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CROP IDENTIFICATION USING ERTS IMAGERY[1]

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ABSTRACT

Digital analysis of August 15 ERTS-I imagery for southeastern South Dakota was performed to determine the feasibility of conducting crop surveys from satellites. Selected areas of bands 4, 5, 6, and 7 positive transparencies were converted to digital form utilizing Signal Analysis and Dissemination Equipment (SADE). The optical transmission values were printed out in a spatial format. Visual analysis of the printouts indicated that cultivated areas were readily distinguished from non-cultivated areas in all four bands. Bare soil was easily recognized in all four bands. Corn and soybeans, the two major crops in the area, were treated as separate classes rather than as a single class called row crops. Bands 6 and 7 provided good results in distinguishing between corn and soybeans.

1. INTRODUCTION

Crop resources are the food and fiber which we use every day. Satellite surveillance of crops planted, crop condition, yield and harvest offers significant advance in the management and reporting of crop resources.

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Considerable background has already been developed for interpretation of remote multispectral imagery of agricultural crops (Hoffer, 1967) and in crop species discrimination from Apollo 9 imagery (Wiegand et. al. 1969). Mapping of crop, soil, and geological features using digitized multispectral satellite photography has been discussed by Anuta et. al. 1971.

Recent studies on the use of nonparametric methods for pattern recognition (Hahn and Nelson, 1972) show considerable promise for machine classification of crops.

The study reported here utilized ERTS-I imagery, ground truth, and K-classification using SADE (Signal Analysis and Dissemination Equipment).

2. PROCEDURE

The study area investigated was a 3.2 km by 14.5 km strip located south of Centerville, South Dakota. The major crops grown in the area were corn, soybeans, and oats. During the month of June, 1972, the study area was surveyed and mapped to determine field sizes and crop species planted in the various fields. Ground truth information was gathered during the time of the first ERTS overpass on August 15, 1972.

The initial analysis was performed on August 15 ERTS-I imagery. An area corresponding to the study area was masked off for bands 4, 5, 6, and 7 on nine inch positive transparencies. The mask was prepared by applying opaque photographic tape directly to the transparencies.

Each of the four transparencies was digitized at a resolution of 36 data points per mm using Signal Analysis and Dissemination Equipment (SADE). The coded outputs proportional to optical transmission for each band were printed out in a spatial format. The format divided the 0 to 255 range of coded outputs into 55 increments of five values each. A specific character was assigned to each increment.

Three classes consisting of corn, soybeans, and fallow were selected for the initial analysis. Oats were not used because all oats had been harvested by August 15. Three corn fields, two soybean fields, and two fallow fields representative of the three classes in the study area were located on the printouts. An 8 point by 8 point matrix inside each field boundary was used as the statistical sample of data points for the field. Since the data points on the printouts were in terms of characters assigned to the various output increments, the points had to be converted to actual output values. This was accomplished using a computer program with inputs being the initial x and y coordinates of the matrix along with the size of the matrix. The coordinates were only measured on the band 6 printout under the assumption that errors in the masking operation would not be great enough to cause some of the sampled points to be outside the field boundaries in bands 4, 6, and 7. Nonparametric K-class classification (Zagalsky, 1968 and Hahn and Nelson, 1972) was performed on the data.

3. RESULTS

Results obtained with the K-classifier are shown in Table 1. Using one feature the highest percent correct classification was obtained using band 6. Using two features, best results were obtained using bands 4 and 6 or bands 5 and 6. Using three features, good results were obtained using bands 4, 5, and 6; bands 4, 6, and 7; and bands 5, 6, and 7. Results obtained using all four features were also satisfactory.

TABLE 1. Percent total correct classification of the training samples

Feature in terms of ERTS bands	Percent total correct classification
4	46.65
5	47.10
6	87.28
7	42.86
45	61.38
46	83.04
47	46.65
56	93.75
57	45.10
67	90.40
456	81.92
457	63.84
467	82.59
567	93.53
4567	81.47

Figures 1, 2, 3, and 4 show the probability density functions of each class in bands 4, 5, 6, and 7 respectively. The peaks and valleys in the curves are due to the small number of data points that were sampled. It is assumed that a larger sample of data points would result in smoother curves.

