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An Integrated Feasibility Demonstration for Automatic Population of Geospatial Databases

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Contents

Preface

The following tasks from our Statement of Work summarize the work being carried out by SRI International and its subcontractors GDE Systems and Vexcel Corp. on the DARPA Automatic Population of Geospatial Databases Integrated Feasibility Demonstration contract.[1] A description of our activities in the latest reporting period in support of each task follows the task description. Because of the late start of the program all scheduled reports and deliverables will be delayed three months from the schedule in our proposal.

This report is also available via the WWW at the URL `http://www.ai.sri.com/~apgd/reports/`.

[1]The information from the monthly reports from GDE and Vexcel has been integrated into this report. The full text of the the GDE and Vexcel reports are included as appendices for reference purposes.

1 Technology Development

1.1 Refine the BOS architecture

Review the current BOS architecture, enhance it, and distribute a description of it to the APGD community. (Q1–2)

(No change in status.)

We have developed and continue to enhance an end-to-end example (raw data to visualization) of linear delineation for railroads. This is being used as an initial check on the suitability of the architecture to acomplish the BOS modeling and visulation goals. At this point in time no modification to the architecture is needed.

1.2 Develop CBACS

Extend and enhance existing RADIUS HUB architecture to meet the requirements of the CBACS to serve as the control structure for invoking feature extraction algorithms. (Q3–6)

The CBACS support for a given algorighm consists of three major components:

- The algorithm itself.
- A descriptive wrapper that tells CBACS how to set parameters for a given context and the expected performance, including known problems.
- A benchmarking sub-system that allows performance evaluation of the algorithm and comparison with alternative algorithms available for the same purpose. This a generic facility provided by CBACS for a given class of algorithms (e.g. linear delineations). There is a protocols for algorithms to specify customizations required to evaluate the specific algorithm. For example, an algorithm that does not recover road network topology will not be evaluated on that basis.
- A feature-class-specific editor. A central concept to our approach is editing function is the significant cost in using a given algorithm, so there must be a nominal editing environment for each type of feature that takes in to account the errors the algorithm is likely to make.

  The editor has two aspects:

  – A generic aspect. The editor must be able to fix the classes of errors the algorithms are likely to make.
  – A specific aspect is that the editor must be able to create the reference data used in the benchmarking component.

    GDE and Vexcel have specified editing environments for buildings and material classification algorithms.

The CBACS portion of the architecture is concerned with the detailed specification and implementation of the above items.

We have been using the low-resolution linear delineation subsystem as the driver for refining the design of these components. Currently, we have a prototype benchmaking facility and a workable version of the editing environment in place and are experimenting with the wrapper specification for this class of algorithms.

1.3 Develop feature extraction managers

Design and develop feature extraction managers for terrain, linear, area, compact 3-D features, and dynamic objects. (Q3–4)

A skeletal implementation of the FEM for LOCs has been completed. It was demoed at the IPR.

1.4 Survey automated model extraction techniques

Identify potential algorithms for improving the performance of planned or installed BOS feature extraction capabilities and extending the operating domain of existing algorithms. (Q1–2)

We have completed the compilation of bibliographies for the three major feature extraction subsystems that we are currently concerned with. Two of the three are already on available on the Virtual Lab. The third will be added shortly. We also plan to augment these with summaries of the approaches.

1.5 Develop feature extraction and consistency enforcement algorithms

Adapt, integrate, and enhance IU algorithms for extracting terrain, linear features, area features, 3-D compact objects, and dynamic objects. Develop new techniques that capitalize on the complementary aspects of radar data and E-O and multi-spectral data. Adapt the Model-Based Optimization (MBO), deformable mesh, and consistency enforcement technology to work with extracted features and their attributes. (Q3–8+)

The BOS implementation of the low-resolution linear delineation subsystem has been completed and packaged with a user interface. This will allow testing and evaluation on a variety of images. Copies are being provided to GDE and Vexcel. GDE will be undertaking an evaluation of this algorithm as part of their MURI and RCVW projects.

GDE has taken delivery of USC's monoscopic and multi-image building extraction systems and is currently evaluting them.

Vexcel has been evaluating the surface material classification algorithms that use SAR and/or MS imagery.

