Introduction

CS 7640: Advanced Image Processing

January 10, 2017

Course Description

In-depth study of advanced methods and research topics of current interest in image processing and analysis. Covers PDEs, shape representations, deformable models (snakes, level sets), statistical shape analysis, scale-space and registration. Focus and list of topics might change from semester to semester.

Who Should Take This Course?

Graduate students who are interested in getting advanced knowledge in image processing and analysis, following the course CS6640 Introduction to Digital Image Processing or equivalent. The course is particularly important for students involved in image processing research and is a core course of the Image Analysis track.

Prerequisites

- CS6640 Introduction to Digital Image Processing or equivalent
- Advanced programming skills related to imaging (C++, Java, Python, Matlab, or R, etc.)
- Basic mathematical skills (linear algebra, multivariate calculus, probability)

Students with different background and curriculum need to discuss suitability and options with the teacher.

Course Objectives

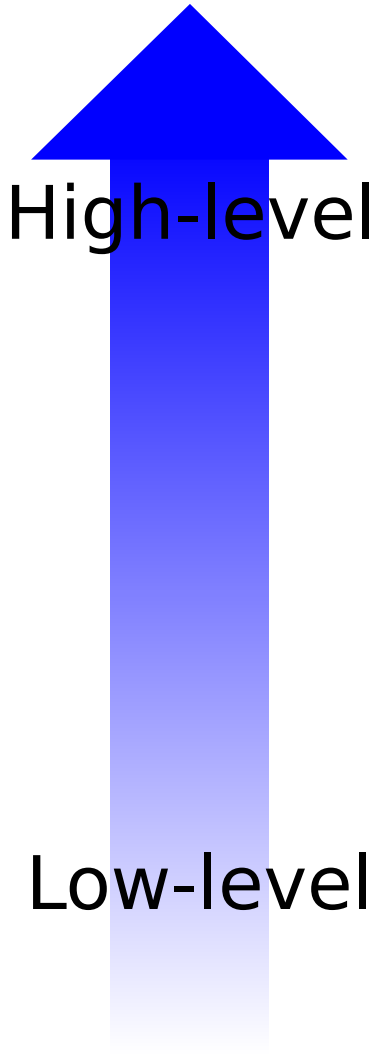
- To discuss advanced topics in image processing and analysis that build on the introduction course
- Scientific methodology: Reading of scientific publications and book chapters, summarizing the contents, developing strategies to implement algorithms, and finally presenting the theory, tests, and applications to the audience
- To enable participants to implement solutions for complex image processing problems

Course Objectives cont.

- To enable participants to better understand novel, advanced methodology that is discussed in the image processing and image analysis literature
- To enable participants to teach image processing materials to the group by preparing and presenting a class lecture

Grading

- Projects (5-6): 70%
- Presentations (1 paper, 1 project): 20%
- Class Participation: 10%



Computer Vision

Object detection, recognition, shape analysis, tracking
Use of Artificial Intelligence and Machine Learning

