033175

THIRD QUARTERLY REPORT - 1974-75

Reporting Period: January 1, 1975 - March 31, 1975
Contract Number: NAS9-14016
Title of Investigation:

Research in Remote Sensing of Agriculture, Earth Resources, and Man's Environment

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I. LACIE Field Measurements Project

Work on the Field Measurements project during the third quarter included further project planning, preparation for data collection, data processing, and data analysis. The activity associated with each of these areas is described in the following paragraphs. The activities at LARS are emphasized, but our role in providing technical coordination to the project is also indicated.

Project Planning. On January 14-15, 1975 representatives of each of the institutions participating in the project met at NASA/JSC in conjunction with the review of the LACIE Research and Development projects. Review of the project plan was the primary activity. Specific areas discussed included objectives, sun angle-canopy modeling data collection plans, thermal data collection and analysis, data requirements of experiment participants, construction of calibration panels for S-191H, data collection plans for the NASA 24-channel scanner, data collection schedules, and preparation of documentation describing plans for data acquisition, processing, and analysis.

On March 5-6, 1975 a project meeting was held at Purdue-LARS with representatives from all participating institutions. The agenda included the following items: data collection plans including schedules, data flow, and responsibilities for each sensor system and ground observation data, procedures for making canopy reflectance measurements, procedures for obtaining leaf area index data, sensor calibration techniques, definition of experimental plots to be observed at the Garden City research farm, S-191H and A/C scanner data collection schedules, data processing status, review of data collected by Exotech Model 20C at Garden City in October and November, wheat yield information to be collected by ASCS, and design of data collection plans at Williston.

The project plan is being revised to make it current and accurate. Copies will be distributed in early April. Preparation of the Data Acquisition Plan is in draft form. Writing of the Data Processing Plan is in progress.

We have been in communication with the superintendant of the research station at Williston, North Dakota concerning the design and layout of plots there. A tentative plan has been formulated which consists of a factorial experiment with three replications of the following treatments:

Varieties - semi-dwarf and standard height
Planting dates - May 1 and May 14
Fertility levels - no fertilizer and fertilizer application according to soil test
Soil moisture regimes - on 1974 wheat ground and fallow ground

In addition there will be a seeding rate experiment planted on the two moisture regimes and an experiment with several spring wheat varieties, and two varieties each of durum wheat, barley, and oats; plus other cover types common to the area.

Data Acquisition. Most activity this quarter has been in preparation for the spring and summer data collection. This has primarily been for the LARS data acquisition system, although we have provided consultation and advice to ERL, TAMU, and JSC concerning their systems. Specific tasks performed include:

1. Constructing reflectance standards for use with the ERL Exotech and JSC VISS.

2. Designing a data acquisition system for ERTS band radiometer and thermal sensors. The system is to be multiplexed with digital printer output.

3. Realigned the optics of the reflective unit of the Exotech spectroradiometer.

4. Identified an offset problem in the reflective data from the near-IR reflective unit of the Exotech. Analysis indicates the problem is in the electronics. Corrective measure will be made prior to data collection.

5. Continued to work on the multiplexor for houskeeping signals for the Exotech.

6. Repaired tape recorder and realigned hard copy recorder.

7. Designed plan for acquisition of thermal measurements at Williston and began construction and acquisition of instrumentation.

8. Repaired generator which had been damaged in transit to Garden City last fall.

Marvin Bauer and Barrett Robinson were at Garden City, Kansas on March 19-20 to assist in starting the spring data collection efforts there. Overall the operations went smoothly and are in good shape. We were particularly pleased with the S191 H data collection; it seemed to be particularly well organized. We were not able to observe the ERL Exotech system in operation because of the tape recorder problems, but procedures have been defined for that system. Texas A & M personnel were also present to collect data with an ERTS band radiometer, leaf area index, and other canopy modeling data. Several problems were identified in their procedures and will be modified for their next mission .

Data Processing. Tasks completed in preparation for Exotech 20C data and receipt of data from EOD and ERL include: finalized data storage format for the project, development of a data quality monitoring algorithm, procedural design for data flow, initiation of a training program in order that more people will be in a position to handle Exotech 20C data reformatting, and a multitude of software upgrades and new programs.

The data format agreed upon for storage of all spectrometer data collected for the project consists of a slightly modified form of the format used for LARS Exotech Model 20C data. Modifications include addition of identification header data: facility name, crop row direction, and data quality parameters. Also, standard spectral bands for both the reflective and emissive regions of the spectrum were defined for storage on library tapes. To handle the standard spectral band specifications for LACIE, a program was written to convert Exotech 20C data as currently reformatted into the specified standard band form.

