MSC Software

Case Study:
University of Technology of Compiègne

Adams Helps Unravel the Complexities of Hand Motion for Manipulation of Virtual Objects

Overview

The manipulation of objects is fundamental to virtual reality applications. Better methods are needed to grab and manipulate virtual objects by moving one's hands in 3D space. But the anatomical complexity of the human hand makes it very difficult to accurately track manual motions. Haptic technology, which recreates the sense of touch by applying forces, vibrations, or motions to the user, provides cues in object manipulation. Haptic interfaces are essential in order to generate sensations relating to touch and effort. Active hand mounted devices make it possible to accurately track the hand and feel virtual objects with the fingers but they are complex and costly.

Motion capture with Vicon System 18 T160 Cameras

“This model is believed to be one of the most detailed model of the hand that computes muscle forces and joint loads during hand motion.”

Frederic Marin, Professor, University of Technology of Compiègne

Challenge

The MANDARIN project (www.anr-mandarin.fr) which is funded by the French National Research Agency (ANR) is working to fill this need by developing a simple, compact, light and relatively inexpensive force feedback glove. The interaction paradigm proposed by the MANDARIN project is a hand-held elastic input device that maps the motion of the user’s hand to a virtual glove capable of interacting with virtual objects. The operation of the virtual glove depends on the gripping force applied to the haptic glove. The haptic glove provides force feedback that gives the user feedback on manipulation efforts that are performed in the virtual environment. The MANDARIN project is also designing new physical simulation algorithms and software to compute finger forces and communicate them to the glove controller to facilitate use of the glove in virtual environments.

The development of these algorithms requires a musculoskeletal model that simulates the articular and muscles of the hand during the use of the hand. The design of an accurate musculoskeletal model is difficult because of the complexity of the hand and forearm anatomy. Some researchers have addressed this challenge in the past with simplified models that addressed parts of the hand such as the thumb only or static kinematic data only. “Our goal in this project was to develop a highly accurate musculoskeletal model of the hand and forearm guided by real kinematic data that is composed of 21 segments, 38 muscle units a,” said Frederic Marin, Professor at the University of Technology of Compiègne. The model was developed by Marin and Khalil Ben Mansour, Research Engineer, Clint Hansen, Post-Doctoral Student, Pierre Devos, Doctoral Student. This research was part of the MANDARIN project.

Solution/Validation

The first step in creating the model was capturing motion from the hand and forearm. A total of 55 reflective markers were attached to a subject’s hand and forearm and these markers along with bony areas of the hand and forearm were captured with an optoelectronic system. The kinematic data was imported into MSC Software’s Adams multibody dynamics simulation software to drive massless elements fixed to the hand and forearm skeletal model using spring components. The model was adjusted to minimize the differences with the kinematic data. An inverse dynamic process was then carried out followed by a forward dynamics process to simulate the operation of the musculoskeletal system during motion. The output data of the model included joint angulations and muscle flexion and extension kinematics, muscle forces and joint loads.

The results showed that major active muscles when grasping a cylinder include the extensor

