LARS Information Note 103167
Purdue University

LABORATORY FOR AGRICULTURAL REMOTE SENSING

Quantitative Multiband Spectral Data

The purpose of this information note is to show some typical multi-band optical mechanical scanner data, and to discuss the use of this data in a quantitative fashion. The discussion will center around the three attached figures. Figure 1 shows a conventional panchromatic air photo of an agricultural area within the corn belt production region of the United States. The area is in Tippecanoe County, a part of the Statistical Reporting Service's fourth crop reporting district, and is roughly 1 square mile in size. Also shown in the figure is a computer-obtained pictorial printout of data from one band from an optical mechanical scanner gathered over this area. Letter symbols have been placed over the various fields to indicate the type of agricultural cover. Symbols used denote the following:

A - Alfalfa	P - Pasture
BS - Bare Soil	RC - Red Clover
C - Corn	R - Rye
DA - Diverted Acres	S - Soybeans
O - Oats	W - Wheat

Optical mechanical scanners have been described frequently in the literature.[1] The purpose here is to illustrate the manner in which data from such a device can be manipulated so that the data in image form and in quantitative form can be available to the researcher as nearly simultaneously as possible. Here the term "quantitative" refers

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[1] D. Landgrebe and T. Phillips, <u>A Multichannel Image Data Handling System for Agricultural Remote Sensing</u>, Seminar on "Computerized Imaging Techniques", Washington, D. C., June 1967, sponsored by Society of Photo-optical Instrumentation Engineers.

to the gray scale of a particular resolution element. That is, it is desired to associate a number with each resolution element on the ground in each band which is proportional to the amount of radiant energy from that resolution element in that band. In order to do this, it is most convenient to work in digital form. Therefore, the data is first digitized by dividing the entire dynamic range of a given band into 256 possible levels, level 0 being the brightest and level 255 being the darkest. Each scan line is sampled 220 times, and each sample is assigned the appropriate gray level.

Then, to obtain the printout shown in Figure 1, a set of symbols which vary uniformly in gray level are selected and a certain range of gray levels are then assigned to each symbol. That is, at the time of making the printout the samples are examined one by one to see to which symbol each should be associated on the basis of its gray levels. The gray level bands and their corresponding symbols are given in the heading above the printout. For example, all points with amplitude level between 198 and 201 are printed out in this printout using the symbol 'X'. By printing these out, one after another, a (somewhat crude) image is reconstructed.

Figure 2 shows the same air photo together with corresponding printouts for fourteen spectral bands. The spectral bands were gathered through three separate apertures. The ultraviolet band (.32-.38μ) and the 8-14 micron band were collected through separate apertures. The other twelve bands were all collected through a common aperture.

An inspection of the twelve band data and the 8-14μ channel reveals that it has been printed out with twice the resolution of the ultraviolet band (twice as many points per line and twice as many lines)*. It is possible to increase the resolution further by this technique. Even at this resolution level with the unaided eye, it is beginning to be difficult to realize that the picture is really made up of many alphanumeric characters. A closer inspection (with the aid of a hand held magnifier) will reveal that the characters are still discernable. Each can be seen individually in this fashion.

A simple way to obtain a (rather gross) quantitative measure of radiance from a particular point on the ground is by the following example (refer to the ultraviolet channel printout). Notice, first, that in this band as with all the bands, all rows and columns are numbered. As a result, each point of each printout has an unique address. Now, locate the field just to the left of the center road, and near the center of the flight line marked Diverted Acres, Bare Soil on the air photo. This field is in the vicinity of line No. 125. The resolution elements printed out as dashes scattered through this field can be seen (by referring to the character set in the heading above) to have gray levels in the range 100-102. If one desires, one could in this fashion trace the gray level of a given resolution element in this field in all fourteen bands. In the 12 bands gathered from the single aperture, it is seen that a given point on the ground has the same address in all bands.

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*It is also seen that the 8-14μ aperture had approximately half the field of view of the other two apertures.

From this example it is apparent that the gray level interval to which each point on the ground belongs is available by inspection. If a more detailed knowledge of the gray scale of a given point is required, the particular one of the 256 gray levels to which a given point on the ground belongs is available from the digital magnetic tape. This is done by referencing the row and column number through computer programming.

The locating of the data for specific points on the ground can be achieved simply and accurately by this method. Consider, for example, the farmstead just to the right of the center line road in the photograph and near the lower field marked Diverted Acres--Rye. Compare the layout of the farm buildings with the symbols in the printout near lines 220 in the twelve channel data.

There are, of course, many types of analysis methods one can use to analyze these data. For example, one might wish to determine the statistical variation of the spectral response in a given band or set of bands for a particular type of ground cover. Now that the address on the digital tape of radiance from any point on the ground is readily available, it is a simple matter to program a computer to carry out a desired analysis. An illustration of the applicability of these steps is given in Figure 3. In this case, samples have been edited in the fashion described from four different types of ground cover, bare soil, water, green vegetation and a fourth category called other. This category includes all types of cover not in the first three. The particular type of statistical variation of each of these four cateogries was determined from these edited samples. The computer was then programmed to go back and examine each sample of the entire flight line and classify it according to which of the four categories it was most like. The results are seen in Figure 3. The symbols used on the printout are:

G - Green Vegetation	I - Water
X - Bare Soil	(Blank) - Other