Estimation of Multi-Dimensional Homeomorphisms for Automated Image Registration

Automated image registration is required whenever information obtained from different views of an object needs to be combined or compared. Given two images, one is looking for a transformation, such that one transformed image becomes similar to the second image. While an extensive amount of work has been done on this problem the fundamental question of how to reliably and efficiently estimate the transformation relating two images remains largely unsolved. Here we propose an approach aimed at solving directly this fundamental problem by modeling the transformation as a general continuous 2D mapping approximated by a parametric model. We then propose a method for estimating the parameters of the transformation in a computationally efficient manner involving a linear estimation problem rather than an extensive search! Once the transformation (or its inverse) has been estimated we proceed to map one image onto the other, i.e., to perform image registration.

Specific aims of the proposed work
- Studying a general parametric mathematical model for characterizing the class of deformations/transformations between the images that need to be registered.
- Developing computationally efficient linear techniques for estimating the transformation parameters from the given images. This is a very challenging problem, due to the inherent nonlinear nature of the problem. Existing methods are computationally intensive since they require the solution of non-convex minimization problems.
- Developing performance bounds on the accuracy with which image registration can be performed. This can be done in a natural way within our framework.
- The proposed solution will have applications to problems of interest in a wide range of areas, such as in automatic detection and recognition of deformations and anomalies in medical images; in security systems where claimed identity has to be verified by comparing an acquired image of a person or object to an existing database; in object based low bit rate image coding: most of the information on the moving objects in the scene can be faithfully described and tracked as a set of continuous transformations applied to a small set of templates providing the object appearance from various observation angles; or in remote sensing image registration where the problem becomes especially severe when images are taken at low angles and are therefore highly deformed by the perspective projection. The proposed algorithms will be applied to one of these key application areas.

Collaboration: The proposed research is closely related to our collaboration with the group of Prof. Joseph Francos at Electrical and Computer Engineering, Ben-Gurion University of the Negev, Israel.

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