Robotics and Virtual Prototyping Applied to Musculoskeletal System Analysis

Abstract
- Increases in computational power and advances in the development of computational tools have led to significant advances in the engineering fields.
- Benefits can be seen in other professional arenas, specifically the biological sciences field, by making use of these developments.

Introduction of the development of a Musculoskeletal Analysis Toolkit.
- Reciprocal Formula (W): Associated with each active joint for the given muscle are calculated
- Collecting the SNRS for the prismatic joints of all serial chains and the SNRS for the single revolute joint (Wj) we get.

Preliminary Simulation
- As a preliminary course of action a virtual prototype and simulation were created using existing computational tools.
- A virtual model was generated in by converting CT scans of the skull/ mandible structure to CAD model.
- This CAD model was then exported to a dynamic simulation software (VisualNastran)
- Constraints were placed on the system in the form of linear actuators (muscles) and a revolute joint (jaw joint).
- An external force representing the bite force was applied to the system and forward and inverse dynamic simulations were attempted.

Mathematical Model
- The selectively non-reciprocal screws (SNRS) associated with each active joint for the given muscle are calculated
- Solving the above equation for \( f_i \), the forces associated with each prismatic joint and the reaction force at the jaw joint are found.
- The simulation and analysis of the system met with limitations due to the current computational tools the mathematical model and virtual simulation tool were developed.

Mathematical Modeling – Set Up
- The skull/ mandible structure of the cat will be modeled using screw-theoretic methods, serving as a low-resolution computational model.
- This modeling method is typically seen in the context of parallel (robotic) manipulators.
- As a result of the limitations of the current computational tools the mathematical model and virtual simulation tool were developed.

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GUI Implementation
- Implementing the mathematical model in the basis of the GIU a low-resolution computation tool is developed
- Enabling the user to easily choose the muscle and external force locations and outputting the resultant muscle forces.

Future Work
- Future work will involve expansion of model to encompass 3-D and the creation of a mechanical prototype for Hardware-in-the-Loop testing.

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