1.6 Develop techniques for multi-sensor registration

Extend the Model-Supported Positioning technology to include radar imagery and multi-spectral imagery. These will co-register images from different modalities in a common coordinate system. Extend the sensor model API in the RCDE to provide a homogeneous interface to the full range of data, including the transformations to map back and forth between image coordinates and 3D coordinates. Implement photogrammetrically rigorous error analysis and propagation facilities in the RCDE. (Q1–4)

No recent activity. The facilities we currently have are adequate for our current needs.

1.7 Refine the design of, and implement, the persistent store

Specify the data format (syntax and semantics) and API for the spatio-temporal database component of the BOS, based on the requirements derived from the selected SE and MSE applications. Implement the dynamic database component of the BOS. (Q1–4)

Recent (low-level) activity has surveyed different approaches for representing uncertainty.

2 APGD Community Development and Technology Transfer

2.1 Produce, maintain, and distribute calibrated datasets to FRE and IUBA contractors

Collect, calibrate, and document classified and unclassified sets to be distributed to the community for experimental and evaluation purposes. (Q1–8)

A complete dataset for Ft. Benning is being finished. It will be ready for distribution in early November and will consist of the following:

- 33 panchromatic aerial survey images with control
- 2.5m GSD SAR/IFSAR coverage mosaicked and rectified to UTM
- 0.4m GSD SAR/IFSAR coverage in SCH format
- control data survey compiled by DMA in 9/95
- 1m grid-post digital terrain model in DMA DTED format
- Daedalus MS collection

2.2 Construct and distribute ground-truth models

Interactively construct attributed, detailed 3D models of three sites (e.g. Ft. Hood, Ft. Irwin, and Ft. Benning) to be used for benchmarking and evaluation. (Q1–8)

GDE is completing ground-data models of the buildings at selected parts of Ft. Hood. These will be used in the benchmarking facility for building extraction. Ground-data models are complete for the MOUT area at Ft. Benning.

2.3 Develop evaluation metrics and procedures and perform evaluations

Design an evaluation process that can be used to identify significant advances in feature extraction or attribution. Enhance metering facilities currently available in the RCDE. Periodically run evaluations to document the current competence of the evolving system. These results will be posted on the network for comment and comparison. (Q1–2)

Evaluation metrics for linear delineation have been formulated. An benchmarking facility based on these will be available on the Virtual Lab within the next couple of weeks.

2.4 Establish and maintain the APGD virtual lab

Provide continuous access to data, ground-truth models, and results on a WWW site. In this way, any group can compare its results with the current best results. (Q1–8+)

The algorithm bibliographies have been added to the virtual lab. The SRI low-resolution linear delineation system continues available for experimental evaluation via the Remote Execution Facility. An update version which is suitable for SAR will go on-line within the next couple of week.

A first implementation of a benchmarking facility for linear delineation has been completed and will be available shortly. This will make use of a "ground truth" reference image to test algorithms for accuracy in extraction of geometry and topology. Users will be able to download selected imagery and upload the results computed by their algorithms. The results will be evaluated and the score returned to the user. For demonstration purposes, the output of the linear delineation algorithm on the virtual lab can be fed into the benchmarking facility.

2.5 Interface to FRE contractors

> *For each FRE, select one of the three partners to be the primary interface for that FRE.* (Q1–8+)

GDE is working closely with USC to evaluate their multi-image building extraction system and preparing the Ft. Benning dataset.

The radar short course was given at Vexcel's on August 18 and 19.

Vexcel is preparing the MS and SAR components of the Ft. Benning dataset.

2.6 Develop and perform demonstration scenarios

> *Identify realistic processing scenarios and demonstrate prototype systems for them. Include scenarios and demonstrations for systems working with classified data.* (Q4 & Q8)

This will be discussed at the upcomming workshop.

2.7 Transfer technology

> *Develop and carry out pilot insertions of the developed technology into existing systems, such as GDE's SOCET SET and Vexcel's mapping system.* (Q5–8)

Work continues on establishing a data path between RCDE and SOCET Set and Vexcel systems.

The recently completed linear delineation system is being supplied to GDE and Vexcel.

3 Meetings and Reports

An IPR was held at SRI 14 August. There were approximately 12 government visitors and representatives from GDE, Vexcel, and SRI.

An SRI/Vexcel TEM took place on 8/20. The next one is scheduled for 11/13.