Image Analysis

Segmentation, image registration, matching

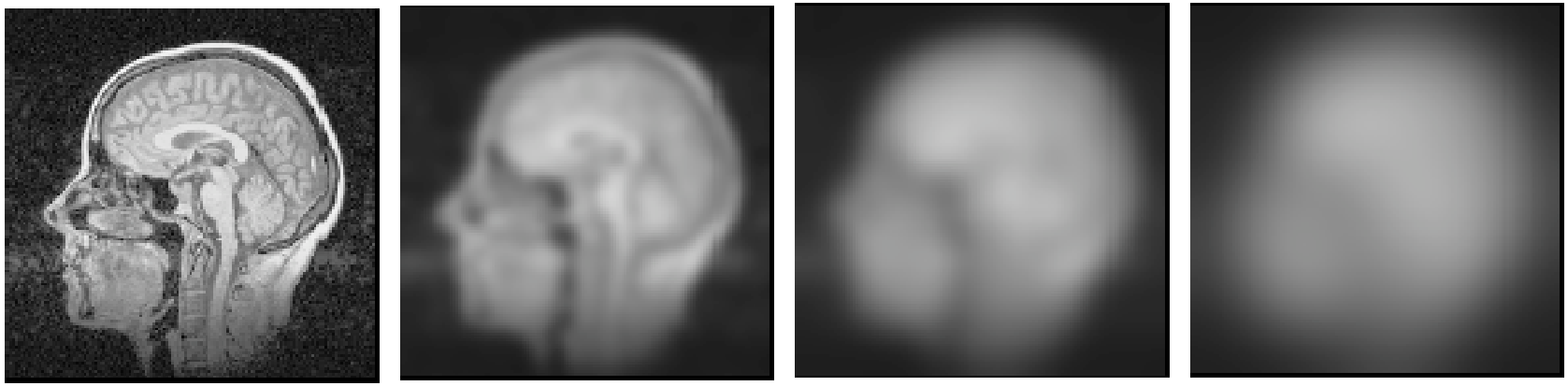
Image Processing

Image enhancement, noise removal, restoration,
feature detection, compression

Topics

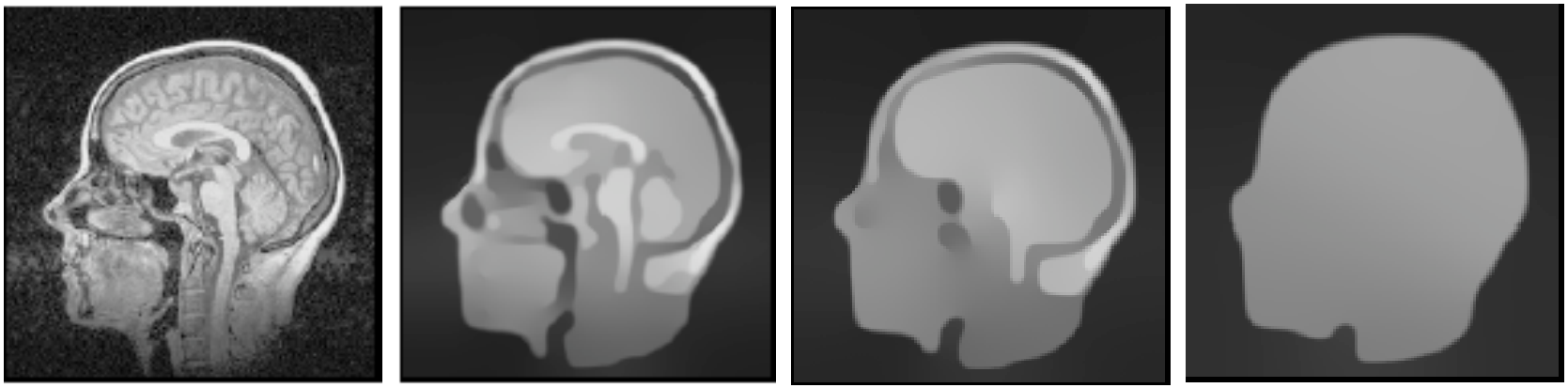
- Feature Detection
  - Scale space
  - Gaussian derivatives
  - Nonlinear scale space and anisotropic diffusion
  - Differential invariant structure
- Image Registration
  - Deformable registration
  - Atlas building
  - Mutual information

