Reconstruction of three-dimensional geometric femoral model using X-ray and three CT images

A healthy subject (25 years, height 177cm, weight 75kg) has participated to generate accurate 3D template bone model by using CT-scan of a 1mm slice. 6 patients have participated to provide antero-posterior (AP) and lateral (LAT) X-ray images. In addition, five CT slices of the patient’s distal femurs are given to generate the deformed femoral bone models for the rotational deformity. The X-ray images were taken by CXDI-40G device [(Canon Inc., Tokyo, Japan) which has max 2,688 x 688 pixels, 43cm x 43cm image size] with our scaling-tool, which is able to measure an approximate size of the bone and angles between two X-ray image.

2.2 Three-dimensional reconstruction of the femoral model from two X-ray images and three CT slices

The process of our 3D reconstruction method can be summarized in three steps (shown in Fig. 1):
1. Generate a template 3D bone model using CT scan of a healthy subject with normal height and weight.
2. Obtain X-ray images taken from any direction, but usually front (AP) and side (LAT), and three CT slices of distal femurs.
3. Deform a template 3D bone model until the images from a template 3D bone model match the CT slices corresponding to its cross-sectional contours.
4. Then optimization is used to minimize dissimilarity function and align the X-ray with the projection images and CT slices with the cross-sectional contours.

3. RESULTS

3.1 Shape accuracy

In order to validate the deformed femoral models obtained by 5 participated subjects, we compared them to the models generated by 1 mm CT scan dataset. The experimental results of this study showed that this deformed femoral model was close to the femoral model obtained by millimetric CT-based reconstruction method.
3.3 Reconstruction time

The reconstruction time in generating 3D deformed femoral models from 5 subjects was from max 3 min 9 sec to min 2 min 55 sec and mean reconstruction time was 3 min 4 sec. This system is implemented by Matlab and runs on quad core 2.40GHz PC. These results indicate the remarkable improvement for time in generating geometric 3D bone model using the proposed method.

4. CONCLUSION

A low radiation dose, time efficient and cost effective patient-specific reconstruction method for the femur was developed using FFD techniques with two X-ray images and three CT images. A patient-specific femur model was reconstructed by deforming a 3D template model of the femur from a healthy subject using two X-ray images and three CT images. The results suggested that the obtained femur model is closer to a CT-based 3D femur model in comparison with the reconstruction method using only X-ray images. This method will have benefits for many clinical and biomechanical applications, such as computer-aided diagnosis or planning systems for orthopaedic surgery, as well as personalized biomechanical and biomedical analyses.

후기

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참고문헌


