Soft-tissue Artifact Compensation for Electromagnetic Motion Capture

G. Taylor Dickinson, Steven K. Charles
Brigham Young University, Neuromechanics Research Group

Introduction: Motion capture systems have been used extensively for capturing upper limb motion for the development and evaluation of kinematic models. Kinematic models of the upper limb include joint angle calculations by which the orientation of the skeletal structure is defined. The sensors (or markers) utilized for defining these orientations are typically placed on the surface of the skin and their motion is recorded. Due to the elastic nature of skin and soft tissue, these sensors positioned on the skin can move independently of the skeleton. Soft-tissue artifact (STA) is this movement of soft-tissue over the underlying skeletal structure. Issues can arise in joint angle estimations because STA can lead to significant errors. For the upper arm, humeral axial rotation (HAR) and forearm axial rotation (FAR) are most affected by STA through underestimation of the rotation angle (Schmidt, et al. 1999) (Cutti, et al. 2005). Currently there are algorithms that compensate for STA in optoelectronic motion capture systems but there are few for electromagnetic systems. The purpose of this study is to develop a compensation algorithm for the upper arm for electromagnetic systems that is simple and only requires a one-time calibration. A secondary purpose is to determine the effectiveness of this compensation algorithm.

Materials and Methods: Inverse kinematics calculations are required for determining joint angles from motion capture data. The inverse kinematics method in this paper requires a calibration which locates specific body segment landmarks and constructs the needed rotation matrices. Sensors were placed on 10 subjects (5 male and 5 female) and the calibration data were recorded. The subjects were then asked to make a number of movements exploring the range of motion for each degree of freedom of the upper arm. The inverse kinematics calculation first converts sensor angles to rotation matrices and then combines them with rotation matrices determined from calibration. These new rotation matrices are then run through the compensation algorithm and joint angles are extracted. Following a method previously developed by Schmidt et al. for optoelectronic systems, we compensated STA in HAR by using forearm orientation to define the axial orientation of the humerus. The compensation algorithm for STA in FAR utilizes the orientation of the hand to define the axial orientation of the forearm. We also tested the combination of the two STA compensation algorithms.

Results and Discussion: We have completed the development of the inverse kinematics method and integrated the STA compensation algorithms into the inverse kinematics calculations. These algorithms have been implemented in Matlab and will be available on the Mathworks file exchange. We are currently analyzing the experimental data collected from 10 subjects to determine the effectiveness of the STA compensation algorithms.

Figure 1: Shoulder movements in humeral axial rotation (HAR) with and without compensation for soft-tissue artifact (STA), demonstrating that inverse kinematics calculations without STA tend to underestimate HAR.

Conclusion: The purpose of this study is to propose a simple method to compensate for STA that can be implemented in a wide range of applications. From the results so far, the proposed method appears promising.

References: