A 3D RECONSTRUCTION OF KNEE BONES FROM BIPLANAR X-RAYS

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INTRODUCTION

The importance of three dimensional concepts in clinical studies and personalized biomechanical finite element models (Fréchède, Skalli et al., 2001) has created a need for accurate geometric reconstruction methods of bone structures. Furthermore 3D representation and morphometric information is essential to computer-assisted surgery. Currently geometry acquisition methods are available from CT-Scan or MRI. These methods require that the patient be in a lying position, which is incompatible with many diagnostic protocols. The purpose of this study is to evaluate the 3D reconstruction accuracy for knee bones of a method, based on identifiable 2D contours extracted from biplanar X-Rays

METHODS

A biplanar radiographic environment calibration and a generic object representing the structure to be reconstructed are the technical prerequisite to the method. The principle is to consider it as an initial solution of the structure to reconstruct, and to transform it in term of shape and location, in order to make it coherent with projected 2D contours and information in the X-Ray images. The method can be divided in 5 steps:

- 2D contours identification onto the radiographs,
- Calculation of the 3D contours on the generic object (tangent X-Ray location on the object surface),
- Projection of these contours on each image,
- Optimization of the distances between the 2D identified contours and projected ones (by means of translations, rotations and homothetic transformations).
- Kriging deformation of the object in order to superimpose radiographic and projected contours.

Generic model of the distal femur (556 nodes), proximal tibia (1400 nodes) and patella (1190 nodes) were used for reconstruction. In order to estimate the method accuracy, dry specimens 8 femurs (5 left, 3 right), 7 tibias (4 left, 3 right) and 6 patellas (3 left, 3 right) were reconstructed. Two orthogonal calibrated X-Ray films of each bone were acquired at the Saint-Vincent de Paul Hospital (Mitton, W. Skalli et al., 2000),. Reference models were obtained from CT-Scan 3D reconstructions (1 mm accuracy. De Guise and Martel (1988). These models were superimposed by using a least square matching. The quantitative comparison of the shapes between the two models was made using the point to surface distance with the reference models (Mitton, D. and D. J. de Guise et al 2000). The mean errors, RMS (Root Mean Square) and maximum errors were calculated for the whole surface of each model and for the femur and tibia articular surfaces.

The accuracy analysis of articular surfaces yields to similar values, but with lower local maxima (4.5 mm for the femur and 5.5 mm for the tibia).

Table 1: Shape errors (Point to surface distances, mm)

	Global Surfaces		
Errors (mm)	Mean	RMS	Max
Femurs	*0,9*	*1,2*	*5,0*
Tibias	*0,8*	*1,1*	*7,0*
Patella	*0,6*	*0,8*	*3,3*

DISCUSSION AND SUMMARY

This paper presents a method for accurate 3D personalized knee bones reconstructions from stereoradiography using 2D contours extracted onto the radiographs. This technique appears to be an interesting alternative to CT-Scan 3D reconstructions, with the advantage of low radiation. Once extensively validated, it will be of great interest for clinics (Figure 1) and 3D applications such as finite elements studies.

Figure 1: In vivo biplanar X-Rays and 3D knee reconstruction

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