Biomechanics of Soft Tissues using Moving Particle Simulation

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Abstract

Moving particle simulation (MPS) method has been developed to analyze continuum mechanics without the aid of mesh (Koshizuka and Oka, 1996). It has been applied to many problems in the field of fluid dynamics and heat transfer (Koshizuka, 2011). The MPS method was extended to elastic solid dynamics using the concept of Hamiltonian (Suzuki and Koshizuka, 2008; Kondo et al., 2010).

It is expected that the particle method is used for biomechanics of soft tissues because the meshless approach is favorable for large deformation. Particle generation based on medical images with noises is more robust than mesh generation. In the present study, MPS analysis for biomechanics is provided.

The first example is lung deformation due to breathing. The shape of lungs is made from the medical images. A rib motion model and a diaphragm motion model are developed by considering the mechanisms. The lungs are deformed by the forced motion of the ribs and the diaphragm. The simulation result is compared with the measurement. This study will be useful for enhancing the dose evaluation in radiation therapy of lung cancers.

The second example is fluid motion in semicircular canals. The shape is made from the medical images. Fluid flow in the semicircular canals is simulated with rotational and translational forced motion. This study is expected to understand the mechanism of dizziness.

The third example is swallowing which is accompanied by complex motion of the tongue, pharynx, epiglottis, larynx and trachea. Particularly, motion of the epiglottis is the key for successful swallowing. Aspiration may cause severe pneumonia for elderly. The swallowing simulation is expected to understand the reason of aspiration.

Keywords: Biomechanics, Lung Deformation, Semicircular Canals, Aspiration, Particle Method

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