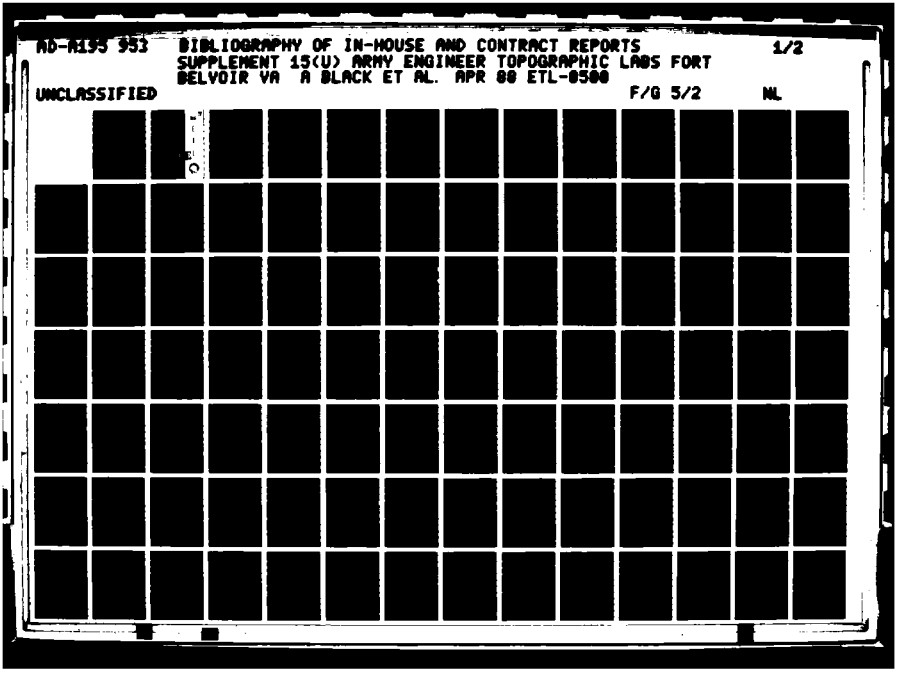
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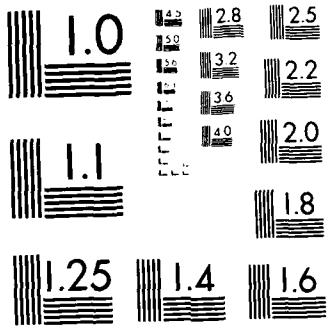

MICROCOPY RESOLUTION TEST CHART
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Bibliography of In-House and Contract Reports, Supplement 15

Annemarie Black
E. James Books
Karen Carroll

April 1988

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060-5546

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This is Supplement 15 to the ~~ETL~~ *Bibliography of In-House and Contract Reports*. This supplement provides author and title indexes, abstracts, and AD numbers for the 1986 and 1987 additions to the continuing bibliography. It also contains a complete title index designed to be used in conjunction with the 15 published bibliographies and refers to them by year and number.

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PREFACE

This is Supplement 15 to the report titled, "Bibliography of In-House and Contract Reports" AD-877 653L; Supplement 1, AD-890 066L; Supplement 2, AD-905 548L; Supplement 3, AD-B005 275L; Supplement 4, AD-B010 642L; Supplement 5, AD-B019 966L; Supplement 6, AD-055 468; Supplement 7, AD-A068 744; Supplement 8, AD-A084 111; Supplement 9, AD-A099 803; Supplement 10, AD-A113 006; Supplement 11, AD-A128 400; Supplement 12, AD-A141 778; Supplement 13, AD-A160 607; and Supplement 14, AD-A173 750. It is a continuing bibliography of reports prepared by and for the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia. This bibliography includes reports that were published from 1 January 1986 through 31 December 1987.

Reports with AD numbers can be purchased by Department of Defense agencies from the Defense Technical Information Center; other agencies and individuals can purchase copies from the National Technical Information Service, Springfield, Virginia 22161-2171. Reports with a "B" in the AD number are limited in distribution to U.S. Government agencies unless permission for release is granted from the controlling office. Reports are available on an interlibrary loan from the Scientific and Technical Information Center, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia 22060-5546.

COL Alan L. Laubscher, EN, was Commander and Director, and Mr. Walter E. Boge was Technical Director of the Engineer Topographic Laboratories during the report preparation.

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ETL-0392 AD-B113 792L

ADVANCED DEVELOPMENT PROTOTYPE (ADP) FOR THE QUICK RESPONSE MULTICOLOR PRINTER (QRMP)
May 1987

Green, Dale L. Froelich, Ronald W. Lehmann, Ernest H.
Griffin, Gordon R. Strobele, Caljon H.
Nothmann, Gerhard A. Davidson, James R.

Xerox Corporation

DAAK70-80-C-0112

Keywords: Map Printer, Color Xerography, Quick-Response Color Reproduction, Color Laser Printer, Color Image Processing, Laser Scanning Xerography, Laser Reprography, Color Reproduction

The report discusses the design, fabrication and testing of an Advanced Development Prototype (ADP) for the Quick Response Multicolor Printer (QRMP). The ADP is a color electronic reproduction system which produces high quality 24- by 30-inch copies of maps, terrain analysis printouts, photographs, and similar products. For the field Army, the QRMP will be able to quickly provide full color copies of these products on high wet strength paper. The ADP can reproduce a color map sheet in 1 minute or produce 75 full color copies per hour.

ETL-0400 AD-A168 347

TECHNIQUES TO IMPROVE ASTRONOMIC POSITIONING IN THE FIELD
December 1985

Baldini, Angel A.

Keywords: Astronomic Positioning Observations and Computations, Effects of Instrumental Errors

This paper deals with new methods and techniques for improving astronomic positioning in the field. Latitude and longitude are obtained by observing transit times of pairs of stars over a fixed vertical plane, independent of azimuth and zenith distances. A unique solution is derived for each pair. Higher accuracy in latitude can be obtained by observing transit times of star pairs over the prime vertical, where the parallactic angle reaches its maximum value. The vertical plane of observation can be fixed within 90 arc seconds with respect to the prime vertical without changes in the star's parallactic angle, and a function of it, the latitude, can then be computed. The star transit times over different vertical lines are thereby reduced to the central line of collimation plane, as a function of the parallactic angle. Higher accuracy in longitude can be achieved by observing the transit times of pairs of stars over a vertical plane fixed within 20 arc minutes with respect to the meridian plane. Each individual star pair will determine a solution. Since each pair does not depend on azimuth orientation, the star pairs can be chosen arbitrarily with respect to declination or zenith distance, and short periods of clear sky observations can be utilized. When several pairs are observed an adjustment can be carried out through the equations of conditions that allow one to detect errors in either the transit times or in the star's right ascensions.

ETL-0401 AD-B101 097L

SYNTHESIS GUIDE FOR HELICOPTER LANDING ZONE AND DROP ZONE SITES
December 1985

Falls, Robert A.

Keywords: Helicopter Landing Zone, Drop Zone, Topographic Map, Factor Overlay, Synthesis, Terrain Analysis

This report provides a step-by-step instruction for synthesizing helicopter landing zones and drop zones from previously prepared terrain factor overlays. The synthesis procedure is essentially manual and relies on precalculated tables and nomagraphs to produce a map-like terrain product for fully loaded aircraft.

ETL-0413 AD-B101 706L

AUTONOMOUS LAND VEHICLE
July 1986

Lowrie, J. Greunke, R.
Gremban, K. Thomas, M.
Gothard, B. Koenig, R.
Celvi, G. Rehn, R.

Martin Marietta, Denver Aerospace **DACA76-84-C-0005**

Keywords: Robotics, Image Understanding, Unmanned Vehicles, Automation, Artificial Intelligence

The Autonomous Land Vehicle (ALV) project is sponsored by the Defense Advanced Research Projects Agency as part of its Strategic Computing (SC) Program. Its purpose is to advance the state of the art in artificial intelligence, image understanding, and advanced computer architectures and to demonstrate the applicability of these technologies to advanced military systems. The Strategic Computing Program is separated into three primary areas--technology base, applications, and infrastructure. The ALV project is one of the SC program's application areas aimed at advancing and demonstrating the state of the art in autonomous navigation.

