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Medical Imaging meets Machine Learning

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Lecture 1: A Graphical Introduction to Probabilistic Graphical Models

This talk will introduce probabilistic graphical models (PGMs), AKA “Bayesian Networks.” We will begin with a summary of the Bayes’ approach to modeling and inference. Building on this, PGMS will be described, including their utility for providing a high level view of a problem, clarifying the sharing of random variables and clarifying assumptions. Subsequently several common methods of inference will be summarized, including maximum likelihood (ML), maximum a-posteriori probability (MA), the expectation-maximization algorithm and Markov-chain Monte Carlo.

The methodology will be used for a retrospective summary of some of the common methods of medical image analysis, including variants of segmentation and registration. A unified visual presentation style will be used.

Lecture 2: “Real Slow Registration”: Exploratory Work on Uncertainty in Registration with MCMC

Most deformable registration systems produce, as their “answer” to the registration problem, a “best” estimate of the transformation that relates the image data being registered. We believe that, as deformable registration is increasingly applied to interventional applications, it is important to characterize the level of uncertainty in the results. In this talk I will summarize a thread of research at the Brigham and Women's Hospital Surgical Planning Laboratory that is aimed at estimating posterior distributions on the deformations that result from registration.

The approach uses a Gaussian-like prior on mechanical configurations that depends on elastic deformation energy and the Markov-Chain Monte-Carlo (MCMC) approach for inference. Preliminary results will be shown for visualizing geometric uncertainty in image-guided neurosurgery, and estimating the uncertainty in delivered dose in head and neck radiation therapy.

Lecture3:"Excellent Magic": A multi-perspective introduction to the EM algorithm

The Expectation-Maximization algorithm was summarized and characterized by Dempster, Laird and Rubin in 1977. It is frequently used in estimation with missing data, and for inference on models that have latent discrete random variables, e.g., mixture models. This talk will describe the basic approach, beginning with maximum likelihood and MAP contexts. A convergence argument will be summarized. Several special cases and examples will be discussed.