Introduction

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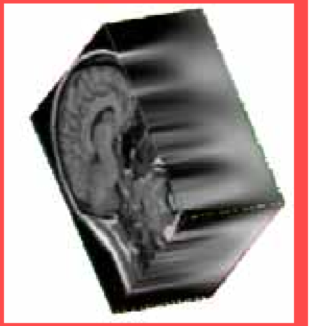
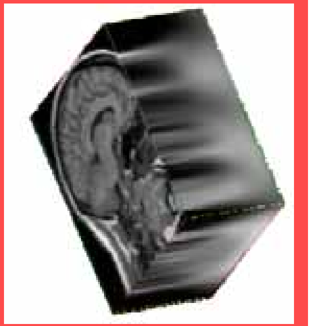
CS 7960, Spring 2010



CS7960 Advanced Image Processing

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 attend?

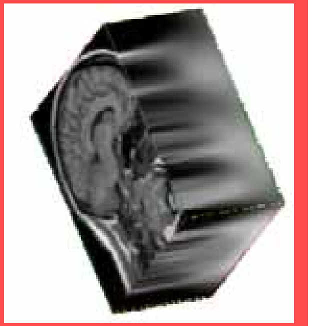
Graduate students who are interested in getting advanced knowledge in image processing and analysis, following the course *6640 Introduction to Digital Image Processing* or equivalent. The course is particularly important for students involved in image processing research and will be a core course of the newly established imaging track.

Prerequisites

Course 6640 Introduction to Digital Image Processing or equivalent. Advanced programming skills related to imaging (C++, imaging libraries, Matlab or equivalent). Students with different background and curriculum need to discuss suitability and options with the teacher.

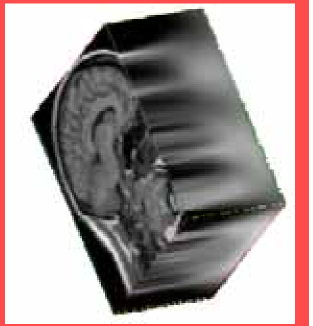
Goal and Objectives

- 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.



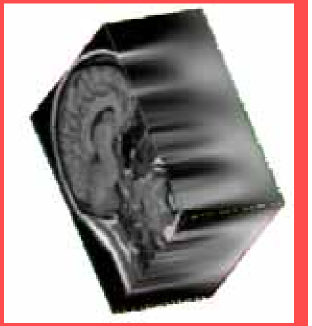
Goal and Objectives ctd.

- 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.



Learning Approach

- Students will **read the relevant publications or chapters** of books books and/or reading assignments BEFORE the class lectures.
- In the course, the material will then be discussed in detail and motivated with real world examples and applications.
- Students will actively participate in teaching by **preparing a class lecture**.
- **5-6 projects** where material discussed in class will be implemented, tested, and applied to image data and **presented.**



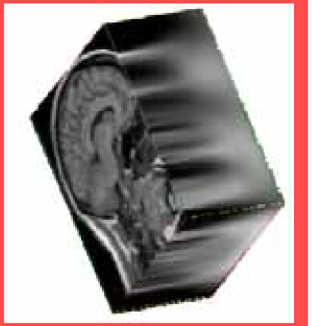
Grading

- Projects (5-6): 80%
- Class Lecture: 10%
- Participation: very important
- Presentation of one project: 10%

Late Policy: There will be 10 point deduction per week (out of 100) for late project submission.

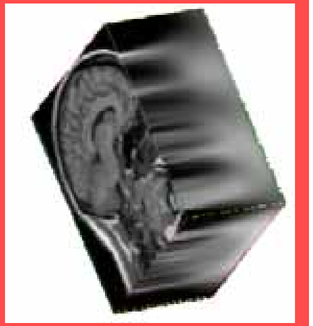
Contents

- Feature Detection and Characterization
  - Notion of Scale Space
  - Gaussian Derivatives
  - Differential Invariant Structure
  - Nonlinear Scale Space
  - Anisotropic Diffusion
  - Diffusion of Higher Order Derivatives



