N83 35453

ORSER PREPRINT

THE ORSER SYSTEM FOR THE ANALYSIS OF REMOTELY SENSED DIGITAL DATA[1]

Wayne L. Myers and Brian J. Turner[2]

Abstract.--The ORSER system is a comprehensive package of computer programs developed by the Office for Remote Sensing of Earth Resources (ORSER) at The Pennsylvania State University for analyzing various kinds of remotely sensed digital data. It is now probably the most widespread remote sensing computer analysis package in the world, being available at more than 28 locations in the United States and in 8 other countries. A general-purpose interface is being constructed so that information extracted by the ORSER system can be used readily to augment and update geographic information systems (GIS). Application of this capability for statewide monitoring of gypsy moth defoliation is discussed.

INTRODUCTION

Remote sensing has been used as an input to natural resource inventories long before the term "remote sensing" was coined. Such early work, however, was based entirely on aerial photography. Aerial photography from conventional aircraft offers the advantage of high resolution, making it possible to associate a high degree of location specificity with the information extracted. On the other hand, procurement of such imagery is relatively expensive and extraction of the information is a manual and somewhat subjective process. One alternative for reducing costs is to use small-scale imagery from high-flying aircraft. Information taken from small-scale airphotos is less location specific, and the extraction process becomes considerably more subjective. LANDSAT provides relatively inexpensive, broad area coverage in computer-compatible form. The computer-compatible nature of LANDSAT data makes it possible to replace slow and subjective human interpretation by more rapid and objective statistical techniques for extraction of information. LANDSAT usage has evolved as the computerized equivalent of small-scale aerial photography, with a relatively low degree of location specificity being attributed to the information extracted. LANDSAT data are, however, intrinsically quite location specific. The next step in evolution of LANDSAT usage is to take advantage of that location specificity. When this step is taken, computer analysis of remotely sensed digital data becomes a very versatile method of augmenting and updating natural resource information systems. The ORSER system has proven itself repeatedly in the traditional mode of LANDSAT analysis, and is now undergoing expansion for in-place applications.

BASIC STRUCTURE OF THE ORSER SYSTEM

The ORSER system is a comprehensive package of computer programs developed by the Office for Remote Sensing of Earth Resources (ORSER) at The Pennsylvania State University for analyzing various kinds of remotely sensed digital data. It is now possibly the most widespread remote sensing computer analysis package in the world, being available at more than 28 locations in the United States and in 8 other countries. It has the substantial advantage of being relatively easy to implement on any large general-purpose computer having a FORTRAN compiler.

The system is dynamic and continually evolving and, because of its modular construction, it can be easily updated. The preprocessing subsystem can now read data from most satellites which have collected earth resources information. Data can be merged, edge-joined, transformed in a variety of ways, and geometrically corrected. The analysis subsystem provides the user with an array of analytical programs, including both supervised and unsupervised classification procedures. The display subsystem can produce output maps for display on a wide variety of devices including line printers, cathode ray tubes, film recorders, and incremental plotters. Line data from a digitizer can be superimposed on these displays and used to delineate areas for area statistics.

The basic approach in the ORSER system is to treat channels of data as vector dimensions in hyperspace. Original channels and ancillary data of a metric nature may be recombined in various ways to produce additional "synthetic" channels. The entire vector space can undergo both Euclidean and non-Euclidean transformations. Transformation to canonical axes has proven particularly useful. Geometric registration is achieved by translation, rescaling, rotation, and rubber-sheet stretch through resampling processes. Extensive use of vector and matrix notation is made in documentation of the system.

As of this writing, the ORSER system consisting of some 35 individual programs can be purchased as FORTRAN code on magnetic tape for $3,000. Most organizations which have acquired it have had large IBM computers, although the system has also been installed on large CDC, Honeywell, and Burroughs main frames. Ease of installation has varied, depending more on the ability of the installer than on the particular computer configuration. Since all code is now in near-ANSI FORTRAN IV, the latest version should be easier to install than previous ones.

Students and short-course participants have found the system to be relatively easy to use. Typical run decks, or "stems," are shown in the "ORSER User Manual" (Turner et al. 1978). Card users can use these as a base, and teletypewriter-terminal users can call the stems for all programs from stored files and edit them. Control cards are set up as a keyword followed by appropriate parameters. In most cases, format is fixed. Defaults are used extensively. Most programs can be run successfully with only a few control cards, and users can then refine the results by modifying or adding control cards. Control cards are described in the manual, and many of them are common to several programs.

A user-friendly "front-end" to some of the most commonly used ORSER programs, called OCCULT, has been developed at NASA/Goddard Space Flight Center. It has been used extensively in their training sessions (National Aeronautics and Space Administration 1979). At Penn State, we have used our INTERACT editing system to develop a similar procedure for all programs. The role of both of these "front-ends" is to allow the user to set up a run file (JCL and control cards) in a conversational manner and submit it for batch processing. Such an interactive system, however, is not essential for operation of the ORSER system.

Typical applications of the ORSER system have dealt with land use, soils, geology, and vegetation. Typical end products have been classification maps and enhanced color images.

ORSER IN RELATION TO IN-PLACE INVENTORIES

Research on natural resource information systems at Penn State and a NASA project to monitor

gypsy moth defoliation in Pennsylvania have both provided impetus for enhancing the capabilities of the ORSER system to extract location-specific information. Although the capacity to isolate and process data from polygonal areas has existed within the system for some time, it has been necessary to go through the entire analytical sequence on a polygon-by-polygon basis. This becomes quite cumbersome when the polygons are small or numerous. Furthermore, there were no provisions for subsequent compilation or logical overlay operations by polygon classes when the classes were defined in terms of attribute data. Such limitations are typical of the current state of the art in systems for analyzing remotely sensed digital data.

