15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-50

2D/3D REGISTRATION OF THE PROSTHETIC HIP FROM X-RAY IMAGES: A METHOD FOR RETRIEVAL OF ROTATION OF THE ACETABULAR CUP AROUND ITS SYMMETRY AXIS.

Fabio D'Isidoro, Stephen J. Ferguson

ETH Zurich, Switzerland
fisidoro@ethz.ch, sferguson@ethz.ch

Keywords: 2D/3D registration, Fluoroscopy, Hip arthroplasty kinematics

Summary: Video fluoroscopy is used for the accurate analysis of in vivo kinematics of the hip joint, especially in the context of hip arthroplasty. A sequence of X-ray images of the joint of interest is collected with a high temporal resolution, while the subject performs a motion task . For each frame, the 3D pose of the joint is retrieved by matching a 3D model of each joint segment to its 2D projection in the corresponding image, a process called 2D/3D registration. Hip prosthesis motion is reconstructed from the sequence of registered poses, by computing the relative motion between the femoral and the acetabular component.
2D/3D registration for prosthetic implants relies on the extraction of silhouettes of each component in the image, and accuracy improves with the amount of available contour details. Since the acetabular cup is symmetric, its rotation around the symmetry axis can not be uniquely determined with the sole use of contours. For this reason, the 3D pose of the acetabular cup, and thus the anatomical kinematics of the hip joint, cannot be fully retrieved by standard registration methods. This issue was not addressed by previous fluoroscopy studies of hip joint kinematics.
In this study, a solution of the problem is described, based on additional information from the pelvic bone, if an appropriate 3D model is available (e.g. segmented pelvic CT or MRI scan, statistical shape model, 3D bony landmarks, or otherwise skin markers attached to the pelvis of the patient). The rigid position of the pelvic bone model relative to the acetabular cup is determined from a reference image. For each new image, the acetabular cup is partially registered from contours. The unknown rotation is finally determined as the rotation around its symmetry axis needed for the pelvic bone model to match with its projection in the image. The accuracy in retrieval of the unknown rotation of the cup is limited by the accuracy of the rigid relative position between cup and pelvic bone model. This method was successfully implemented on in vivo fluoroscopy measurements of hip arthroplasty patients performing activities of daily living.