Modeling Human Mastication and its Applications

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Objectives: As part of the Physiome Project, which aims to provide a framework for modeling the human body using computational methods, we present an anatomically-based computer model of the human masticatory system that provides an initial framework for simulating the chewing process. Further, we introduce an anatomically accurate model of the mandible based on a given patient's CT scan.
Methods: To track the motion of the mandible during chewing, we used the motion capturing system VICON MX located in the Department of Sport and Exercise Science at the University of Auckland. For our computational models, we use the Finite Element method with cubic Hermite basis functions. To obtain an accurate representation of the mandible, the material properties of the bone are determined at a large set of locations from CT scans.
Results: A kinematic model of one chewing cycle is simulated by solving for deformations of the muscles given the location of the mandible at a sequence of time steps. A realistic description of a chewing process is achieved via our ability to record the location of the mandible in intervals of 0.01 seconds using the motion tracking system mentioned above. Stress and strain calculations are presented for different loading conditions of the mandible.
Conclusions: The use of cubic Hermite basis functions provides an efficient representation of anatomical structures in the jaw. With the use of the motion tracking system and by solving the equations of finite elasticity, we can realistically simulate a normal chewing cycle. We have demonstrated how this model can be customized to a given person. Most important, we have an extensible framework to which we can add more detail to further improve our representation of the mastication process.
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