There are two possible avenues of approach to overcoming these limitations. One is to build the capabilities into the remote sensing system itself. Success in this endeavor would almost surely lead to a very large and complex system--much more so than the current 40,000 lines of FORTRAN code already comprising the ORSER system. Such a system would also have a rather large inertia to overcome in keeping pace with the rapidly moving technology of geographic information systems. Complexity and inertia of this order are contrary to the philosophy of design in the ORSER system. We wish to keep the system modular and retain the ability to alter one component easily without affecting the other components.

The second approach to developing the desired capabilities is to build an interface between the remote sensing analysis system and a companion geographic information system (GIS). This way the main data base containing all sorts of information is hosted and manipulated by the GIS. The remote sensing analysis system becomes one of many methods for augmenting and updating the data base. The essential feature of such an interface is the ability to summarize information extracted from the remotely sensed data for each of the geounits already defined in the GIS, and to provide these summaries in a form that can be loaded directly into the data base as an additional layer of information. The geounits can be counties, townships, forest districts, timber stands, eco-types, sampling strata, etc. Given this linkage for one GIS, liaison with another GIS becomes mostly a problem of reformatting the geounit summaries.

This latter approach has been chosen as the method of giving the ORSER system capabilities for providing truly location-specific information from LANDSAT or other sources of remotely sensed digital data. The interface system currently being developed is called ZONAL (ZONation ALgorithms). Given a set of polygonal geounits, ZONAL will simulate the action of a raster scanner and produce a set of "pixels" for each geounit that corresponds to the pixels in the remotely sensed digital data. Instead of reflectance values, however, the ZONAL pixels will contain geounit identifiers. The geounit identifiers in the ZONAL

pixels constitute the indexing information needed for compilation by geounit.

This procedure has the major advantage of not requiring modifications in either the GIS or the remote sensing analysis system. It does require the capability for accurately registering the remotely sensed data to the map base used in the GIS. It also requires the capacity to process blocks of data large enough to encompass the geounits of interest. The ORSER system has both the necessary registration capabilities and the ability to process a full LANDSAT scene.

DEVELOPMENT OF A GYPSY MOTH MONITORING SYSTEM

A proposed statewide system for monitoring gypsy moth defoliation in Pennsylvania will exercise the full capabilities of ORSER/ZONAL. Development of the prototype system is being sponsored by NASA/Goddard Space Flight Center under the direction of Mr. Darrel Williams and Dr. Lisette Dottavio, and in cooperation with ORSER at Penn State. The general structure planned for the system is as follows.

A map-registered set of LANDSAT data covering the entire State of Pennsylvania is being assembled by NASA. This initial statewide data set will be classified by NASA into forested and nonforested categories. Pixels in the forested area will be assigned a value of one and pixels in nonforested areas will be assigned a value of zero to form a binary mask that can be superimposed in multiplicative fashion on LANDSAT data collected subsequently. The reason for this binary mask is that past research at NASA/Goddard and ORSER has indicated an overlap of LANDSAT signatures between defoliated forest areas and certain features in nonforested areas. The binary mask will restrict analyses to forested areas, thus eliminating any confusion with features in nonforested areas. LANDSAT data collected subsequently will be registered to the same map base, and will thus be in registration with the binary mask.

Three different sets of geounits (polygons) will be used in the monitoring system. Counties will constitute one set of geounits. Forest districts will constitute a second set of geounits. And, units in the Pennsylvania State Forest Pest Locator Grid will comprise a third set of geounits. The system is designed to provide area statistics on moderate and severe defoliation by

any of these three types of geounits, as well as changes in defoliated area from year to year.

Since gypsy moth defoliation tends to move in progressive fashion from areas affected the previous year, it should not be necessary to obtain or process LANDSAT data over the entire state every year. Data procurement and processing in any given year can be restricted to areas having likelihood of infestation as judged from occurrence in the previous year.

For this particular application, the GIS need not be very sophisticated. In fact, something as simple as SYMAP with a small "front-end" should suffice. A background information system will also be needed to handle the mask, ZONAL indexing sets, and large quantities of LANDSAT data that will be accumulated over a period of time. For this purpose, the various data sets will be partitioned and stored in a series of files. A file management subsystem is being developed to retrieve specified partitions and edge-join them into larger blocks as required.

When the monitoring system calls attention to specific geounits, currently available facilities of ORSER for handling individual polygons can be used to prepare detailed maps showing distribution or defoliation within a particular geounit.

If inclement weather makes it appear unlikely that LANDSAT data will be available over the area of interest, estimates of defoliation can still be developed from aerial observation and entered directly into the GIS. This ability to bypass LANDSAT processing and substitute information from other sources is an additional virtue of the ZONAL interface technique, as opposed to making the GIS logic an integral part of the system for processing remotely sensed data.

LITERATURE CITED

National Aeronautics and Space Administration. 1979. OCCULT users' manual. Goddard Space Flight Center, Greenbelt, Md.

Turner, B. J., D. N. Applegate, and B. F. Merembeck. 1978. Satellite and aircraft multispectral scanner digital data user manual. ORSER Technical Report 9-78, The Pennsylvania State University, University Park, Pa.