Contents II

- Shape Analysis
  - – Fundamentals in Shape Analysis
  - – Moment Invariants
  - – Contour-based Invariants
    - Active Shape Models (ASM)
    - Active Appearance Models (AAM)
    - Elliptical Harmonics
  - – Medial Axis Representation

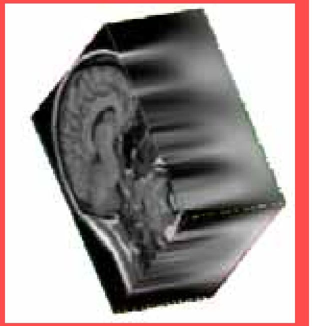


Contents *III*

- Object Segmentation
  - Generalized Hough Transform
  - 3D Deformable Models
  - Snakes
  - Level set evolution
- Others
  - Normalized Graph Cuts
  - Etc.

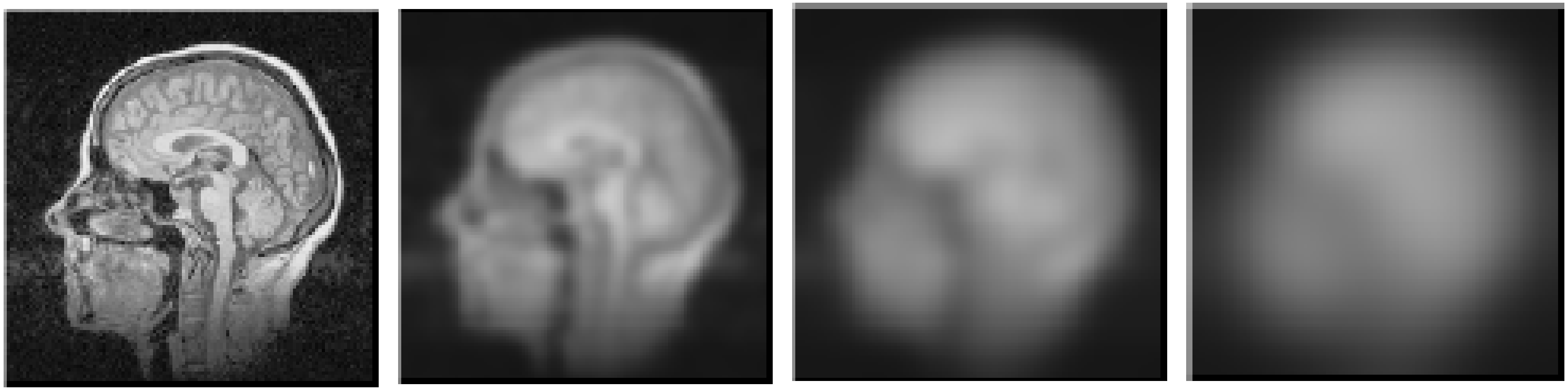
Contents IV

- Image Registration



Linear Diffusion

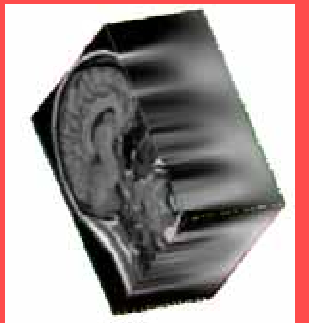
- Edge locations not preserved
- Region boundaries are preserved
- Gaussian blurring is local averaging operation and does not respect natural boundaries