Work on the statistical data quality monitoring software has been completed. Statistical values indicating data quality are stored in run header records for analyst's use. The values represent standard deviations of reflectance values as measured by the individual scans of a run. Values are computed and stored for seven wavelength bands centered at: .55, .65, 1.05, 1.65, 2.2, 4.5, and 10.0 micrometers.

Other software upgrades completed for reformatting Exotech 20C data include: provisions to handle header record parameters scene type, illumination source and certain comments, a new program for displaying unreformatted digital data on a graphics display terminal for data quality control, generation of special forms to aid in accurate data flow, and software provisions to enable data reformatting on a batch computer ID.

Four people within the data remormatting group are being trained to reformat Exotech 20C data. This will expand the number of people who can operate the 20C reformatting software from 2 to 6, and thus provide the through-put capacity required for the project.

Upgrades and modification completed within the data analysis program EXOSYS include: proper handling of null data values, addition of ID parameters row direction, and addition of an optional data plotting format. New software programs have been written for transferring data from EOD S-191 and VISS, and ERL Exotech 20D system data tapes to LARS spectrometer data library tapes. To date, none of these programs have been tested with real data.

Exotech 20C data collected October 18, 19 and November 5, 7, 1974, at the Kansas test site have been reformatted and stored in the spectrometer data library for analysis.

During the March 5-6, 1975, project planning meeting, Mike McEwen reported that helicopter S-191H data processing software was completed and the fall Kansas data would be sent to LARS by March 31. In a telephone conversation February 27, 1975, Al Morgan reported that the VISS data reformatting software writing was in progress.

In a telephone conversation March 21, 1975, Jerry Stevenson, a Lockheed programmer, reported that software was being written into existing programs to compute data quality values, and to compute reflectance ratio values as needed for the project. When those modifications are completed a program to convert ERL data tapes to LARS compatible format will be written. A test tape was received from ERL which successfully established a compatible format.

Data Analysis. Analysis of the spectral data collected with the Exotech 20C system at Garden City in October and November, 1974 has been nearly completed. The analysis has been performed using the four ERTS bands, plus two middle-IR bands. Comparisons have been made of several fields of wheat with ground covers ranging from zero to ten percent and of the wheat with other cover types including bare soil, corn, grain, sorghum, soybeans, sugar beets, and alfalfa stubble. The means and standard deviations of each of these treatments were computed and analysis of variance performed to determine if differences were significant. In general, reflectance differences of wheat were non-significant for the low amounts of ground cover present; however, wheat was generally significantly different from the other cover types in one or more wavelength bands. In addition to providing limited information on the spectral characteristics of the early stages of wheat growth, the analysis has provided an opportunity to develop and test our analysis software system (EXOSYS) and statistical analysis techniques. During the next quarter we want to implement a multivariate analysis of variance program for use with the field measurements project data analysis. This program will be meaningful in that it will relate to analysis of scanner data using LARSYS type pattern recognition methods (i.e. multiple bands are analyzed or considered simultaneously instead of single bands one at a time).

II. LACIE - CITARS

During the third quarter our major activity has been to statistically analyze, interpret, and document the classification results. At the request of EOD, Barbara Davis spent a week at JSC/EOD in January setting-up and running analyses of variance. In mid-February, Volume IX, Analysis of Results, of the final report was prepared at LARS and distributed to ERIM and EOS personnel for review. In preparation for writing a volume interpreting the results, a series of five conference calls were held with EOD and ERIM personnel to discuss the material in volume IX. An outline of the CITARS paper to be presented at the Purdue Symposium, Machine Processing of Remotely Sensed Data, was also prepared and discussed with the other authors from EOD and ERIM. We are currently writing several sections of the paper and coordinating its preparation. This paper will summarize the CITARS results and discuss their significance in relation to LACIE and future research and development. In addition, several experiments performed to help understand the CITARS results were completed. These will be included in Volume VI, LARS Results, of the final report which we are currently preparing.

III. LACIE Spectral Class Definition

During this quarter, the "Spectral Class Definition" (spectral statification) effort advanced on two fronts: (1) acquisition and analysis of LACIE data, and (2) development of techniques for spectral stratification.