ETL-0414 AD-A164 304

ASTROGEODETIC-INERTIAL METHODS FOR VERTICAL DEFLECTION DETERMINATION

December 1985

Bose, Sam C.

Applied Science Analytics, Inc.

DACA72-84-C-0017

Keywords: Inertial Surveying, Deflections of the Vertical, Astrogeodetic Observations, Azimuth Observation, Inertial Error Models, Kalman Filter Updating, Statistical Collocation, Least Squares Estimation

Considerable progress has been made in inertial surveying by the Position and Azimuth Determining System (PADS) developed by Litton Systems, Inc., for the U.S. Army Engineer Topographic Laboratories (ETL). Following the installation of an improved vertical accelerometer and other modifications, the PADS has been renamed Inertial Positioning System (IPS). The IPS, with some software changes as to gyro error control, has served as the Rapid Gravity Survey System (RGSS) for ETL. The present RGSS operates as a quasi-local level system and permits Kalman stochastic error control using observed velocity errors at vehicle stops. A new optimal data reduction method for estimating the deflections of the vertical is presented. The method requires RGSS horizontal velocity errors at each stop and the inertial system real-time Kalman filter update gains. Storage of real-time covariance data is not necessary. Survey traverse initial and terminal astrogeodetic deflections are utilized along with terminal platform azimuth error observation to estimate approximate gyro biases. The error models used preserve the inertial system dual horizontal interaction and exploit statistical collocation techniques to preserve correlations between the two components of the deflection of the vertical which are least squares estimated using all data simultaneously.

ETL-0415 AD-B098 897L

AN EXPERT SYSTEM FOR THE COMPUTER-ASSISTED IDENTIFICATION OF FEATURES ON SAR IMAGERY
January 1986

Pascucci, Richard F.

Autometric, Incorporated

Keywords: Expert System, SAR Imagery, Knowledge Base, Descriptor Sets, Computer Vision, Condition/Action Rules

This investigation tested and validated descriptor sets that had been compiled in an earlier investigation. The research project then went on to develop the basis for an expert system that consists of (1) a knowledge base containing expert radar image analysts' units of knowledge in the form of feature descriptors along with condition/action rules for combining the descriptors into sets that are formulated as complex Boolean expressions containing the logical operators AND, OR, and NOT; and (2) an automated inference engine that decomposes the complex Boolean expressions into simple AND statements and applies if-then rules to the knowledge base, thereby inferring the identification of features from the AND-statement descriptor sets. In the system's present form, SAR imagery is examined by image analysts who record feature descriptors and enter them into the knowledge base. The goal of ensuing phases of the investigation will be to develop computer vision techniques that will recognize these descriptors and enable the system to perform automated feature recognition.

ETL-0416 AD-A170 138

WORLD WEATHER EXTREMES
December 1985

Riordan, Pauline
Bourget, Paul G.

Keywords: Extremes, Weather, Weather Observations, Meteorological Charts, Temperature, Precipitation (Meteorology), Atmospheric Pressure, Solar Radiation, Wind (Meteorology), Weather Intelligence, Humidity, Fog, Thunderstorms

This report consists of a worldwide map of weather extremes and a separate map for the United States and Canada, with comments on the reliability of the records shown. Included are highest and lowest temperatures, largest temperature variations, greatest and least amounts of precipitation for various durations, maximum precipitation variabilities, greatest thunderstorm frequencies, highest and lowest atmospheric pressures, highest solar radiation, largest and heaviest hailstones, greatest snowfalls, highest wind speeds, high dew point, and most frequent occurrences of fog. Where appropriate, the value for the highest and lowest annual mean is also given. As far as possible, the records are taken from official sources, and all of them are documented. Conditions of site, instrumentation, observational procedure, and other factors such as environmental and meteorological conditions pertinent to the reliability of extremes are discussed.

ETL-0417 AD-A168 337

RESEARCH IN EXPERT INTERACTIVE CARTOGRAPHIC SYSTEMS
May 1986

Hanson, Andrew J.

SRI International DACA72-85-C-0008

Keywords: Spatial Reasoning, Cultural Object Detection, Image Segmentation

We have carried out a research program in the application of interactive environments to the development of knowledge-based methods for image understanding. As a sample domain, we chose to work mainly on the problem of locating generic cultural objects in aerial imagery. The discovery of such objects was accomplished by defining a generic model for rectilinear objects, along with rules for parsing the image geometry and correcting probable errors of the segmentation algorithm. These tools permit the semantic resegmentation of an initial syntactic scene partition to yield well-delineated buildings. The method owes its success to the combined utilization of both high-level and low-level knowledge about the target object context and the image.

ETL-0418 AD-A168 376

CUMULATIVE PROBABILITY TABLES FOR TESTING CONSENSUS IN RANKING EXPERIMENTS
May 1986

Crombie, Michael A.
Webb, Jennifer

Keywords: J-Statistic, Monte Carlo, Ranking Experiments, Consensus

Probability tables are provided that will enable analysts to test for consensus among N judges when comparisons are made R at a time of M items. The purpose of the tables is to provide a statistical basis for determining whether rank ordering of alternatives can best be determined by reviewing the M options all at once or ranking R<M at a time.

ETL-0419 AD-A172 315

CONVERSION OF THE CALAP PROGRAM FROM FORTRAN TO DUCK
Final Report
September 1986

Corporate Authorship

Smart Systems Technology, Incorporated DAAK70-82-C-0027

Keywords: CALAP, DUCK, Artificial Intelligence, Logic Programming

An expert advisor program named CALAP (Computer Aided Landform Analysis Program) was developed by Dr. Robert Leighty, working at the U.S. Army Engineer Topographic Laboratories. The original program was developed in FORTRAN on an HP-1000, a minicomp· ter. CALAP was reprogrammed in an Artificial Intelligence (AI) language called DUCK. DUCK is a Logic Programming Language developed at Yale by Prof. Drew McDermott. CALAP has previously been translated into another AI language called OPS5. The experience of translating CALAP to DUCK is documented here.

ETL-0420 AD-A171 575

DEFENSE MAPPING AGENCY ADVANCED RASTER-TO-VECTOR BENCHMARK TESTING
June 1986

Selden, David D.

Battelle Memorial Institute DAAG2°-81-D-0100-1801

Keywords: Raster-to-Vector, Cartographic Data Capture, Benchmark Testing, Scanning, Editing, Error Detection/Correction

Battelle Columbus Division in cooperation with the U.S. Defense Mapping Agency and U.S. Army Engineer Topographic Labs has developed a methodology for testing and evaluation of automated cartographic editing functions provided by cartographic data capture systems. Editing functions include gap closure, spike removal, "snow" removal, node snapping, centerline adjustment, etc. These functions are often implemented in three modes: automatic, computer-assisted, and manual. The Battelle benchmark testing method focuses on automated editing. The testing and evaluation method consists of a single analog (film positive) edit test sheet and a series of test procedures. The edit test sheet portrays a column of cartographic patterns with anomalous versions of these cartographic geometries arrayed in rows to their right. Different lineweights and pattern orientations are also utilized. The full range of editing functions are applied to the data to test for rates of success and sensitivity to geometry, lineweight, and orientation.

ETL-0421 AD-B103 847L

SIMPLIFIED ELECTROSTATIC COLOR PRINTING
June 1986

Chou, Hsin-hsin
Kidnie, Kevin M.
Mikelsons, Valdis

3M

DACA72-85-C-0016

Keywords: Mapping, Digital Systems, Electrostatic Printing, Plotters, Cartography, Graphics

The potential of the "direct" and "transfer" imaging methods for high quality multicolor electrostatic printing has been evaluated on the basis of experimental work done in this laboratory and on information available in open literature.

The liquid development process and the subsequent image drying step appear to be the limiting factors for the rate at which full-color images can be generated. Sharp, brightly colored images with good color transparency have been produced on a thermoplastic receptor surface. The "transfer" process was selected as the imaging method of choice because of easier color registration and, possibly, lower sensitivity to ambient relative humidity effects.

ETL-0422 AD-A169 609

IBIS QUERY -- SOFTWARE TO SUPPORT THE IMAGE BASED INFORMATION SYSTEM (IBIS) EXPANSION FOR MAPPING, CHARTING, AND GEODESY

June 1986

Friedman, Steven Z.
Walker, Richard E.
Aitken, Robert B.