Example: Scale Space



Source: http://www.csee.wvu.edu/~tmcgraw/cs593spring2006/index.html

Example: Anisotropic Diffusion

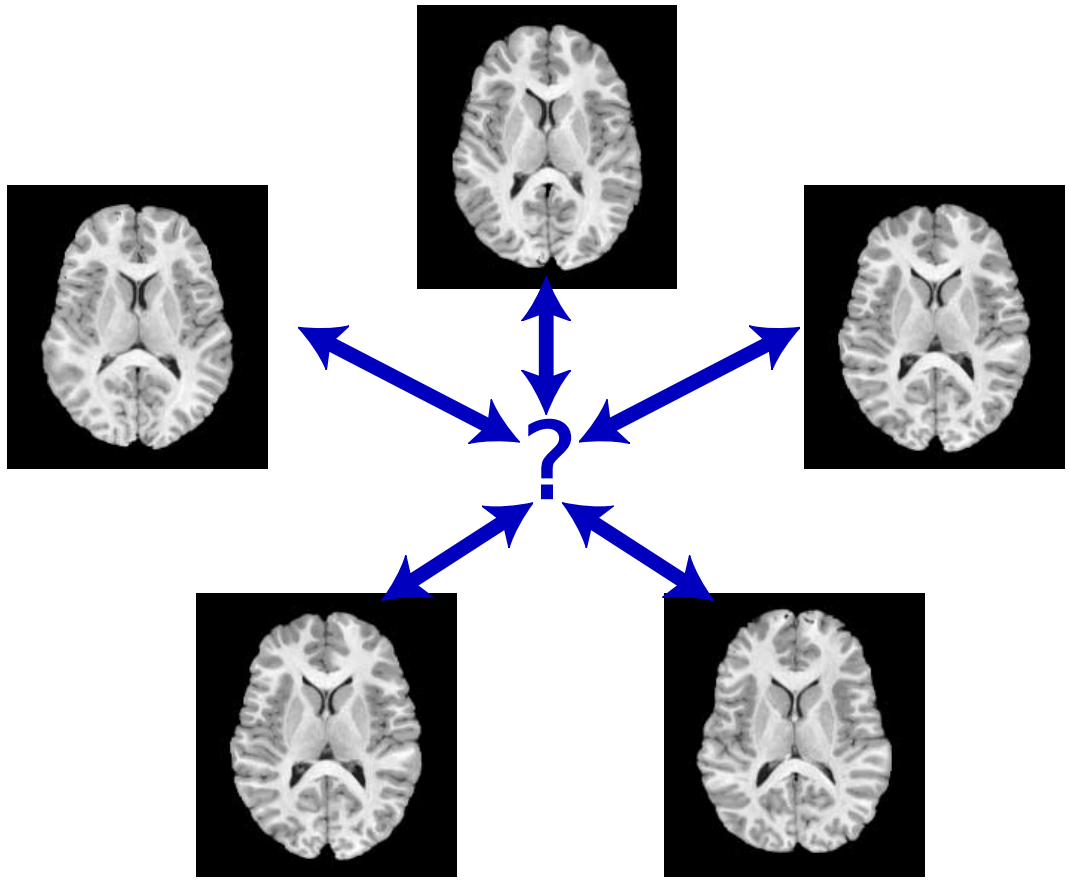


Source: `http://www.csee.wvu.edu/~tmcgraw/cs593spring2006/index.html`

Example: Deformable Image Registration

How do we map the anatomy of one person onto another?