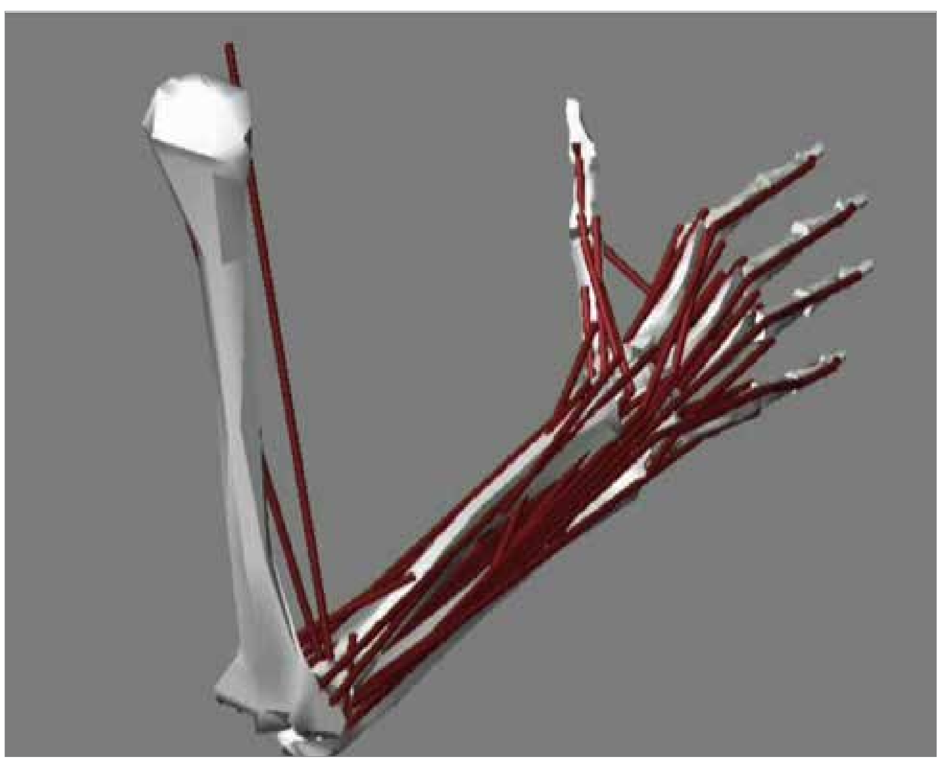
Key Highlights:

Product: Adams

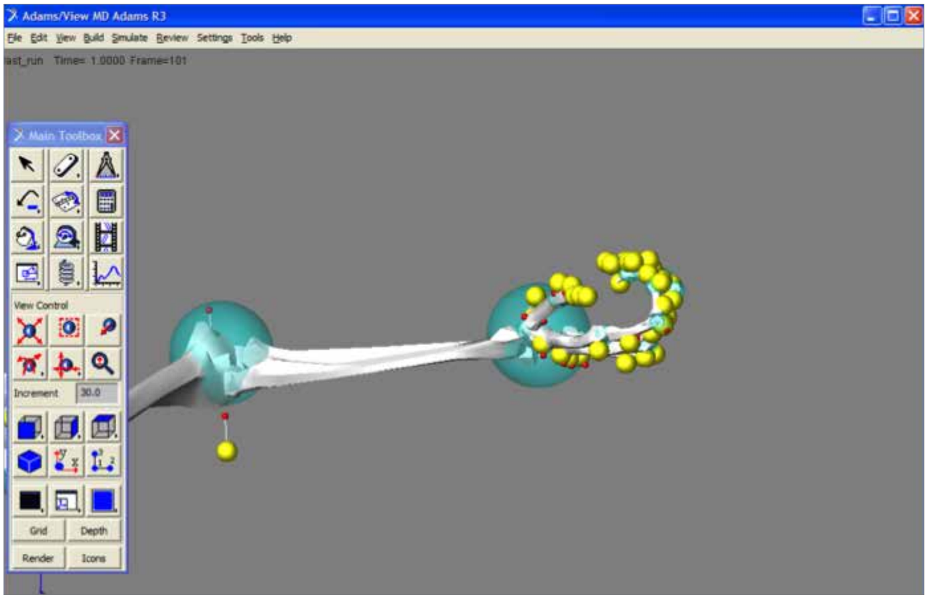
Industry: Virtual Reality

Benefits:

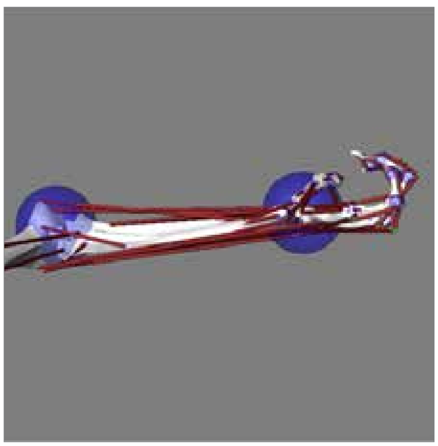
- Develop a highly accurate muscularskeletal model of the hand and forearm from real kinematic data
- Simulate the operation of the musculoskeletal system during motion
- Unravel the complexities of hand motion