Jet Propulsion Laboratory

Keywords: Geographic Query, Spatial Data, Polygon Overlay

The Image Based Information System (IBIS) has been under development at the Jet Propulsion Laboratory (JPL) since 1975. It is a collection of more than 90 programs that enable processing of image, graphical, and tabular data for spatial analysis. IBIS can be utilized to create comprehensive geographic data bases. From these data, an analyst can study various attributes describing characteristics of a given study area. Even complex combinations of disparate data types can be synthesized to obtain a new perspective on spatial phenomena.

In 1984, new query software was developed enabling direct Boolean queries of IBIS data bases through the submission of easily understood expressions. An improved syntax methodology, a data dictionary, and display software simplified the analysts' tasks associated with building, executing, and subsequently displaying the results of a query. The primary purpose of this report is to describe the features and capabilities of the new query software. A secondary purpose of this report is to compare this new query software to the query software developed previously (Friedman, 1982). With respect to this topic, the relative merits and drawbacks of both approaches are covered.

ETL-0423 AD-B105 842L

ELECTRONIC PRINTING SYSTEMS

July 1986

Gladden, James W.

Keywords: Battelle's GSC Process, Digital Maps, Electronic Printing Systems, Ink Jet Printing, Ionographic Printing, Laser Color Photography, Laser Xerography, Magnetic Printing, Non-Impact Printing, Thermal Transfer Printing

A technical review is given of different electronic printing systems that analyzes the systems for suitability in Quick Response Multicolor Printing. The systems treated include ink jet printing, ionographic printing, laser color photography, laser xerography, magnetic printing, and thermal transfer printing. The respective electronic printing systems are compared and contrasted.

ETL-0424 AD-A173 601

SPARSE AREA STEREO MATCHING EXPERIMENT
July 1986

Crombie, Michael A.

Keywords: X-Parallax, Optimum Resolution, Y-Parallax, Cooperative Processing, Digital Imagery, Semiautomatic Processing

The algorithm used in this experiment is considered by many to be state-of-the art for calculating x-parallax over rural regions. Even so, its output must be refined in sparse areas in order to meet accuracy requirements. The major result of this experiment showed that x-parallax should be measured from digital imagery containing no more than 10 line pairs per millimeter.

ETL-0425 AD-A170 884

INTEGRATION OF ARTIFICIAL INTELLIGENCE CONCEPTS INTO THE METHODS FOR EXTRACTING LINE OBJECTS FROM MONOCHROMATIC AERIAL IMAGERY
March 1986

Kazmierczak, H.

European Research Office **DAJA45-84-C-0014**

Keywords: Automatic Image Processing, Object Extraction, Artificial Intelligence Aspects, Digital Elevation Data

Procedures for automatic extraction of line shaped objects from aerial images have been improved and completed. A general model of road network has been used to complete road extraction from images. Digital elevation data has been used to guide the process of river and creek extraction from images. The methods have been implemented on a DEC VAX 11/780. The functions are described in detail. Test results and assessment are included in the report.

ETL-0426

AUTOMATIC CORRELATION OF USGS DIGITAL LINE GRAPH GEOGRAPHIC FEATURES TO GNIS NAMES DATA
August 1986

Heard, Andrew M.

Battelle Memorial Institute

DAAG29-81-D-0100

Keywords: Artificial Intelligence, Automated Cartography, Automated Map Generation

An accelerating interest in automatic name placement has revealed a growing need for the creation of cartographic data bases. An effort has been made to create such a data base from two extant types of digitized United States Geologic Survey map data. Features are defined by geographic data stored as graphic elements in the USGS 1:2,000,000 Digital Line Graph data files. These features are then used as a set *onto* which names extracted from the Geographic Names Information System data files are mapped. This mapping serves as a cartographic data base, supplying both a label and a graphic description of specific geographic features. Automatic generation of this data base draws nearer the realization of automated map generation.

ETL-0427

A STATE-OF-THE-ART ASSESSMENT OF AUTOMATIC NAME PLACEMENT
August 1986

Freeman, Herbert

Battelle Memorial Institute

DAAG29-81-0100

Keywords: Artificial Intelligence, Automated Cartography, Automated Map Generation

This report reviews the state of the art of map name placement. A literature survey is provided of all the recent publications dealing with this topic. Some good-quality experimental systems are currently available; however, considerable further development is required before a fully automatic name placement system will be available that approaches the aesthetic quality obtainable from experienced manual placement.

ETL-0428 AD-B106 994L

KNOWLEDGE-BASED VISION TECHNIQUES-- TASK B: TERRAIN AND OBJECT MODELING RECOGNITION

August 1986

Lawton, Daryl T.
Levitt, Tod S.
Glicksman, Jay
McConnell, Christopher C.
Miltonberger, Thomas E.
Muller, Hans E.
Nelson, Philip C.
Neveu, Charles F.

Advanced Decision Systems

DACA76-85-C-0005

Keywords: Model-Based Vision System, Terrain Modeling, Schema-Based Reasoning, Perceptual Processing, Image Understanding Tools, Spatial Representation, Hypothesis Management, Navigation, Image-To-Map Matching

This report describes research in perceptual processing and object modeling for several tasks necessary for the functioning of an Autonomous Land Vehicle. These include terrain classification, object recognition, automatic landmark extraction and recognition, and representing *a priori* and derived information about the environment in a spatial map that can be updated and also represent the uncertainty of perceptual inferences.

Key results include:

-Design of a vision system architecture and the implementation of a supporting environment and system components for experimentation. These include data bases and a uniform query mechanism for extracted perceptual structures, grid-based and object-based terrain models, and rules for perceptual processing and instantiating object models.

-Development of schemas and schema networks for modeling and recognizing objects and terrain.

-Development of recognition processes using perceptually-based grouping processes controlled by heuristic measures of interestingness. This allows for recognition to be an active process and for instantiating qualitative predictions made from instantiating object models.

-Development of a two-dimensional edge operator and ribbon-extraction algorithms.

-Demonstration of terrain, tree and road modeling, prediction, and recognition.

-Design and implementation of the Perceptual Structures Data Base (PSDB), automatic query compilation for PSDB access, and novel grouping processes to operate on PSDB information.

-Design of a calculus for spatial reasoning.

-Implementation of transformations and data base technology for long term grid, overlay, and landmark data.

-Demonstration of landmark recognition and model-based road-following from the Martin Marietta test site.

ETL-0429 AD-A170 979

INVERSE PERSPECTIVE OF A ROAD FROM A SINGLE IMAGE
August 1986

DeMenthon, Daniel

University of Maryland DACA76-84-C-0004

Keywords: Computer Vision, Autonomous Navigation, Road Following

A method is presented for reconstructing the geometry of a road from a single image of the road. The road is modeled as a space ribbon defined by a spine (centerline) and generators which are horizontal line segments cutting the spine at their midpoint at a normal angle. Properties of two neighboring generators of such a ribbon are examined, and it is found that if a generator is known, a neighbor is completely defined if one of its ends is known. The proposed method uses this property to reconstruct the visible part of the world road, by iteratively finding a series of generators. The proposed method is tested against a simple method which assumes that the ground is flat and against another method which uses vanishing points.

ETL-0430 AD-B104 556L

THE AUTONOMOUS LAND VEHICLE 1ST QUARTERLY REPORT
May 1986

Lowrie, James

Martin Marietta, Denver Aerospace DACA76-84-C-0005

Keywords: Autonomous Navigation, Computer Vision, Road Following

The report covers problems and progress on the Autonomous Land Vehicle (ALV) Project at Martin Marietta during the first quarter of 1986, approximately January to April, and summarizes plans for the second quarter of 1986. This report provides a description of the basic road-following software system as developed for the November 1985 and May 1986 demonstrations, specifically the reasoning and vision software. The physical vehicle and its electronics have remained largely unchanged from the configuration outlined in the 1985 ALV Annual Report. The focus of this quarterly report is road-following software. In addition, research on advanced architectures to support 1987 and beyond demonstration requirements is included.