Example: Image Atlas Building

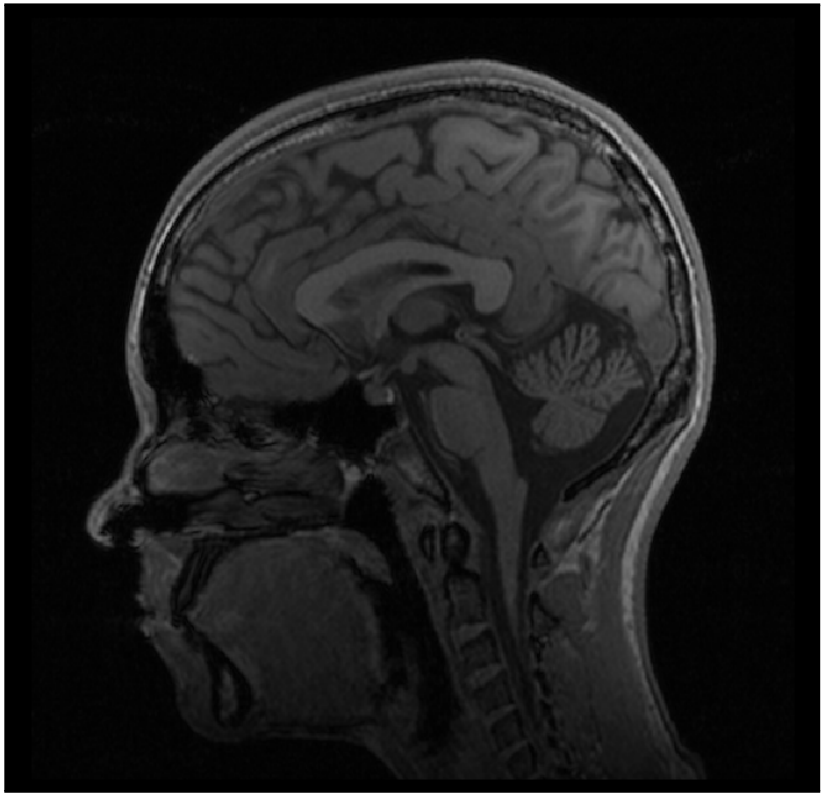


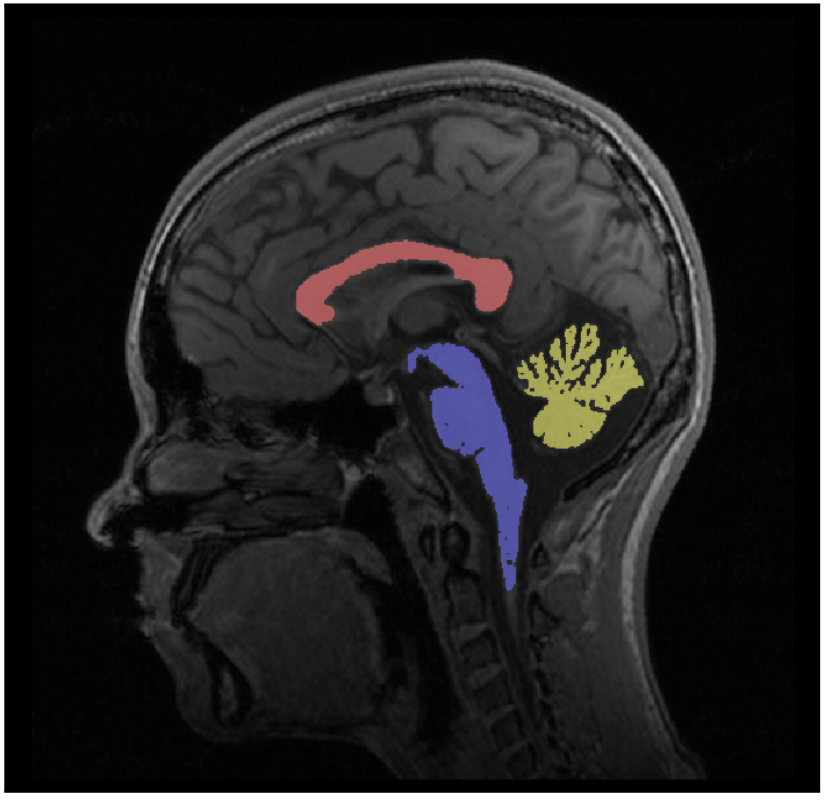
How can we estimate the “average” brain image of a population?

Topics

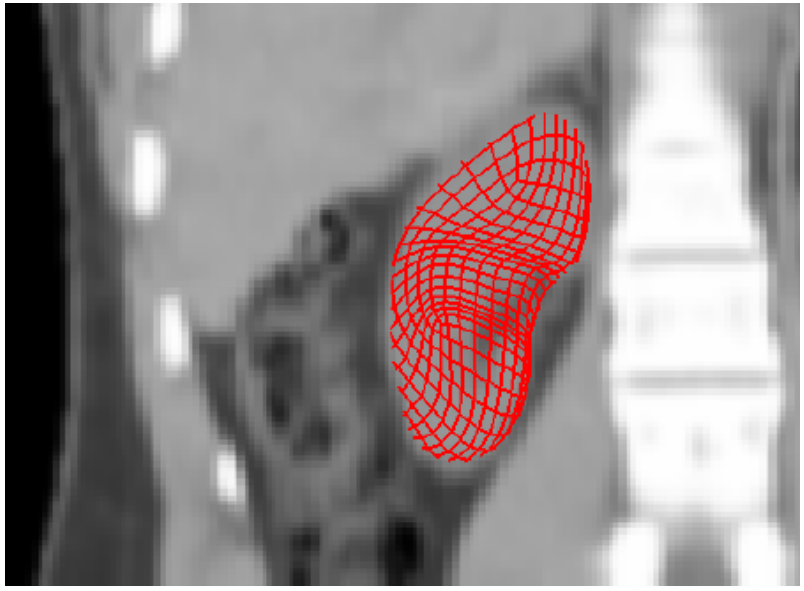
- Shape Analysis
  - Shape representations
  - Theory of shape spaces
  - Shape statistics (means, variability)
- Segmentation
  - Level set segmentation (PDE)
  - Deformable models
  - Markov random fields
  - Mean shift

Example: Level Set Segmentation





Example: Deformable Model Segmentation



Shape priors in segmentation

Mathematics in Image Analysis

- Calculus (multivariate)
- Linear Algebra
- Probability and Statistics
- Harmonic Analysis (Fourier, wavelets, etc)
- Differential Equations (ODEs and PDEs)
- Differential Geometry