A. Acquisition and Analysis of LACIE Data

Five ERTS frames containing the Finney and Morton County LACIE intensive test sites were received from NASA/JSC/EOD in mid-January. In mid-March, 13 additional frames containing the Ellis, Rice, and Saline county intensive sites were received. All of the data has been reformatted and the intensive sites in the first five frames have been located and geometrically corrected. In addition, multitemporal full-frame registration and geometric correction of those frames are in process.

Analysis of the five original frames has been initiated. We are concentrating on frame 1583-16525, acquired 2/26/74 and containing both Morton and Finney counties and frames 1654-16453 and 1672-16450, acquired 5/8/74 and 5/26/74, respectively, and containing Finney County. Our initial analysis work has been directed toward determining the spectral characteristics of wheat and other crops present at these times and places. Results from this effort indicate that there are more spectral classes of wheat present in both areas than expected, although the number of decreases as the wheat crop matures. The greater number of classes (8 or more) present in February than in May (8 or fewer) is attributed to the smaller amount of vegetative cover (and therefore more bare soil) in February than in May when the amount of vegetative cover would be approaching its maximum.

Other results obtained show that classification accuracy for wheat test fields was 85 to 90 percent for local training and classification for both Morton and Finney Counties in both February and May. The one case where we have tried to extend training statistics from Finney to Morton County and vice versa gave very poor classification results. Examination of ancillary data, in particular soil maps, shows that the two areas are quite different. For one thing, the Finney County site has been leveled and furrow-irrigation is practiced extensively, whereas there is almost no irrigation in the Morton County site.

During the next quarter we will be defining and delineating spectral (signature extension) strata for these entire ERTS frames as well as initiating analysis of the frames containing the other LACIE sites in Kansas.

Technical Problems Encountered. The evaluation of the signature extension strata will be limited by the available crop identification information. There is really insufficient data from the intensive test sites to do this job adequately. Our initial results indicate that each site may very likely be members of different spectral strata. Having only one intensive site in each stratum will prevent training with one segment and classification in another segment to verify the stratification results. We have requested and have been promised at least a portion of the 1974 SRS segment data. This data will have the advantage of being widely distributed over the scene, but at the same time it will be difficult to locate the segments (which are generally about a square-mile in size) in the data. A request has also been made for a duplicate copy of any color or color IR imagery obtained from the RB-57 over Kansas in 1974.

B. Development of Spectral Statification Techniques

Commencing this quarter, a concerted effort is underway at LARS to determine the potential impace on spectral class definition and spectral stratification of the analysis techniques research supported by the SR&T contract. The increased emphasis reflects the urgency of the problem and its importance relative to the LACIE project. This section of the report details progress made in the various approaches which are considered promising as contributing to the spectral stratification task.

Cluster Analysis. Cluster analysis is one of the principal approaches being investigated because of its essentially unsupervised nature (i.e., it does not inherently depend on reference data -- ground truth). Work has been pursued this quarter on new techniques which determine the number of clusters inherent in a data set. A measure of the ratio of the within-cluster scatter of the data to the total scatter of the data was added to the LARSYS cluster processor. This measure (Wilks) indicates which of several sets of clusters best fits the data.

An approach to clustering based on the ISODATA/ISOCLAS program developed at Lockheed by Kan and Halley has been programmed. The process begins by assigning initial cluster centers along the axis of maximum variation in the data. The initial number of clusters is the maximum allowed. Then the sequence of operations is as follows: DCS DCS DCS DC, where D represents a Delete operation in which all clusters with less than a set number of points are deleted; C represents a Combine operation in which two or more clusters are grouped together when the transformed divergence between every pair is less than a user-specified threshold; and S represents a Split operation in which a cluster is split into two new clusters along the data component with maximum variance. After each D, C, or S operation, all points are reassigned to the nearest cluster center.

It is anticipated that these facilities will be available for use in the spectral stratification study before the end of the next quarter.

Sample Classification and Boundary Finding. Most of the effort during this quarter has been devoted to documentation of this data analysis technique. The bulk of the technical report is written. In conjunction with this writing, some additional analyses were performed and class-conditional and unconditional spatial correlation functions were measured for possible inclusion in the report.

The boundary finding and sample classification programs have been applied to some CITARS data sets, but the results are not as yet complete.

The application of the boundary finding and sample classification programs to the LACIE spectral strata problem and LACIE classification problems will be investigated in the next quarter.