ETL-0431 AD-B105 997L

KNOWLEDGE-BASED VISION TECHNIQUES
August 1986

Tseng, D. Y. Vilnrotter, F. M.
Daily, M. J. Reiser, K.
Olin, K. E.

Hughes Aircraft Company DACA76-84-C-0007

Keywords: Computer Vision, Obstacle Detection, Obstacle Avoidance, Virtual Sensors, Knowledge Representation

The Hughes system is designed to achieve the perceptual requirements of the Autonomous Land Vehicle (ALV) for navigation in an unconstrained outdoor environment. The system reflects the new approaches needed to perform image understanding in support of an ALV planning and navigation system. The Hughes Obstacle Avoidance system is a multilevel knowledge-based perception system capable of extracting features from sensed images as well as reasoning about perceived objects. Each layer of the system reflects a different level of data assimilation versus data immediacy. Reasoning about expected world objects is performed by both the perception and planning systems, and provides the most consistent world model at each level. The system supports temporal understanding and sensor fusion as required for obstacle avoidance maneuvers.

This report documents the first year of effort for the Knowledge-Based Vision Techniques contract. It includes a discussion of the conceptual design of the multilevel perception system, the feature extraction algorithms developed for obstacle detection with laser range and color imagery, and the merging of multisensor information into a local map to be used for avoidance planning and maneuvering.

ETL-0432 AD-A171 618

VISION-BASED NAVIGATION FOR AUTONOMOUS GROUND VEHICLES
1986 ANNUAL REPORT
August 1986

Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Autonomous Navigation, Road Following, Computer Vision

This is an annual report for the project "Vision-based navigation for autonomous ground vehicles" being conducted under Contract DACA76-84-C-0004 (DARPA Order 5096) for the period 1 July 1985 through 30 June 1986. The project to date has focused on three tasks: (1) support of Martin Marietta as the Autonomous Land Vehicle (ALV) integrating contractor, (2) development of a vision system for autonomous navigation of roads and road networks, and (3) experiments using this vision system on the ALV. Progress on each of these topics is described in this report.

ETL-0433 AD-A171 561

A PROGRAMMING ENVIRONMENT FOR PARALLEL VISION ALGORITHMS
August 1986

Brown, Christopher

University of Rochester DACA76-85-C-0001

Keywords: Parallel Processors, Butterfly Computer, Computer Vision

During the first year of the award period, the Computer Science Department of the University of Rochester has pursued three main lines of work: systems support algorithms, butterfly programming environment, and vision applications. Today's multiprocessor computer architectures are not efficiently programmed or even conceptualized with standard computer languages, and their operating systems and debugging tools are also challengingly different. The University of Rochester is doing work in the area of tools for controlling large-grain parallelism, as one finds in a distributed multiprocessor application like the Autonomous Land Vehicle, or in tightly coupled processors like the Hypercube or the Butterfly Parallel Processor.

ETL-0434 AD-A173 750

BIBLIOGRAPHY OF IN-HOUSE AND CONTRACT REPORTS, SUPPLEMENT 14
August 1986

Books, E. James
Fox, Margaret F.
Holmes, Alice L.

Author and title indexes are provided for the ETL *Bibliographies of In-House and Contract Reports*. The indexes are designed to be used in conjunction with the 14 published bibliographies: AD-877 653L (1970); AD-890 066L (1971); AD-905 548L (1972); AD-B005 275L (1975); AD-B010 642L (1976); AD-B019 966L (1977); AD-A055 468 (1978); AD-A068 744 (1979); AD-A084 111 (1980); AD-A099 803 (1981); AD-A113 006 (1982); AD-A128 400 (1983); AD-A141 778 (1984).

ETL-0435 AD-A173 883

AN EDGE DETECTION EXPERIMENT USING THE MARR OPERATOR
August 1986

Crombie, Michael A.
Bosch, Edward H.

Keywords: Edge Detection, Marr Operator, Binary Image-Processing

An edge detection experiment using the MARR operator was conducted at ETL to determine if the operator could be used in an interactive manner to extract well-defined edges from noisy pictures. Three binary image-processing functions, namely, line thinning, line thickening and clutter removal were found to be useful tools in the interactive process. The results of the experiment demonstrate that the MARR operator was not biased and performed as well as the Prewitt and Haralick operators, all of which is contrary to an experiment conducted by Haralick where the operator was used incorrectly.

ETL-0436 AD-B106 844L

THE AUTONOMOUS LAND VEHICLE 2ND QUARTERLY REPORT
September 1986

Lowrie, James

Martin Marietta, Denver Aerospace DACA76-84-C-0005

Keywords: Autonomous Navigation, Computer Vision, Road Following

The report covers problems and progress on the Autonomous Land Vehicle (ALV) Project at Martin Marietta during the second quarter of 1986, approximately April to July, and summarizes plans for the third quarter of 1986. A description of the new parallel processing computer hardware architecture designed for phased implementation on both the vehicle and in the research lab, in preparation for the 1987 ALV demonstration and technology status review, is provided. Performance of the video data processing portion of the perception subsystem has been improved through the implementation of a processing technique labeled "power windows," which is detailed. A correlator is described which has been designed to aid the navigator. In addition, data collection by the Environmental Research Institute of Michigan (ERIM) at Martin Marietta in support of the ALV project is continuing.

ETL-0437 AD-A173 209

DYNAMIC IMAGE INTERPRETATION FOR AUTONOMOUS VEHICLE NAVIGATION

September 1986

Riseman, Edward M.
Hanson, Allen R.

University of Massachusetts

DACA76-85-C-0008

Keywords: Scene Interpretation, Sensor Motion, Spatial Reasoning

The University of Massachusetts Autonomous Land Vehicle Project has been concerned with a variety of problems associated with sensor motion analysis and dynamic image interpretation for autonomous navigation.

In particular, our research has the following long-range research goals that relate to Task D in the autonomous vehicle navigation program:

1. Determine the motion parameters of a sensor relative to the static environment.
2. Distinguish moving objects from the static environment and determine their motion parameters.
3. Develop algorithms for tracking and predicting the motion and environmental location of the sensor and moving objects.
4. Build a reliable depth map of the environment from combined motion, stereo, and laser range data.
5. Identify major objects (both static and moving) in the environment while the sensor is either stationary or in motion.
6. Interpretation of the environment (i.e. object identification in road scenes) to provide constraints for identifying and tracking moving objects.
7. Provide information to update an environmental model of the moving sensor, including location of the sensor, other moving objects and distinguished stationary objects.
8. Provide control information to an expert navigational and spatial-reasoning system for the purposes of path planning and obstacle avoidance.
9. Integrate all of the above capabilities into a flexible and extensible system for dynamic scene interpretation.

ETL-0438 AD-A175 103

THE HOUGH TRANSFORM ON THE BUTTERFLY AND THE NCUBE
September 1986

Chandran, Sharat
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Parallel Implementation, Butterfly Parallel Processor, NCUBE, Hough Transform

This report describes the parallel implementation of the Hough Transform, a technique to detect colinear edge points. Specifically, two contrasting architectures, the Butterfly Parallel Processor, essentially a shared memory machine, and the NCUBE, a direct connection machine in which processors are interconnected in the form of a hypercube, are considered.

Developing parallel Hough transform algorithms involves addressing questions of optimal processor allocation and parallel "peak" selection in image neighborhoods. Fast, practical algorithms (subject to inherent lower bounds) are presented, and relevant complexity issues are discussed.

ETL-0439 AD-B107 697L

KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM
September 1986

Fischler, Martin A.
Bolles, Robert C.

SRI International DACA76-85-C-0004

Keywords: Knowledge Representation, Computer Vision, Mission Planning, 3D Descriptions

The goal of this research is to develop techniques for representing knowledge about complex cultural and natural environments so that a computer vision system can successfully recognize key navigational features, such as roads, bushes, cliffs, and buildings. Our research strategy is to (1) develop representations and techniques for storing (or incrementally learning) semantic and geographic information about a specific geographic area to permit both mission planning and knowledge-based interpretation of sensed data, (2) develop representations for natural and man-made objects, (3) develop techniques to predict distinctive features of these objects that can be used to identify them, and (4) develop techniques for building three-dimensional descriptions of an environment from data gathered by range or intensity sensors moving through this environment. In this report we describe our progress and plans in these areas.

