SURGETICA 2017

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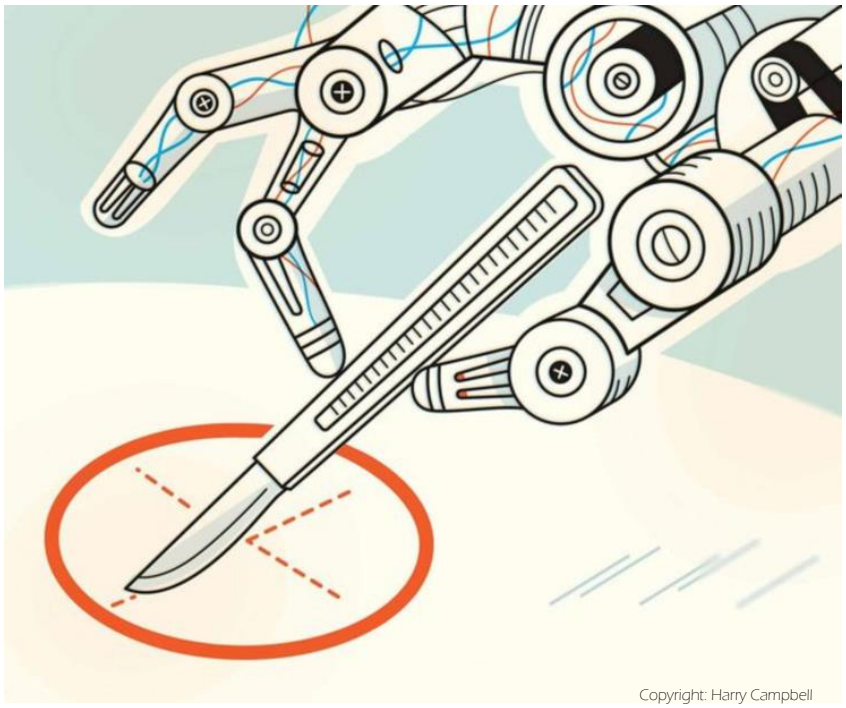
Strasbourg

Conference Proceedings



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Computer Assisted Medical Interventions

scientific issues, tools and clinical applications

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Foreword

The present Proceedings contain the oral and poster contributions accepted for presentation at the 2017 edition of Surgetica. They also include the abstracts of the keynotes delivered at the conference.

"Surgetica" is a conference series that aims at gathering clinicians, scientists and industry professionals acting in the field of Computer Assisted Medical Interventions (CAMI). The venue provides a unique opportunity to examine the state-of-the-art in CAMI and to promote scientific collaboration and exchange amongst the community. The 2017 edition of Surgetica is hosted in the city of Strasbourg, Region Grand Est (France). Healthcare is at the center of the region's development strategies with an increasing number of initiatives to support research in the field and to develop new medical technologies. The ICube Laboratory, a major actor involved in these strategies and initiatives, is privileged to organize and host the conference for its first edition out of Grenoble. Welcome to Strasbourg!

Surgetica, which benefits from the endorsement and the unfailing support of the CAMI Labex, has - in its present edition - partnered with France Life Imaging and benefits from the support of the University of Strasbourg, Strasbourg Eurométropole and Kuka Robotics. For this, we thank all the partners and sponsors of the event. We cease this opportunity as well to thank all esteemed members of the CAMI community who have gathered to support the conference through their high-quality submissions and contributions.

The 2017 edition of the conference covers all medical specialties and all scientific topics of CAMI with 28 papers accepted for oral presentation and 29 others accepted for poster presentation. Furthermore, the conference features five renowned experts in the field who have kindly accepted to deliver exciting keynotes at the conference: Pr. Sébastien Ourselin (University College London, UK), Pr. Brad Nelson (ETH Zürich, Switzerland), Dr. Nicolas Padoy (University of Strasbourg, France), Dr. Jean-Michel Lemée (CHU Angers, France) and Dr. Marc-Olivier Gauci (CHU Nice, France).

With such rich and diverse high-quality program, we wish you a fruitful and productive conference. Enjoy your stay in Strasbourg and do not miss on visiting this beautiful region.

Pierre Renaud, Professor, INSA Strasbourg
AVR-ICube, Strasbourg, France

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Conference Program

A robust method to compute the 3D symmetry line and the torsion of the human back surface: application to scoliosis

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The aim of this study is to devise a new robust method for computing the 3D symmetry line of the back surface and assessing the surface rotation along the line.

1 Introduction

Scoliosis is a deformation of the spinal midline (i.e. the curve which goes through the center of vertebrae) in the coronal and sagittal planes caused by the rotation of vertebrae [1]. This spinal disease provokes a severe impairment of the outer appearance of the individual. These trunk asymmetries are generally the basis of a first clinical assessment. A definitive diagnosis is confirmed by an X-ray examination of the vertabrae and the spinal shape. However, radiological hazard is a major concern, especially for children and preventive medicine. This is why many methods based on 3D measurements of the back surface using various optical devices (photogrammetry, structured light, laser stripe...) have been proposed [2]. The common challenge of these methods is the deduction of internal spinal parameters from the back topography. For instance, Drerup [2, 3] proposed to compute the midline from the symmetry line of the back surface and use the normal vectors along this line to estimate vertebral rotation. This approximation may be considered valid if there is no large deformation.
The purpose of this study is to devise a robust method for computing the symmetry line and assessing the surface rotation along this line.

