Forensic Facial Reconstruction using HRBF

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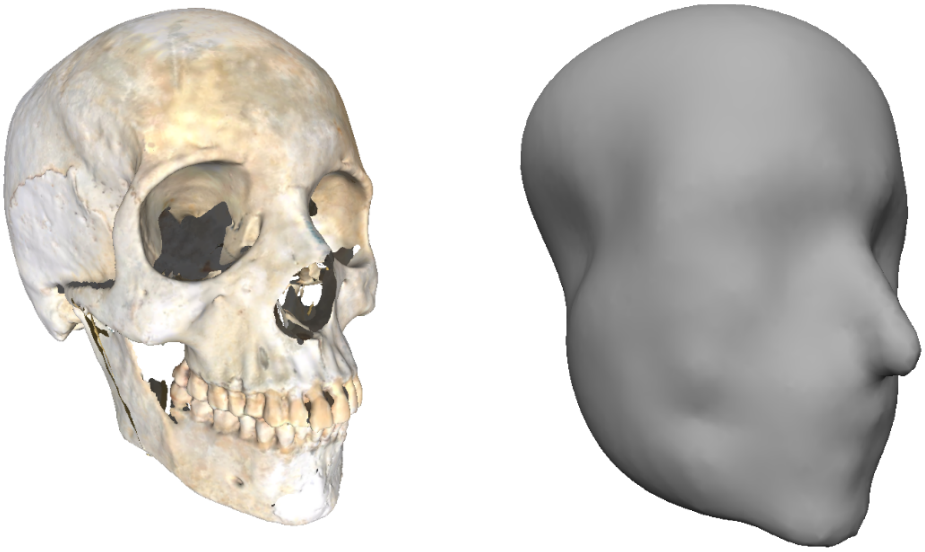


Fig. 1. From the scanned skull (left), our method produces an approximate model of the face (right).

***Abstract*—In forensic investigations, facial reconstructions directly from skulls are used as a means of recognition and identification. However, the traditional techniques based on manual clay modeling are, at some degree, subject to the artist's interpretation. In this work, we propose a computerized facial reconstruction method that uses hermitian radial basis functions (HRBFs) to generate the surface of the face.**

***Keywords*-facial reconstruction; human identification; forensic anthropology; forensic science**

I. Introduction and Related work

The manual techniques usually begin by fixing tissue depth pegs at the skull or skull replica. The skull is then covered with clay until the pegs are completely hidden, modelling the facial musculature and skin in the process. The length of those pegs are specified by tables with the average anatomical values for a person belonging to an ethnic group, gender and age [1].

Different computerized methods have been proposed to automate facial reconstructions. In the work of Vanezis [2], a face is chosen from a database of face templates so that it more closely resembles the morphological features of the skull. This template is then deformed to accommodate the skull, resulting in the reconstructed face. Since these templates were generated by scanning the faces of real people, the results obtained can be somewhat biased.

In a recent work, Pascual et al. [3], propose a method to interpolate the input points and create a triangular surface mesh of the face. However, since no extra information or restrictions are given, the results are far from sufficient for identification.

In this paper, we propose a method to find some points on the face related to a supplied scanned skull and interpolate them smoothly with hermitian radial basis functions (HRBFs). The goal is to supply enough information about a human face to the system, without being biased towards predefined templates.

II. Point restrictions

A. Point acquisition

An interface (Fig. 2) was built to allow a professional in the field of forensic medicine to select points over the surface of the skull. Each selected point receives from the user an identification name and the thickness of the soft tissue in that region. The normal vector of each point can be obtained from the skull mesh. The thickness of the soft tissue combined with the normal vector yields a point that lies on the face. This way, for every point selected on the skull, a corresponding point on the face is found.

