

Evaluation of Craniofacial Reconstruction using Geodesic Network

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Abstract

The goal of craniofacial reconstruction is to infer from a person's skull the shape of their face. It is frequently used in forensic medicine, archaeology, cosmetic surgery, and other fields. However, the assessment of craniofacial reconstruction receives minimal attention. The geodesic network-based reconstruction of the craniofacial faces is evaluated both globally and locally using an objective method proposed in this paper. First off, the geodesic networks of the original face and the reconstructed craniofacial face are created using geodesics and geodesics, respectively, whose intersections constitute network vertices. Then, the weighted average of the shape index values in a neighbourhood is defined as the feature of each network vertex, and the absolute value of the correlation coefficient of the features of all related geodesic network vertices between two models is considered as the holistic similarity. Additionally, the local similarity is calculated for each of the six subareas of each model's geodesic network, which are the forehead, eyes, nose, mouth, cheeks, and chin. The subjective judgement received from 35 people in five groups is broadly similar with the evaluation made by our method, according to experiments using 100 pairs of reconstructed craniofacial faces and their corresponding original faces.

Keywords: Craniofacial reconstruction; CT scans; Neurodevelopment; Image augmentation

Introduction

Craniofacial reconstruction uses the connection between soft tissues and the underlying bone structure to predict an individual's face appearance from their skull. Numerous fields, including forensic medicine, archaeology, medical cosmetic surgery, and public safety, use it extensively. The research on computer-aided craniofacial reconstruction has drawn a lot of attention as a result of the advancement of 3D digitalization technology. The improvement of craniofacial reconstruction techniques greatly benefits from the evaluation of the procedure. However, the majority of studies on craniofacial reconstruction concentrate on the rebuilding process alone, giving little thought to how the results of the reconstruction are evaluated [1].

One of the most intricate geometrical structures in the natural world is the craniofacial face. The evaluation of the outcomes of the craniofacial reconstruction remains a difficult problem. Three different types of craniofacial reconstruction evaluation techniques are currently in use: subjective qualitative evaluation, objective quantitative evaluation, and combination methods of subjective and objective evaluation. By developing various evaluation procedures, subjective evaluation methods evaluate the outcomes of craniofacial reconstruction subjectively. Although the subjective evaluation approach is in line with human cognitive theory, the evaluation procedure is labour-intensive and time-consuming, and human subjective factors affect how accurate the evaluation results are [2].

A preliminary study on assessing the outcomes of craniofacial reconstruction using an objective manner was conducted by certain academics. By calculating the number of relative angles in various intervals, they were able to define the probability density function of the relative angle-context distribution. By measuring the bending of a reference hemisphere to a craniofacial model, the RACD algorithm was expanded to bending-relative angle-context distribution (BRACD) to address the calculation instability and high time complexity of RACD. Examined the relationship between the shape of the skulls and the faces, and then used the distance between matching spots on the rebuilt craniofacial face and the original face to calculate the craniofacial reconstruction error [3].

Many academics merged their subjective and objective assessments. As an illustration, VaneZis asked 20 assessors to select the top three matches among 10 rebuilt craniofacial faces of a single skull and the original face. They also used mathematical shape analysis assessment and Procrustes Analysis to compute the correlation between the subjective and objective evaluation outcomes. Despite the fact that the findings are not statistically significant, they do show that the objective technique does appear to capture some perceptual similarity in human observers. They carried out a subjective investigation in which a group of people (12 people on 180 3D faces) judged the similarity of pairs of faces (a total of 5490 pairs of similarity scores). They retrieved Gabor features from 3D faces' texture photos and automatically detected feature spots on the range in terms of objectivity. Finally, they showed how strongly these traits connected with people's ability to judge similarity [4].

In this research, we provide a brand-new geodesic network-based global and local evaluation method for craniofacial reconstruction. The feature of one vertex is defined as the weighted average of the shape index value in a neighbourhood. The degree of similarity between two models is determined by the absolute value of the correlation coefficient of each characteristic of all associated geodesic network vertices. It provides direction for improving the techniques used in craniofacial reconstruction and lays the groundwork for qualitative and quantitative examination of the results [5].