Characterization of Spatial Information. Possible influences on the geographic limits of spectral strata include soils, topography, the acreages and shapes of fields being planted, weather patterns, and other cultural and management factors influencing crop growth. These influences may be manifested as spatial differences between parts of the scene. One possible way to extract spatial information from ERTS imagery is through the use of Fourier transforms. During the past quarter, the literature and existing software for computing spatial Fourier transforms have been studied, and areas where decisions are needed have been outlined. Four problem areas are under study:

1) Rate of movement of the aperture block. After a

Fourier Theorem has been applied to a block of data, a new data block must be chosen a certain number of pixels away from the first. The optimum rate of movement must be determined. From the Nyquist Sampling Theorem, the data block should not be moved more than one-half the size of the smallest object which is desired to be seen. If the data block is moved only one pixel at a time, the Fourier transform will show the spatial characteristics of objects two pixels in size. A different rate can be chosen to enhance objects of different sizes. Trail classifications will determine the effects of different movement rates on classification accuracy.

2) Selection of optimum feature for transformation. After a data block of size nxn has been transformed for one channel, there exist n^2 new transformed data points. Data compression techniques, such as "circular ring" sampling, can reduce this number. Each one of the compressed points can be written on a data tape as an additional channel. Current LARSYS programs limit the number of channels to thirty. Because of this limit, it has been decided to take the Fourier transform of only one channel of the data block. The optimum channel must be determined. Several possibilities exist for determining the optimum channel to be transformed:

   a) trial classifications to determine if any one channel yields the best results.

   b) if the optimum rate of aperture movement is found, a choice of channel may be obvious--that which makes the objects desired for a given problem most distinct.

   c) a principal components transformation to combine several channels into a single optimum channel.

3) Sampling techniques. After an nxn data block has been transformed, it is necessary for software reasons to employ data compression techniques to put the useful information into reduced form. Possibilities for data compression include: circular, square, and wedge sampling. Circular sampling has the effect of minimizing small orientation differences in the data. Wedge sampling emphasizes the orientation dependencies of the data. Trial classifications will be run using circular, square, and wedge sampling to determine the optimum technique. Also, after the optimum rate of aperture movement is found, it may be known exactly what frequency responses contain the bulk of the spatial

information. Those specific frequencies could be used for data compression. This would be more efficient than circular, square or wedge sampling and might make feasible the transformation of more than one channel.

Technical Problems Encountered. No unanticipated technical problems were encountered this quarter. However, work on the overall spectral stratification problem continues to progress much more slowly than expected because key personnel associated with the project are still tied up with analysis and documentation of the CITARS results. We have discussed this fact with personnel of NASA/JSC/EOD because the scope of the CITARS effort we are now pursuing at the request of NASA is well beyond that originally projected for LARS. These discussions have reconfirmed that high priority should continue to be given to the CITARS work.

IV. LACIE Image Registration

A reorganization of this project took place at the beginning of this quarter at the request of the sponsor. The overlay of non-ERTS data task was dropped and the remaining data base interface tasks were combined under the LACIE Image Registration.

The primary activity in the period was the further evaluation of enhancement and correlation algorithms for registration of LACIE site ERTS data. It is expected that these comparisons will be completed and a report prepared by the end of the fiscal year. Enhancements which are currently being tested include various gradient schemes including the gradient defined by the Computer Sciences Corp. for LACIE registration, and including binary image slicing. Correlators tested were: standard correlation coefficient, correlation coefficient without normalization and absolute value of the difference. Test sites in Hill County, Montana, Tippecanoe County, Indiana and Finney County, Kansas for up to six time periods were used for the evaluations. Results compiled thus far tend to be similar for the particular temporal data used.

The problem of correlation of temporal scene pairs having low correlation coefficient was hampered by the lack of a zero registration error reference for temporal data. Development of a statistical model for temporal data was explored as a method of generating temporal misregistration test scenes for algorithm evaluation. The use of different spectral bands of the same frame as a test of temporal correlation capability was also explored. It is expected that results on the relative ability of the enhancements and correlators to register image pairs having low correlation will be available by the end of the next quarter.

The development of improved registration functions for describing the image distortion necessary for registration continued and a prototype cubic spline function algorithm was completed. The cubic spline image distortion function is expected to be able to represent any degree of distortion in an image should the need arise. The present bi-quadratic function may not be able to accurately describe the required registration distortion for the full frame or large fraction of a frame registrations. Problems remain in computation of two dimensional inner products for the cubic spline approximation and solutions are being pursued.