ETL-0440 AD-A183 548

DETERMINING AN AZIMUTH WITH A GYROTHEODOLITE
October 1986

Logan, Kevin P.

Keywords: Gyrotheodolite, WILD GAK1, Azimuth Determination, Survey Procedures

This report is intended as a practical guide to surveyors for making measurements to determine an azimuth using a gyrotheodolite. This report gives a brief description of how the gyro works, improved observing procedures for its use, and the results of field observation. Accuracies of ± 5 arc seconds can be obtained.

ETL-0441 AD-A183 812

SIMPLE ANALYTICAL METHODS FOR ESTIMATING SHORT-TERM RAINFALL
November 1986

Wexler, Ruth L.

Keywords: Climatic Index, Daily Rainfall, Hourly Rainfall, Instantaneous Rainfall, Rainfall Distributions, Rainfall Models, Short-Term Rainfall

Information on short-term rainfall is of interest to agriculturists, hydrologists, geomorphologists, and construction or radar engineers. Short-term rainfall has implication for soil moisture, field operations, electro-optical sensors, and equipment design or malfunction. Military planners are especially concerned with such information because of the impact of rain on mobility and trafficability. Data for rain accumulations over short periods of time are usually not available. Routine climatic precipitation data for much of the world consist of the average monthly and/or annual total amounts of rain and the corresponding number of rain days.

The principal objective of this study is to provide simple analytical methods for recovering the frequency distributions of any short-term rainfall. The required data are the total rainfall for a given period of time and the actual duration of the rain in days, hours, or minutes for estimating daily, hourly, or instantaneous rainfall, respectively. Average annual hourly rainfall may be estimated at times as a function of mean annual temperature. Instantaneous rainfall is limited in this study to 1-hour storms or rainy periods within storms.

Two rainfall models are provided. The first, the general model, is based mainly on a particular skew distribution that was found previously to represent rainfall under very diverse conditions. This model recovers a considerable range of information for almost any rainfall occurrence. The second, or explicit, model is specific for a given average rain rate. The latter model may be utilized for situations not covered by the general model or as an alternate method. In contrast to certain of the earlier techniques, the above models (a) depend on viable rainfall mass distribution for the situation at hand and (b) determine

short-term rainfall, first with respect to the percent frequency of the total duration of the rain and then with respect to real time.

The results yield reasonably accurate short-term rain rates for nearly 98 percent of the rain period. Either model readily determines the percent of time the average rain rate or any selected rain rate is equalled or exceeded. Of significance is the fact that the mean daily, hourly, or instantaneous rain intensity for any duration tends to be greatly exceeded for at least 5 percent of the time. The graphs and computer programs given not only facilitate the rapid estimation of short-term rainfall for almost any situation, but also serve to improve understanding of short-term rainfall spectra.

ETL-0442 **AD-A183 370**

CLASSIFICATION OF SELECTED RADAR IMAGERY PATTERNS USING A BINARY TREE CLASSIFIER
October 1986

Fox, Neil D.

Keywords: Binary Decision Tree, Bayes Classifier, Radar Imagery, Feature Selection

This report details the results of classifying radar imagery using a binary tree classifier. It was found that this classification algorithm works well with radar imagery, which would indicate a normal (Gaussian) feature vector distribution. The number of elements in each feature vector is the limiting factor; classification time is negligible once the tree structure has been created.

ETL-0443 **AD-A183 537**

PATTERN CLASSIFICATION TECHNIQUES APPLIED TO HIGH RESOLUTION, SYNTHETIC APERTURE RADAR IMAGERY
November 1986

Hevenor, Richard A.
Chen, Pi-Fuay

Keywords: Radar Imagery, Pattern Recognition

This report describes the application of 10 pattern classification techniques to selected samples of high resolution, synthetic aperture radar imagery taken over the Huntsville, Alabama, area. Sections of the radar imagery were digitized and stored on a digital disk unit. A Lexidata system 3400 image processor and a Hewlett Packard 1000 computer were used to display the images on a cathode ray tube and to take 100 samples for each of four terrain classes from the imagery. The 400 image samples were then used as training sets to derive the 10 classifiers. Once the classifiers were derived, the training set data were then used as input to the classifiers to see how well each would do in classifying the original training sets.

ETL-0444 AD-B107 142L

RESEARCH IN KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM
September 1986

Nevatia, R.
Price, K.

University of Southern California DACA76-85-C-0009

Keywords: Autonomous Land Vehicle, Motion Analysis, Target Detection and Description, Knowledge-Based Vision

This report describes our research in motion analysis and estimation techniques for the period of June 1, 1985 to May 31, 1986. This research is of particular relevance to the DARPA Autonomous Land Vehicle (ALV) program, but should also be of other general utility.

Our approach to detecting and tracking motion is to extract and match features, such as lines and regions, from a sequence of images. We present two matching techniques with some results.

We also present two methods for 3-D motion estimation from 2-D image correspondences. One of our methods uses more than two frames; under some assumptions of constancy of motion, the analytical solution is simplified and also shown to be robust to noise.

Our motion detection and estimation techniques exist as separate modules at this time and are not integrated into a complete system. We are currently working on such integration.

ETL-0445 AD-A174 786

DOMAIN-DEPENDENT REASONING FOR VISUAL NAVIGATION OF ROADWAYS
October 1986

LeMoigne, Jacqueline

University of Maryland DACA76-84-C-0004

Keywords: Autonomous Navigation, Road Following, Computer Vision

A Visual Navigation System for Autonomous Land Vehicles has been designed at the Computer Vision Laboratory of the University of Maryland. This system includes several modules, among them a "Knowledge-Based Reasoning Module" that is described in this report. This module utilizes domain-dependent knowledge (in this case, "road knowledge") in order to analyze and label the visual features extracted from the imagery by the Image Processing Module. Knowledge and general hypotheses are given in section 2. The Reasoning Module itself is described in section 3 and results are presented in section 4. Finally, some conclusions and future extensions are proposed in Section 5.

ETL-0446 AD-A183 773

A USER'S GUIDE FOR THE ANALYTICAL PHOTOGRAMMETRIC POSITIONING SYSTEM (APPS)
November 1986

Newbury, George E.

Keywords: Remote Sensing, Analytical Photogrammetric Positioning System (APPS), Stereo Imagery, Stereoplotter

The purpose of this report is to describe the Analytical Photogrammetric Positioning System (APPS) and the Automated Geographic Information System (AUTOGIS). The report describes the recommended approach for using the hardware and software, and gives some examples of projects that may make use of the systems.

ETL-0447 AD-A174 794

DEVELOPMENT OF ELECTRONIC CONTROL OF A SUPERCONDUCTING GRAVITY GRADIOMETER -- PHASE II
November 1986

Paik, H. J.

University of Maryland DACA72-85-C-0010

Keywords: Gravity Gradiometer, Gravity Survey, Inertial Navigation

During the contract period, we have completed the design and assembly of the breadboard feedback circuit for the new NASA superconducting gravity gradiometer. The circuit applies three kinds of feedbacks to the gradiometer instrument: (1) high frequency rejection, (2) cold camping, and (3) force rebalance. The primary purpose of these feedbacks is to increase the dynamic range of the instrument. The circuit has been tested at room temperature and is awaiting a test in connection with the actual gradiometer.

ETL-0448

LOCAL GRAVITY FIELD MODELING
December 1986

Rose, Eugene J.

Keywords: Deflection of the Vertical, Digital Terrain Models, Collocation, Geoid, Geoid Undulation, Geodesy, Gravity, Isostacy, Spherical Harmonics

In this report, an experiment is described wherein a local gravity field model was computed in mountainous terrain using digital terrain data, spherical harmonic coefficients, and local observations. The accuracies of free air gravity anomalies, deflections of the vertical, and geoid undulations computed are discussed.

ETL-0449 AD-B114 172L

SOFTWARE SYSTEM DESCRIPTION FOR MINEFIELD SITE PREDICTION EXPERT SYSTEM
February 1987

Barth, Stephen
Downs, Anne L.
Long, Orrin
Stock, James A.