Little separation of classes was achieved in band 4 except for one corn field represented by the curve in the left hand portion of figure 1. The difference between this corn field and the other corn fields does not appear to be related to soil differences. No explanation of the differences between the corn fields has been found. The sharp fallow peaks indicate that some discrimination of bare soil was achieved. Also, some separation of soybeans was achieved.

Figure 2 shows some separability of corn for lower output values. It also shows significant overlap of the three classes. Some discrimination of fallow and little discrimination of soybeans was obtained in band 5.

Figure 3 shows that almost complete separation of classes was obtained in band 6. The excellent separation of classes achieved in band 6 is reflected in K-classifier results where this band is included.

An analysis of the band 7 printout indicated that discrimination of the three classes was possible in band 7. This does not completely agree with figure 4. The reason for the discrepancy lies in the masking operation on the band 7 transparency. When the matrix coordinates based on band 6 measurements were fed into the computer, the masking error caused some of the data points in band 7 to be sampled outside the field boundaries.

4. SUMMARY

The ERTS-I imagery selected for detailed processing has been of excellent quality. Imagery from band 6 (0.7-0.8 μm) has given greater than 90% accuracy in nonparametric K-classification of three classes - fallow, corn, and soybeans. The number of fields classified to date have been limited due to development of techniques.

One of the greatest difficulties encountered has been in accurately locating field boundaries and in masking off the appropriate area of the transparencies for digitization.

It appears that through the use of sequential ERTS imagery, machine processing (SADE), and limited ground truth a timely and accurate picture of crop resources can be prepared.

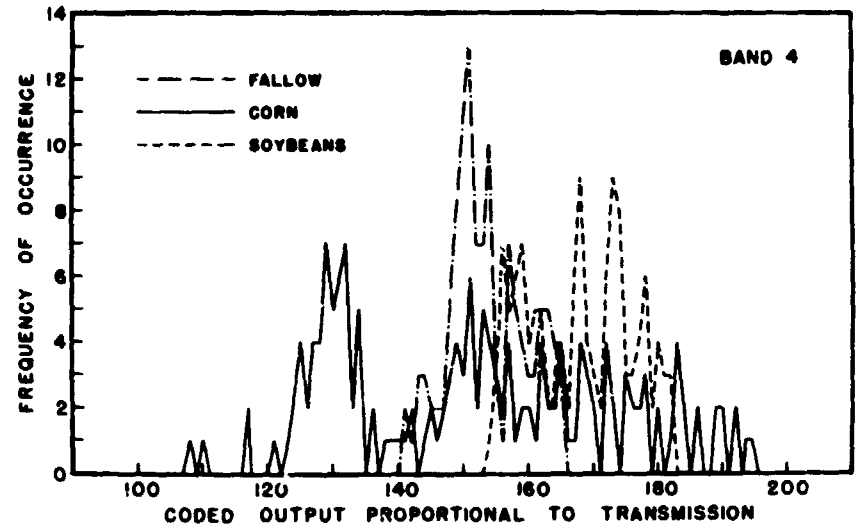

Figure 1. Probability density functions of corn, soybeans, and fallow in band 4 (0.5–0.6 μm)

