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FLOWCHART OF FREE SOFTWARE METHODOLOGY FOR ANALYSIS OF FACIAL ASYMMETRY AND FORMATION OF HISTOGRAM MAPS AS A SURGICAL GUIDE

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ABSTRACT Surgical treatment of facial asymmetry poses challenges not only in execution but also in evaluation and planning. Image analysis methods bring advantages and disadvantages compared to subjective forms. Virtual planning technology using three-dimensional images is an alternative, though underutilized due to the cost of commercial software licenses. By using free software such as Blender® and CloudCompare®, students and healthcare professionals, including plastic surgeons, have access to an objective and effective low-cost method for pre-surgical evaluation and planning. This study established a methodology flowchart for analyzing facial asymmetry and constructing a histogram map as a surgical guide.

KEYWORDS : Facial Asymmetry, Computer Assisted Three-Dimensional Imaging, Software, Low-Cost Technology

INTRODUCTION

The treatment of facial asymmetry, in both congenital and acquired deformities, poses a challenge not only in choosing the therapeutic approach, which can range from fat grafting or fillers to the use of implants, but also in the complexity of planning in cases of facial asymmetry [1–6]. For evaluation, surgeons can rely on subjective assessment, which technically depends on the operator, or on objective methods. Imaging tests visually and metrically reveal asymmetries, among the various available options. The assessment of facial symmetry with three-dimensional images has the advantage of not being ionizing like Computed Tomography, not being affected by gravity due to supine capture, not being operator-dependent like ultrasonography, and not being influenced by probe pressure on the skin during image capture. However, the acquisition of three-dimensional meshes remains an impediment to the use of this method, as well as the use of software, most of which are proprietary, making the study expensive or unfeasible. The study of facial asymmetry in patients with Parry Romberg Syndrome using a color scale is an objective method for both planning and post-surgical monitoring.

In this study, researchers collect and analyze data on a group of individuals with facial asymmetry. The process by which facial asymmetry measurements were made and the histogram map was created is described in detail, highlighting the use of free software.

Objective

To describe the methodology flowchart using free software for analyzing facial asymmetry and constructing a histogram map.

Method

This project was submitted to CEP - HCFMUSP under number 3.972.761 and CAAC: 29875420.1.0000.0068. Sixteen patients from the Cranio-Maxillo-Facial Surgery outpatient clinic at USP, diagnosed with Parry Romberg Disease, were evaluated. All of them completed and signed the specific TSCLE.

The equipment used was a Dell Inspiron 15® computer with an Intel® Core™ i7-7700HQ CPU @ 2.80GHZ and 16.0 GB RAM.

Photogrammetry of the patients was performed using the +ID protocol (photo capture with a smartphone and photogrammetry executed with OrtogOnBlender® on the Blender® 2.91.0 platform) [7,8], with the distinction of using 36 photos, 12 in each axis of capture (Fig. 1).

Figure 1 Legend: Photogrammetry performed using Ortog On Blender®.

Mesh adjustments were made to encompass only the face, removing nearby images captured during the photogrammetry. A duplication of the face was performed (Blender® Command; Shift + D) and mirrored on the "X" axis of the duplicated mesh (Blender® Commands: Ctrl + M + X). The alignment of the face mesh copy over the original face mesh was achieved using fixed points of the nasium, nasal tip, menton, and external canthal ligament, with fine tuning through the grab command (Blender® command: G key), and this was named the mirrored mesh (Fig. 2).

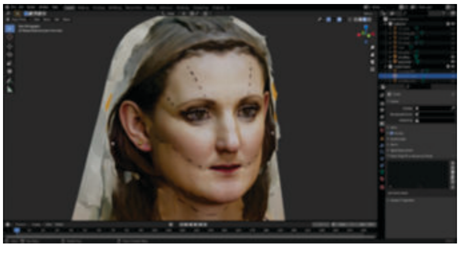

Figure 2 Legend: Alignment of the original mesh with the mirrored mesh in Ortog On Blender®.

