3-D Dynamic Modeling and Validation of Human Arm for Torque Determination During Eating Activity Using Kane's Method

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Abstract

Upper limb disability is one of the major adversities faced by post-stroke patients. Eating is one of the fundamental activities of survival for all living beings. The robotic rehabilitation systems for people with upper limb disabilities must have the capability of assisting the patients, providing appropriate forces/torques, during various eating activities. In this study, a 3-D, four-DOF dynamic, mathematical model of human arm, including wrist and elbow joints, focusing on elbow flexion/extension motion, forearm pronation/supination, wrist flexion/extension and wrist adduction/abduction is formulated, for predicting the torques during different eating activities. A simulation study and experimental validation has been conducted involving five different food types and using two types of cutlery, which are, a fork and a spoon, to study their effect on the corresponding torques produced. It was observed that the maximum torque is obtained in both wrist and elbow joint when the subject digs into the food and eats (event B) in the majority of the eating tasks. The accuracy of the model, in terms of torque prediction, was compared to that of the load cell, for all eating activities, using RMSE as a statistical measure, to the test the performance of the model. The results indicate that 3-D dynamic model formulated fits all the torques for all eating activities very well, with the average RMSE of 0.05 Nm and the performance of the model is good. These results verify that the proposed Kane's model, successfully models the HUL, during different eating tasks and using different types of cutlery.

Keywords

Author Keywords: Dynamic modeling; Wrist; Elbow; Eating; Kane's method; RMSE
KeyWords Plus: BIOMECHANICAL MODEL; UPPER EXTREMITY; STROKE; WRIST; HAND; RMSE

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