Inertial Measurements for Motion Compensation in Weight-bearing Cone-beam CT of the Knee

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The main cause of artifacts in weight-bearing cone-beam computed tomography (CT) scans of the knee is involuntary subject motion. Clinical diagnosis on the resulting images is only possible if the motion is corrected during reconstruction. Existing image-based or marker-based methods are time consuming in preparation or execution. We propose a motion correction using inertial measurement units (IMUs) attached to the leg of the subject to record the motion during the scan. The measured local acceleration and angular velocity are transformed to the global coordinate system in a multi-stage algorithm and used for a rigid motion compensation. To validate this novel approach, we present a simulation study using real motion of seven healthy standing subjects recorded with an optical 3D tracking system. With this motion, we animate a biomechanical model via inverse kinematics computation and simulate the measurements of a virtual IMU placed on the shank of the model. Furthermore, we non-rigidly deform the XCAT numerical knee phantom using the measured motion and simulate a CT scan leading to motion corrupted projection images. When applying our proposed correction approach to this data, motion artifacts in the reconstructed volumes are visibly reduced. The average structural similarity index and root mean squared error with respect to the motion-free reconstruction are improved by 13-21% and 68-70%, respectively, compared to the motion corrupted case. The comparison with a state-of-the-art marker-based method shows qualitatively and quantitatively comparable results. The presented study shows the feasibility of the proposed approach and is a first step towards a purely IMU-based motion compensation in C-arm CT. This work was published in [1].

References

1. Maier J, Nitschke M, Choi JH, et al. Inertial Measurements for Motion Compensation in Weight-Bearing Cone-Beam CT of the Knee. In: Medical Image Computing and Computer Assisted Intervention – MICCAI 2020; 2020. p. 14–23.