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BRIEF REVIEW OF REMOTE SENSING LITERATURE PERTAINING TO
CLASSIFICATION AND GEOSTATISTICS

First Interim Report (RSSUSA - 1)

by

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13. ABSTRACT (Maximum 200 words) This first report summarizes the most relevant information for the project from among the wide range of literature on remote sensing. The facilities offered by IMAGINE have been examined. IMAGINE is a digital image processing package that can store, manipulate and analyse georeferenced data. It is the most widely used software for remote sensing applications. The other literature cited relates specifically to the aim of the project, i.e. to optimize field sampling from remote images using geostatistics. It includes applications of kriging and spatial filtering to classify remotely sensed data, and to enhance the image, the neural net approach, fuzzy classification, sampling images effectively and economically, the use of training data, confidence levels for classification, and the redundancy of information.				
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ABSTRACT

This first report summarizes the literature on aspects of remote sensing that are of direct concern to the project, i.e. that deal with supervised and unsupervised classification, or with the application of geostatistics to particular problems, or both. The papers and books were selected from a broad range, as was the handbook chosen. The report also considers the functions available in IMAGINE, a package of software for image processing.

INTRODUCTION

This report is preliminary to our obtaining the SPOT image from Dr Slocum of TEC, Alexandria, USA. In preparation we (Dr Margaret Oliver and Professor Richard Webster) have been compiling information and reading relevant papers and books (see list of references), so that we shall have the necessary background when we receive the data and shall be able to proceed with analysis immediately. We have bought the book by Richards (1993) on remote sensing as a handbook. It covers all the essential topics and is up to date. We are now fully cognisant with the jargon of remote sensing, and in this report we summarize the aspects of remote sensing on which we have focused and list the major references. In addition I have familiarized myself with the facilities offered by IMAGINE - the software for image processing available at the University of Reading.

IMAGINE

IMAGINE is a digital image package that can store, manipulate and analyse georeferenced data. It is based on an X-windows interface and the UNIX operating system. It is the most widely used software in the world for remote sensing applications. An image is automatically contrast-stretched according to the statistical distribution of the data, which are stored with the image. The data at any visible position can be investigated using the cursor enquiry mode. The zooming and panning options allow parts of the image to be magnified, which will be valuable when deciding how to stratify images.

It is also possible to combine values from several layers to obtain a single output value for each location. This will provide us with a partial multivariate view of the image. It is possible to filter the image if necessary using a kernel, the size of which can be varied and which examines the data field exhaustively. High pass filtering enhances the edges within the image, and this should aid the initial classification of the image before an optimal sampling scheme is designed.

The package has many other features, such as a texture filter, image transforms, principal components analysis, and error checking. For image resampling some kind of interpolation is needed to relate the image values to the georeferenced grid. At present this is done by nearest-neighbour analysis, bilinear interpolation and cubic convolution.

For classification we might have to revert to ERDAS Imagine version 7.5 if it is still not supported by IMAGINE. Supervised and unsupervised classifications are possible: these will be the responsibility of TEC. However, we understand the procedures that TEC will use to achieve them. Training areas will also have been selected by TEC, and these will be used to control and to test the classifications. For supervised classification

the analyst defines information classes by identifying examples. The classification procedure then assigns each pixel in the image to the most similar class. The spectral range for each class is estimated from the training pixels. A set of rules is then given in ERDAS to classify the pixels. The program compares the spectral response in various bands with those of the training data (Van Der Meer, 1993). In unsupervised classification spectral clusters are sought statistically. The ultimate aim is to match the spectral classes to the natural information that the end user wants.

GENERAL LITERATURE

Van Der Meer (1993) used geostatistics, in particular indicator kriging, to classify spectral information directly without any prior knowledge from the training data. He showed that it performed better than conventional classification methods. This is important in terms of how the sampling should be optimized.

Caillol *et al.* (1993) show that fuzzy classification is better than hard classification in the sense that its rate of correct assignment was greater. Bonifazi *et al.* (1993) used a neural net approach to discriminate between different urban areas on an image. Goossens *et al.* (1993) applied spatial filtering techniques in classifying remotely sensed data. They also discussed the problem of loss of information with classification, and how the reliability of classification depended on the relations between pixels in a given neighbourhood, i.e. the degree and extent of spatial dependence. The latter is also crucial in deciding how to sample.

Vairinho *et al.* (CODATA, 1993) used kriging in combination with image processing methods and found that this enhanced specific features of the image to obtain the best classification.

Atkinson *et al.* (1990) showed how economy can be achieved by sampling remotely sensed data. Spatial dependence and the many correlated wavebands mean that the data contain much redundant information, and so it is important to improve efficiency. The sampling scheme chosen for the purpose will depend on what is known already of the spatial variation, and its results will also help future understanding and further improvements in sampling. Atkinson *et al.* (1990) tested optimal sampling of images and reconstruction based on kriging using data from an airborne scanner at 600 m. They have since shown how to plan the combination of ground sampling and radiometric data in different wavebands to optimize the use of resources (Atkinson *et al.*, 1992, 1994).

The geostatistical approach to sampling has been explored to some extent to identify objects in imagery (Woodcock *et al.*, 1988 a and b).

A SPOT image has a resolution of 10 to 20 m. The covariance structure within the image is influenced by averaging within the field of view. This effect is known as regularization in geostatistics, and it can be taken into account.

According to Foody *et al.* (1988) the training stage of supervised classification has had relatively little attention. This project will enable us to determine how geostatistics can assist in choosing the training data and in the subsequent evaluation. It is necessary to ensure that the training data are a representative sample and that they are selected objectively. The basis of geostatistics is autocorrelation, and this underpins the structure present in most remotely sensed.

Confidence levels for classification can be determined whatever the procedure used to group the pixels. Determining these requires ground data (Thomas *et al.*, 1987).

M A Oliver
Reading January 1995

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