Materials and Methods

The Institutional Review Board (IRB) of Beijing Normal University's Image Center for Brain Research's National Key

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Received: 29-Aug-2022, Manuscript No: jmis-22-75008, Editor Assigned: 01-Sep-2022, pre QC No: jmis-22-75008(PQ), Reviewed: 15-Sep-2022, QC No: jmis-22-75008, Revised: 20-Sep-2022, Manuscript No: jmis-22-75008(R), Published: 27-Sep-2022, DOI: 10.4172/jmis.1000145

Citation: Rennie J (2022) Evaluation of Craniofacial Reconstruction using Geodesic Network. J Med Imp Surg 7: 145.

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Laboratory of Cognitive Neuroscience and Learning gave its approval to this study. The study was conducted using a database of 208 whole head CT scans on voluntarily participating individuals, primarily from the Han ethnic group in North China, ranging in age from 19 to 75. The Siemens Sensation16 clinical multislice CT scanner equipment was used in Xianyang Hospital in western China to produce the CT scans; we first extract the skull and face borders from the original CT slice images before using a marching cubes technique to reconstruct the triangle mesh models of the 3D skull and skin surfaces [6].

The three-dimensional craniofacial mesh models that were created frequently have flaws including holes, gaps, degeneracies, or lack of manifold topologies. To turn the 3D face model into a complete and well-structured manifold, we must fill in the gaps and holes and eliminate the scattered points. All 3D craniofacial data are converted into a single Frankfurt coordinate system to remove the impacts of data gathering, posture, and scale. Since there are too many vertices in the entire head and the face features are primarily concentrated on the front region of the head, we choose a craniofacial data set as a reference template and remove the back portion of the reference craniofacial model [7].

Discussion

We use the partial least squares regression (PLSR) method to reconstruct the craniofacial models in order to collect experimental data. Of the 208 CT scans, 108 pairs of skulls and face skins are used as training data, and the remaining 100 skulls are used as test data for the craniofacial reconstruction. As a result, we are left with 100 pairs of original craniofacial models and the reconstructed face models. We first introduce the method we developed for the subjective evaluation in order to compare it with it. The proposed objective method is then used to evaluate the results of the reconstruction both globally and locally [8].

We asked 35 people to evaluate the 100 rebuilt craniofacial face models in order to assess the proposed objective procedure. Each group contained 20 pairs of the 100 pairs of craniofacial face models that were separated into five groups. Twenty pairs of reconstructed craniofacial faces and corresponding original craniofacial faces were evaluated by each group of seven participants from a total of 35 subjects, who were divided into five groups. Every pair of faces on the screen was shown to the subjects, and they were instructed to select the degree of overall similarity from the five options shown in Figure 5: sufficiently (above 90%), substantially (70%–90%), somewhat (50%–70%), somewhat (30%–50%), and lowly (0%–30%) [9]. The six subareas of the face—the nose, eyes, mouth, forehead, cheeks, and chin—were also requested to be chosen as the most and least similar. Each respondent was only tasked with assessing twenty pairs of craniofacial faces in order to prevent visual exhaustion. 100 pairs of craniofacial faces were compared subjectively by the five groups, and it was found that each pair had seven similarity degrees between seven individual subjects. We calculated the mean minimum similarity score using the lower limits and the mean maximum similarity score using the higher limits of the seven similarity degrees. As a result, using a subjective evaluation, we were able to determine a similarity interval for each pair of craniofacial faces [10].

The objective similarity score between the reconstructed craniofacial face and the corresponding original face is obtained by comparing the characteristics of all the geodesic network vertices in the overall evaluation. Local evaluation measures how closely the reconstructed craniofacial face resembles the corresponding original craniofacial face in six subareas: the forehead, nose, eyes, mouth, cheeks,

and chin. We compare the most and least comparable regions with the arbitrary evaluations. The geodesic network vertices' features are used to calculate the local similarity scores for three sets of craniofacial faces in each subarea [11].

