Doctoral thesis review:

Ing. Linda Havelková:
BIOMECHANICAL MUSCULOSKELETAL MODEL

Evaluation of the significance of the doctoral thesis

The chosen topic is highly relevant and desirable. Investigative methods in medicine are becoming more technically advanced. For medical doctor it is convenient if the engineer or better interdisciplinary specialist in biomechanics help increase the efficiency of extracting information from captured examinations. Radiologically acquired data can be, by using special software and procedures, foundation for creating 3D models. Description and overview of the spatial arrangement of the different structures in observed region (the area of shoulder in this work) could be beneficial for medical doctors. But this is only the base - this structural information also can serve to detect and calculate the values of forces and internal stress in the region. It represents loading of articular surfaces, ligaments, tendons and muscles. It brings, for clinical practice and technical and biomechanical specialist, information during function (e.g. abduction in joint) of musculoskeletal system. The contemporary medicine, thanks to an increase in technical support, an individual health problem solving and finding appropriate solutions. Such models also allow predicting what impacts will the chosen method of treatment, just at individuals and their specifics.

Approach to solving the problem and used methods

This thesis solves the various steps of creating of model for analyzing the musculoskeletal system. It creates an overview of existing types of mechanical and computational biomechanical models of shoulder. Author describes process of developing a model of muscle replacing from the most simple (straight-line) to more intricate progressive obstacle-set method. This is the principle of a kind of "circumvention or wrap" obstacles. The author applicate this new procedure to shoulder region. There are solving situations when, due to the big range of motion and the arrangement of structures cause a change input conditions, created model had to adapt the new conditions. MRI methods take data for the particular person. It is transformed into the model, which is further used for calculation of internal mechanical conditions. The model was created in the system AnyBody Modeling system, but it was modified in the sense contemplated by simplifying muscle and functional joints. The muscle paths were modeled using the obstacle-set method and according to Hill, the bones as rigid bodies. Calculation jobs inverse dynamics is solved through optimization. There were carried EMG measures of muscle activity to validate the calculated muscle forces. Detected muscle strength and the actual length of the muscle during abduction correspond to the results reported in the literature. There are certain limitations, given as a result of the very specific large range of motion and muscle arrangement especially deltoids (pinnate muscle and insertion places). The major merit is that the model generated using the obstacle-set method gives a valid value and is usable in further applications.

Benefit of results and student´s original contribution

The main purpose of this work is to create a model shoulder region and it´s validation. A significant benefit is the using of new set-obstacle techniques to model the correct muscle trajectory. The goal was achieved including verification used method and its application in the context of modeling musculoskeletal system.

It represents a sample how to generate such a model. Moreover, in text is given a good overview of the current possibilities of access to the solution of partial tasks. This experience will certainly be used in the creation of other models and their applications in collaboration with the clinical environment. Opportunity for employment can be seen not only for orthopedists and surgeons, but also in the area of medical rehabilitation, occupational therapy and possibly sports coaches.

Text clarity and appropriateness of used form and language

Text arrangement into particular chapters is suitable. The text is clear and transparent and is suitably accompanied by pictures and graphs. The used English language is good and acceptable.

Student´s publication

Overview of publications shows that the student is actively cooperating on preparation of scientific publications, and participates in international scientific conferences, for many years (since 2011). In most cases can be seen as a first author. She focuses on the analysis and modeling of structures musculoskeletal system. Works are published in internationally recognized peer-reviewed journals (Scopus records, Impact factor), which is in accord with the requirements of the relevant study board.

Closing statement of reviewer

The presented work demonstrates ability of Ing. Linda Havelková (roz. Valdmanové) for independent creative scientific work.

So, I definitely recommend the thesis for defence and doctor's degree, Ph.D. awarding.

In Prague 17.7. 2016

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Evaluation of Ph.D. thesis by Linda Havelkovà

The PhD thesis is entitled:

Biomechanical Musculoskeletal Model

Summary of the thesis

The thesis is a 97 pages monograph. The thesis shows a novel approach to model muscle contact in musculoskeletal models by using a torus obstacle. The thesis gives a brief introduction to the shoulder anatomy and state-of-the-art muscle wrapping. The major part of the thesis is to derive a new torus obstacle method to be used for musculoskeletal models. Therefore, multibody dynamics in general and special aspects of musculoskeletal modeling are show. The torus obstacle method is shown in detail. Following the theoretical formulation of the given problem, an implementation of a simplified shoulder model with few anatomical details has been generated in Matlab and basic experiments have been conducted to measure motion and muscle activation data. An additional musculoskeletal model, derived from a commercially available system has been created for validation purposes.

Evaluation

In general, the methods used in the study are appropriate and are described in detail. The representation of the data is clear and meaningful. Language and style is appropriate. The study is well designed and structured. Especially the mathematical description of the methods is done nicely. The given task has been fulfilled and potential implications on the results of musculoskeletal models could be shown. The validation of the model shows some discrepancy to literature data, but this can be expected for this type of models. It would have been nice to see the performance of the new wrapping with a more detailed model, but this is work for the future. The project itself is original and points at a major drawback of current musculoskeletal (shoulder) models. With the shown approach, a promising tool for further development of more refined and reliable musculoskeletal models is given. And the work will have potentially an impact on the next generation of models.

The publications of the candidate are mostly not directly related to the PhD thesis work and rather low ranked. The novel derived method seems to be only published in conference proceedings up to now.

Nevertheless, the presented work is original, well written and contributes to the field of biomechanics. Therefore, I suggest to recommend the thesis for defense.

S. Dendorfer

Prof. Dr.-Ing. Sebastian Dendorfer