SPATIAL INFORMATION PROCESSING IN DIGITAL IMAGE ANALYSIS SYSTEMS

Eugene E. Derenyi, Professor
Rostam Yazdani, Research Associate
University of New Brunswick, Fredericton, N.B.
Canada
Commission II

ABSTRACT

The utility of digital image analysis systems extends beyond the processing of remotely sensed imagery data. It can successfully be used for overlaying and interrelating results of multidate classifications performed over the same geographic area, or to correlate information obtained from various remote sensing and/or non-remote sensing sources. The concept of information processing in digital image analysis systems is introduced, the methodology is outlined and examples are presented.

INTRODUCTION

Digital image analysis systems are designed for interactive processing of imagery data, which is in raster or cell format. The two principal operations performed are image enhancement and image data classification. These activities are augmented by a number of support operations such as geometric and radiometric correction, statistics generation, image display and manipulation.

Image enhancement highlights features in an image to facilitate the extraction of information by visual interpretation or further digital processing. The output remains to be image data and does not serve as a direct input to geographic information systems (GIS).

Classification, on the other hand, is utilised for the extraction of thematic information of the kind displayed on maps or stored in geographic information systems. Forest cover types, agricultural crop types, soil types are just a few examples. In fact, the most common way of utilizing the information generated by this operation is to display it as a graphical plot which can then serve as a thematic map or be overlayed on other maps for visual correlation with other information. Eventually, the result of the classification may find its way to a GIS through digitization of the graphical product, or by transforming the digital output from the image analysis system into a format compatible with the GIS in question. Usually the latter requires a raster to vector conversion.

Basically, digital image analysis systems are utilized for generating "raw" information just like digitizing tables or stereo plotters are, which is then further manipulated by mapping, visual and digital overlay techniques, or numerical modelling to provide the kind of refined, integrated information that decision makers need. Upon careful examination of the capabilities of such systems it becomes

clear that the potential exists to expand this narrow scope of operation.

PRINCIPAL OF INFORMATION PROCESSING

Image classification isolates from the data set clusters of picture elements (pixels), which represent a certain thematic information or theme. These clusters are analogous to polygons in a vector oriented GIS. Further manipulation of these clusters is termed information processing. A large number of these themes (up to 32 in the system used by the authors) can be displayed colour coded, singley or in groups on a monitor for viewing. Programs are readily available in the software package to generate tabulated statistics of the area covered by particular themes within user specified geographic boundaries. Individual themes are identified by a numerical value assigned to all pixels belonging to the same theme. This means that a combination of disparted information layers can be achieved by simple arithmetic operations of addition, subtraction, multiplication and division, to create new layers of information. Weights can be assigned to themes by applying a constant multiplier. The theme composites can then be viewed on the monitor in pseudo-colour, which is formed by the addition of the original theme layer colours. This process is far less complex than polygon overlay in a vector based GIS, where the intersection and union of polygon webs superimposed upon another must be determined to create new polygon sets.

A more sophisticated overlay operation can be performed by treating the theme files as ficticious image files and applying one of the classification algorithms. This procedure allows the overlay of themes from many files, in various combination and in a selective manner. (Up to 16 files can be handled simultaneously in the system used by the authors).

Finally, it should be pointed out that digital image analysis systems can process any data which are in raster format. Thus, maps digitized in this format can serve on the screen as background for thematic information. Furthermore, thematic information extracted from maps can be included as additional data set in the classification or in the subsequent information processing operation. This option can substantially improve the classification accuracy and can provide an added dimension to information processing. A proper geometric registration of all data sets is, of course, essential.

A case study is now presented to illustrate the principle of information processing in digital image analysis systems.

EXAMPLE: CROP ROTATION MONITORING

The objective of this project is to ascertain the frequency at which farmers alternate the agricultural crops grown in individual farm fields. Four subsequent growing seasons are considered and geometrically corrected Landsat MSS data are used.

First, each of the four data sets are subjected to a supervised classification in the digital image analysis system to separate areas where the three principal crop types of potato, grain and hay are being grown. The results from each of the four years, are stored in separate theme files, where each theme pixel (crop type) is identified by a unique binary number. A unique colour is associated with each of these numbers when the themes are displayed on the monitor. In this example the code numbers and the corresponding colours assigned to each crop are as follows:

Potato (P): 1 - red (R)
Grain (G): 2 - green (G)
Hay (H): 4 - blue (B)

Area statistics can now be generated for each crop, if desired. Normally, the operation in the image analysis system is concluded at this point. Each theme file is stored on magnetic tape and then graphical plots produced for overlaying on base maps. The actual crop rotation information is compiled by visual comparison of the three plots or by entering the output from the image analysis into a GIS for further processing. Implementing the information processing operation can, however, change all this. Various alternatives are open:

Theme Overlay

When all three theme files are displayed superimposed on the monitor, a mixture of the original theme colors is created which signals the existence or absence of crop rotation.
A similar effect is created by displaying each theme file through a different colour gun of the monitor. Colour intensity is modulated by the digital number of individual themes and the pseudo-colour composite represents the frequency of occurrence of the individual themes. The sequence of occurrence is, however, not discernable.

Theme overlay provides only a visual presentation of crop rotation. Numerical processing of the theme files is needed to obtain permanent records.

Arithmetic Operation

In this method a digital overlay is generated by a pixel-by-pixel addition of the numerical values of themes in the three files. The new pixel values indicate the frequency of occurrence of the three crop types during the three year period. Once stored on tape, a permanent graphical record is produced in a plotter. Three crop types over a three year study period can yield a total of ten combinations as listed below:

PPP = 3 (3)	GGP = 5 (5)
GGG = 6 (8)	GGH = 8 (20)
HHH = 12 (24)	HHP = 9 (9)
PPG = 4 (6)	HHG = 10 (12)
PPH = 6 (18)	PGH = 7 (19)

There is one ambiguity, however, since both GGG and PPH add up to 6. This problem is easily overcome by changing the assignment of the pixel values in one of the files from 1, 2 and 4 to say 1, 4 and 16. The arithmetic combiantions now yield the values shown in brackets and no more ambiguity exists.

Theme Classification

It is possible to subject the three files to a classification process in the same manner as image files are. The result indicates not only the presence or absence of a particular crop in a field for the three year period, but also provides this information in a year specific way. For example PPG, PGP and GPP can be separated although each has some value in the arithmetic operation type overlay. This method provides the most sophisticated digital information processing.

CONCLUSION

Standard digital image analysis algorithms can be utilized successfully for further processing and analysing the information generated by the classification of digital image data. Therefore, digital image analysis systems can be utilized as simple land resource information systems.