Modelling and Compliance Control of a Linkage Chewing Robot and Its Application in Food Evaluation

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Cheng Sun

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ABSTRACT

Many instrumental techniques have been developed to provide quantitative data on food texture as an alternative to sensory methods for food texture characterisation. However, most instrumental measurements are not able to simulate whole chewing sequences, the jaw movements and the influence of teeth geometry involved in mastication. Several devices have been proposed to simulate human mastication but they either cannot simulate human chewing trajectory or are difficult to be controlled. A novel simple linkage chewing robot was previously developed to reproduce human chewing trajectory. The aim of this thesis is to simulate human chewing behaviour by applying compliant chewing forces and velocity on the food during mastication.

In order to allow the entire mastication process to be continuously reproduced, the chewing robot was upgraded with a 3D force sensor, an automatic food manipulation system with 3D carved teeth and a spring mass system to apply passive force control. Aiming at the compliant chewing, the dynamic model of the chewing robotic system was developed, including the linkage mechanism, gear transmission, DC motor and food models. The simulation model of the chewing robot was validated by comparing the simulated torques and the experimental torques of the crank required to drive the robot. A control algorithm to achieve the compliant chewing for the robot is formulated in terms of adaptive fuzzy logic control, and is able to achieve fast coordination of chewing velocity and forces required for different type of foods, and validated in simulations in terms of chewing velocity and forces. The chewing experiments with the robot chewing on real foods were carried out and analyzed in terms of the adaptation of chewing velocity and force to the food texture changes during chewing process. Both simulation and experimental results show that the proposed algorithm is adaptive and able to simulate human chewing behaviour on foods with different texture, which indicates the usefulness of the developed robot in food texture evaluation.

The chewing robot developed has been used routinely in our laboratory and exhibited a great potential as a tool for the evaluation of food properties and bolus preparation.

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RELATED PUBLICATIONS

Sun, C., Bronlund, J., Xu, W., & Huang, L. A linkage chewing machine for food texture analysis. *International Journal of Intelligent Systems Technologies and Applications*, 8(1), 303-318.

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