The APGD workshop is scheduled for 11/19 & 11/20. In addition to SRI, Vexcel and GDE will be attending.

We continue to coordinate efforts through weekly conference calls, in addition to email and in-person meetings as needed.

A GDE Monthly Report

APGD Monthly Report August 10, 1997

SUMMARY: Work during this period has emphasized the selection of baseline building extraction algorithms, definition of a benchmarking procedure and preparation of test data sets.

DETAILED WORK DESCRIPTION (BY SOW ITEM):

1. ARCHITECTURE REFINEMENT: No activity

2. ALGORITHM SURVEY: We are completing a bibliography of building extraction techniques to document our survey.

3. ALGORITHM DEVELOPMENT: Although the USC building algorithm has been tentatively selected as the baseline, we are devoting some effort to extending and solidifying our in- house algorithms for comparison with the baseline and to fill any gaps that may emerge during evaluation and benchmarking.

4. MULTI-SENSOR REGISTRATION: No activity

5. DYNAMIC DATABASE: No activity

6. DATASET PRODUCTION & DISTRIBUTION: The test data sets have been selected from the Fort Benning imagery, and we have begun generating terrain and features using current manual procedures to act as ‘‘ground truth’’. Those data sets will be made available as soon as they are completed.

7. EVALUATIONS: Our building extraction algorithm benchmarking procedure has been completed, documented, and reviewed by the prime. We plan one final technical meeting with the team before presenting it at the upcoming IPR.

8. INTERFACE TO FRE CONTRACTORS: We have scheduled a visit to USC on August 11 to begin the transfer of their building extraction algorithm to our lab. We will begin by transferring the monoscopic algorithm and using it to work out data transfer and format issues. The stereo algorithm, which has tentatively been selected as our baseline, should be available within the next few weeks. Our discussions with UMass have been positive, but lack of funding on their part will prevent transfer of their Ascender system to us at present.

9. DEMONSTRATION SCENARIOS: No activity

10. TECHNOLOGY TRANSFER: No activity

11. OPTION YEARS: No activity

12. PROGRAM MANAGEMENT: We are continuing to work according to the priorities agreed on with the prime. We keep in close contact with team members via weekly conference calls and e-mail communications as appropriate.

Technical Section

Summary

Work during this period has again emphasized building extraction algorithm implementation, preparation of test data sets and algorithm benchmarking.

Detailed Work Description (by SOW Item):

1. Architecture Refinement No activity

2. Algorithm Survey A bibliography representing the scope of our algorithm survey has been delivered to the prime. It refers to the work of six groups in the U. S. and seven in Europe.

3. Algorithm Development We have continued work on our confidence measure for reducing editing times.

4. Multi-Sensor Registration No activity

5. Dynamic Database No activity

6. Dataset Production & Distribution Work continues on extracting the features from the identified test areas to serve as ground truth for algorithm benchmarking. A representative subset of the test data will be made available as soon as the feature extraction has been completed and validated.

7. Evaluations We have completed and furnished to the prime a description of the editing environment we anticipate using to determine our cost-of-editing metric.

8. Interface to FRE Contractors We have imported and begun to test our current baseline building extraction algorithm, the stereo algorithm from USC

9. Demonstration Scenarios No activity

10. Technology Transfer No activity

11. Option Years No activity

12. Program Management We are continuing to work according to the priorities agreed on with the prime. We keep in close contact with team members via weekly conference calls, e-mail messages, and face-to-face meetings as appropriate.

B Vexcel Monthly Report

Automatic Population of Geospatial Databases
Monthly Report to SRI for August

Bob Wilson
Vexcel Corporation
21 August 1997

1. MAJOR TECHNICAL ACCOMPLISHMENTS

1.1 Processing Aerial Photography of Ft. Hood to Create "Truth" Dataset for IFSAR Classification and Feature Extraction (in progress)

Despite trying several different photogrammetric techniques, we have been frustrated by the poor quality of the mosaics we have obtained. The originally supplied exterior orientations appear not to be accurate enough to prevent large pixel shifts along the seams of the mosaic. We are continuing to work with Aaron Heller on this problem.

1.2 Organization of SAR/IFSAR Tutorial (in progress)

The short course was scheduled for 18-19 August at Vexcel's new offices. We constructed a program for the course and arranged for the participation of two guest speakers: Paul Eichel (Sandia) and Jakob van Zyl (JPL). Announcements were broadcast via e-mail. A registration packet was prepared and sent out via snail-mail to people who had expressed an interest in the course.

