SIMULATING FINGER-TIP FORCE USING TWO COMMON CONTACT MODELS: HUNT-CROSSLEY AND ELASTIC FOUNDATION

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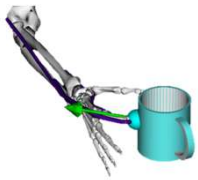
Incorporating hand contact mechanics into musculoskeletal models is relatively unexplored



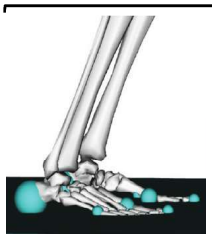
- Separately, musculoskeletal modeling and contact mechanics are well understood.
- Contact mechanics are rarely included in musculoskeletal models of the hand, thus limiting our ability to model hand-object interactions.[1]
- Accurately modeling the finger pad could improve our ability to use musculoskeletal simulations to study hand-object interaction.

PURPOSE: Examine how two common contact models (Hunt-Crossley and Elastic Foundation) can be used to represent contact mechanics of the finger pad.

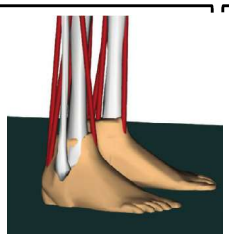
Simulations to measure finger-tip force in two contact models with varying input parameters

Contact Models

Explored | **Relatively Unexplored**



Foot-Floor Hunt-Crossley [2]



Foot-Floor Elastic Foundation [2]

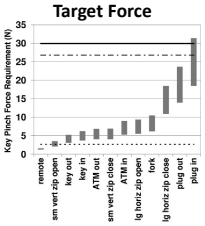
Hand-Object Hunt-Crossley

Hand-Object Elastic Foundation

Adapted Upper-Extremity model [3,4] with contact sphere [OpenSim v. 3.3]

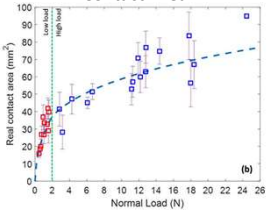
Parameters Derived From Data

Target Force



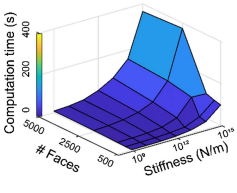
Force requirements estimated from thumb-force for tasks [5]

Contact Area



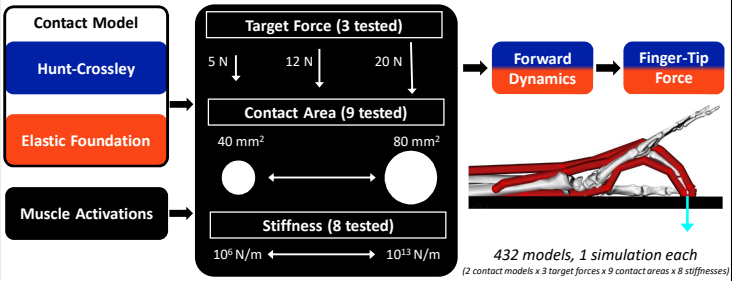
Contact area from human subject experiment in a young adult [6]

Stiffness



Stiffness of object interaction affects computation time [7]

Simulation Framework

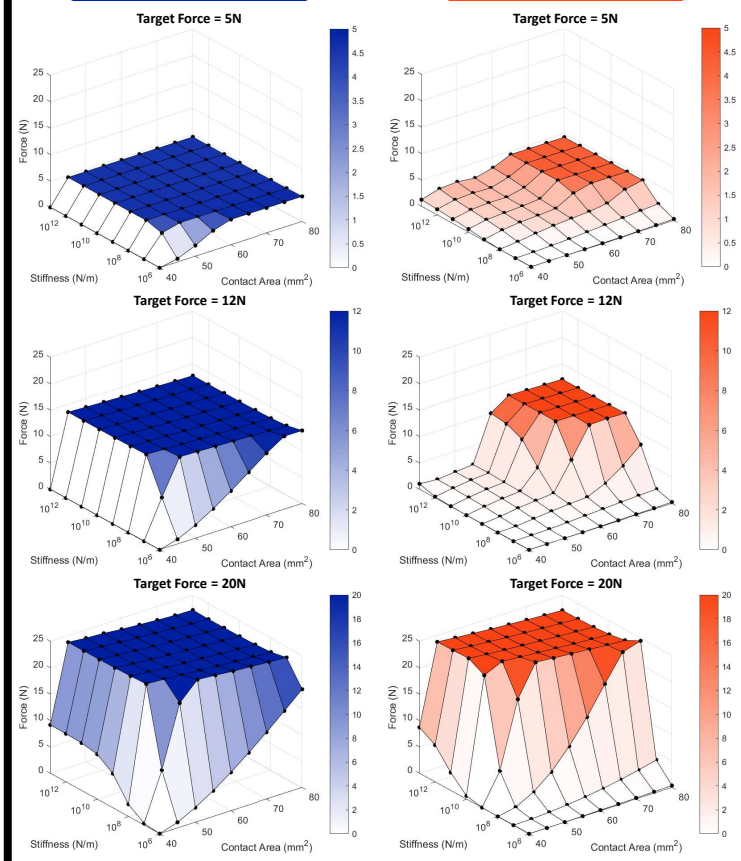


432 models, 1 simulation each
(2 contact models x 3 target forces x 9 contact areas x 8 stiffnesses)

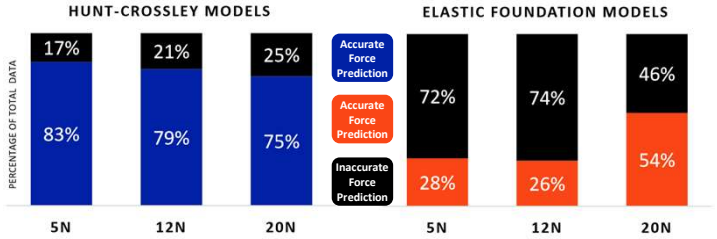
- Musculoskeletal models of the index finger parameterized over the range of each input parameter were used in simulations.
- Model parameters, most notably contact area and stiffness, were taken from experimental studies.
- Forces between the contact sphere, which represents the finger pad, and a flat, planar surface are reported.

Estimated finger-tip force varies with model parameters

Hunt-Crossley Model | **Elastic Foundation Model**



- In both contact models, larger contact area and stiffness values more closely predicted target force.
- Predicted finger-tip forces over the range of each parameter are more similar between contact models at larger target forces.



- Hunt-Crossley model accurately estimates finger-tip force across a larger variety of input parameters than the Elastic Foundation model.

Ability to estimate finger-tip force depends on choice of contact model and input parameters

- The most appropriate model for representing contact mechanics of the finger pad *depends* upon the hand-object interaction under study.
- Simulating hand contact has unique challenges due to force magnitudes that are much smaller than those in foot-floor contact.
- Future studies will evaluate finger-tip force estimates during complex tasks, such as pinch and grasp.

Acknowledgements

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References

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