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Master thesis

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Constitutive modeling of liver regeneration
Konstitutive Modellierung der Leberregeneration

The liver has high regenerative properties. In practice, this existing knowledge is already used by performing liver resections in which up to 3/4 of the liver can be removed, for example in case when a tumor is found in a liver lobe. The regrowth of the liver after resection itself is a process occuring over many scales which requires input and output values between different scales [1]. A result of segmental resection is hyperperfusion as the same amount of blood is passing a smaller remaining liver that leads to higher blood velocity and thus higher shear stresses in the sinusoidal capillaries. At the microscale the shear stress in these microvessels is essential for triggering the regrowth of the liver.

One main part of this work will be a literature review on the multiscale regrowth process of the liver (mechanical, biochemical and physiological factors). A particular focus lies in connecting the microscale shear stresses with the growth parameters of the macroscale growth model. The macroscale growth model can be implemented within the framework of the so-called finite growth theory [2] that has been heavily studied in literature for other applications (cardiac wall thickening, cardiac dilation, artery growth) [3,4]. An implemented version of the growth model is already existing and further studies can be build up based on this code. Basic continuum mechanics and FEM knowledge is sufficient to understand and implement constitutive evolution equations on a simple benchmark which will be the main part of this work. The thesis can be done in German or English.

Requirements:

- Knowledge about Continuum Mechanics and FEM
- Knowledge about Programming

Objectives:

- Obtaining fundamental understanding about the multiscale regrowth process of the liver (mechanical, biochemical and physiological factors)
- Obtaining knowledge on material modeling for a biomechanical application
- Implementing growth evolution equations on a simple geometry e.g. on a cube

Literature:

[1] N. HOHMANN ET AL (2014): "How does a single cell know when the liver has reached its correct size?". PloS one, 9(4):e93207.

[2] D. AMBROSI ET AL. (2011): "Perspectives on biological growth and remodeling". Journal of the Mechanics and Physics of Solids 59.4, 863-883.

[3] S. GÖKTEPE ET AL. (2010): "A generic approach towards finite growth with examples of athlete's heart, cardiac dilation,and cardiac wall thickening". Journal of the Mechanics and Physics of Solids 58, 1661-1680.

[4] A. MENZEL ET AL. (2012): "Frontiers in growth and remodeling". Mechanics Research Communications 42, 1-14.