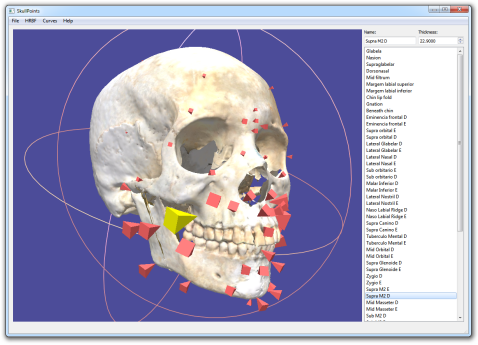
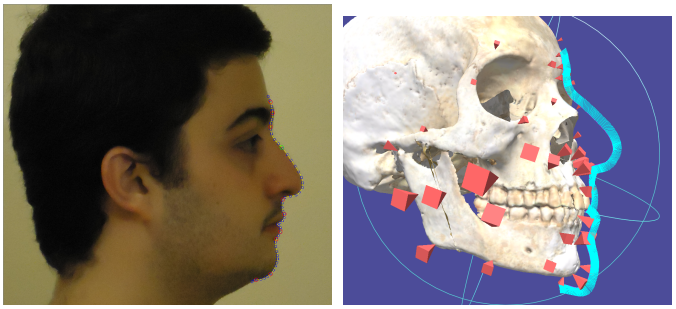


Fig. 2. Interface for point acquisition.



(a) Curve acquisition. (b) Adaptation to the skull

Fig. 4. Profile curve restriction.

B. Surface generation

We assume, for simplicity, that the normal vector of a point on the face is the same of the corresponding point on the skull. The surface is then generated by feeding the set of points and normals of the face to the HRBF algorithm [4]. From the generated HRBF surface, points are sampled for visualization (Fig. 3).

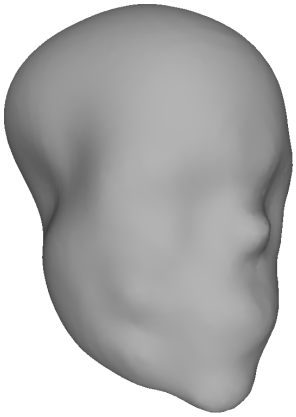


Fig. 3. Reconstruction with point (position and normal) restrictions.

III. Curve restrictions

A face cannot be completely described from it's skull, since it lacks information in regard to the shape of some soft tissue structures like ears, lips and nose. For these structures, we chose to complement the skull with additional curves.

A. Curve acquisition

Another interface (Fig. 4, a) was built to allow the manual creation of two-dimensional curves over a picture, modeled as Catmull-Rom splines [5]. The interface also allows the user to pick points on the curve and give names to those points.

B. Curve adaptation

The adaptation of the curve to the skull is done in three steps. First we match the named points of the curve against the known points of the face with the same names. Then we compute the position, orientation and scale of the curve that best fits the matching pairs by solving the orthogonal procrustes problem. Finally, we deform the curve as rigid as possible using moving least squares for an exact fit (Fig. 4, b).

C. Reconstruction using curves

Points are sampled from the adapted curve and their normals evaluated. Feeding those points and normals together with the previous restrictions, the HRBF algorithm produces an improved result. Fig. 1 illustrates an example of reconstruction with an additional profile curve.

IV. Conclusion and future works

Using only the skull is not sufficient to direct the facial reconstruction. It is clear that the quality of results can be dramatically improved by appending additional curves. That said, we intend to add more curves other than the profile curve, and research new ways to impose restrictions without letting the results become biased. We are also investigating methods to add parts of the face, such as ears and eyes, by geometrically describing anatomical rules from the facial reconstruction literature.

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References

[1] C. Wilkinson, "Facial reconstruction anatomical art or artistic anatomy?" *Journal of Anatomy*, vol. 216, no. 2, pp. 235–250, 2010.

[2] M. Vanezis, "Forensic facial reconstruction using 3-d computer graphics: evaluation and improvement of its reliability in identification," Ph.D. dissertation, University of Glasgow, 2008.

[3] L. Pascual, C. Redondo, B. Sanchez, D. Garrido, and A. Galdon, "Computerized three-dimmensional craniofacial reconstruction from skulls based on landmarks," in *Federated Conference on Computer Science and Information Systems (FedCSIS)*, sept. 2011, pp. 729 –735.

[4] I. Macedo, J. P. Gois, and L. Velho, "Hermite radial basis functions implicits." *Comput. Graph. Forum*, vol. 30, no. 1, pp. 27–42, 2011.

[5] E. E. Catmull and R. R. J., "A class of local interpolating splines." *Computer Aided Geometric Design*, pp. 317–326, 1974.