Par Government Systems Corporation **DACA72-86-C-0017**

Keywords: Expert System, Minefield Site Prediction, Terrain Analysis, Quadtree

This document describes the software system for a Minefield Site Prediction Expert System. The three major components of this system are the expert system, the user interface, and the data base. The main software interfaces described are the Explanation Interface, Advice Interface, Graphic Display Interface, and Attribute Manager.

ETL-0450 AD-B113 785L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM, THIRD QUARTERLY REPORT
November 1986

Lowrie, James

Martin Marietta, Denver Aerospace

DACA76-84-C-0005

Keywords: Autonomous Navigation, Computer Vision, Road Following

The report covers problems and progress on the Autonomous Land Vehicle (ALV) Project at Martin Marietta Denver during the third quarter of 1986, approximately July to November, and summarizes plans for the fourth quarter. In the third quarter, the 1986 Technical Status Review (TSR) was successfully accomplished. The TSR demonstrated perceptual fusion of color video and laser range data for obstacle detection and description (object model), local trajectory planning for obstacle avoidance (using the Martin Marietta Corporation planner and Advanced Decision Systems planner), and obstacle detection at 3 Kph with road following at 17.5 Kph. Prototyping of the hardware components for the new 1987 computer hardware and Local Area Network architecture was initiated. The preliminary design and organization of the Perceptual and Reasoning software subsystems to be implemented on the 1987 architecture was completed.

ETL-0451 AD-A183 493

DEVELOPMENT OF COMPUTER VISION TECHNIQUES FOR AUTOMATIC FEATURE EXTRACTION

January 1987

Gordon, Daniel K.
Pascucci, Richard F.

Autometric, Incorporated

Keywords: Computer Vision, SAR Imagery, Descriptor Sets, Automatic Feature Extraction, Expert System

In previous work, 52 descriptors (feature identifiers) and 501 descriptor sets were identified as being used by image analysts for the characterization of features found in radar imagery. In the research investigation described herein, the descriptor sets were tested and validated. Following this, computer vision techniques were identified and developed to automatically recognize these descriptor sets. The identification procedure includes image preprocessing (e.g. edge enhancement, density slicing, neighborhood encoding and thinning), raster to vector conversion, and the processing of the resultant vector data (e.g. identification of points, lines, and areas, referred to as primitives, including a description of primitive size, shape, position, and orientation). Finally, the relative positions of primitives were examined, and the similarity between groups of primitives and descriptor sets was quantified. The images used were softcopy versions of graphic, line-drawn examples of the descriptors that were identified in the previous work. The computer vision techniques that were developed have been demonstrated successfully, in a tightly controlled environment, on images containing little extraneous information. Research is currently being expanded to include carefully selected, uncluttered radar examples. The final goal of the investigation is the automatic identification of selected features from images acquired under a variety of conditions.

ETL-0452 AD-A184 075

TWO DIMENSIONAL PATH PLANNING WITH OBSTACLES AND SHADOWS

January 1987

Puri, Sunil
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Robotics, Navigation, Path Planning, World Modeling, Vision

A mobile robot navigates with a limited knowledge of its environment because of the restricted field of view and range of its sensors, and the occlusion of parts of the environment in any single image. Most path planning algorithms consider only free regions and obstacles in the robot's world for path planning. The objective of this report is to extend the classical path planning paradigm to include occluded regions. This introduces the new problem of deciding when (or whether) to employ the sensor system during the execution of the path to, potentially, reveal the occluded regions as obstacles or free space for the purpose of replanning.

ETL-0453 AD-A183 754

SHAPE FROM PROJECTING A STRIPE PATTERN

January 1987

Asada, Minoru
Tsuji, Saburo

University of Maryland DACA76-84-C-0004

Keywords: Computer Vision, Robot Vision, Stereo Vision, Surface Orientation

This paper presents a simple method which determines the shape of an object by projecting a stripe pattern onto it. Assuming orthographical projection as a camera model and parallel light projection of the stripe pattern, the method obtains a 2(½)D representation of objects by estimating surface normals from the slopes and intervals of the stripes in the image. The 2(½)D image is further divided into planar or singly curved surfaces by examining the distribution of the surface normals in gradient space. Some applications and evaluation of the error in surface orientation are described.

ETL-0454 AD-A183 756

ON COMPUTING HISTOGRAMS OF IMAGES IN LOG η TIME USING FAT PYRAMIDS
February 1987

Bestul, Thor
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Histogram Computation, Hypercube, Pyramid Algorithm, SIMD Multiprocessor

This paper presents an algorithm for the log η computation of the complete histogram of an η x η gray-level image. It uses a "fat" pyramid implemented on an SIMD hypercube multiprocessor with very high processor utilization. A "fat" pyramid is a pyramid in which the size of a processor associated with a node in the pyramid depends on the level of the pyramid in which the node appears. We describe how to embed fat pyramids in hypercubes using Gray Codes, and then describe the histogramming algorithm.

ETL-0455

IRS: A SIMULATOR FOR AUTONOMOUS LAND VEHICLE NAVIGATION
July 1987

Veatch, Phillip A.
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Computer Simulation, Navigation, Path Planner, Range Image, Vision

IRS is a computer simulation program that provides a software testbed for autonomous navigation algorithms. The program allows the user to describe a complex world built from spheres, parallelepipeds, planar surfaces, cones, and cylinders. The program simulates the movement of an Autonomous Land Vehicle and constructs video and range images based on the ALV's field of view as the vehicle moves through the world. Ground maps of the world, as perceived by the ALV, are also created.

ETL-0456 AD-A183 755

PARALLEL ALGORITHMS FOR COMPUTER VISION
January 1987

Poggio, Tomaso
Little, James

Massachusetts Institute of Technology DACA76-85-C-0010

Keywords: Computer Vision, Connection Machine, Parallel Algorithms

The general goals of this research effort is to explore the potential applications and performance of fine grained computer architectures for vision. The body of this report gives a brief overview of the results of the research during the first 12 months of effort. A taxonomy of parallel vision algorithms has been refined. Parallel versions of several Class 1 algorithms (for early vision, directly derived from regularization methods) have been designed. This preparatory work allowed the implementation of several of these algorithms on the Connection Machine within a few days when it became available to the researchers. Class 2 and 3 algorithms have also been designed, while at the same time studying some of the associated basic problems in recognition and representation.

ETL-0457 AD-A183 859

A PROGRAMMING ENVIRONMENT FOR PARALLEL VISION ALGORITHMS
February 1987

Brown, Christopher

University of Rochester DACA76-85-C-0001

Keywords: Parallel Processors, Butterfly Computer, Computer Vision

During the second year of the award period, the Computer Science Department of the University of Rochester continued work in: 1) systems support algorithms, 2) the Butterfly programming environment, and 3) vision applications. This research produced several internal and external reports as well as much exportable code. The University of Rochester also employed DARPA Parallel Architecture Benchmark problems to test different algorithms using four different Butterfly programming environments. These tests produced several interesting results and demonstrated that the Butterfly architecture is a flexible general purpose architecture that can be effectively programmed by non-experts, using tools developed at BBN and Rochester. The University of Rochester is continuing to study the issues and concerns surrounding the effective implementation of parallel algorithms.

ETL-0458 AD-A188 184

A SMART MAPPING, CHARTING AND GEODESY CONTROL GENERATOR, PHASE I
March 1987

Leberl, Franz W.
Kober, Woody
Harjes, Mark F.

VEXCEL Corporation DACA72-86-C-0008

Keywords: Image Registration, Geographic Information Systems, Automated Control Generation

The real-time automated registration of multi-sensor imagery begins with the generation of control information. A specific application may require the registration of newly acquired data to an existing spatial data base (absolute registration), or to other images of a series (relative registration). This study examines the feasibility and upper-level design of a system capable of providing the control information required for a range of image registration tasks and image types. In general, we suggest that the control generator will be guided by a spatial data base maintaining information about the feature content of the area of interest. A rule-based query generator will extract candidate ground control optimized for the particular image type and geometry at hand.

ETL-0459 AD-B113 994L

AUTOMATED INDUSTRIAL FEATURE EXTRACTION FROM SYNTHETIC APERTURE RADAR IMAGERY
April 1987

Lambird, B.
Lavine, D.
Josephs, M.

