ISSUES IN HIGH RESOLUTION IMAGE ANALYSIS

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Abstract—This paper provides a brief outline of issues involved in high-resolution image analysis.

1 INTRODUCTION

There are three basic resolutions involved with reference to Remote Sensing Data. These are Spatial, Spectral and Radiometric. The spatial resolution refers to the size of the pixel on the ground. For example, if an area of 5m X 5m gives rise to one pixel, then the spatial resolution is taken as 5m. The spectral resolution refers to the number of spectral windows used. Radiometric resolution deals with the number of quantization levels used to represent the energy received from the ground.

The main tasks involved in Remote Sensing data analysis are:

Classification
Object recognition
Image fusion
Change detection
Registration / Matching

Each of the above tasks is influenced by the three resolutions referred to above. Area-based or pure pixel based classification methods are better suited for coarse spatial resolution where as shape and texture based approaches are needed for high spatial resolution images. High spectral resolution calls for Rule Based approaches or a systematic preprocessing to reduce the spectral resolution and choose different combinations of bands for specific purposes. Radiometric resolution generally does not add to the complexity of processing except to increase the volume of data and also to give rise to issues regarding signal to noise ratio. In this note, some of the tools which are necessary to handle high spatial resolution data are described. These are by no means exhaustive and are based on our experience.

2. NEED FOR ANALYSIS AT MULTIPLE SCALES

Even though high spatial resolution is generally very desirable, in automating image analysis, often there are problems associated with high resolution. For example, if the objective is to identify 'Roads' in an image, then the avenue trees on either side of the road as well as markings and dividers become 'noise' and hamper the Road identification. Hence, it is necessary to generate data at lower resolution from high resolution data and then use it for Road identification. The tool used for this purpose is called *Diffusion*.

2.1 Diffusion

The diffusion process establishes a scale space. It is a transparent process that tends to level out concentration differences. The basic differential equation is

$$\partial_t u = \nabla (D . \nabla u)$$

$$(\nabla^2 = \partial_{xx} u + \partial_{yy} u)$$

where D is a diffusivity parameter, t is a scale parameter, x,y are space parameters. A constant value of D will give isotropic diffusion which will blur edges. Nonlinear isotropic diffusion with scalar D being adapted to local image structure will not blur edges. Nonlinear coherence anisotropic diffusion with tensors D being adapted to the local image structure will be far more flexible.

3. REGISTRATION

Registration refers to the matching of one image to another or to a map. This is essential for geotagging as well as to make use of information already obtained (like an already analysed image or an annotated map). Registration involves Feature determination, Feature matching, Transform model estimation, Image resampling and transformation. The features could be points, lines or regions. Region based methods are essentially correlation, SSDA and phase correlation. A new promising approach is the Mutual Information based method. The Mutual Information (MI) between two images is defined as

$$Mz(X,Y) = H(X) + H(Y) - H(X,Y)$$

where H stands for the entropy function. We have observed that Mz performs better with high resolution textured images.

4. SHAPE RECOGNITION

The basic objective in high spatial resolution image analysis is to detect man-made objects based on their shape. The preprocessing steps involved are edge detection, segmentation, edge joining, feature extraction based on the edges and their classification.

4.1 Active Contour Models

However when we want to look for a shape in an image that is smooth, forms a closed contour but is not analytically definable, then we restrict to a method called Active Contour Model (SNAKES). Snakes often have a very simple form. They are essentially defined by a few control points which are connected together. An Energy function is defined for the Snake which defines the length, curvature, elasticity etc. By suitably defining these parameters and putting constraints on these, any required shape can be extracted from an image.

5. Issues Related to High Spectral Resolution

In statistical pattern classification, the probability density functions of different classes are estimated from training samples. The number of training samples needed to estimate the density function parameters depends upon the number of features or bands. Since this is normally difficult to obtain, the classification accuracy increases with number of bands initially and then falls. This phenomenon is referred to as Hughes phenomenon.

5.1 Data Reduction

To overcome the above difficulty, often the data is reduced dimensionally. The principal component analysis and maximal noise fraction are the two methods used. However these have limitations. PCA merely selects bands with maximal variance without caring for class reparability, where as in MNF, there is a need to estimate the Noise Covariance function. Projection pursuit overcomes this limitation.

6. Conclusion

A brief outline of some issues and solutions in high resolution image analysis is given in the talk.