QUANTITATIVE IMAGE ANALYSIS

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What is image analysis? The extraction of information from pictures.

e.g. Which line is the longer?
Who is this?
The human eye/brain is a superb image analyser.

So, why use a computer?

- better for quantitative tasks
- repeatable/non-subjective
- cheaper/less tedious
- capable of different techniques
An example of non-automated image analysis:

Cross-section of turbinate bone

Using sno-pake and black ink.
But automating image analysis is hard, because all a computer ‘sees’ is:

Could you recognise Mona Lisa from this?
And alternative graphical displays of the data are of no help:
What are the data?

What variate is measured?

How is the specimen sampled?
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0. Introduction
1. Enhancement
2. Segmentation
3. Measurement
4. Summary
PLAN

0. Introduction

1. Enhancement:
   - Change in contrast
   - Enlargement
   - Noise reduction
   - Edge detection

2. Segmentation

3. Measurement

4. Summary
1. Enhancement: Change in contrast

In CT images, pixel values range from $-1000$ to $> +1000$ Hounsfield units. According to how we display these values we obtain different images.
1. Enhancement: Enlargement

region of interest

smooth interpolant
1. Enhancement: Noise reduction

Moving average filter

small window

larger window
Morphological operations

thresholded CT $\rightarrow$ erosion $\rightarrow$ erosion + dilation
1. Enhancement: Edge detection

Prewitt’s edge filter
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0. Introduction
1. Enhancement
2. Segmentation: – Thresholding
   – Boundary tracking
3. Measurement
4. Summary
2. Segmentation:

In these two applications, the aim of segmentation is to automatically draw the red lines.
2. Segmentation: Thresholding

Thresholding is the simplest method for segmenting images, by identifying all areas with pixels of certain values, e.g. all CT values $> 250$ Hu
2. Segmentation: Boundary tracking

We consider the pattern of pixel values on either side of a boundary, averaged over many images.

For the ultrasound images this gives:
We compare the patterns with the different possible locations of a boundary, where darker values denote better fits:

The best boundary is the darkest path between the two sides of the image
For the CT images, it is slightly more complicated as we first have to ‘unroll’ the images.

- polar transformation
- boundary pattern
Here we see the resulting \textit{automatic}, and \textit{hand-drawn}, boundaries:
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3. Measurement:  – Areas, lengths, shapes
                – Effects of mixed pixels

4. Summary
3. Measurement: Areas, lengths, shapes

CT cross-section of eye muscles

- Area
- Width, depth, shape = width/depth
- Boundary curvature
3. Measurement: Effects of mixed pixels

We want to estimate the proportions of fat and muscle in segmented CT images.
However, many pixels represent a mixture of more than one constituent. This can be seen at the edge of the cradle in which the sheep lies:
We have developed a **mixed-pixel distribution**, which fits the histogram better than that for **pure muscle and fat pixels alone**:

and provides a more accurate estimate of tissue proportions.
4. Summary

Automated image analysis is a challenging problem, but offers the possibility of

- more accurate,
- faster,
- more sophisticated, measurements.

For further details, see


and research papers on

http://www.bioss.ac.uk/~chris