Medical Imaging Summer School 2014

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Medical Imaging meets Computer Vision

Nikos Paragios
Ecole Centrale Paris, France

Lecture 1: Introduction to Deformable Registration: Transformations, Metrics & Inference

Deformable registration/fusion is a pillar of biomedical image analysis. It consists of finding a non-linear transformation that will map one multi-dimensional signal to another through a geometric transformation. The task is often expressed as an inverse modeling one where given a family of transformations and similarity criterion we seek the instance of this family that creates an optimal alignment between the two signals. In this lecture we will introduce the theoretical foundations of deformable registration. In particular we will provide a generic mathematical framework to express existing methods and discuss stated of the art techniques in terms of (i) type of deformations, (ii) similarity criterion and (iii) optimization methods.

Lecture 2: Deformable Registration: Setting the State of the Art through coupling of iconic/geometric methods using Discrete Models

In this lecture we will introduce a generic formalism for solving linear/non-linear registration that is able to account for various type of deformations, different similarity metrics and is able to integrate information coming from images with geometry (landmarks). This will be achieved through a interconnected graphical model coupling image matching constraints with landmarks correspondences. Such a graphical model will encode similarity on singleton costs, smoothness on intra-graph pair-wise terms and consistency/coupling of iconic/geometric information through inter-graph pair-wise connections. In order to impose linearity constraints higher order terms will be also considered. The resulting theoretical formulation can deal with linear, non-linear, mono-modal/multi-modal 2D-2D/3D-3D/2D-to-3D registration and once endowed with efficient optimization methods would provide state of the art results when efficiency vs precision is considered.

Lecture 3: Discrete Biomedical Perception: Efficiency, Modularity & Scalability

Perception, interpretation and understanding of images is a well studied problem. The process consists of defining a set of parameters that should be determined given the observations. Discrete modeling consists of associating this inference process as a graph optimization problem where parameters correspond to nodes, labels to a discrete sampling of the optimization space and connectivity on co-dependencies between variables. This lecture will provide the theoretical foundations of a generic

mathematical formalism exploiting low as well as higher order probabilistic graphical models for biomedical image analysis. Furthermore, efficient generic/scalable methods for their inference will be presented demonstrating the extreme potentials of such an approach. Last but not least, concrete biomedical imaging examples will be considered like shape registration, organ and tumor segmentation, high level reasoning to better illustrate the interest of such a perception paradigm.