3D Geometric Model Reconstruction from MR Images

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Introduction

• Virtual therapy and surgery planning
• Training platform
• New medicine

Examples
Volume Information
Black and White Images

- **GRAYVALUE images:**
  - Value = 0: BLACK (no illumination / energy)
  - Value = 255: White (max. illumination / energy)

```

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Processes

Segmentation

3D Reconstruction

Smoothing

6/21/2007 6/20
Segmentation: Edge detection

Edges are places in the image with strong intensity contrast. Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when we want to divide the image into areas corresponding to different objects. Edges are pixels where image brightness changes abruptly.

Brightness vs. Spatial Coordinates
Edge Detection

- Edge information in an image is found by looking at the relationship a pixel has with its neighborhoods.
- If a pixel’s gray-level value is similar to those around it, there is probably not an edge at that point.
- If a pixel’s has neighbors with widely varying gray levels, it may present an edge point.
Edge detection

Since edges consist of mainly high frequencies, we can, in theory, detect edges by applying a highpass *frequency filter* in the Fourier domain or by *convolving* the image with an appropriate *kernel* in the spatial domain. In practice, edge detection is performed in the spatial domain, because it is computationally less expensive and often yields better results.

\[
\nabla I = \nabla h \ast I \quad \text{first derivative (gradient)}
\]

\[
\nabla^2 I = \nabla^2 h \ast I \quad \text{second derivative (Laplacian)}
\]
• **Procedure:**
  - place a weight matrix or *mask* at each pixel location $p_{ij}$
  - this mask weighs the pixel’s neighborhood and determines the output pixel’s value
Convolucion

\[
\frac{1}{9} \left( 10 \times 1 + 11 \times 1 + 10 \times 1 + 9 \times 1 + 10 \times 1 + 11 \times 1 + 10 \times 1 + 9 \times 1 + 10 \times 1 \right) = \frac{1}{9} \cdot 90 = 10
\]
- Roberts operator
- The Sobel operator
- Prewitt operator
- The Laplacian operator

\[
\begin{array}{ccc}
0 & 1 & 0 \\
1 & -4 & 1 \\
0 & 1 & 0 \\
\end{array}
\begin{array}{ccc}
1 & 1 & 1 \\
1 & -8 & 1 \\
1 & 1 & 1 \\
\end{array}
\begin{array}{ccc}
1 & 2 & 1 \\
2 & -4 & 2 \\
-1 & 2 & -1 \\
\end{array}
\]
Geometric Model reconstruction

http://www.csse.uwa.edu.au/~pk/Research/MatlabFns/
Geometric Model reconstruction
General Procedures

1. **Noise reduction**, where we try to suppress as much noise as possible, without smoothing away the meaningful edges.

2. **Edge enhancement**, where we apply some kind of filter that responds strongly at edges and weakly elsewhere, so that the edges may be identified as local maxima in the filter’s output..

3. **Edge localization**, where we decide which of the local maxima output by the filter are meaningful edges and which are caused by noise.
Surface reconstruction

Original contours

Surface mesh fitted

Dr. Xu, Dept of Chemical Engineering, Imperial College of Science, London
Designing free form surface

Non Rational B-Spline Surface (NURBS):

\[
S(u, v) = \frac{\sum_{i=0}^{n} \sum_{j=0}^{m} w_{ij} p_{ij} N_{i,k}(u) N_{j,l}(v)}{\sum_{i=0}^{n} \sum_{j=0}^{m} w_{ij} N_{i,k}(u) N_{j,l}(v)}
\]
The geometry consists of 9999 NURBS Patches.
Thank You!