Once the meshes were aligned, cuts were made to isolate only the area of interest to be measured (Fig. 3).

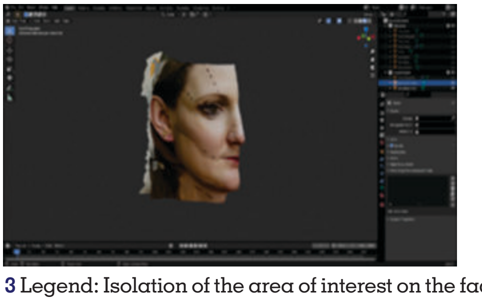

Figure 3 Legend: Isolation of the area of interest on the face in OrtogOnBlender®.

Two .stl files were exported, named as "original mesh" and "mirrored mesh," into a folder created for each patient (Fig. 4).

Figure 4 Legend: Preparation of .stl files in OrtogOnBlender® for export.

The importation of the original and mirrored meshes into CloudCompare® v2.13.Beta software was conducted by selecting both files in the folder and dragging them onto the workspace. Automatically, the program created a hierarchy with the location of the source folder and the mesh name, which were renamed to 'original' and 'mirrored'. The original mesh was selected and, with the "shift" key pressed, the mirrored mesh was selected, establishing the original mesh as the reference for comparison using the "compute cloud/mesh distance" command. Upon activating the "compute" box, the color map (histogram) appeared, showing the displacement difference of the mirrored mesh relative to the original mesh, thus delineating the areas of asymmetry (Fig. 5).

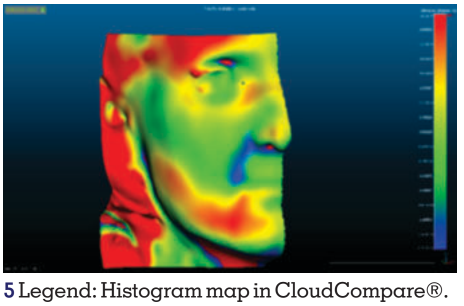

Figure 5 Legend: Histogram map in CloudCompare®.

The time spent processing each case was recorded. This is a descriptive observational study, where the authors establish a step-by-step process for creating a quantitative map of surface differences in cases of facial asymmetry.

RESULTS

The entire digital processing was conducted using free software, Blender® and CloudCompare®. From capturing the images with a smartphone to constructing the color map, the process incurred no processing costs. The complete planning process was feasible to be conducted on a standard laptop, without the need for dedicated graphic computing hardware. On average, 30 minutes of work were spent from the capture of the photographs to the construction of the mesh through photogrammetry, exporting and importing the files, as well as the process of constructing the color map.

DISCUSSION

Facial scanning has been effectively conducted using monoscopic photogrammetry, well-established in anaplastology, which requires submillimeter details in 3D meshes for adapting prostheses to patients [9]. Consequently, acquiring surface meshes with a smartphone is an effective and low-cost practice. In this study, the number of photos was increased from 15 to 36, with 12 in each capture axis, i.e., 12 above, 12 at the horizontal level, and 12 below. This modification aimed to enhance the data for the photogrammetry algorithm, improving the details of the hemiface. Currently, free mobile apps like Scaniverse® (NIANTIC, INC.) or 3D Scanner App™ (Laan Labs), available for iPhone® Pro 12 or iPad® Pro from version 12 onwards, utilize iPhone's Lidar technology. Similarly, the Polycam – LIDAR & 3D Scanner® (Polycam) works on Android smartphones, enabling low-cost facial scanning with easy mesh export. However, the realistic texture aspect (UV map) of photogrammetry remains of superior quality. For this study, mesh processing was conducted in .stl files, i.e., three-dimensional meshes without texture, which did not affect the histogram map's results used for defining asymmetry differences.

The entire photogrammetry process was carried out using the OrtogOnBlender add-on (http://www.ciceromoraes.com.br/doc/pt_br/OrtogOnBlender/). It's a tool developed for and used in Blender® software, which is licensed as GNU GPL (General Public License), owned by its contributors (https://www.blender.org/about/).

