

Opponent's review of the diploma thesis

Posudek oponenta diplomové práce

Author of the work / Autor práce: Ondřej Havlíček

Thesis title / Název práce: **Muscle interaction in the context of muscle deformation modelling by a Position Based Dynamics method**

The thesis addresses the challenging problem of simulating the dynamics of the human musculoskeletal model. While bones can be modeled as rigid bodies, the muscles attached to the bones are elastic and should deform in a specific manner when the model is in motion. To achieve semi-realistic deformation, muscles are modeled as fibres attached to the bones, and additional constraints are used to handle collisions, preserve volume, limit the flexibility of fibres, etc. The main contribution of the thesis is that the simulation of physics is performed using the Extended Position Based Dynamics (XPBD), which aims to overcome the shortcomings of previously used PBD. The results appear more visually plausible than the previous solution.

The thesis is well-prepared and well-written. The author begins with a brief motivation and clearly states the objectives. Following this, the structure and function of muscles is described from the top level to the atomic scale, including the orchestration of muscles during selected motion scenarios. The analysis continues with the study of how deformable flexible objects can be simulated and previous work related to simulating musculoskeletal models with PBD, including a discussion of its shortcomings. This analysis leads to the proposed solution using the fibre model for muscles, XPBD for its simulation, collision handling, and potential problems. Results are presented on selected scenarios of musculoskeletal motion and are critically evaluated against PBD. This evaluation is done not only through subjective judgement of visual plausibility but also numerically by comparing the fibre lengths during motion. After the conclusion, the thesis is supplemented with numerous illustrative figures. The thesis cites 30 sources from international conferences and journals.

Supplementary material includes 2,1 GB of compressed data. It contains the implementation, i.e., runnable binaries and documented source code, including the OpenSim framework and 3rd party libraries, all inputs and results. Thesis source code (TeX) and figures are also included.

The diploma thesis meets the assignment.

Questions / Dotazy k práci

1. Have the results been consulted with domain experts, i.e., individuals with education and experience in human anatomy? If yes, what was their opinion on the realistic behavior of muscles simulated this way?
2. With the current state of this musculoskeletal model implementation, is it ready to be used by medical professionals? What else needs to be done so they could really decide whether to “perform invasive surgery on the musculoskeletal system and prevent such consequences” as stated in the introduction?

I propose a grade of **excellent** and recommend the work for defense.

Navrhuji hodnocení známkou **výborně** a práci doporučuji k obhajobě.

In Pilsen / V Plzni, 30. 5. 2024

Mgr. Martin Maňák, Ph.D.