Universität Basel

Research Project

Localized Statistical Shape Models using Kernel Methods

Third-party funded project

Project title Localized Statistical Shape Models using Kernel Methods
Principal Investigator(s) Vetter, Thomas ;
Project Members Bouabene, Ghazi ; Gerig, Thomas ; Schönborn, Sandro ;
Organisation / Research unit
Departement Mathematik und Informatik / Computergraphik Bilderkennung (Vetter)
Department
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Statistical shape models have become an indispensable tool in medical image analysis. Despite the large amount of research done on shape models, the way of building these models has not changed since their introduction in the 90s. The idea is to model the variability of a shape by taking linear combinations of a set of example shapes. This simple approach is inherently global, as a linear combination is always taken of the full shapes. Therefore a local variation cannot be explained without affecting the full shape. This has been recognized as one of the major flaws of current statistical shape models.

In this proposal for a basic research project, we propose to develop a conceptually new approach to statistical shape modeling to overcome this problem. This proposed shape modeling concept will be based on our recently introduced framework for shape modeling, which is based on kernel methods and Gaussian processes. The use of these concepts from machine learning is fundamentally new in shape modeling. This framework unifies the many different concepts surrounding shape models, most notably nonrigid registration and shape model fitting, into one general and compact mathematical formulation. We will extend this kernel-based approach to develop localized and scale dependent statistical shape models. This will allow the model to represent both local and global shape variation around any given point of a shape. We believe that this approach can overcome the problems associated with current shape models.

In particular, it has the following advantages:

A) Decoupling of the local and global variations allows us to obtain a better covariance estimation. The local shape variation is simpler to model and thus needs fewer training examples for obtaining a good estimation. Given some additional example for the global shape, the local models are easy to integrate into a global model.

B) Images on which the modeled anatomical structure is only partially represented can for the first time be used as training examples for the local model, which greatly increases the number of available data.

C) Statistical shape models have a fixed point, typically at the center of the mean shape. Deformations far away from this point mostly reflect change in position rather than shape changes. Our proposed approach allows us to perform the alignment separately for each local model, thus separating position from shape information.

D) Local models built on different scales can be combined in a fitting procedure. This enables us to detect pathologies or fit the model to partial data.

The main research effort will be directed at developing a localized, multi-scale approach to shape modeling. This will be done by extending our approach for shape modeling using kernel methods in two ways: First we extend our registration method towards a multi-scale approach using multi-scale kernels. Second we formulate the new localized multiscale shape models and a new procedure for building these models. To demonstrate their practical use in medical imaging, we will apply our novel models to the problem of registration and model fitting of medical images with pathological or missing data, with the concrete goal of finding being able to fit fractured and traumatized bones.

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