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Ph.D. Dissertation

Title: *Committing Medical Image Analysis*
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Synopsis

The topic of this dissertation is medical image analysis with focus on multi-scale methods and the task of segmentation. The main theme is how to move from explicitly non-committed approaches to methods that incorporate prior knowledge and thereby become specialized to the given task. The presented work explores a path from a non-committed multi-scale segmentation method towards more committed methods for segmentation and shape modeling.

The multi-scale watershed segmentation method by Fogh Olsen is the starting point for much of the work in this dissertation. In this non-committed method, the segmentation problem is addressed with the only assumption that there should be some contrast across the boundaries of the desired objects.

The investigation of specialization in segmentation and object modeling is grouped in three main bodies of work.

The first body of work is focused on specializing the multi-scale segmentation method through the use of non-linear diffusion. We present a *Generalized Anisotropic Non-linear* diffusion scheme with methods for optimizing the parameters and evaluating the performance. The results apply for segmentation of both 2D and 3D objects and show considerable performance improvements through the use of GAN. Upper limits for this performance gain are empirically established through experiments on artificial ideal objects. The methodology is evaluated on segmentation of brain structures in both 2D and 3D and shows significant improvements in segmentation efficiency.

Secondly, non-linear diffusion is analyzed in more detail via the introduction of the *Diffusion Echo* that allows explicit analysis of the local filters in non-linear diffusion schemes. We use this approach to investigate the connection between linear and non-linear diffusion given by scale selection.

While non-linear diffusion allows a large degree of incorporation of prior knowledge and thereby facilitates specialization towards a specific task, the work shows that for the multi-scale segmentation program, the possible performance improvement due to non-linear diffusion is not unlimited. Specifically, near-automatic segmentation seems unfeasible without further commitment of the method. The most promising way of incorporating additional prior knowledge is through the use of a shape model.

The final body of work is focused on shape modeling via the medial shape representation known as the M-rep. We present an essentially automatic method for generating a statistical shape model from a training collection. We demonstrate the method for constructing a prostate shape model.