A full frame registration task was begin in the quarter as a demonstration in response to a need expressed by the JSC LACIE management. Successful full frame registration of three ERTS passes over Western Kansas was completed by March 15 using nearest neighbor pixel interpolation. The frames overlayed were 1654-16453 May 8, 1974, 1672-16450 May 26, 1974 and 1708-16435, July 1, 1974. Software modifications were completed to implement cubic convolution interpolation for pixel resampling as requested by JSC. The overlay using cubic interpolation is expected to be completed by April 15, 1975. These registrations were carried out using resources remaining in the LACIE Image Registration Task.

V. Forestry Applications Project

Activity during this reporting period has been centered on analysis of data for the Sam Houston and Hoosier National Forests. During the FAP semi-annual review, February 25 & 26, current results were presented to an audience consisting of U.S.F.S., Lockheed and NASA/JSC personnel. A paper will be forthcoming from this presentation.

Results will be presented separately for the Sam Houston and Hoosier National Forest Test Sites.

SAM HOUSTON NATIONAL FOREST SITE

Major Activity

Edit 9, Mx230 was selected for intensive analysis because it contained both deciduous and coniferous cover types. Edits 6 and 12 were also selected because of coincident east-west overlap of the flight line data. Our intention was to utilize this data set to test for training set extensions from one flight line to another.

Because of problems with aircraft altitude and scanner-look angle, especially when dealing with training set extension, work on edits 6 and 12 lessened and analysis of edit 9 was stressed. Even so, the problem with scanner-look angle was still bothersome. Look angle varies from perpendicular at nadir to nearly 40 degrees at the edge of a flight line. This results in the creation of a wide range of spectral classes whose position in the data is largely dependent on their angular distance from nadir. This holds constant even though there is no variation in ground cover type.

The look angle problem can be reduced through mathematical correction of the data. However, the correction applied to the SHNF data was not adequate to significantly reduce the effect. In this situation the only alternative when classifying the data is the creation of additional training classes to account for differences caused by look angle.

Additional classification problems were encountered because of the 20 foot resolution of the scanner. Basically, at this resolution spectral information is gathered from both the light and dark side of the tree, including any between crown shadow detail. The spectral signature is composed of all these variables which the analyst must sort and identify as to their significance for the classification. The combination of both angle and resolution require that the analyst create numerous classes which he must then identify.

The LARS approach for analyzing these data sets is through use of the clustering algorithm. With clustering, the spectral classes are identified and then with additional analysis procedures, these classes are associated with ground cover types. Results from analysis of aircraft data, although preliminary, appear promising. However, the time spent in generating these results has been extensive due to factors mentioned above.

An analysis of LANDSAT-I data collected May 8, 1973 was undertaken. This data was part of a three date temporal overlay over the SHNF. Due to misalignment of the overlay, only one date was analyzed. A temporal analysis will be performed once LARS has corrected the overlay.

Training sets derived from clustered aircraft data were used to classify: water, bare land, cut-over forest, seedling and sapling types, bottom land hardwoods, mixed pine-hardwood, and pine. The pine was further broken down on the basis of three broad crown closure classes.

Work on the SHNF will continue to address the problems of multitemporal analysis and training set extension.

Solutions to Previous Problems

Problems encountered with aircraft data tapes (refer to previous quarterly report) have been corrected.

Technical Problems

A data tape containing a three date overlay of a portion of the Sam Houston National Forest test site was received on November 15, 1974. The following problems were found:

1. Image inverted for LARSYS use.

2. Calibration codes incorrect. This causes negative data values to be supplied to computer.

3. Entire test area not covered. Only two (edits 9 and 18) of the eight test areas were included in the data set.

4. The overlay accuracy (correlation between dates) is very poor. Vertical and horizontal errors are as great as 9 and 4 resolution elements respectively with an average Euclidian error of about 4.2 to 4.3 at various positions in the data set. This error represents a distance of a thousand feet or more on the ground and is far too great for meaningful temporal analysis of the data set. A properly prepared overlay of this size should have an error of one sample or less.

Proposed Solutions

The image inversion and calibration codes have been corrected with LARS data processing software. Although the LARS data processing staff has been successful in converting all data types to useable condition, the process is expensive and time consuming and reduces the time available for the analysis procedures. Since the data set does not cover the test site, the overlay was not corrected. Instead, the LANDSAT data tapes for the entire frame are being supplied to LARS by FAP personnel at JSC, and the rotation and overlay will be done at LARS. The existing data set was used for single data analysis of the Edit 9 and 18 portion of the test site. The temporal analysis of the entire site will be undertaken as soon as the data arrives and is processed.