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

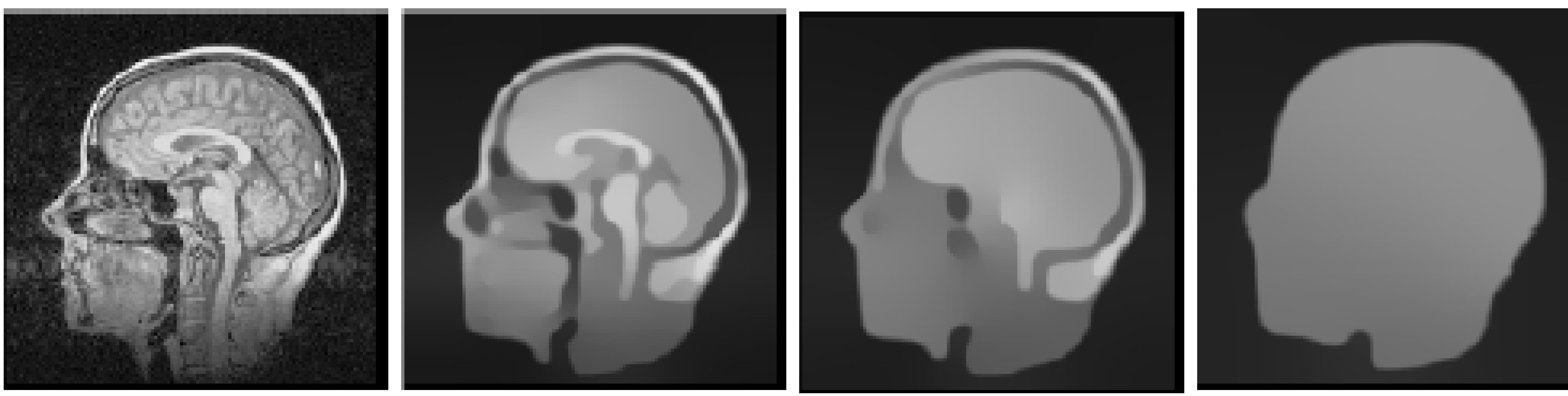
Linear vs. Nonlinear Diffusion

- **Linear Diffusion**: blur in all directions
- **Inhomogeneous diffusion**: blur in all directions, but attenuate diffusion by an amount proportional to the magnitude of the gradient
- **Anisotropic diffusion**: blur only in directions where the magnitude of the gradient is changing minimally, halt blurring across boundaries



Nonlinear Diffusion

Multiscale image representation: Details in images should only exist over certain ranges of scale.



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Shape Analysis & Modelling

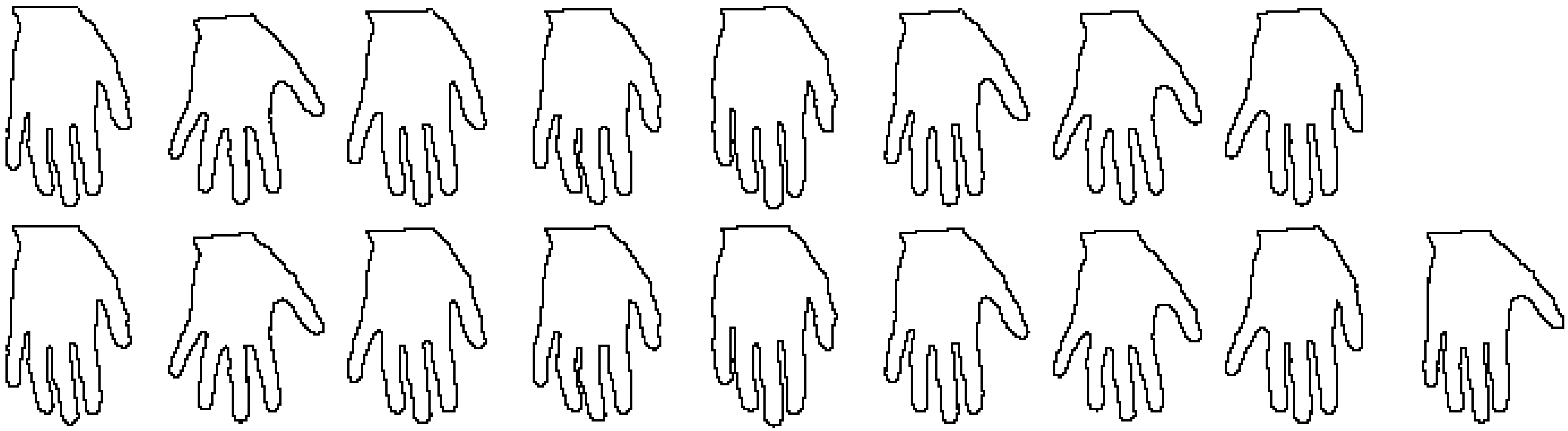
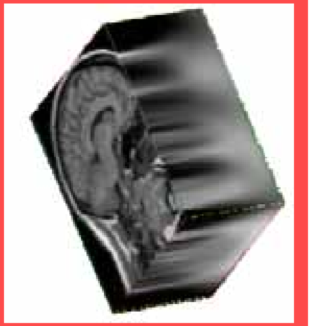


