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Making a Mechanical Jaw Chew Food – An Engineering Approach

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Background: The architecture of the human mastication apparatus and its control are very sophisticated. From a mechanical engineering perspective it is possible to build a robot that achieves the same masticatory function in a simpler way.
Objectives: This paper outlines the design of a robot to reproduce human masticatory function in such a way that direct comparison of actuator work and control with the human mastication apparatus was possible.
Methods: Degree of freedom analysis showed that the full range of movement of the jaw requires six linear actuators attached with spherical joints. These actuators were used to replace the temporalis, masseter and lateral pterygoid muscle groups based on published biomechanical findings on how human muscles work while chewing food. Each muscle group was evaluated to derive the optimal length and placement of the actuators to best reproduce the direction and magnitude of force applied to the jaw. The resulting platform robot was simulated using SolidWorks and COSMOS/Motion. The mandible representation was scanned from a human jaw using computer tomography. The three dimensional coordinates of the muscle attachment points were assessed from eight cadavers.
Results: The simulation results showed that the platform robot design could follow human mandible movement trajectories. By implementing recorded incisor trajectories in the software simulations, real human chewing patterns have been reproduced. It is very difficult however, to select appropriate real actuators for the mandible movement trajectories and still meet the space, displacement, velocity, acceleration, and force specifications required by the human chewing apparatus.
Conclusions: The complexity of the human system may be a necessity for masticatory function given the constraints it must work within. The solutions that nature has developed to meet these requirements may provide useful approaches for future robotic design.
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