HOOSIER NATIONAL FOREST SITE

Major Activity

During the third quarter, FAP research activities have included:

- Testing of four procedures for statistically evaluating classification results,
- Developments and refinement of modified cluster technique for producing training statistics, and
- Formulation of wavelength band selection study.

Activities in the first phase of this research have been directed toward answering the question, "How can one quantitatively evaluate classifications in an unbiased fashion? The objective of this study was to define and test an evaluation procedure which would enable unbiased evaluation of classification performance and reliability. Different analysis techniques, and different wavelength band combinations would be studied. The procedures followed included: 1) randomly and systematically locating equally-sized test fields over the test site; 2) retaining fields which represented one cover type as determined by photointerpretation; 3) utilizing an arcsin $\sqrt{p}$ transformation to transform the binominal data to normally and independently distributed data; and 4) performing a two-factor analysis of variance to detect significant differences among field-selection methods and among cover types. No significant differences were found between the four methods. The statistical methods generally indicated lower classification performance than the commonly used, numerical test-field approach.

Formulation of training statistics is undoubtedly the most important step in computer-aided analysis of MSS data. The objective of this phase was to develop a technique for some efficient definition of training statistics. The approach taken combined the characteristics of supervised and non-supervised training procedures into a hybrid technique, the modified cluster. The modified cluster enables: 1) more effective analyst/data interaction; 2) less computer time for statistics formulation, and; 3) higher classification performance. Modified cluster was compared with the other major statistics formulation procedures, and was found to be superior in classification performance.

The obvious importance of wavelength band selection to forest cover mapping is made especially clear when temporally-overlayed data sets are analyzed. The large number of channels and increased complexity introduced by spectral-temporal interactions suggest that we must study the importance of different wavelength regions to forest cover mapping, particularly as the time dimension is added to the analysis scheme. The objective of this phase is to evaluate the spectral region of a single ERTS date in comparison with the same and additional wavelength regions afforded by SKYLAB S-192 data gathered over the same test site. Thus, we shall attempt to better understand the single-date relationships before approaching the multi-date case. Test and training fields are currently being selected to statistically compare the following channel combinations: all 4 ERTS channels, all 13 SKYLAB bands, "best 4 SKYLAB, 4 SKYLAB bands comparable to LANDSAT, "best" 2 LANDSAT, "best" 1 LANDSAT, and various SKYLAB bands which will indicate the importance of the visible, near infrared, middle infrared, and thermal portions of the electromagnetic spectrum to forest cover mapping.

Technical Problems Encountered

Geometric warping in the SKYLAB S-192 data will make selection of the identical ground areas in both LANDSAT and SKYLAB data a difficult task.

Proposed Solutions

We plan to use a Bausch and Lomb Zoom transfer scope to better match the data sets for field selection.

The arcsin $\sqrt{p}$ transformation solved the problem with the statistics data mentioned in the previous quarterly report.

The Hoosier National Forest LANDSAT data sets have been correctly overlayed.

Conclusions

During this reporting period LARS personnel requested specific information from the Sam Houston National Forest Test Site. LANDSAT data tapes, Mx 230 color infrared aircraft data, and timber compartment information was requested. As of this report copies of the LANDSAT data tapes, timber compartment information and hard copy prints of selected areas in the SHNF have been received. We are expecting a duplicate roll of CIR from Mx 230 and timber compartment maps for the SHNF test site.

LAND USE STUDIES (RAP)

Major Activity

The following data has been received since December 1, 1974:

LANDSAT 1127-16260
LANDSAT 1146-16314
LANDSAT 1288-16261
LANDSAT 1505-16230
BEG maps of Matagorda Bay
Mx 145 color photography
Mx 145 color IR photography
Mx 191 color IR photography

Two meetings were held during this reporting period, one at LARS on February 6-7, 1975 and one at Houston on March 21, 1975. Details of these meetings are documented in NASA/JSC memoranda TF5/75-46 and TF5/75-88, respectively.