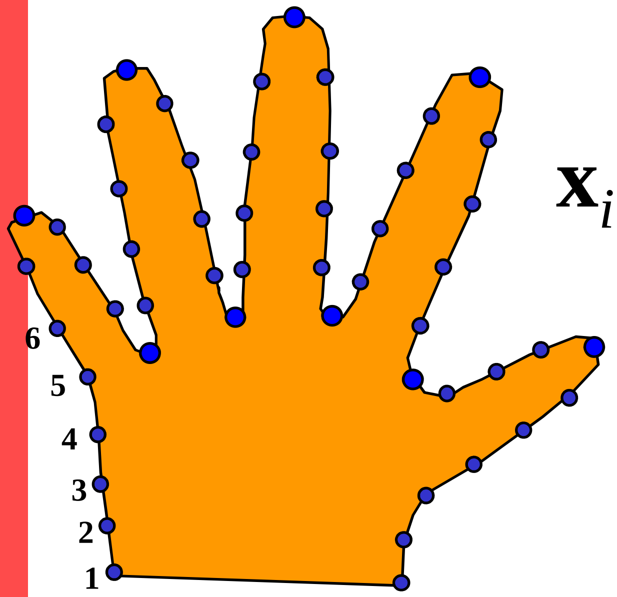
Figure 3.1. A training set of hand outlines.

