Topic: A Look at the Past: Simulating Movements of Extinct Animals

Mammals and dinosaurs first appeared approximately 230 million years ago. Between the Early and Middle Jurassic, mammals are hypothesized to have shifted from one to several modes of locomotion [1]. However, little is known about how the first mammals stood and moved. Fossil footprints offer valuable direct information about locomotor behavior and provide dynamic information produced by the extinct animal when it was alive, currently under-utilized. As such, it represents a window to validate functional hypotheses about locomotion of early mammals.

The extremely well-preserved tracks and trackways recovered from Middle Jurassic outcrops in Argentina, offer a unique opportunity to study how early mammals moved. These fossil footprints, e.g. *Ameghinichnus patagonicus*, display a wide spectrum of gait styles including walking, running, hopping, and galloping [2]. Hypotheses exist about the trackmaker of such footprints, but these need further evaluation in order for the inferred behavior to better understand mammalian evolution and locomotion of early mammals. Currently, tracks and trackmaker are linked using a synapomorphy-based approach, which provides a coarse correlation based on similarities between fossils and fossil footprints, and currently existing animals and their footprints [3]. Linking the track with the trackmaker can provide critical information about spatiotemporal distributions, body size, organism-substrate interactions, soft tissue anatomy, and even behavior of their producer.

We would like to investigate these fundamental questions about early mammalian locomotion using biomechanical modeling and simulations. Biomechanical modeling and simulations have been used successfully to better understand and predict performance of human gait, e.g. to predict the effect of a prosthesis on gait [4]. Similar to a prediction with a novel prosthesis, no experimental locomotion data exists for early mammals. Therefore, our aim is to investigate locomotion of early mammals based on similar techniques. The goal is to investigate if we can extract information about the animal's body size and inertial parameters from the trackways using simulations.

The proposed work consists of the following parts:

- Literature study into the selected fossil and fossil trackways, and into movement simulation of extinct species
- Design and implementation of biomechanical models suitable for the fossil
- Simulation study of locomotion using biomechanical model
- Comparison of simulation outcomes to trackway patterns

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code has to be documented and provided.

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Student:
Start – End:

References

[1] Chen, M. & Wilson, G. P. A multivariate approach to infer locomotor modes in Mesozoic mammals. *Paleobiology* **41**, 280–312 (2015).
[2] de Valais, S. Ichnotaxonomic revision of Ameghinichnus, a mammalian ichnogenus from the Middle Jurassic La Matilde Formation, Santa Cruz province, Argentina. *Zootaxa* **21**, 1–21 (2009).
[3] Carrano, M. T. & Wilson, J. A. Taxon distributions and the tetrapod track record. *Paleobiology* **27** 564–582 (2001)

[4] Koelewijn, A. and Van den Bogert, A. J..: *Joint contact forces can be reduced by improving joint moment symmetry in below-knee amputee gait simulations.* Gait & Posture, 2016.