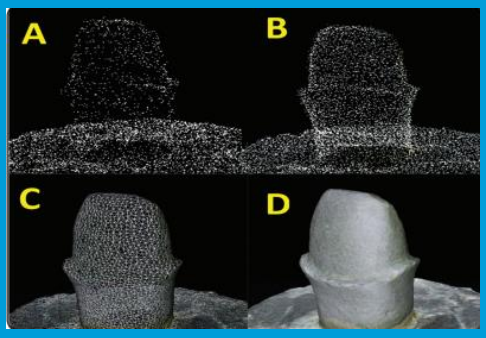

Figure 3: Steps for creating 3d model in photogrammetry software

A: creation of sparse or scattered point cloud, B: Dense point cloud, C: mesh creation & D: Textured mesh creation. [7]

Software	*Number of image input*	*Number of images in aligning result of SfM*	*Number of cloud points*	*3D reconstruction time (minutes)*
Agisoft Metashape	60	60	3924	20
3DF Zephyr	60	9	416	10
Regard 3D	60	60	2520	30

Table (1): Time required for photogrammetry software to make 3D models. [9]

The second important issue is the adjustment of photos positions to ensure overlap between images that provide data for image correlation and reconstruction by the software

Gates of the future.

As technology develops and hardware processing computers are always in progress. The affordable technique of photogrammetry scanning can have a chance to be applied on wide scale in dental practice.

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Egyptian Prosthodontic Association (EPA)

Address: 15 Ahmed Abo El-Ela St. – 8th district Nasr City, Cairo Egypt.

Mobile : 010 28203484 (Calls & Whatsapp) Phone: 02 26705035