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Section Two: Study B

COMPUTER LAND USE MAPPING VIA TV WAVEFORM ANALYSIS OF SPACE PHOTOGRAPHY*

by

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and

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A literature review indicates that orbital color photography offers a potential in geographic problem solving because such imagery records spatial patterns representing physical and cultural phenomena. However, as photo banks rapidly increase some form of automation is needed with the capability that will contribute to a method whereby the vast quantities of spatial data can be processed and integrated into geographic analyses. This paper describes an instrumentation and computer system which offers the potential for analyzing photo geographic distributions.

To satisfy the requirement for computer acceptance, a television and waveform system was developed to transpose pictorial or iconic photo forms to the analytic. A video conversion was accomplished, and each pattern visible on the original photography was represented by a certain range of percentages. With spatial occurrences in digital form, a computer program was developed that could identify, analyze, and map geographic inputs.

Earlier research by Principal Investigator James P. Latham demonstrated that a television camera and waveform analyzer converted various image types (e.g., panchromatic, thermal infrared, color infrared, and color) into graphically expressed electronic waveforms. A black and white TV camera extracted density characteristics in a form convertible to graytone percentages. With color and color infrared imagery, the television system

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detected tone variations present in photographic hues since graytones are one of the three coordinates or dimensions of color.

When using the television-waveform technique, the arrangement of equipment was similar to that of a normal television scan, but major emphasis was placed on the waveform analyzer rather than a receiving monitor. Because a televised image is constructed of parallel scan lines, the image can be electronically dissected, line by line, utilizing the waveform analyzer. The instrument simply provided a graphic display of how a pattern of spatially distributed phenomena were being intercepted in TV monitors.

A television camera differs from some other scanning devices because it has the capability to produce graytones signal which may be measured as either relative or absolute percentages. There are major drawbacks in using the latter form in instrumented photo-interpretation because such values fail to compensate for the many factors that vary on photographs (e.g., light and sun conditions, atmospheric environment, length of exposure, and processing variations). Television-waveform analysis largely reduced the limitations of these parameters because percentages were adjusted to reflect the density range in each particular image.

Data from such a system permitted a statistical comparison of various imagery patterns and provided the means for instrumentation interpretation which reliably identified many land use and land type categories. Identifications were made from 5,000 foot, 15,000 foot, and orbital color photographs. Therefore, the basic problem was solved for computer applications; and the iconic forms of the original photography were converted into an analytic substitution - graytone percentages. The following describes how a computer was used to process the waveform analysis of orbital color photography.

To evaluate computer analysis and mapping experiments, digital data in the form of graytone percentages were visually lifted from the waveform analysis of a portion of the orbital photograph depicting the lower Nile Valley. The waveform analyzer portrayed graytone percentages as one dimensional for a single scan line, but two dimensions resulted when percentages were extracted from traverses which were equally spaced from a predetermined line. Once the initial scan line was selected, graytone percentages were recorded every centimeter along the Y-axis. When completed the horizontal scan was moved eight lines along the X-axis and the process repeated.

A total of 22 lines were used, and along each line 20 graytone percentage readings were made.

A vertical scan movement of eight lines on a 945 line monitor (normal TV utilizes 525 lines) corresponded to one horizontal reading every centimeter on the waveform analyzer. These distances insured a square field of coverage and eliminated distortion problems. The graytone percentages represented a transformation of a land surface area to an array of numbers holding a direct position relationship.

The graytone percentages were placed on punch cards along with a Fortran IV language program that was designed especially for this type of digital analysis. The data was ordered into an IBM computer, and the program instructed the computer to perform the following:

1. Transform graytone percentages to letter equivalents. Percentage ranges for each land type were placed on a series of punch cards, and each graytone occurrence was classified when contacted in the digital search. Double letter codes were used to equalize the graytone conversions.
2. Map graytone distributions. Once the digital data were categorized, the computer was programmed to print the letters in map form, both as to a composite land type map and individual distribution maps.
3. Estimate the area of each graytone distribution. The computer counted the number of occurrences corresponding to each land type, and based upon a scale of 1:600,000 calculated the square mile and percentage coverage of each distribution.

The computer technique developed for processing the waveform analysis of imagery proved very successful. As evidenced in Illustration which follows, the computer converted graytone percentages to letter codes, mapped graytone distributions, and quantitatively analyzed the distributions.

At this point it should be emphasized that the computer method did not constitute a closed system. Establishing graytone ranges for land types had to be performed manually. Then based upon the parameter of these ranges the computer decided to which category graytone occurrences belonged. Since only a minimal amount of time was required to establish range levels, the manual phase did not hinder the total analysis technique. Computation time for the Nile Valley example was less than 20 seconds. Total computer