LNK Corporation DACA72-86-C-0012

Keywords: Artificial Intelligence, Image Understanding, Expert Systems, Synthetic Aperture Radar Image Analysis

LNK Corporation investigated the feasibility of automatic extraction of military industrial features from SAR (Synthetic Aperture Radar) imagery. LNK implemented an interactive, general Image Processing System (IPS) on a SUN-3 Workstation and demonstrated promising results on a few industrial features, using a combination of image processing and artificial intelligence techniques. The use of rules and structural models was demonstrated on the extraction of large buildings. Quick preprocessing steps for three other industrial features (breakwaters, parking lots with lights, and POL tanks) were devised to isolate likely candidates for each of these features. The Phase I results were generally very promising. A design for an industrial feature extraction system is presented. It combines image processing with two artificial intelligence techniques: rule-based expert systems and a novel structural modeling technique developed by LNK Corporation.

ETL-0460 AD-B117 190L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM, FOURTH QUARTERLY REPORT
February 1987

Koenig, Rainer

Martin Marietta, Denver Aerospace DACA76-84-C-0005

Keywords: Computer Vision, Obstacle Detection, Obstacle Avoidance, Artificial Intelligence, Image Understanding, Knowledge Representation, Strategic Computing (SC)

The Autonomous Land Vehicle (ALV) Fourth Quarterly Report covers program activities and progress made during the period from 1 Dec 86 through 28 Feb 87. During this period, efforts concentrated on developing, prototyping, and testing concepts and components of the 1987 ALV vehicle and computer lab computer hardware architecture. A program critical design review (CDR) was held between 3-4 February 1987, to focus on the evolving architecture. The report includes the progress and status of several program research and development activities, including the design of the initial increment configuration of the reduced 87 computer hardware architecture; the modification and improvement of the vehicle platform and body shell; the Vehicle-Lab communication subsystem; plans for future integration of a FLIR sensor; ultrasonic obstacle detection and avoidance sensor testing; Perception, Reasoning, Utilities, and Data Transport (LAN) software design developments; the status of becoming an ARPANET subscriber; and a summary of the December 1986 ALV Program Quarterly Review meeting, held in Key West, Florida, which highlighted the military applications of autonomous land vehicle technology.

ETL-0461 AD-A185 421

RANGE IMAGERY ALGORITHMS FOR THE DETECTION OF OBSTACLES BY AUTONOMOUS VEHICLES
July 1987

Veatch, Phillip A.
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Image Segmentation-Range, Autonomous Navigation

Algorithms are presented which segment range images and classify regions as being navigable or unnavigable by a land vehicle. The algorithms are applied to data collected from an active laser range sensor mounted on an autonomous land vehicle and their comparative results are analyzed. The sensitivity of various algorithms to uncertainty in the orientation of the range sensor is studied. Experiments on sensor calibration and image enhancement are also presented. A computer model of an autonomous land vehicle and its environment is described which provides a valuable tool for investigating many issues of navigation with range sensors. Obstacle detection algorithms are used in conjunction with the model to demonstrate a vehicle navigating itself through an obstacle-strewn world to a goal location.

ETL-0462 AD-A184 246

A TIGHT UPPER BOUND FOR THE SPEED-UP OF PARALLEL BEST-FIRST BRANCH-AND-BOUND ALGORITHMS
May 1987

Huang, Shie-rei
Davis, Larry S.

University of Maryland DACA76-84-C-0004

Keywords: Butterfly Multiprocessor, Combinatorial Search, Operations Research, Parallel Algorithm, Queueing Model

Most previous studies of the speedup of parallel branch-and-bound algorithms are based on the amount of work done in the parallel case and in the sequential case. Any evaluation of a parallel algorithm should include both the execution time and the synchronization delay. In this paper, a finite population queueing model is used to capture the synchronization delay in parallel branch-and-bound algorithms and to quantitatively predict the behavior of their speedup. A program to solve the Traveling Salesman Problem was written on a BBN Butterfly multiprocessor to empirically demonstrate the credibility of this theoretical analysis. Finally, we note that similar analyses can be applied to evaluate parallel AI systems in which processes communicate through a shared global data base.

ETL-0463 AD-A184 043

END OF YEAR TECHNICAL REPORT: DYNAMIC IMAGE INTERPRETATION FOR AUTONOMOUS VEHICLE NAVIGATION
May 1987

Riseman, E. M.
Hanson, A. R.
Kitchen, L. J.

University of Massachusetts

DACA76-85-C-0008

Keywords: Scene Interpretation, Sensor Motion, Spatial Reasoning

This report describes work conducted at the University of Massachusetts for the Autonomous Land Vehicle Project (under contract DACA76-85-C-0008) during the 1-year period from February 26, 1986 to February 25, 1987. In pursuit of the goal of achieving dynamic image interpretation for autonomous vehicle navigation, we have made significant progress in the knowledge-based interpretation of road scenes, in visual motion analysis, and in mobile robot navigation. This work has been supported by development of necessary software tools, installation of appropriate hardware, and concurrent investigations into applicable techniques for image analysis.

ETL-0464 AD-A183 879

1986 YEAR END REPORT FOR ROAD FOLLOWING AT CARNEGIE-MELLON

May 1987

Thorpe, Charles
Kanade, Takeo

Carnegie-Mellon University

DACA76-85-C-0003

Keywords: Mobile Robots, Computer Vision, Autonomous Navigation

This report describes progress in vision and navigation for outdoor mobile robots at the Carnegie-Mellon Robotics Institute during 1986. This research was sponsored by DARPA as part of the Strategic Computing Initiative. Our work during 1986 culminated in two demonstration systems. The first system drives the Terregator, a desk-sized robot with six wheels, around the network of campus sidewalks. This system, named Sidewalk II, uses a video camera to follow sidewalks and a laser rangefinder to detect and avoid stairs. Sidewalk II makes extensive use of map data, for visual predictions and for path planning.

The second system, Park Navigation, uses the Navlab, our new Chevrolet Van robot. The Park system concentrated on vision for following difficult roads, including curves, dirt and leaves, shadows, puddles, and both moving and fixed obstacles.

We developed vision techniques for handling difficult roads, and built range finder programs for detecting and avoiding obstacles.

Both the Sidewalk II and Park experiments were built into complete systems using CODGER, a novel whiteboard developed as part of the project. CODGER provides tools for handling geometry, motion over time, multiple processes, and multiple languages.

This report is divided into four main sections. Section 1 is an introduction and overview, including a chronology for the project and a list of 1986 publications. Section 2 describes the Sidewalk II system; section 3 describes the Park experiments; and section 4 is about CODGER.

ETL-0465 AD-A184 243

AUTONOMOUS LAND VEHICLE (ALV) PLANNING AND NAVIGATION SYSTEM
April 1987

Keirsey, D. M.
Mitchell, J. S. B.
Payton, D. W.
Tseng, D. Y.
Wong, V. S.
Zikan, K.

Hughes Aircraft Company

DACA76-85-C-0017

Keywords: Autonomous Vehicles, Route Planning, Hierarchical Planning, Terrain Navigation, Mobile Robots

The Hughes planning system is designed to achieve the reasoning requirements of the Autonomous Land Vehicle (ALV) for navigation in unconstrained outdoor environments. This system is designed specifically to handle diverse terrain with maximal speed, efficacy and versatility. The hierarchical architecture for this system is presented along with the detailed algorithms, heuristics, and planning methodologies for the component modules. The architecture is structured such that lower-level modules perform tasks requiring greatest immediacy while higher-level modules perform tasks involving greater assimilation of sensor data, making use of large amounts of *a priori* knowledge.

This report documents the first year of progress under contract to DARPA for the Planning and Navigation System for ALV. It includes a discussion of the technical design of the multi-level planning system and its component modules. Specific details of progress made in developing map-based planning capabilities for the Martin Marietta test area, simulation capabilities to support development of real-time sensor-based motion planning, and several reflexive behaviors and virtual sensors which provide basic road following and obstacle avoidance capabilities.