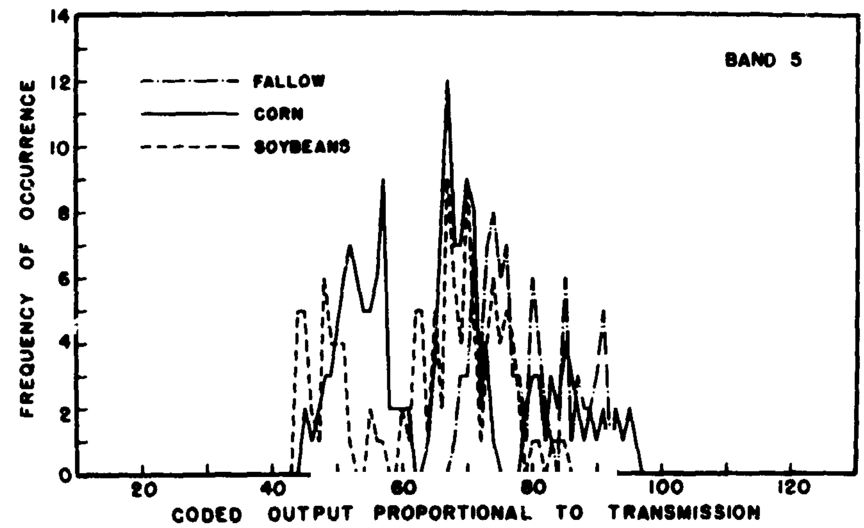

Figure 2. Probability density functions of corn, soybeans, and fallow in band 5 (0.6–0.7 μm)

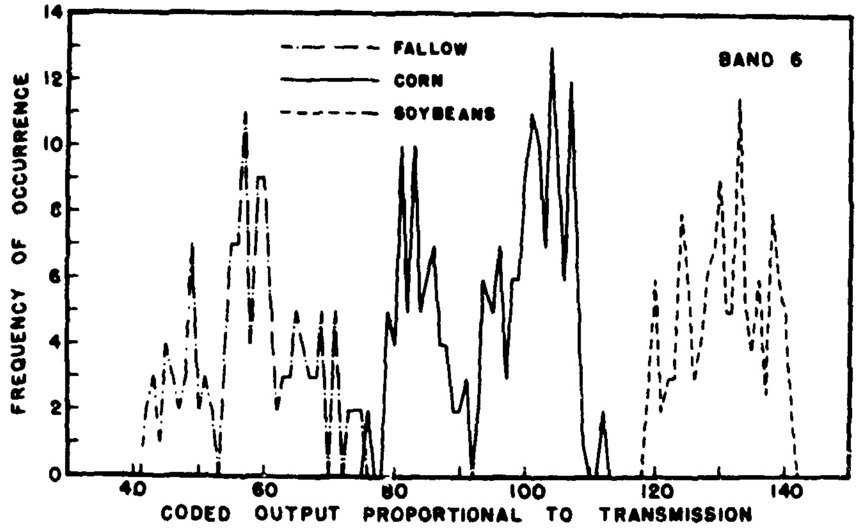

Figure 3. Probability density functions of corn, soybeans, and fallow in band 6 (0.7-0.8 μm)

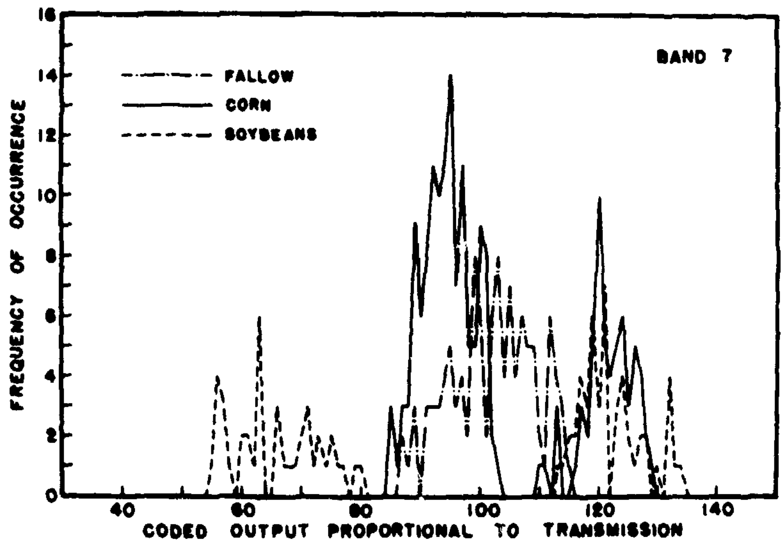

Figure 4. Probability density functions of corn, soybeans, and fallow in band 7 (0.8-1.1 μm)

5. REFERENCES

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