Automatic Generation of Subject-Specific Model for Accurate Markerless Motion Capture

David Kennedy University of Rhode Island Biomedical Engineering

Markerless motion capture (MMC) is a system getting a lot of attention from fields such as biomechanics, clinical, and sports, etc. Accuracy is important and can be accomplished with the MMC tracking system.

In the past MMC systems used passive models with video systems used for motion capture. But with these systems automatic and accuracy is an issue. Thus a new system is being developed to provide for these two areas. The new system will be using a laser scanner instead of the motion capture video system.

The new system uses continuous space and from this an algorithm for pose and shape iterative registration. This allows for automatic generation of a subject-specific model from a single static pose.

The body was modeled with a series of 13 segments consisting of the head, torso, pelvis, arms, forearms, thighs, shanks, and feet. These segments were joined together by 12 joints each with 6 degrees of freedom. The rotational degrees of freedom use exponential maps which allow a better formulation of the point's positions derivatives within rotational parameters.

Each of the degrees of freedom were constrained separately from each other. Thus making each joint and segment's allowable ranges of motion equal to the anatomically possible ranges of motion.

From this the pose registration algorithm was extended to articulated rigid bodies using a variation of iterative closest point (ICP) algorithm. This algorithm uses model points and the data points following the nearest neighbor criterion. A space model with respect to the joints rotational and translational parameters was computed by taking into account the hierarchical organization of the body.

The shape registration algorithm was made using space of human shapes. This allows for body shapes to be expressed as free-form mesh. The shape algorithm then would find the best shape parameters to match the model of the human shape space to target data mesh.

The final step in this process is to combine the pose and shape registration results. This allows for all provided models to be expressed in the same pose making them more easily comparable.

In order to accurately track MMC sequences an model with morphological and joint information is needed. The old method was to learn the optimal joint centers location in a subject specific model. The new system learned using a pool of 5 male and 4 female participants. Ranging in body weight and height.

A training set was generated by using a laser scanner to locate markers placed on anatomical landmarks on the body. These landmarks were used to find the 10 joint centers at the shoulder, elbow, hip, knee, and ankle.

The markers were manually located in 3-D space. Once the joint centers were located the pose shape registration algorithm was used to bring the data mesh and the joint centers into the reference pose of the space of human shapes.

In order to make the joint centers locations information automatically available, joint centers locations were linked to reliable features on the mesh. For every subject and every joint a set of points on the model mesh representing the closest points to a joint was identified. This was used to minimize the generalization error

As a result the new system developed provided a solution to make model-based MMC fully automated and sufficiently accurate for most of the joints. Thus bringing quantitative biomedical value to the human shapes space database. This represents the first available tool of the generation of seamless mesh models with accurate kinematic model information.

Work Cited:

Corazza, S.; Gambaretto, E.; MÃ¼ndermann, L.; Andriacchi, T. P.; , "Automatic Generation of a Subject-Specific Model for Accurate Markerless Motion Capture and Biomechanical Applications," *Biomedical Engineering, IEEE Transactions on* , vol.57, no.4, pp.806-812, April 2010 doi: 10.1109/TBME.2008.2002103
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4682716&isnumber=5437399 [I.F. (2007): 1.677]