We assess each of the 100 rebuilt craniofacial faces locally and contrast the global assessment with the local assessments of six subareas. As we can see, the global similarity and the similarity of the nose are fairly constant, while the global similarity and the similarity of the eyes are essentially unconnected. Additionally, using the 100 examples, we calculate the absolute value of the correlation coefficients between the local similarities of the six subareas and the global similarities. We can also observe that the similarities between the nose and the rest of the face are strongly correlated, whereas the similarities between the eyes and the rest of the face are least correlated. We calculate the average similarity score for each of the 100 face pairs' subareas. We can see that the chin area has a maximum and the eye area has a minimum. This suggests that the area around the eyes needs more reconstruction. The conclusions of this objective examination agree with those of the subjective evaluation [12].

Conclusions

Craniofacial reconstruction is often employed in a variety of disciplines, including forensic medicine, archaeology, medical cosmetic surgery, and others. The majority of research on craniofacial reconstruction, however, focuses solely on the rebuilding procedure and pays little attention to how the reconstruction is assessed. This study provides a method for objectively assessing the reconstructed craniofacial faces both globally and locally based on the form index of geodesic network vertices. Geodesics are used in the construction of the craniofacial geodesic networks and are themselves geodesics. The weighted average of the shape index value in a neighbourhood for each vertex of a geodesic network is what we refer to as the feature of the network vertex.

The measure of similarity between two models is the absolute value of the correlation coefficient of every related geodesic network vertex. In order to assess our procedure, we used 100 pairs of matched original faces and reconstructed craniofacial faces. We also asked 35 volunteers to assess the reconstructed craniofacial faces visually in order to compare their assessments with the subjective ones. Experimental findings demonstrate that our method's evaluation is roughly consistent with the subjective evaluation. We can advise on how to enhance the techniques for craniofacial reconstruction by assessing the consequences of reconstruction both nationally and locally. In addition, the suggested method is appropriate for the craniofacial faces with minor expression variation because small face expression may be seen as an isometric deformation, under which the geodesic distance is invariant.

Conflict of Interest

None

Acknowledgement

None

References

1. Snow CC, Gatliff BP, McWilliams KR (1970) Reconstruction of facial features from the skull an evaluation of its usefulness in forensic anthropology. *Am J Phys Anthropol* 33: 221-228.
2. Stephan CN, Henneberg M (2001) Building faces from dry skulls: are they recognized above chance rates. *J Forensic Sci* 461: 432-440.

3. Feng J, Ip HHS, Lai LY, Linney A (2008) Robust point correspondence matching and similarity measuring for 3D models by relative angle-context distributions. *Image Vis Comput* 26: 761-775.
4. Deng Q, Zhou M, Shui W, Wu Z, Ji Y, et al. (2011) a novel skull registration based on global and local deformations for craniofacial reconstruction. *Forensic Sci Int* 208: 95-102.
5. Lawrence ND (2004) Gaussian process latent variable models for visualisation of high dimensional data. *Adv Neural Inf Process Syst* 16: 844-851.
6. Lee S, Wu C, Lee ST, Chen P (2009) Cranioplasty using polymethyl methacrylate prostheses. *J Clin Neurosci* 16: 56-63.
7. Gool van AV (1985) Preformed polymethylmethacrylate cranioplasties. *J Oral Maxillofac Surg* 13:2-8.
8. Marchac D, Greensmith A (2008) Long-term experience with methylmethacrylate cranioplasty in craniofacial surgery. *J Plast Reconstr Aesthet Surg* 61: 744-752.
9. Lu JX, Huang ZW, Tropiano P (2002) Human biological reactions at the interface between bone tissue and polymethylmethacrylate cement. *J Mater Sci Mater Med* 13: 803-809.
10. Friedman N, Linal M, Nachman I, Pe'er D (2000) Using bayesian networks to analyze expression data. *J Comput Syst Biol* 7: 601-620.
11. Quatrehomme G, Balaguer T, Staccini P, Alunni-Perret V (2007) Assessment of the accuracy of three-dimensional manual craniofacial reconstruction: a series of 25 controlled cases. *Int J Legal Med*
12. Claes P, Vandermeulen D, De Greef S, Willems G, Clement JG, et al. (2010) Computerized craniofacial reconstruction Conceptual framework and review. *Forensic Sci Int* 201: 138-145.