

# AUTOMATED X-RAY ANALYSIS FOR PATIENT-SPECIFIC 3D FEMUR MODEL GENERATION AND CLASSIFICATION FOR PRE-OPERATIVE PLANNING

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## Introduction

In the orthopaedic domain, surgeons perform numerous kinds of joint replacement operations with variable outcomes (Prendergast, 2001). Appropriately designed mechanical models and accurate simulations can help extend lifetime of such replacements, thereby preventing undesired consequences of operation. A barrier to computer simulation, in particular finite element analysis, is generating a suitable 3D model of the patient anatomy. A method of generating 3D models from a planar X-ray image is proposed in this work.

## Materials and methods

There are three steps in this work: (i) femur contour extraction from an x-ray image (ii) generation of a database of generic models, and (iii) choosing and warping the best fit generic model to match the patient's geometry. Generated models were analyzed and classified into several groups according to distributions of patient's dimensions (Noble *et al.*, 2003)

**(i) Femur contour extraction from X-ray image.** The developed method was based on Chen *et al.* (2005). An X-ray image is subjected to image processing and analysis. Anatomical features and distinct parts of the femur borders are found taking into account standard femur dimensions and their distributions. An initial contour, or "snake", for the Active Contour (AC) algorithm is calculated, and the AC method is used to extract the extracortical femur boundary.

**(ii) Library of generic models.** For creation of the library the standardized femur model from the BEL Repository (Biomechanics European Laboratory) was used. It was scaled to maximum, minimum and average sizes taking into account distributions of patients' dimensions (Noble *et al.*, 2003).

**(iii) Choosing and warping closest generic model.** As a next step the contour extracted from the X-ray image is scaled to the original size and placed into the ZX plane so that the femoral origin is coincident with the coordinate system origin. Each model is rotated from -10 to +10 degrees about the Z axis in steps of 1 degree. Sections of the model using the ZX plane are built and compared to the extracted contour from step (i). Warping is performed in 2 steps: (i) the femoral

neck is deformed by the difference between generic model neck-shaft angle and the angle of the contour, and (ii) the model is cut into a large number of slices with each slice scaled according to the corresponding section of the contour.

## Result and Discussion

Thirty two sample models were created, e.g. Figure 1,



**Figure 1 Femur model extracted from X-ray**

and classified according to Noble (2003). Run times for the fully automated system were acceptable (5-10 minutes using the Matlab environment on a 3GHz Pentium 4 processor). Further work is needed to validate the method by comparing the geometries extracted from X-rays against corresponding geometries for the same patients from 3D reconstruction techniques such as CT and MRI. Several improvements can be made: the library of generic models will be extended, robust algorithms will be applied in the image processing part (Papari *et al.*, 2006) Finally, the proposed 3D model generation procedure will be integrated with computer simulations developed to predict implant performance pre-operatively, such as Lennon *et al.* (2006).

## References

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