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THE USE OF THE TEMPORAL DIMENSION IN CLASSIFYING AND MAPPING ERTS-1 MSS DATA

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ABSTRACT

ERTS-1 MSS data from two scenes of the same central Pennsylvania area were brought into registration by translation and then merged. The two scenes were viewed on different dates, but from adjacent ground tracks, as frequent cloud cover in Pennsylvania made it impossible to choose two scenes from the same track. Targets selected to be mapped included river water, railroad yards, creeks, urban areas, industrial areas, and vegetation. Equivalent training areas were chosen from each of the original scenes and from the merged data. Classification maps were produced for each, and a comparison was made. Scene brightness was found to have the most important effect on classification differences.

The temporal dimension of remote sensor data afforded by the ERTS-1 system is universally acknowledged to be one of the most important aspects of this satellite program. An investigation was launched to determine how well MSS bulk digital data taken at two different times for the same ground area could be merged. It was found that, at least for test areas of 100 scan lines and 100 elements, adequate registration could be obtained simply by translation; rotation was not required. Data for a test area for the two dates were merged and an investigation was begun to compare the data for the two dates and to evaluate the combination of the data. The objectives were twofold. First, by combining data it would appear possible that signature reinforcement could be achieved thus leading to improvement in classification. Emphasis was placed on this aspect. Second, temporal changes could be detected by analysis of combined data. Less emphasis was placed on this aspect. This report presents the major initial findings.

An area in the vicinity of Harrisburg, Pennsylvania, was chosen because of the variety of targets available including such diverse ones as water, urban and suburban areas, agriculture, major transportation systems, and industrial complexes. The specific area was chosen to include as a distinctive feature, the Conodoguinet Creek that flows into the Susquehanna River directly opposite metropolitan Harrisburg. Figure 1a shows the general pattern of targets in the test area.

Because of the frequency of cloud cover in Pennsylvania, it was not possible to pick two dates separated exactly by one or more eighteen-day cycles. The clearest dates for which MSS tapes were available were August 1, 1972, and October 11, 1972. These dates are one day less than four eighteen-day cycles apart. The data were brought into registration by translation. The scan line and element translation values were found by computer processing the data for each date and then using a light table to adjust one map over the other until a match was found. The distinctive features in the test area were of most help in this task. The data were then merged accordingly onto one tape making eight channels instead of four for each observation.

Digital processing was done using a variety of programs in a system described by Borden (1972). The programs will not be discussed here except for the classifier that was used. Classification was made by using the spectral signatures obtained for the targets and by applying the following scheme:

1. Determine the class for which the euclidean distance from the unknown observation is smallest.
2. If the distance is smaller than a given critical value, assign the observation to the class.
3. If the distance is greater than the given critical value, assign the observation to the unclassified or "other" category.

Using the merged data, classification and mapping runs were made for each date separately and for the combined dates. The critical distance was in all cases the same, i.e., ten. In this algorithm a different critical value can be set by the user for each category and this feature has had the desired effect of improving the classification in other work. However, the limit here was set at ten for all classes in order to avoid confounding the comparison between dates with different critical values.

Seventeen spectral signatures that were represented as seven mapping classes were used in the analysis. In Table 1, six signatures are presented, each of which was the dominant signature in each of six mapping categories. The seventh mapping category was forest, which, for this report, was assigned a blank as the mapping symbol; thus, for mapping purposes, combining it with the "other" category. The symbols for each of the six categories are given in the table. The six mapping categories and their symbols are railroad (:), river (W), urban (*), creek (C), suburban (-), and industrial (+). The suburban class was composed of five signatures and the industrial class contained six signatures. The two forest signatures completed the set of seventeen signatures.

The signatures were obtained by means of supervised and unsupervised analysis programs. The subareas, training areas, and cluster analysis areas, which were used for this purpose, were identical for the analysis of the two separate dates as well as the combined dates.

In addition to classification and mapping, the program that was used computes the euclidean distance between all pairs of signatures. These distances are presented in Tables 2 and 3.