2 The reference method

Many methods have been proposed to detect the symmetry line for erect postures from a 3D scanned human back surface [4]. We selected the method described by Di Angelo *et al.* in [5] because this method performs at a similar level of accuracy than the method proposed by Drerup and Hierholzer [3] which was validated in clinical conditions. Moreover, this is the only one which introduced an extension to evaluate the symmetry line in asymmetric postures [6]. The method can be described by the following scheme:

- Computation of the planar profile curves C_i resulting of the intersections of the back surface with a set of parallel planes between the prominent vertebra and the intergluteal fold;
- For each C_i, definition of the symmetry point P_i as the point which minimizes a symmetry index, which is based on the orientation of the normal unit vectors along the profile over a distance L_0;
- Estimation of the symmetry line by interpolating the set of P_i with a parametric curve. We can also associate to each P_i the vector $\mathbf{n}_i$ which is locally normal to the back surface.

This method is based on the symmetry of each local planar profile curve C_i. If the intersecting slice is not exactly perpendicular to the spinal curve or if the morphology of the back is very asymmetrical, the localization of P_i and its $\mathbf{n}_i$ may be incorrect. In addition, the result varies with the choice of L_0.
Our idea is to work with thick sections of the back surface and compute their symmetry plane instead of a single point. By reducing the dependency on local features, the hope is to enhance the robustness.

3 Our proposed method

The objective is to find the plane Π_i which effectively minimizes the difference between a surface and its symmetrical reflection. This method has already been used to study the asymmetry of the trunk [1, 7, 8] but only on a global basis. Here, we want to study the local assymetry by defining horizontal thick sections regularly spaced between the prominent vertebra and the intergluteal fold. The intersection of the thick layers with the back surface results in non-planar strips S_i of a given height. For each S_i, we relied on the method proposed by Combès *et al.* [9] which is inspired by the Iterative Closest Point algorithm:

Initialization:
A first estimation of the symmetry plane Π_i is obtained by performing a Principal Component Analysis of all the points of the back surface.

Optimization:

1) We reflect the back surface with respect to the current plane Π_i and each reflected point is paired with the closest original point;

2) The new values of the symmetry plane parameters $(\mathbf{u}_i, d_i)$, where $\mathbf{u}_i$ is its unit normal and d_i its distance to the origin, are computed by formulas given in [9];

3) If the new estimation of Π_i is very different from the previous one, a new iteration is run.

We can define a symmetry point P'_i at the intersection between the plane, the back surface and the center plane of the thick layer. As suggested by Drerup [2], it makes sense that the axial rotation ρ_i of each vertebra is the angle formed by Π_i and the sagittal plane.

4 Results

The BIOMOD^{TM} [1]system (AXS MEDICAL - DMS Imaging), which is based on the non-invasive Moiré topography method, has been used to obtain the 3D point mesh representing the back surface. Acquisitions of 21 patients affected by light scoliosis were performed in standing position.
Concerning the localization of the symmetry lines, our method has been quantitatively compared with the reference method proposed by Di Angelo *et al.* [5]. To make this possible, the parallel planes of the reference method are taken as the center-planes of the layers used in our method. Moreover, in order to correlate the axial rotation of each vertabra with the rotation of each Π_i, we define as many strips S_i as the number of vertabrae within the zone of interest.
Figure 1 shows the two symmetry lines obtained by the reference method (blue) and our method (red). The difference between P_i (obtained by the reference method) and P'_i (obtained by our method) was computed and the mean deviation is 4.86 mm, with a maximum of deviation equal to 19.8 mm and the minimum of deviation equal to 0.06 mm. Knowing that the inter-operator error introduced by a cutenaous method is evaluated to 5 mm [4], our method has a similar accuracy than the reference method without depending on the choice of a parameter such as L_0.

[1]http://www.dms.com/biomod-3s/

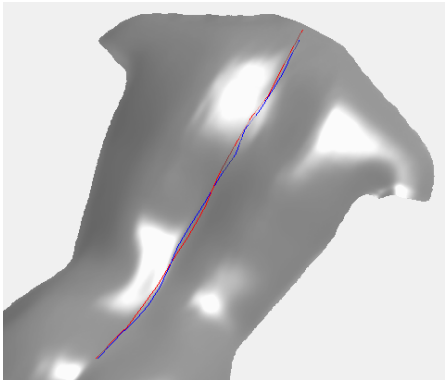

Figure 1: *Symmetry line detection.*

Concerning the back surface rotation along the symmetry line, a qualitative analysis compares the two methods as showed figure 2. Because the surface normal computation used by Drerup [2] to assess the surface rotation is a local property, the method is sensitive to noise such as local deformities or low mesh density. By adopting a more global approach over thick sections, it is reasonable to assume that our method is more resistant to local imperfections.

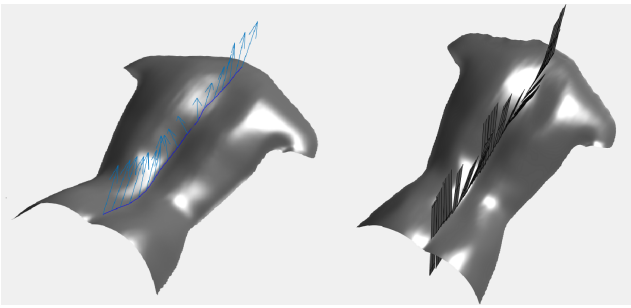

Figure 2: *Comparison of the back surface rotations between Drerup [2] (left) and our method (right).*

5 Conclusion

A new robust non-invasive method was presented to compute the 3D symmetry line of the back surface and local planes representing an estimation of the rotations of the vertebrae. The preliminary results seem promising and will be further validated by comparison with radiographs. We also plan to extend the detection of the symmetry line and local planes to patients in lateral bending or rotation positions.

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