Dr. Weisblatt (LEC) visited LARS in February and spent three days working with Dr. Kristof. Three LANDSAT data sets were analyzed. These sets were acquired November 1972, May 1973 and December 1973. Data covering Calhoun County or Matagorda Bay, Texas, were spatially registered to produce multichannel temporal data sets. The data were also geometrically corrected. For overlayed and geometrically improved LANDSAT data the four bands were observed singlely and also in color composites. Photomosaics of the study area were made in black and white and in color. The entire area is divided into nine quadrangles according to the USGS 7 1/2' quad sheets which cover the following nine sites:

Pass Cavallo SW
Port O'Connor
Austwell
Seadrift NE
Seadrift
Tivoli SE
Port Lavaca E
Point Comfort
Lolita

Two computer-aided techniques were used. The first was an unsupervised maximum likelihood classification technique. It was used to classify the data of each quad into fourteen or seventeen spectral classes utilizing all four bands for all three dates. Those cluster classes were used to classify all of the data points in the quadrangle. Since no ground information was available except for topographic maps at a scale of 1:24,000, statistical information such as relative spectral response values, standard deviations and calculated histograms is used to relate each spectral NSCLAS to the ground features. Those results are shown on the computer printout with the individual image units of LANDSAT data displayed as individual symbols. Each feature on the ground was assigned to one of fourteen or seventeen spectral classes, but sometimes several spectral classes were assigned to one ground feature.

Also, classification results were obtained with sets of ground truth data. With ground truth data the quadrangles of Port O'Connor and Pass Cavallo were mapped. The obtained results are very promising.

The results of the supervised classification were more accurate than the product of the nonsupervised (NSCLAS) classification.

The Regional Applications Project supported the remote sensing effort of the state of Texas by allowing the Office of Information Services to access the LARS/Purdue terminal via 3 RAP computer ID's. Usage to date (3/31/75) by these ID's totals 7.2 CPL hours.

Dr. Kristof is beginning to write the documentation of the work accomplished this fiscal year under the RAP effort.

Technical Problems Encountered

Sufficient ground truth was not available during this reporting period to accurately correlate spectral classes with information classes.

Proposed Solutions

The ground truth of the test site has been requested from NASA/JSC and is expected to arrive the first half of April. A ground truth expedition to the test site is also scheduled for April. Both types of information should suffice for ground truth and enable Dr. Kristof to produce information classes.

VII REMOTE TERMINAL AND TECHNOLOGY TRANSFER

Work on the final report for the Remote Terminal Project continues. Since each of the remote terminal locations have entered into separate agreements for the support of their terminals beginning January 1, 1975, no other activities have been conducted with respect to the remote terminal project. Technology Transfer activities, however, are continuing.

Technology Transfer activities under the SR&T contract during the third quarter were concentrated in three areas: revision and updating of LARSYS Education Package materials, continued development of a LANDSAT case study unit to augment the LARSYS Education Package, and development of single concept tutorial materials.

Revision of the LARSYS Education Package instructional materials has been completed. The new materials have undergone substantial inhouse review by persons familiar with LARSYS and by new analysts. These materials are now in the process of being reproduced and printed. A letter describing the new materials along with sample printed materials will be mailed to all remote terminal locations.

A working draft of a LANDSAT data analysis case study has been completed. Designed to augment the LARSYS Education Package this case study provides a detailed description of a typical analysis sequence using LANDSAT data, illustrates the approach by means of an example and directs the student through the analysis of a LANDSAT data set. The case study is currently being tried and evaluated by several graduate student analysis teams. The material will be put in final form for inclusion in the LARSYS Education Package.

An addition to the single concept FOCUS series was completed during this quarter. The new unit on Mapping Soil

Characteristics illustrates the role computer analysis of remote sensing data can play in assisting soil sciences in their work.

III. Pre-Processing Algorithms

Printing of the final report on optimal scanner field of view compensation was completed. The correction algorithm was implemented to enable image areas up to 1000 columns and 750 lines to be enhanced and other refinements were added to achieve compatibility with LARS tape formats. The filter was applied to several ERTS images for testing its effectiveness. The enhanced imagery is being written on film with a precision film writer by an external vendor. No results were received from the vendor by the end of the quarter. Examples of enhanced versus unaltered ERTS imagery from several test sites are expected by the end of the next quarter.

An information note entitled "Interpolation of ERTS-1 Multispectral Scanner Data" by Professor C. D. McGillem was printed. This report describes work done on pixel resampling schemes earlier in the year. The methods described are conventional applications of interpolation to LANDSAT data, and do not compensate for the scanner aperature as does the algorithm discussed above.

Work continued on evaluation of the effects of filtering and interpolation on classification accuracy. A test case was chosen in which lake areas are to be estimated from LANDSAT data. Aerial photographs, aircraft scanner data, LANDSAT data and filtered and interpolated LANDSAT data were used to estimate area. Preliminary results indicate that the enhanced ERTS data gives significantly higher accuracy in lake area estimation than unenhanced LANDSAT data using the low altitude data as reference. This work will continue into the next quarter to further explore the apparent classification accuracy improvements.