A change detection program was written for the project. It compared the map symbols, element by element, between two classification maps and then output a map showing symbols which defined the outcome of the element-by-element comparisons. All character maps for this report were converted to line maps which were output on a plotter. These maps are shown in Figures 1a, 1b, 2a, and 2b.

The most important result of the investigation was that scene brightness had the greatest influence on the classification. From visual inspection of the ERTS-1 images for channel seven for each date, it appeared that the October 11th scene was brighter than the August 1st scene. This interpretation was not supported by the data. The data indicated that the August 1st scene was decidedly brighter. In Table 1, the comparison of August 1st signatures with those of October 11th shows that, for all channels and for all signatures, the values are all substantially greater for the August 1st scene.

The scene brightness had a very definite influence on the classification by the method that was used. Because of the greater signature values in each channel for August 1, the euclidean distance of separation among classes was greater than for the October 11th date. By using a common value of ten for the critical distance, there were more observations that could not be classified August 1st as compared to October 11th. The same effect was present for the merged data, but it was more pronounced. Compare the distances of separation between the October date in Table 2 with corresponding values for the merged data given in Table 3. The distances of separation for the merged data are, overall, approximately fifty percent greater than for the October date. The August date distances were intermediate. The effect on classification was very pronounced for the merged data with 23 percent of the observations remaining unclassified as compared with only 1 percent for October 11th. The effect can be seen in the maps given in Figure 1a and Figure 1b where the greater blank area for the merged data map indicates the increased number of unclassified observations.

Because of the large difference in scene brightness, the signature for each class could not be directly compared between the two dates. Relative responses in the four channels were computed by first normalizing the signatures. After this was done, it was found that, for all of the categories except one, the normalized signatures were essentially the same for the two dates. The only one that had changed in a non-negligible way was for river water. The reason for the change will be investigated, but it is likely that a difference in turbidity, aquatic plant growth, or a similar temporal influence caused the difference.

Because of the effect of different scene brightness, the classification comparison between dates yielded only fair results. The comparison maps are presented in Figures 2a and 2b. These maps represent another level of abstraction beyond the maps of Figures 1a and 1b and the patterns are more difficult to perceive. The blank areas represent repetitive classification in the same class except for the "other" category. The dotted areas stand for repetitive "other" classification, which includes the two forest categories. The vertically lined areas represent a change from one class to another, excluding "other"; whereas the horizonally lined areas represent a change to a class from "other" and vice versa. The vertically lined areas are of greatest interest and concern since this category would represent land use change, temporal change, or erroneous classification. Land use change in the area could only be inconsequential so the other two aspects, separately or together, must have been responsible. Upon investigation of changes for the various classes, it was found that for most classes changes were small. For three classes, however, changes were major. One forest class gained 10 percent, from 6 percent to 16 percent, from August 1 to October 11. One of the suburban classes lost 10 percent, from 15 percent to 5 percent, and another suburban class lost 4 percent, from 8 percent to 4 percent, from August 1 to October 11. The reason for this shift into forest at the expense of suburban can only be conjectured at this time. The classes were separable by distances of 15.7 or greater for both dates; therefore, there was little possibility for confusion in classification for the two classes. The training area could have been nonrepresentative; however, it appeared to be a typical suburb based on review of U-2 photography of the area. The resolution of this problem will be undertaken in continued study. However, prior to this, the difference in scene brightness will have to be rectified. A number of ways to accomplish this are possible. Before a reliable method of change detection or signature reinforcement can be developed, the effect of scene brightness will have to be accounted for or removed.

LITERATURE CITED

Borden, F. Yates. 1972. A Digital Processing and Analysis System for Multispectral Scanner and Similar Data. Remote Sensing of Earth Resources, Vol. I. Edited by F. Shahrokhi. The University of Tennessee, Space Institute, Tullahoma, Tennessee. pp. 481-507.

Table 1. Unnormalized category specifications.

