

# Statistics of Natural Image Geometry

Ph.D. defense by Kim Steenstrup Pedersen

**Time and Place:** March 28 2003 13:15 at Lille UP1, Datalogisk Institut, Københavns Universitet

## Abstract

In computer vision and image analysis the task is to make inference about images. We want to develop algorithms that map input, consisting of one or more images, into a description of the physical world the images depict. From such descriptions, we want to deduce some information that lets us solve a certain task or problem, such as the problem of making a robotic car capable of driving autonomously in heavy traffic. This thesis focuses on solutions to general problems in computer vision and image analysis, and it consists of two separate parts, each representing an independent track of research.

The first part focuses on building probabilistic models of images and how to apply such models in the solution of computer vision problems. It is argued that the Brownian image model, and to some extent the fractional Brownian model, is a good model of the second order statistics of natural images, since this model captures the scale invariant covariance structure of natural images. The fractional Brownian model is used in the derivation of a scale normalization of image derivatives used in a scale selection approach originally proposed by Lindeberg (1998). A study is also made of the statistics of local image structure in natural images, where the goal is to model probability distributions of local features. In this thesis I settle for estimating the marginal distribution of edges and investigate how the local geometry of natural images distribute with respect to edges. Here local geometry is either represented by the intensity values in a  $3 \times 3$  pixel neighborhood or by the local 3-jet of a linear scale-space representation. This study shows that the local structure of natural images has a scale invariant distribution around a manifold of edges in state space, which follows a power law.

The second part of the thesis introduces a new algorithm for the analysis of motion of fluids and non-rigid bodies. I will present a multi-scale method for computation of optic flow fields. The optic flow field is extracted from normal flow, by fitting the normal components of a local polynomial model of the optic flow to the normal flow. This model fitting is based on an analytically solvable optimization problem, in which an integration scale-space of the normal flow field regularizes the solution. An automatic local scale selection mechanism is used in order to adapt to the intrinsic scale of the local flow structure. The performance profile of the method is compared with that of existing optic flow techniques on benchmark image sequences. The proposed method is also evaluated on a real sequence of smoke circulation in a pigsty.

For more information see <http://www.diku.dk/~kimstp/thesis/>