



# Segmenting ultrasound tensor field data of the abdominal aorta.

Project Management and Software Development  
for Medical Applications

## General Info

Project Title: Segmentation and visualization of ultrasound tensor field images of the abdominal aorta.

Contact Person: Christoph Hennersperger, Diana Mateus

Contact Email: [christoph.hennersperger@tum.de](mailto:christoph.hennersperger@tum.de)

## Project Abstract

Methods for processing of ultrasound data with a new, tensor-based approach will be developed. This concept should be evaluated by segmenting the abdominal aorta based on tensor data to analyze whether this technique can lead to an added clinical value to physicians for vascular diagnosis.

## Background and Motivation

Ultrasound data today is processed based on either log-compressed image data or pure RF data samples received from research devices. In contrast to US, for diffusion tensor imaging (DTI), covariance information is directly incorporated in the imaging modality enabling direct processing of these data [1]. The goal of this project is to follow a new, tensor-based approach where covariance information is reconstructed from the ultrasound data by combining concepts of certainty modeling from ultrasound confidence maps [2] together with either structure tensor information or simulation-based approaches to model the US

propagation, proposed by different groups [3,4]. Based on these fields, US data can be processed and visualized with methods similar to DTI.

One major application field for ultrasound is vascular diagnosis, where the screening of the Abdominal Aorta is of special interest for vascular surgeons to detect malformations like Aneurysms (AAA). The volume and shape of these aneurysms determine strong risk indicators [5] for a rupture of the aneurysm, leading to death in most of the cases. Nevertheless these parameters are not examined in today's clinical practice due to lacking methods for segmenting these structures. One main reason for this is the strongly varying appearance of the vessel structures in ultrasound images within the region of interest due to the high penetration depth up to 20 cm.

With concepts related to an online-segmentation of the carotid artery [5] and segmentation of DTI images, the combination of both - properly modeling the varying ultrasound signal appearances - is promising for segmenting the abdominal aorta. This could bring a great value to today's clinical practice.

## Student's Tasks Description

The student will work on the formation of tensor field images from ultrasound data, develop tools for segmenting and visualizing tensor field data and evaluate them in a clinical setup.

For the tensor field formation, confidence maps will be combined with a modeling of ultrasound data or as an alternative approach by filtering the

Please send the completed document to us ([Ralf.stauder@tum.de](mailto:Ralf.stauder@tum.de)) before the project proposal deadline, April 8<sup>th</sup>. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in the case of acceptance.



data (e.g. with a modified structure tensor). Based on the retrieved tensor fields the goal will then be to define methods for segmenting recordings of the abdominal aorta to evaluate the usefulness of using this new information for the desired clinical application.

For validation, the newly developed algorithms will first be evaluated with preliminary acquired phantom data. Further, recordings of the AA should be acquired together with physicians located at the department for vascular surgery at the clinic Munich rechts der Isar to evaluate the principle also in the direct clinical environment.

### Technical Prerequisites

Mathematical background, profound programming skills (Matlab required, C/C++ and CUDA preferred)

### Administrative Info

Working Time: ~75h (6h per week, 12 weeks)

Project Location: Partially IFL, CAMP and clinic rechts der Isar

Required Equipment: Freehand ultrasound setup including Aurotech portable US device and attached tracking sensors

### Timeline and Milestones

Initial tensor field information should be retrievable for phantom data by end of May. Based on this, a segmentation of tensor field images will be developed by end of June, where

the evaluation phase will start by taking first recordings together with physicians.

### References

- [1] P. Fillard, V. Arsigny, N. Ayache, and X. Pennec, *A Riemannian Framework for the Processing of Tensor-Valued Images*, First International Workshop, DSSCV 2005, 112-123
- [2] A. Karamalis, W. Wein, T. Klein, and N. Navab, *Ultrasound confidence maps using random walks*, Medical Image Analysis, 16(6) 2012, 1101-1112
- [3] H. Gao, H. F. Choi, P. Claus, S. Boonen, S. Jaecques, G. H. van Lenthe, G. Van der Perre, W. Laurikus, and J. D'hooge, *A Fast Convolution-Based Methodology to Simulate 2-D/3-D Cardiac Ultrasound Images*, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 56:2, 404-409, 2009
- [4] J.A. Jensen, and N. B. Svendsen, *Calculation of pressure fields from arbitrarily shaped, apodized, and excited ultrasound transducers*, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 39,262-267, 1992.
- [5] D. A. Vorp, M.L. Raghavan, and M. W. Webster, *Mechanical wall stress in abdominal aortic aneurysm: Influence of diameter and asymmetry*, Journal of Vascular Surgery, 27:4, 632-639, 1998
- [5] J. Guerrero, S. E. Salcudean, F. A. McEwen, B. A. Masri, and S. Nicolaou, *Real-Time Vessel Segmentation and Tracking for Ultrasound Imaging Applications*, IEEE Transactions on Medical Imaging, 26:8, 2007