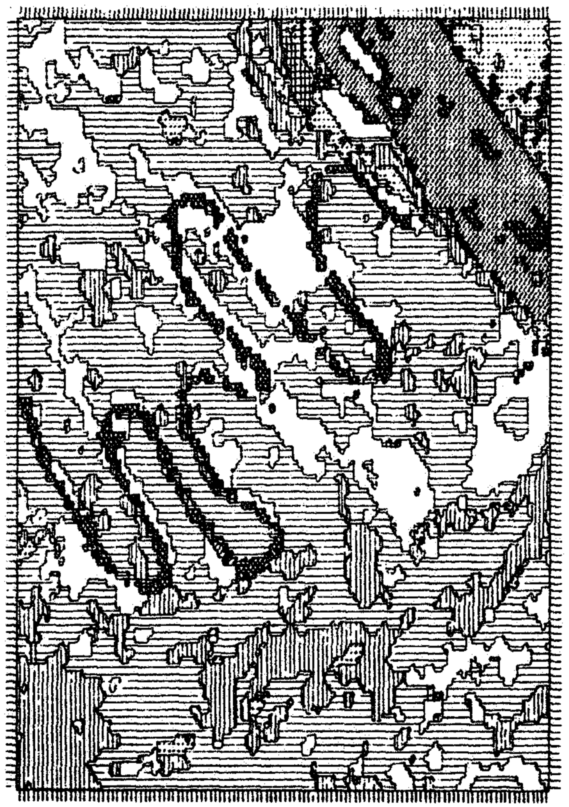
		Channels							
		August 1, 1972				October 11, 1972			
		4	5	6	7	4	5	6	7
1	:	36.51	29.15	29.54	11.32	23.68	17.37	16.05	6.02
2	W	32.62	22.01	17.72	4.80	18.39	10.03	6.09	0.93
3	*	36.34	27.75	33.41	14.76	24.01	17.50	20.43	9.40
4	C	32.68	22.41	30.86	13.18	20.80	13.43	18.89	9.09
5	-	36.48	27.73	48.25	25.67	25.13	17.67	31.98	18.28
6	+	39.27	32.89	42.00	18.64	27.60	22.13	29.20	15.20

Table 2. Distances of separation for categories for October 11, 1972 data.

		1 :	2 W	3 *	4 C	5 -	6 +
1	:	0.0	14.4	5.5	6.4	20.2	17.2
2	W	14.4	0.0	19.1	15.7	32.8	31.1
3	*	5.5	19.1	0.0	5.4	14.6	12.0
4	C	6.4	15.7	5.4	0.0	17.1	16.3
5	-	20.2	32.8	14.6	17.1	0.0	6.6
6	+	17.2	31.1	12.0	16.3	6.6	0.0

Table 3. Distances of separation for categories for merged data.

		1 :	2 W	3 *	4 C	5 -	6 +
1	:	0.0	21.3	7.7	10.3	31.1	22.9
2	W	21.3	0.0	27.5	22.2	49.9	43.7
3	*	7.7	27.5	0.0	9.0	23.5	16.4
4	C	10.3	22.2	9.0	0.0	28.2	23.9
5	-	31.1	49.9	23.5	28.2	0.0	12.9
6	+	22.9	43.7	16.4	23.9	12.9	0.0