From: PhD thesis Rhodri Davies

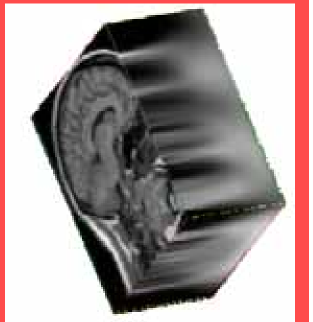


Modelling Shape

- Define each example using points
- Each (aligned) example is a vector

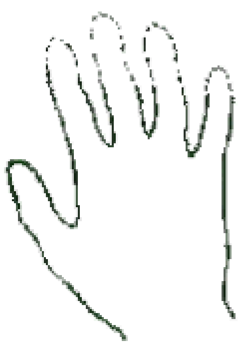


$$\mathbf{x}_i = \{x_{i1}, y_{i1}, x_{i2}, y_{i2} \ldots x_{in}, y_{in}\}$$

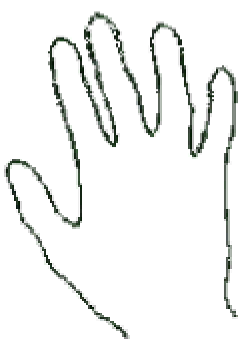


Hand Model

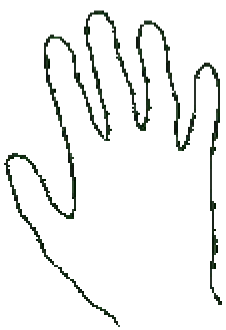
- Modes of shape variation



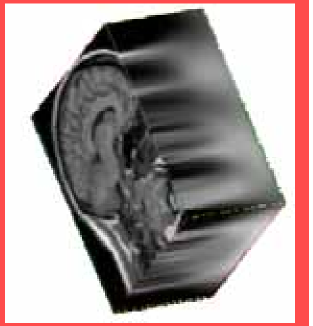
b_1



b_2

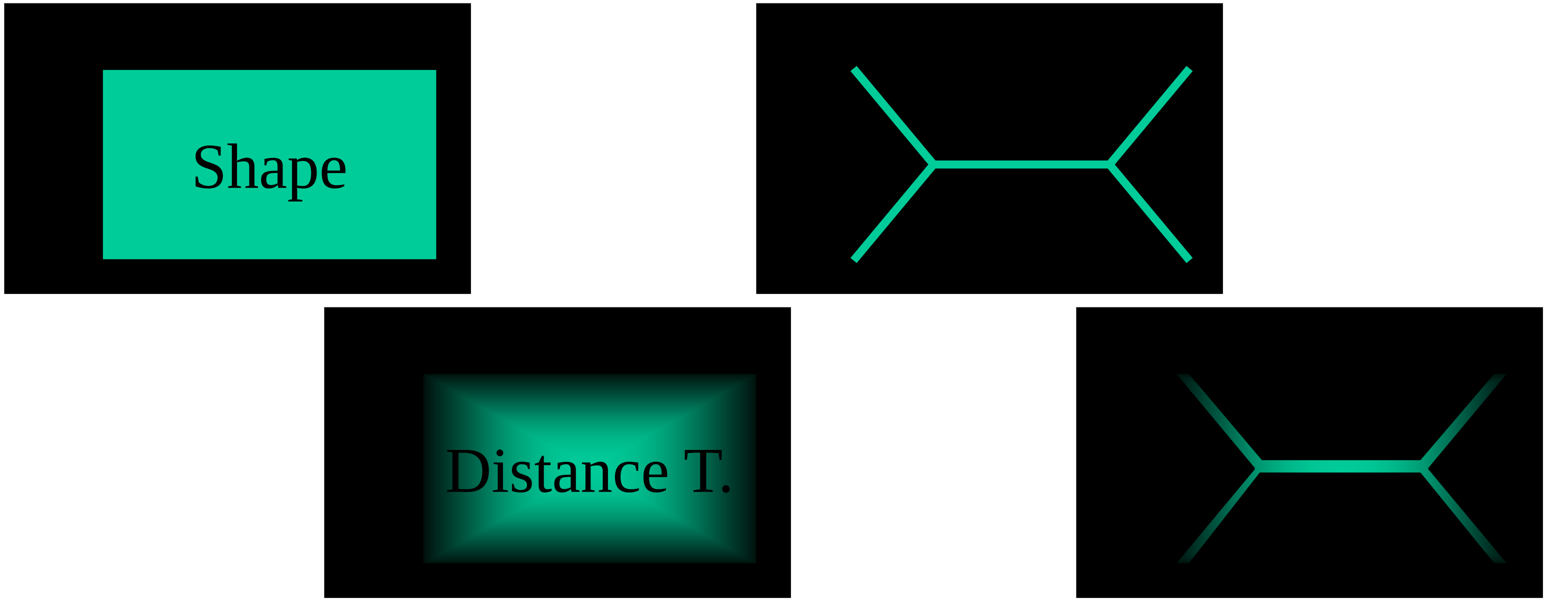


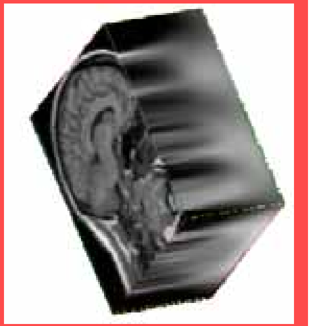
$\mathbf{b}$



Skeleton

- The *Medial-Axis Transform* (MAT) (Blum) is a specific skeletonisation, in which the greylevel of a skeleton pixel indicates distance to the original shape boundary.