1.3 Documentation of Vexcel's IFSAR Terrain Classification Software

Vexcel has developed a package called IFMAP to perform terrain classification and bald earth extraction for IFSARE data. The developer of this package wrote a description of this software, including requirements, parameters, algorithm descriptions, etc. A preliminary draft of this documentation was e-mailed to SRI in preparation for the IPR (14 August).

1.4 Enhanced Web Sites

SRI told us about the addition of on-line road delineation capability and we tried it out. Wanting to exercise it on some IFSAR imagery and provide access to such imagery to SRI, we added TIFF images of the Ft. Benning MOUT site to our APGD web site. The initial set of images were 1K by 1K coregistered feature layers including magnitude, correlation, elevation, correlation gradient, elevation gradient, RMS magnitude, volume decorrelation, land cover classification, and bald earth elevation. Initial experiments indicated that these data posed a difficult challenge for the road finder.

1.5 Obtaining Ground Truth for Ft. Benning MOUT Site

Ernie Reith (NIMA) has provided us with ground truth for this site. It includes a bald earth DEM and an ground cover classification consisting of Arcinfo vector layers. This will be used at Vexcel to evaluate the IFMAP software. After analyzing these data we plan to make them available

via the web.

2. ACCOMPLISHMENTS VIS-A-VIS STATEMENT OF WORK

2.1 Refine the BOS architecture

2.2 Survey automated model extraction techniques

2.3 Develop feature extraction and consistency enforcement algorithms

There is plenty of this work going on at Vexcel, but it has not yet received support under the APGD contract.

2.4 Refine the design of and implement the dynamic database

2.5 Produce, maintain, and distribute datasets and ground truth

1.1, 1.4, and 1.5

2.6 Develop evaluation metrics and perform evaluations

2.7 Interface to FRE contractors

1.2

2.8 Develop and perform demonstrations

2.9 Transfer technology

2.10 APGD program management

weekly conference calls and this monthly report

No travel for APGD took place in the month of July. Next month labor charges will show a spurt due to the SAR/IFSAR tutorial.

Automatic Population of Geospatial Databases
Monthly Report to SRI for September

Bob Wilson
Vexcel Corporation
20 October 1997

1. MAJOR TECHNICAL ACCOMPLISHMENTS

1.1 Evaluation of IFMAP Bald-Earth Algorithm

Vexcel obtained from NIMA a "ground truth" DEM for a 2.5 by 2.1 km region covering the McKenna MOUT site. (The truth data set is very smooth and differs noticably from the USGS contour plot of the same site.) The IFSARE data and truth data were coregistered at 2.5 m elevation postings and comapred by computing the difference. To our suprise the initial average difference was 24.7 m! Eventually this was traced to a geoid height difference of 25 m. The IFMAP software has been modified to automatically extract this parameter from the IFSARE ASCII annotation file. The correlation coeffifient between the two DEMs was 0.91. In general, the difference between the two DEMs was (es expected) largest for pixels classified as "elevated." In these tests, IFMAP (on average) underestimated the heights of trees by 3 m; additional tests are in progress. (Only some of this testing is funded by APGD.)

1.2 Supplied Ft. Hood IFSARE data to USC

The Ft. Hood IFSARE data were sent to Andreas Huertas on 8 mm tapes. In response to his many questions concerning the data, Vexcel also provided a (Postscript) copy of ERIM's "IFSARE Data Format Description."

2. ACCOMPLISHMENTS VIS-A-VIS STATEMENT OF WORK

2.1 Refine the BOS architecture

2.2 Survey automated model extraction techniques

2.3 Develop feature extraction and consistency enforcement algorithms

There is plenty of this work going on at Vexcel, but it was not supported under the APGD contract in September. (Such work has begun in October.)

2.4 Refine the design of and implement the dynamic database

2.5 Produce, maintain, and distribute datasets and ground truth

1.2

2.6 Develop evaluation metrics and perform evaluations

1.1

2.7 Interface to FRE contractors

1.2

2.8 Develop and perform demonstrations

2.9 Transfer technology

2.10 APGD program management

weekly conference calls and this monthly report