Westfälische Wilhelms-Universität Münster

Cells in Motion
Cluster of Excellence

# › Maths meets Biology: CiM Mathematical Modelling Workshop

**Date:** 10 November 2015

**Place:** Department of Mathematics and Computer Science, Lecture Hall M2, Einsteinstraße 64, Münster

**Programme**

9:30-10:30 Benedikt Wirth
(Institute of Computational and Applied Mathematics, WWU)
*Models of biological shapes based on principles of mechanics and optimal design*

10:45-11:45 Davide Ambrosi
(Laboratory for Modeling and Scientific Computing MOX, Politecnico di Milano, Italy)
*A role for mechanics in the growth, remodelling and morphogenesis of living systems*

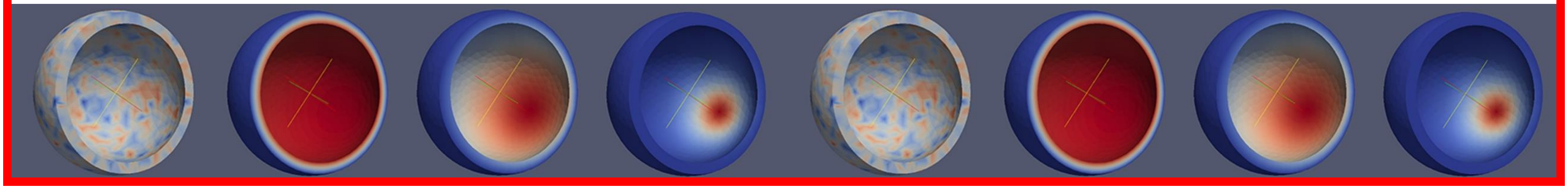
Lunch break

13:30-14:30 Lena Frerking & Hendrik Dirks
(Institute of Computational and Applied Mathematics, WWU)
*Image processing methods for biomedical applications*

14:45-15:45 Christoph Schnörr
(Department of Mathematics and Computer Science, University of Heidelberg)
*Probabilistic graphical models of image analysis*

**Benedikt Wirth:**
**Models of biological shapes based on principles of mechanics and optimal design**

Biological structures such as the vascular network or trabecular bones often exhibit complex patterns. One mathematical attempt to understand them is to postulate that these structures are optimal in a certain sense, for instance, that they fulfill their biological function under minimal energy consumption.
Another attempt is to model mathematically how such structures develop during morphogenesis based on mechanical and chemical laws, for instance, how cell sheets deform during gastrulation to generate specific shapes. Both attempts can employ similar mathematical techniques: One can view the resulting shapes and structures as minimisers of some energy or cost - be it a mechanical deformation energy (in the latter case) or some biological cost associated with a design (in the former case). The task now is to find those minimisers or at least to gather as much information about them as possible. In simple terms I will describe some ideas behind these techniques and give some insight into what can be expected and learnt from such mathematical models.



WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER

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## Davide Ambrosi: A role for mechanics in the growth, remodelling and morphogenesis of living systems

In the XX Century the interactions between mechanics in biology were much biased by a bioengineering attitude: people were mainly interested in evaluating the state of stress that bones and tissues undergo in order to properly design prosthesis and devices. However in the last decades a new vision is emerging. "Mechano-biology" is changing the point of view, with respect to "Bio-mechanics", emphasizing the biological feedback. Cells, tissues and organs do not only deform when loaded: they reorganize, they duplicate, they actively produce dynamic patterns that apparently have multiple biological aims.
In this talk I will concentrate on two paradigmatic systems where the interplay between mechanics and biology is, in my opinion, particularly challenging: the homeostatic stress as a driver for remodeling of soft tissue and the tension as a mechanism to transmit information about the size of organs during morphogenesis. In both cases it seems that mechanics plays a role which at least accompanies and enforces the biochemical signaling.

## Lena Frerking & Hendrik Dirks: Image processing methods for biomedical applications

Nowadays, modern microscopes are able to visualize even the smallest biological processes. However, the automatic data analysis is still a challenging task.
In this talk, based on different examples of biomedical applications, we identify key problems and transfer them into the context of mathematical image processing. We shortly summarize the ideas and advantages of denoising, inpainting (reconstructing missing information), motion estimation and segmentation (dividing an image into clusters of similar characteristics) and apply these methods to the former introduced examples. Our aim is to illustrate the possibilities of mathematical models to enhance the quality of an image and to reveal different kinds of information.
For this purpose we will introduce so-called *variational models*, which can be adapted to the above mentioned tasks.

## Christoph Schnörr: Probabilistic graphical models of image analysis

Graphical models provide a framework for modeling data likelihoods, prior distributions and Bayesian inference. They seamlessly integrate low-level signal models and discrete knowledge-based decision making. This talk informally reviews some major aspects of this development during the last two decades as well as their limitations and connections to other models of mathematical image analysis. A case study of 3D OCT image segmentation illustrates some of this aspects in detail.