Mesh morphing for the mid-size male GHBMC pedestrian model to represent obese subjects

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Abstract

Objective: *Based on the field data analyses, lower extremities are the most frequently injured body region in vehicle-to-pedestrian crashes, and their injury risk is highly related to human characteristics, such as stature, BMI and age. However, the current pedestrian models only focused on the mid-size male subjects. Therefore, the objective of this work is to develop a method to morph the mid-size male GHBMC pedestrian model into pedestrians with a wide range of human attributes.*

Problem to be solved: *Without taking the various anthropometric features in consideration, the original GHBMC pedestrian model cannot represent a large population involved in car accidents.*

Materials and Methods: *The target geometry of pedestrians with varied characteristics included the external body shape and lower extremity bone geometry. The Statistical Body Shape Model (SBSM) was based on whole-body laser scans from ~200 subjects, while the pelvis, femur, and tibia geometry models were based on CT scans from ~300 subjects. Both the SBSM and bone geometry models were developed previously through a series of data analyses, including geometry extraction, data cleaning, template mesh mapping, principal component analysis and regression analysis. As a result, with a given set of age, sex, stature, and body mass index (BMI), the external body shape as well as the pelvis, femur, and tibia geometries can be predicted.*

To morph the mid-size male GHBMC pedestrian model into any predicted geometry target, several steps were involved. First, the posture of the original GHBMC pedestrian model (walking posture) was adjusted to the SBSM-predicted standing posture by a pre-simulation. Second, the external surface mesh of the GHBMC was morphed into the geometry targets based on 45 landmarks defined in the SBSM by a radial basis function using thin-plate spline (RBF-TPS). The morphed mesh was then further projected onto the geometry surface predicted by the

SBSM. Third, the pelvis, femur, and tibia surface meshes from the GHBMC were morphed/projected onto the geometry targets using the same method in the second step. Lastly, all the nodes in the GHBMC pedestrian model were morphed based on the external surface mesh and lower extremity bone meshes in the previous two steps. To conduct the mesh morphing more efficiently, the GHBMC model was divided into five body regions, including the head and torso, two upper extremities and two lower extremities.

Results and Discussion: *As an example, a pedestrian model with stature=1750mm and BMI=35 was generated. The mesh quality of the morphed model was similar to the original GHBMC pedestrian model. The original and morphed GHBMC models were further simulated in a generic pedestrian crash condition. By comparing the results between these two models, we found that the risks of femur fracture and knee ligament rupture were much higher for the higher BMI pedestrian.*

Conclusion: *The present study developed a detailed method for morphing the mid-size male GHBMC pedestrian model into a specific set of anthropometric parameters. Such method can enable future studies focusing on quantifying effects from human characteristics on pedestrian lower extremity injuries.*