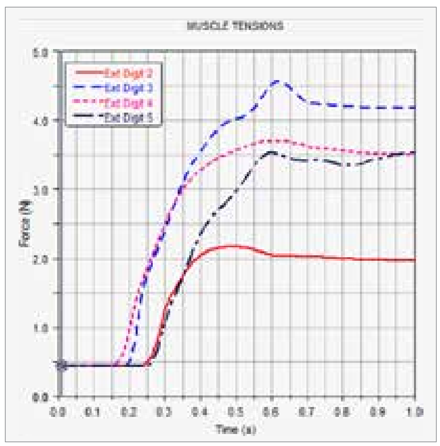
Grap Simulation Musculoskletal Modelling using Adams



Musculoskeletal modelling with Adams



Musculoskeletal modelling with Adams



Grap Simulation Calculation - Musculoskeletal modelling with Adams

digitorum communis, pronator teres, extensor digiti minimi and palmar and dorsal interossei. The muscle force developed by the extensor digitorum communis appeared to be maximal for the third digit. Results obtained for the extensor digitorum of the second digit concurred with results from Chalfoun et al. (2005) in amplitude. Moreover, the third digit seems to develop the maximum force among fingers for a 25-mm cylinder-grasping task, as in the biomechanical model of Sancho-Bru et al. (2003).

Articular results revealed that metacarpophalangeal joints support maximal joint loads between 3.8 and 6.2N during the cylinder-grasping task. This is in accordance with a previous study on joint forces in the hand during power grip actions (Freivalds 2004). Joint loading results were also related to joint torques computed during the simulation. Maximal joint torques for metacarpophalangeal joints of between 130 and 235 N/m were seen during the simulation. These results agree with a study by Kargov et al. (2004). Kargov's team analyzed the grip force distribution in natural hands during a cylinder-grasping task and reported that the highest joint torques were measured at the metacarpophalangeal joints during grasping.

Results

"This model is believed to be one of the most detailed model of the hand that computes muscle forces and joint loads during hand motion," Marin said. "As such it provides an important step to unraveling the complexities of hand motion. Up to this point, we have validated the model by comparing its results to video of actual hand movement and comparing its prediction of forces to published work. We are continuing to develop the model and to improve its predictive capabilities. We are currently working on the import of the subject specific bone geometries coming from medical imaging. The initial application of the model will be within the MANDARIN project in the development of a new haptic glove design. In addition, the model also has potential applications in the medical field where it could be used to better understand how the hand works to prevent musculoskeletal troubles, improve the diagnosis of hand injuries and compare the effects of alternative surgical interventions."

About University of Technology, Compiègne (UTC)

UTC is a founding member of Sorbonne Universités (www.sorbonne-universites.fr) a Higher Education and Research Cluster awarded with an Excellence Grant of 900 million Euros by the French Government. UTC is also a part of a network of three Universities of Technology in France (UTT in Troyes and UTBM in Belfort-Montbéliard) and UTSEUS in Shanghai (China). Enrollment consists of about 4,200 engineering students and 300 doctoral students. The Laboratory for Biomechanics & Biomechanical Engineering is also joined research unit of the National Center of (CNRS) and it is composed of about 90 people with expertise in mechanics, electronics, informatics, physiology, biology and medicine. The laboratory's mission is to provide a better understanding of pathologies and development of bio-artificial organs, biomaterials, diagnosis and evaluation tools for therapeutic or functional treatments.

For more information on Adams and for additional Case Studies, please visit **www.mscsoftware.com/adams**

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