X-ray 이미지를 이용한 환자 맞춤형 3차원 인체 모델 재구성 기술 개발

A Patient-Specific Reconstruction of Three-dimensional Bone Shape from X-ray Images

*고경[1], #김윤혁[2], 박원만[2]
*K. Koh[1], #Y. H. Kim(yoonhkim@khu.ac.kr)[2] , W.M. Park[2]
[1] 경희대학교 산학협력단, [2]경희대학교 기계공학과

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1. Introduction

A geometrical patient-specific three-dimensional (3D) reconstruction of human bones is needed for computer-aided planning of orthopedic surgeries or personalized finite element models [1]. Computed tomography (CT)-based reconstruction method is commonly used to obtain accurate bone shapes [2]. However, this method requires intensive labor needed in generating accurate reconstruction and is a time-consuming process. Moreover, this leads to a high radiation dose for the patient. Consequently, creating time-effective, accuracy and low dose human bone shape from medical images is a challenging goal.

In this paper, we proposed new method for the 3D bone shape reconstruction using two X-ray images taken from any direction. To achieve this goal, low dose X-rays in standing position was proposed to create a patient-specific 3D model. A predefined 3D template bone model, clinically normal and scaled to average size, is needed as a priori knowledge to obtain the 3D reconstruction. Free-form deformation (FFD) scales and deforms the template shape until this shape matches the input X-ray images.

2. Materials and Methods

2.1 Subjects

A healthy subject (25 years, height 177cm, weight 75kg) has participated to generate accurate 3D template bone shape by using CT-scan of a 1mm slice. A osteo-arthritis patient with not severely rotational deformity of a knee(less than 10°) has participated to provide anteroposterior (AP) and lateral (LAT) X-ray images. The X-ray images were taken by CXDI-40G device (Canon Inc., Tokyo, Japan).

2.2 3D reconstruction

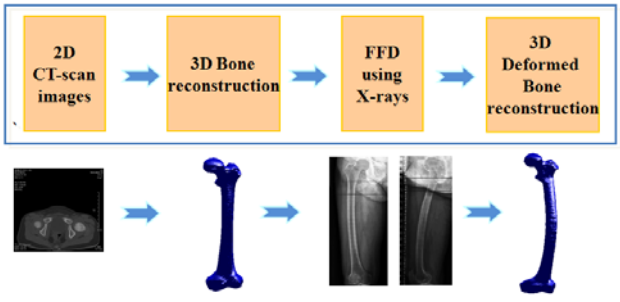


Fig. 1 The flow chart of reconstruction method

The X-ray-based 3D reconstruction method can be summarized in three steps:

1. Generate A template 3D bone shape that is clinically normal and scaled to the average size using CT scan.

2. Obtain X-ray images taken from any direction, but usually front (anteroposterior, or AP) and side (lateral, or LAT).

3. Deform a template 3D bone shape with given X-ray images using FFD algorithm. This algorithm includes dissimilarity function which measure distance between a X-ray image and the image from a template 3D bone shape projected onto a two-dimensional (2D) plane and then optimization is used to minimize dissimilarity function and align X-ray image with template image.

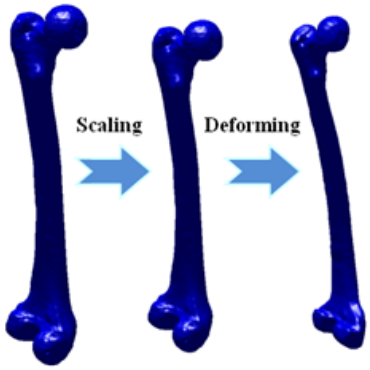
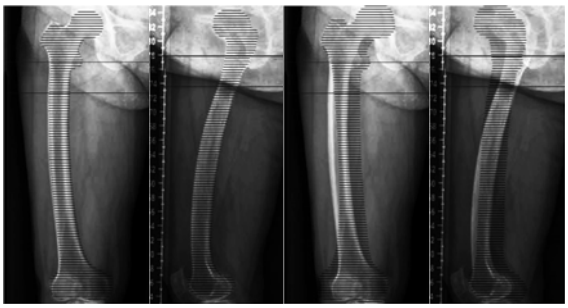


Fig. 2 The process of deforming femoral bone.

3. Results and Discussion

The deformed femur model generated by the proposed method was compared with AP and LAT X-ray images. The comparison of the shapes between the deformed femur model and X-ray images was made using difference of pixel values after setting all pixel values of projection images and X-ray images to 0 or 1. The difference between projection images and X-ray images was less than 7%. The computational time was less than 5 minutes to generate 3D femoral bone shape by the proposed method implemented in Matlab on quad 2.4GHz PC

The 3D bone shape reconstruction based on our method is useful for each of following case studies: osteotomy, computer-aided planning of orthopedic surgeries or personalized finite element models.



(b) (a)

Fig. 3 The comparison of the shapes : (a) The template shape (lined images) and X-rays (b) The deformed shape (lined images) and X-rays.

4. Conclusion

This study proposed the 3D bone shape reconstruction method of femur using AP and LAT X-ray images. The method starts with a template femoral shape generated by a CT-based reconstruction method and deforms it until projection images of the template femoral shape maches AP and LAT X-ray images.

The experimental result of this study showed that the 3D deformed femoral shape is close to a millimetric CT-based 3D bone model with the great advantage of low dose and sufficiently accurate to use clinical studies such as computer-aided planning of orthopedic surgeries or personalized finite element models.

참고문헌

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