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**Review of Commercial Software, Open Source-Software, and Examples in Literature for Human Hand Simulation**

**Open Source Software**

There are several examples of human motion simulation software in existence, however most of them focus on full-body interaction within a workspace. In one paper, authors claim that Jack Human Modeling, Delmia human simulation, and Ramsis human solutions all contain models of the human hand but they use relatively simple methods to simulate grasping and posture. In another, authors claim software packages including Jack, Ramsis, HumanCAD, Safework, and SantosHuman incorporate hand movement and posture but they focus on the entire body, largely ignoring the accuracy of the hand model. Adaptions to Jack’s hand models, as describe below, could make this the software fit the needs of this study.

**Open-Source Software**

Open-source software is limited in regards to human hand simulation. As discussed before, GraspIt ([link](http://graspit-simulator.github.io)) appears to be the only software available to fit within this category, however it look as if it will fit the needs of the study. There are many interacting 3rd party dependencies which must be installed with this software, which makes installing GraspIt difficult without prior software experience.

*Graspit! – A versatile simulator for robotic grasping* explains the interface and mechanisms behind the tool. *From robotic hands to human hands: a visualization and simulation engine for grasping research* details how the tool integrates a realistic human hand model.

**Examples in Literature**

There are many examples of attempts to model the human hand in existing literature, however none of the models are apparently accessible for the public. These examples may serve as suitable guidelines for the creation of a new model.

*Virtual Human Hand: Model and Kinematics*

The authors describe a model of the human hand and the accompanying kinematic equations to govern its movement. The model contains 25 degrees of freedom. The kinematics are describe as the joint range of motion, the relationship between joints as described by the Denavit-Hartenberg method, and end effector (finger-tip) workspace determination.

*Automated Grasp Modeling in the Human Motion Simulation Framework*

A method for rapid object grasping simulation is created for the purpose of general-purpose simulation, an approach which is described as missing in the research context. The authors provide a thorough review of relevant research and a brief review of some commercial products. Methods to develop a new hand model using right-hand motions recorded using the CyberGlove was presented. Principal component analysis of joint angels was used to define hand movement. The model is implemented into a suite of human motion and posture algorithms developed by University of Michigan called the Human Motion Simulation Framework. This framework is design to be implemented into existing software such as Jack and Delmia.

*Towards a Realistic and Self-Contained Biomechanical Model of the Hand*

A very thorough literature review of grasp simulation research is conducted, including those involved in ergonomics and robotics. The review is comprehensive and contains much information not relevant to our goals. Section 2.2 Hand models in ergonomics and 2.3.3 Grasp Synthesis contains particularly relevant material. Based on the literature, a set of guidelines is proposed for the general development of biomechanical human hand models. This includes desired guidelines regarding hand kinematics and skin surface models as well as less-desired guidelines on musculo-tendon action, ligaments, etc. A hand model using this information is presented in *Grasp Modeling with a biomechanical model of the hand.*

*From Robot Grasp to Human Grasping Simulation* (book) ([Link](https://www.amazon.com/Grasping-Simulation-Cognitive-Systems-Monographs/dp/3319018329))

This is an entire book dedicated to the topic. It likely contains much more information than necessary, but based on the table-of-contents, it could be useful for the development of a new hand simulation tool. It was published in 2014, and is therefore likely very up-to-date information.

*Development of a Kinematic Hand Model for Study and Design of Hose Installation*

A kinematic hand model is developed using similar methods to that in *Virtual Hand: Model and Kinematics*. This paper includes a description of a GUI for the model, but does not indicate if it is available for download. The model is also only tested on a cylinder CAD object, as to represent a hose. It is unclear if the model would be as effective with other geometries.

This is certainly not an exhaustive list of relevant literature, however it is a good overview of the state of human hand simulation in academia.