Automatic Generation of Internal Fibres of Skeletal Muscles

Duc Long Hoang[1]

1 Introduction

In modern medicine, musculoskeletal models are used e.g. for contact force estimation and simulations. In the case of muscle models, it is possible to represent the muscle with mechanical fibers which is an approximation of real-life muscle fibers and tendons. The advantage of using these mechanical fibers is the increased calculation speeds while still retaining the accuracy of the calculated results. The two key components when decomposing the muscle into fibers are: (a) the number of muscle fibers created (muscle discretization level), and (b) the number of straight line segments that each fiber is divided into (resolution).

The aim of this work was to research existing methods for muscle decomposition and to propose a new one.

2 Existing methods

The existing methods for muscle decomposition are Kukačka - see Kohout J., Kukačka M. (2014) and VIPER - see Baptiste et al. (2019).

The Kukačka method works by calculating a harmonic scalar field for the muscle surface and cuts the muscle at the iso-lines into `N` slices. Next, it uses a fiber template that is also cut into `N` slices. Lastly, the slices of the fiber template are mapped into the slices of the muscle model, creating the decomposed muscle.

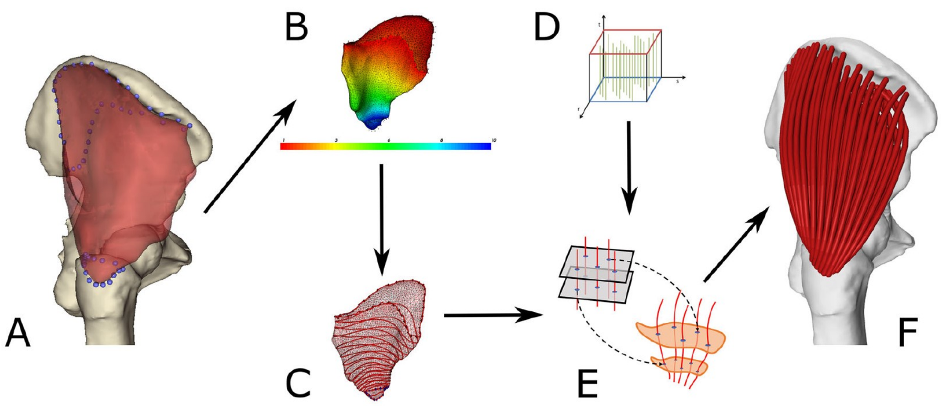

Figure 1: Kukačka method. Image from Modenese L., Kohout J. (2020)

The VIPER method calculates a harmonic scalar field for the volume of the muscle and creates iso-levels. Then, it generates points inside these levels and connects the points across these levels to create the resulting fibers.

[1] student of the bachelor degree program Informatics, field of study Computer Science and Engineering, e-mail: duclong@students.zcu.cz

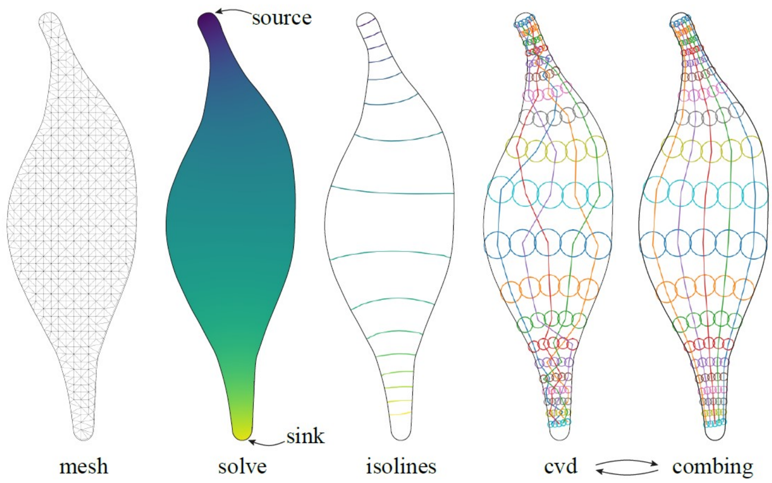

Figure 2: VIPER method

3 New method

The new method for muscle decomposition combines the approaches of the two previous methods. It slices the muscle using the harmonic solve of the muscle surface (like Kukačka) and then it generates points and connects them across slices to create fibers (like VIPER).

4 Testing

The testing consisted mainly of the comparison of the fibers created by the new method and those created by the Kukačka method. The fibers were compared by the distribution of their lengths and by their visual appeal. The time complexity of these two methods was also put into comparison.

5 Conclusion

The new method for generating muscle fibers shows great promise as the quality of the fibers is comparable to those created by Kukačka and in some cases even superior. And although the runtime of the new method is four times longer, it still executes in less than one second which allows for usage in real-time applications.

Acknowledgement

I would like to thank doc. Ing. Josef Kohout, Ph.D. for all his thoughtful inputs and suggestions that helped shape this work. My appreciations also go to my family and friends for their support and encouragement.

References

Modenese L., Kohout J. (2020) *Annals of Biomedical Engineering*, vol. 48, no. 6, pp. 1793–1804.

Angles Baptiste et al. (2019) *Proceedings of the ACM on Computer Graphics and Interactive Techniques*, vol. 2, no. 2, pp. 1–26.

Kohout J., Kukačka M. (2014) *Computer Graphics Forum*, vol. 33, no. 8, pp. 1–15.