Creek
River
Urban
Railroad
Suburban
Industrial

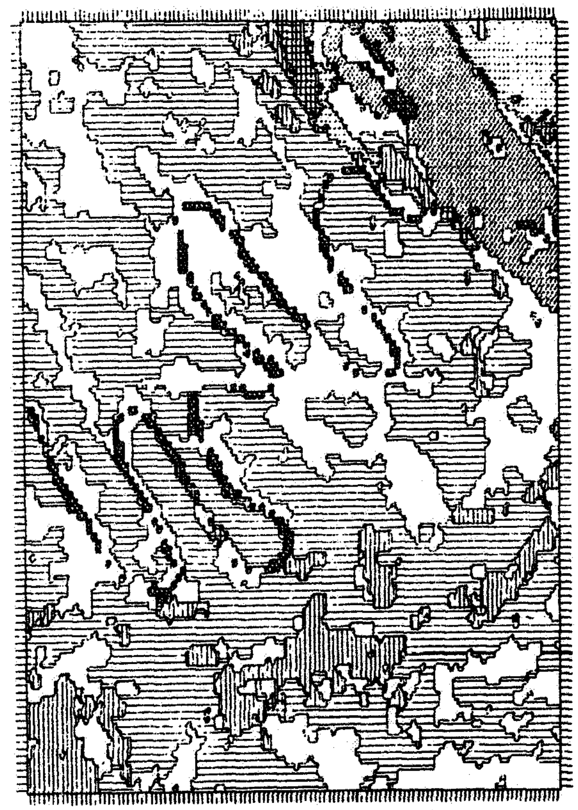
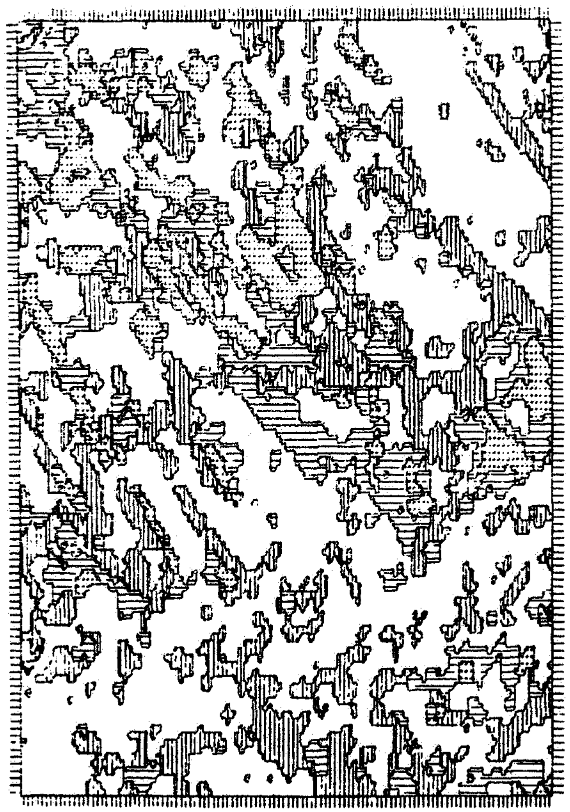
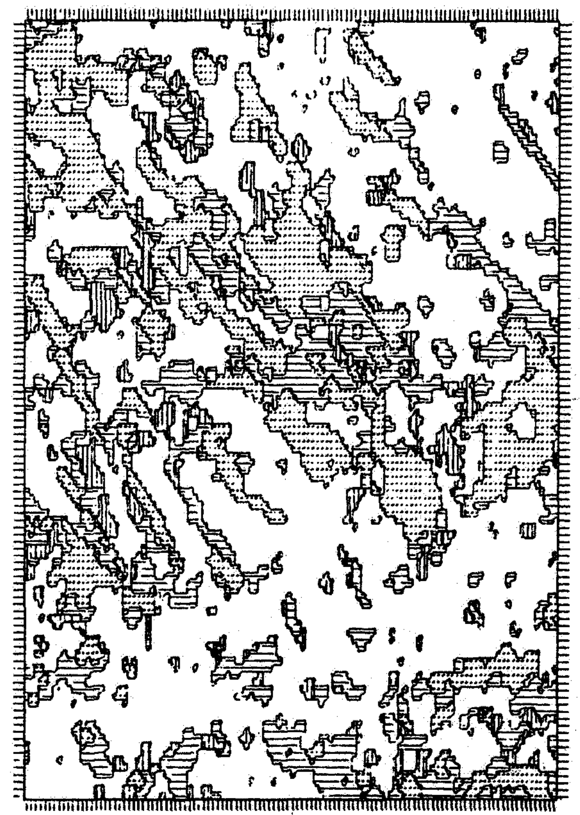


Figure 1a. October 11, 1972, classification map.

Figure 1b. August 1, 1972, merged with October 11, 1972, classification map.





Both classifications equal, but not other: blank
Both classifications different
Both classifications equal other
One symbol .EQ. other
One symbol .NE. other

Figure 2a.
Comparison map of August 1 with October 11.

Figure 2b.
Comparison map of merged data with October 11.