Segmentation by deformable models

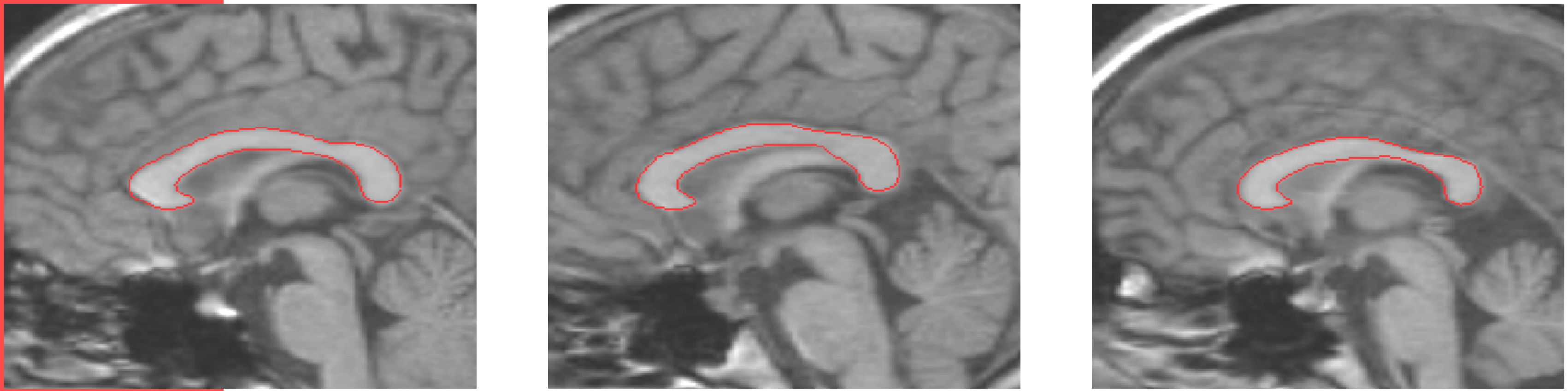
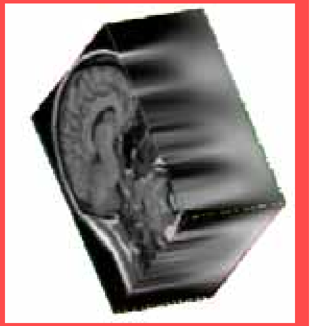


Fig. 1: Visualization of 3 MRI mid-hemispheric slices and the final positions (in red) of the automatic corpus callosum segmentation algorithm using deformable shape models.

shape constrained Fourier snake 2D
(CC-seg-avs1.mov)

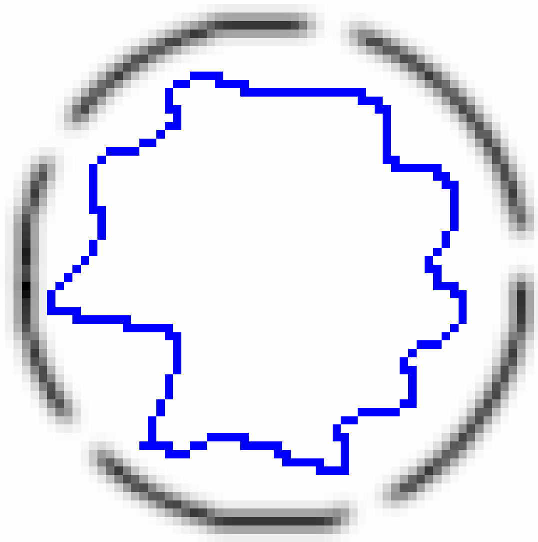


Deformable Models: SNAKES

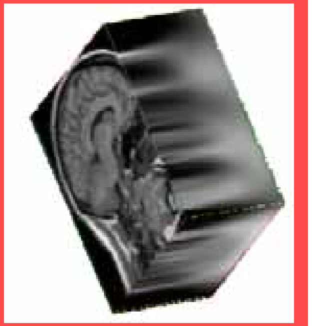
Geodesic Snake:

$$\frac{\partial c}{\partial t} = [\kappa + \alpha]N$$

Implementation: Curve C embedded as zero-level of higher order function φ



$$\frac{\partial \varphi}{\partial t} = (g)^{r_{MCF}+1} \nabla \cdot \left(\frac{\nabla \varphi}{|\nabla \varphi|} \right) |\nabla \varphi| + (g)^{r_{\nabla g}} (\nabla g) \cdot \nabla \varphi + (g)^{r_c} \alpha |\nabla \varphi| + c_s \cdot (g)^{r_s} \nabla^2 \varphi :$$



Use of deformable models in Vision