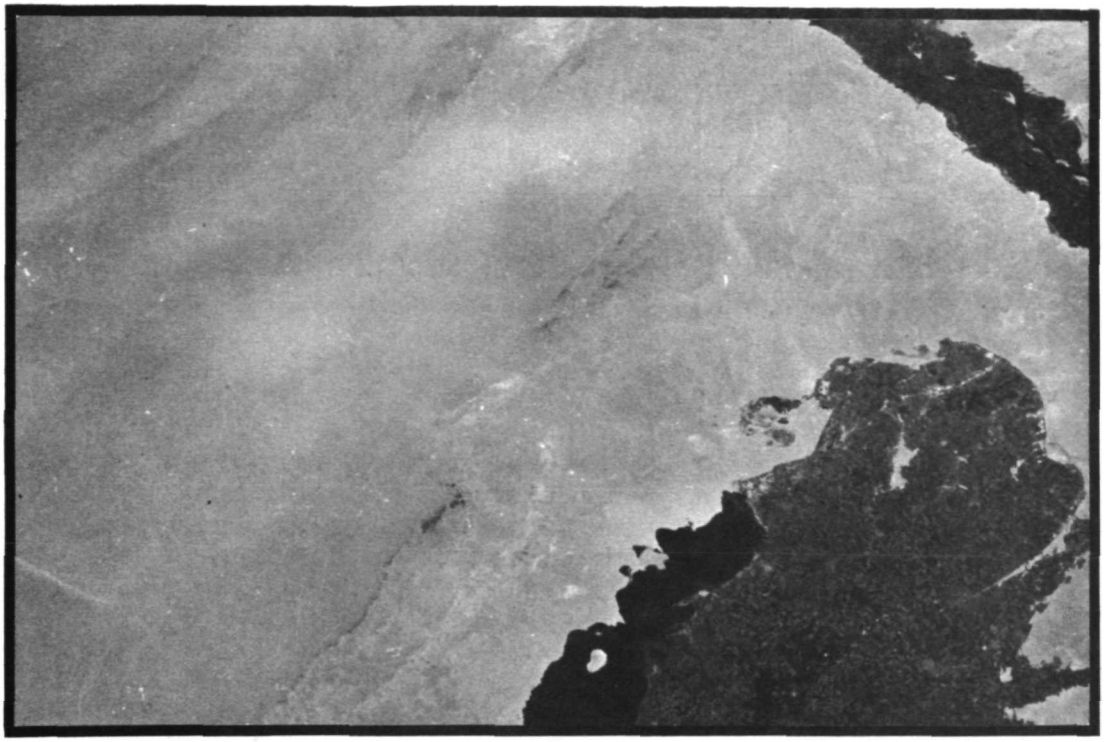
time was approximately 2.6 seconds.

The phase of manually recording graytone percentages onto punch cards can now be automated because of the success of previous tests. A strip chart recorder is planned to become an integral part of the instrumentation system at Florida Atlantic University's Remote Sensing and Interpretation Laboratory. Such an instrument is capable of (1) constructing waveform profiles and (2) accurately recording graytone percentages onto paper or magnetic tape.

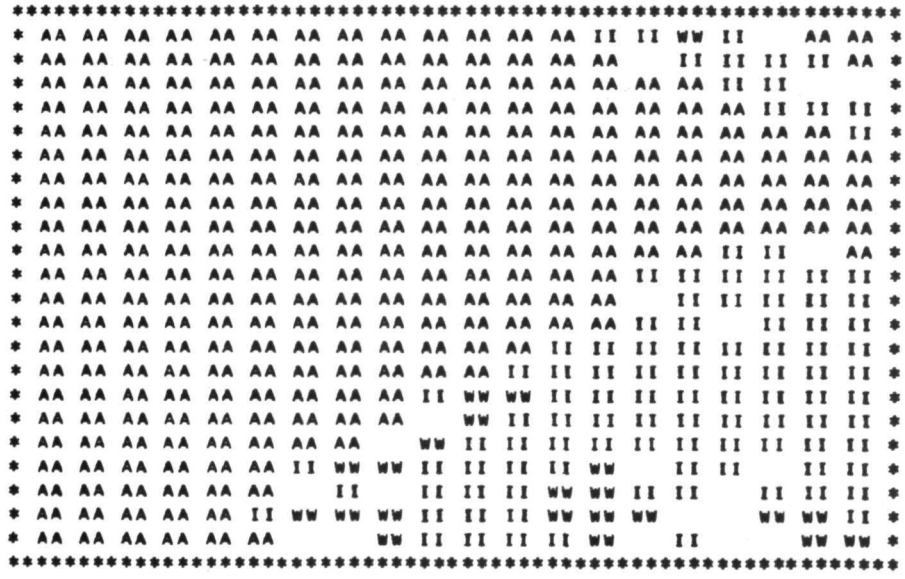
Recorders are available that can record a maximum of 1200 readings per inch. In other words if a waveform had a length of 5 inches, a strip chart recorder could extract 6,000 graytone percentages. The number of readings recorded could vary with the (1) scale of the photography, (2) detail desired, and (3) particular arrangement of ground phenomena. With support from the Office of Naval Research and the U.S. Geological Survey the above instrument can be rigorously tested.

Investigational results have indicated that computer mapping and analysis via the TV-waveform analysis of orbital color photography may aid in geographic problem solving. A primary purpose of the technique would be to analyze distributions found on remote sensor imagery, with the resulting quantitative data and maps supplementing the total analysis package.

Waveform and computer analysis should go hand-in-hand with visual photo-interpretation. It goes without question that the latter is necessary to initially identify distributions and judge their significance. The instrumentation system can then extend the procedure by quantitatively analyzing and mapping the spatial patterns. It is hoped that the instrumentation system will help geographers better analyze the distribution of phenomena.



LAND TYPES



APPROXIMATE AREAS

DESERT	AA	4562. SQUARE MILES	66.6 PERCENT OF TOTAL AREA
WATER	WW	343. SQUARE MILES	5.0 PERCENT OF TOTAL AREA
IRRIGATED LAND	II	1619. SQUARE MILES	23.6 PERCENT OF TOTAL AREA

Figure A. Illustration of computer mapping of land use from TV-waveform analysis of space imagery of Nile Delta area.