After mirroring the 3D mesh, both the original and mirrored meshes had to be realigned, a process based on fixed points like the nasium, nasal tip, menton, and external eye corner. However, in some cases, fine adjustments were necessary due to the presence of laterorrhinia, bone hypoplasia altering the position of the cantal ligament, or menton deviation. The clinical sign of "sabre stroke" in the pathology aided in this alignment.

The CloudCompare® program is an open-source application for processing 3D point clouds and TIN (Triangle Irregular Network). Originally designed for comparing two 3D point clouds (such as those acquired with a LASER scanner) or between a point cloud and a triangular mesh, it evolved into a more generic 3D cloud processing program, including advanced algorithms (registration, resampling, manipulation of color/normal/scalar fields, statistics calculation, sensor management, automatic segmentation, etc.). (https://www.cloudcompare.org/presentation.html). Importing into Cloud Compare® was user-friendly, and few commands were needed to obtain the color map, the histogram, on the mirrored mesh. In addition to the differences observed in the color map, it was possible to generate a scale defining the linear distance between one mesh and another, specifying the color difference, which provided greater visual accuracy between the differences.

The literature shows similar virtual planning processes with color maps, but using proprietary software, often making planning outside the university environment unfeasible, limiting the practice to projects and not in the professional life of plastic and/or cranio-maxillofacial surgeons [1,6]. The ability to objectively calculate differences in facial asymmetry is crucial for treatment reproducibility and uniformity of approach, as it relies on mathematical calculation rather than subjective interpretation.

The use of free software in medicine is a reality [10–12], opening up possibilities for popularizing not only planning methods but also low-cost research. This standardization benefits not only patients but also provides uniformity in teaching and specialist training.

The primary difference between methods is the number of steps and commands necessary to produce the color map. While proprietary software often consolidates these into a few steps for a specific result, free software, though viable, may require more steps or even multiple software, as in this study. However, this is not an absolute restriction, as once the workflow is established, the time required to obtain results decreases.

The author previously published a virtual workflow for volumetric calculation in the case of facial asymmetry, where the calculation generated an absolute volume number missing in a specific area of asymmetry [12], a study conducted in Blender® free software. The same study mentioned the possibility of using a histogram as an analysis of projection difference (Fig.6). Now, with a histogram, it is possible to establish a strategy for distributing the total volume of the fat graft, as it defines the areas of lesser and greater projection, allowing for a stepped distribution of fat from depth to surface, depositing more superficially at points of desired higher projection. This treatment method replicates an altimetric map or hypsometry, used in topography to stratify valleys and peaks, offering projection in pre-determined locations with base support. In cases of Parry Romberg Syndrome, it is important to note that atrophy affects all tissues, and using only the existing fat pads on the face may not correct the desired volume discrepancy. The use of a histogram map standardizes correction by observing global differences rather than just soft tissue, prompting more prospective studies (Fig. 7).

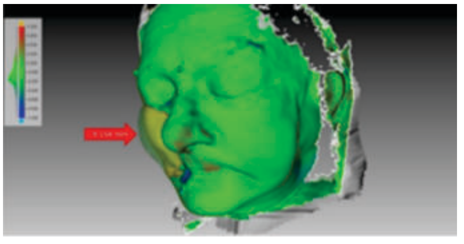

Figura 6 Legend: Histogram map showing the difference in millimeters between the meshes in profile view.

Figure 7 Legend: A - Pre-operative image; B - Intraoperative image; and C – Post-operative image after 6 months. The lipografting procedure followed the markings of the histogram map.

This study provides a comprehensive framework for exploring the application of free software in the planning of facial reconstructions, making a significant contribution to the medical field.

CONCLUSION

The authors have described the methodology flowchart using free software for the analysis of facial asymmetry employing a histogram map, demonstrating its viability for use in virtual planning.

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