A new task was defined at the beginning of the third quarter in which preprocessing techniques are to be applied to LACIE imagery to enhance its visual quality. Two methods are being tested for LACIE field enhancement. One is application of the optimum scanner aperature filter discussed above. The second is a linear combination of bands based on class separability.

The optimum scanner aperature filter was applied to a subframe of LANDSAT data from band 5 over Finney County, Kansas. A 1000 by 750 line block was filtered and interpolated to produce a 3000 column by 3000 line data set. This data is being written on film by a precision drum film written by an external vendor. Unaltered data from the same area is also being written on the drum film writer. Visual comparison will be made between the enhanced data and unaltered data photographically enlarged to the same scale. Small area samples of the enhanced data are also being produced on the LARS digital display for use until precision film products become available. Implementation of the linear combination enhancement scheme proceeded during the quarter and will continue through the next.

IX. Effective Utilization of Data Dimensionality

Layered Classifiers

During this quarter, the testing and evaluation of the heuristic decision tree design program continued. All related research software has been converted to CMS to improve its compatibility with LARSYS.

The heuristic decision tree layered classifier has been used in forty classifications of three data sets: a forest scene in Colorado, an agricultural-forest scene in Indiana, and a multitemporal CITARS segment in Illinois. The results from the Colorado and Indiana scenes are similar to those obtained from the LARSYS maximum likelihood classifier and in most cases take less computer time. The CITARS results are incomplete; in the next quarter, effort will be directed toward analyzing CITARS segments and LACIE test sites. Receiving particular attention is the question of how to best use layered classifiers in the context of multitemporal data.

Technical Problems Encountered

The evaluation of the heuristic search optimization design approach was slowed considerably by discovery of an error in the software. The error was important as the corrected heuristic search program gave quite different trees in those cases which have been compared. The classification performance from both the corrected and the uncorrected programs are similar; however, the corrected program produces trees which are 5 to 50% more efficient. The corrected heuristic search design program also seems to be more sensitive to the choice of program parameters. The error has set back the research into how the program parameters should be chosen to give the desired results for a given problem.

As of January 1975, work on the table look-up classifier has been terminated and effort on the linear combination feature extraction algorithm has been redirected to LACIE the image enhancement task.

X. Extraction and Analysis of Spatial Information

As of January 1, 1975, the effort committed to this project has been redirected to LACIE Spectral Class Definition goals and is reported in that section.

XI. LANGLEY REMOTE TERMINAL

The Langley Terminal was used primarily for the instruction of new students during this quarter. The primary activity of LARS personnel during the quarter was to provide consultation to these new trainees.

Dr. Roger Blais of ODU has indicated he wants to have the terminal moved to Old Dominion University, since it is at least a half hour drive through toll tunnels to Langley. He is currently seeking funding for the terminal for the next fiscal year.

An advance LARSYS Analysis Seminar/Workshop was presented to nine analysts at NASA Langley on March 12, 13 and 14, 1975, by Philip H. Swain and Forrest E. Goodrick. Half-day seminar session topics included pattern recognition concepts, statistical characterization of pattern classes, clustering and nonsupervised classification, descriminate functions separability and feature selection, and sample classification. Workshop sessions covered batch operation and access to the experimental program library, and a survey of lesser used features of LARSYS. The seminar/workshop is scheduled for presentation at NASA/Goddard and the EROS Data Center remote sites in May.

XII EROS Data Center Remote Terminal

Purdue's support of the EDC remote terminal continues, with few problems being encountered. A proposal to continue this support through the next fiscal year has been completed and is being sent out.

Work on the demonstration package is running on schedule. By March, the contents of the package were in various stages of design or draft format. The coordinates of the analysis area had been chosen, posters and a flip-chart had beendesigned and the material for the handout was written. During March, the instructor's guide was written, final photographs were received, and components of the package were assembled in their final form. The demonstration package is expected to be ready for delivery in the near future.

During the two week period of March 10 through March 21, 1975, Dave Greenlee and Charlotte Muchow of EDC were at LARS for a course on LARSYS programming techniques. They also discussed and used reformatting programs and CMS for programming, and improved their analysis techniques.

Plans were made for Dr. Philip Swain and Paul Spencer to visit EDC one week in April for the purpose of studying the

IMAGE 100 and its capabilities with respect to LARSYS. Also in planning is an Advanced Analysis Seminar to be given at EDC by Dr. Swain later this spring.