Progress Toward System-Independent Image Analysis: An Example from Texture Analysis in Optical Coherence Tomography

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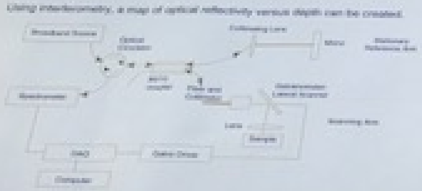
1: Optical Coherence Tomography (OCT)

Optical coherence tomography is an optical imaging technique analogous to ultrasound that uses partially coherent near-infrared light to interrogate a target and create images of sub-surface microscopic structures with a resolution of 10-20 μm or less.

Using interferometry, a map of optical reflectivity versus depth can be created.



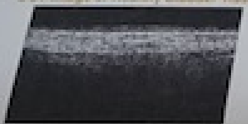
OCT has been shown to produce images with high spatial resolution but, due to the high level of scattering of near-infrared light in biological tissues, penetration depths range from only 1 to 2 mm.

Mucosal cancers, however, such as cancer of the bladder, tend to arise in the urothelium within 600 μm of the tissue surface, which is an ideal imaging depth for endoscopic OCT imaging systems.

2: Previous Study: Bladder Tissue Differentiation Using Texture Analysis

...ave previously developed an algorithm to discriminate cancerous from non-...rous tissue in the urinary bladder, using Optical Coherence Tomography and texture analysis. The algorithm, which had a sensitivity of 92% when ...sing leave-one-out cross-validation, was developed using images taken ...ingle imaging system.

OCT Image of Healthy Bladder Tissue



...ment of our algorithm five approaches to texture analysis were

- Histogram Analysis
- Laws' Texture Features
- Basic Statistical Features
- Co-Occurrence Matrices
- Fourier Analysis

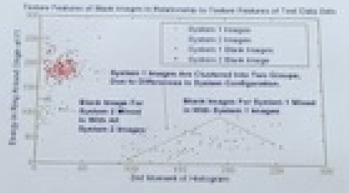
...access to a set of images of the urinary bladder taken with an ...ifferent from that used in the original test set. We have confirmed ...ture features that are significantly affected by the imaging system.

3: Texture Information from Blank Image

Texture features were calculated for a few "blank" images from each system. Images of areas assumed to be without scatterers (imaged of air or saline) were considered blank.

The texture features of the blank images were plotted along with the texture features for all of the images taken with either system. The data points were color coded based on the system used.

There were some features, most of which were measures of the amount of energy in specific areas of the Fourier spectrum, in which the texture features for the blank images fell in the same or similar ranges as the images themselves. This indicates that a blank image taken with a particular system may provide information necessary to correct for differences between systems and or configuration. A graph of two such features is shown below.



4: Texture Information from Background Within Images

The portion above the lining of the bladder, at the top of each OCT image, was recognized using histogram analysis and considered "background." This background within each OCT image was considered as a potential tool in recognizing, and possibly correcting for, differences between systems or system configurations.

Texture features were calculated for the background portion of each image in both data sets, and the resulting features graphed.

The Laws' texture features were particularly useful in differentiating between systems.

Some background features produce data distributions similar to the texture features calculated for the actual images. The relationship between these background features and the image features may prove to be more useful than the absolute texture values.

5: Correcting for Known Parameters

There are certain system or configuration parameters which are known and could possibly be used to compensate for differences between systems or system configurations. For example, the wavelength of the light source used affects both the axial system resolution and imaging depth, which in turn affects the dimensions of the OCT image. Likewise, the average intensity of the sample and reference beams will affect the range of intensities in the image.

We evaluated the effects of normalizing and resizing images on the resulting textu... features by using values for image width, image depth, and intensity range includ... in both sets of image data.

Feature Type	Effect of Normalizing	Effect of Resizing
Histogram Analysis	Necessary	Little or No effect
Laws' Texture Features	Necessary	Usually Necessary
Fourier Analysis	Sometimes	Sometimes
Co-Occurrence Matrix	Little or No effect	Affects, Sometimes Beneficial

Effect of Normalization and Resizing on Example Feature...

6: Conclusions

To develop algorithms that are system independent, it is nece... the effects system differences have on the resulting algorithm... studying the effects OCT system differences have on texture... possible methods of recognizing and compensating for those...

We have determined:

1) System parameters do affect the results of texture ana... features can be used to differentiate between systems...
2) 'Blank' images can be used to identify differences in s... configuration. Fourier analysis was particularly usef... differences.
3) Texture analysis calculated over the background po... to differentiate between systems, and in some cas... the texture features for the images themselves.
4) Known system or configuration parameters can b... such as the width and depth of the image, or ran... This information can in turn be used, in different... compensate for the differences between system...