ETL-0466

CMU STRATEGIC COMPUTING VISION PROJECT REPORT: 1984 to 1985
August 1987

Kanade, Takeo
Thorpe, Charles

Carnegie-Mellon University

DACA76-85-C-0003

Keywords: Computer Vision, Robots, Autonomous Navigation, Road Following

This report is a broad overview of the CMU Strategic Computing Vision Project. The goal of the SCVision project at CMU is to build vision and intelligence for an intelligent mobile robot capable of operating in the real world outdoors. CMU is attacking this on a number of fronts, ranging from building appropriate research vehicles to exploiting high-speed experimental computers to building software for reasoning about the perceived world. This is a progress report rather than a discussion of complete scientific results: some of what is presented is more pragmatic than scientific, and much of the research is still in preliminary stages.

ETL-0467 AD-A184 327

END OF YEAR REPORT FOR PARALLEL VISION ALGORITHM DESIGN AND IMPLEMENTATION
May 1987

Kanade, Takeo
Webb, Jon A.

Carnegie-Mellon University DACA76-85-C-0002

Keywords: Computer Vision, Parallel Algorithms, Warp

This report describes progress for the parallel vision algorithm design and implementation effort at Carnegie-Mellon University for 1986. The goals that were accomplished include several demonstrations of Warp's use for road following, obstacle avoidance using stereo vision and ERIM laser range scanner data, NMR image processing, signal processing, and other vision algorithms. A vision library for low-level vision algorithms, all written in the Warp programming language (W2) was compiled. A specialized programming language called Apply was developed for programming low-level vision algorithms on Warp. Finally, the report describes the first use of Warp as a tool for research into vision algorithms, as opposed to purely being used as a tool for research into parallelism.

ETL-0468 AD-B117 853L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM, FIFTH QUARTERLY REPORT
August 1987

Hoyer, Gustav R., Editor

Martin Marietta, Denver Aerospace DACA76-84-C-0005

Keywords: Autonomous Land Vehicle, Robotics, Image Understanding, Unmanned Vehicles, Artificial Intelligence, Computer Vision Processing

The Autonomous Land Vehicle (ALV) Fifth Quarterly Report covers program activities from February 28, 1987, to May 31, 1987. During this period the ALV vehicle improvement program was completed. Upon delivery of the modernized vehicle, the remaining interior finishing work was completed on the electronic racks, the computer room-style floor, and operator's console. Following this, installation of exterior sensors and communications antennas was accomplished. A new power distribution system and associated wiring was installed. Initial installation of the components of the 1987 computer hardware architecture was begun. Work on the new vehicle-lab local area network (LAN) interface panel and cabling was begun. A summary describing the computer hardware configuration of the ALV lab is presented in this report. The status of the installation work on the DARPA satellite video conferencing system is summarized. A feature article describes the ALV test area and road track at the Martin Marietta Denver Aerospace plant site. Software development included continued refinement and testing of Perception, Reasoning, and Control software modules in preparation for the 1987 Demonstration Readiness Review.

ETL-0469

LINEAR FEATURE EXTRACTION FROM RADAR IMAGERY, SBIR PHASE II BASE CONTRACT
July 1987

Connor, Gary D. McConnell, Christopher C.
Lawton, Daryl T. Milgram, David L.

Advanced Decision Systems DACA72-86-C-0004

Keywords: SAR, Feature Extraction, Edge Detection, Terrain Analysis, Image Understanding

The goal of this effort is to develop and demonstrate prototype processing capabilities for a knowledge-based system to automatically extract and analyze linear features from synthetic aperture radar (SAR) imagery. This effort constitutes Phase II funding through the Defense Small Business Innovative Research (SBIR) Program. Previous work examined the feasibility of and technology issues involved in the development of an automated linear feature extraction system. The current effort continues this examination and is developing the technologies involved in automating this image understanding task.

ETL-0470 AD-A185 717

TERRAIN ANALYST WORK STATION (TAWS): 1AD AFTER ACTION REPORT
August 1987

Quick, John, Maj. Ference, David
Greczy, Laslo Hardaway, Michael G.
Musser, Eric, Capt. Jarrett, Joni
Carroll, Roberta Porter, Liz

Keywords: Terrain Analysis, Automated Terrain Analysis, Terrain Analyst Work Station (TAWS)

At the request of the 1st Armored Division (1AD), the Engineer Topographic Laboratories visited 1AD and demonstrated the Terrain Analyst Work Station (TAWS), demonstrated its capabilities, and provided products for 1AD's area of interest. This after action report describes the TAWS, its capabilities, and the training performed; and reports the comments provided by 1AD and others about the TAWS and products provided.

ETL-0471

3-D ROAD STRUCTURE FROM MOTION STEREO
April 1987

Asada, Minoru

University of Maryland

DACA76-84-C-0004

Keywords: Computer Vision, 3-D Shape Recovery, Motion Stereo

This paper presents a new method for reconstructing the 3-D structure of road boundaries from consecutive images. First, we present a method for estimating depth information by applying a motion stereo method to consecutive images, given an estimate of the interframe motion. The relation between depth, motion and disparity is investigated, since the accuracy of the depth depends on the disparity range. Next, the error of the estimated road structure due to quantization errors and motion estimation errors is examined. Finally, a representation for road boundaries is proposed that makes explicit the error of the road edge location in 3-D space. Experimental results are shown for an input image sequence taken by the ALV simulator robot in the Center for Automation Research at the University of Maryland.

ETL-0472 AD-A188 108

CONTOUR-TO-GRID INTERPOLATION WITH NONLINEAR FINITE ELEMENTS: A FEASIBILITY STUDY
September 1987

Witzgall, Christoph
Bernal, Javier
Mandel, Betty

National Bureau of Standards

Keywords: Cartography, Clough-Tocher Element, Contour Line, Delaunay Diagram, Digitized Data, Finite Element Method, Line Generalization, Surface Interpolation, Synthetic Surface, Terrain Modeling, Thiessen Diagram, Tolerance Band, Triangulation, Voronoi Diagram.

The U.S. Army Engineer Topographic Laboratories and the National Bureau of Standards investigated the computational feasibility of developing a contour-to-grid algorithm by: (1) sampling a large set of digitized cartographic contour data with a tolerance band technique, (2) its subsequent triangulation with a Voronoi (Delaunay, Thiessen) method, and (3) the construction of an interpolating smooth synthetic surface from which grids can be generated at any given interval. This report presents a discussion on the results obtained.

ETL-0473 AD-A188 185

AUTOCORRELATION OF CONTROL POINTS ON 11-BAND MULTISPECTRAL IMAGERY
August 1987

Rand, Robert S.

Keywords: Autocorrelation Measures, Image Registration, Multispectral Imagery, Feature Extraction, Image Segmentation Algorithms

The use of multispectral imagery with other types of imagery requires that the combined set be accurately registered. This study investigates correlation properties between bands of an 11-channel multispectral scanner for 37 control points in support of interband registration that can later be extended to dissimilar image registration. The results show a high degree of correlation between channel 1 through 7, but a lower and unpredictable correlation for other combinations. In addition to providing information about interband registration, the results also have implications for multispectral segmentation algorithms.

ETL-0474 AD-A190 212

CLIMATIC INFORMATION FOR APPLICATION IN DESIGNING AND TESTING U.S. ARMY MATERIEL
September 1987

Niedringhaus, Thomas E.

Keywords: Climate, Climatic Criteria, Climatic Design Types, Daily Weather Cycles, Climatic Elements, Climatic Extremes, Temperature, Humidity, Solar Radiation

This report provides values and other information for the application of extreme climatic conditions in the RDT&E of Army materiel. Values are given for operational conditions and storage and transit conditions. The two sets of climatic criteria are necessary in order to satisfy requirements that equipment be capable of specified performance levels under all but the most severe natural climatic conditions, and that equipment can survive the most severe-expected induced climatic conditions for long periods of time without losing the specified performance capabilities when the more benign natural conditions return.

Climatic criteria are provided for four climatic design types: hot, basic, cold, and severe cold. Each of these design types is represented by one or more daily weather cycles of temperature, solar radiation, and humidity. Anticipated extreme levels for additional environmental elements (rain, snow, icing phenomena, wind, sand and dust, ozone concentration, freeze-thaw, and atmospheric pressure) are also provided. A map of the areas of occurrence of climatic design types is included to illustrate the distribution of climatic conditions for which criteria are provided.

ETL-0475 AD-A179 409

DETERMINING THE TRANSLATION OF A RIGIDLY MOVING SURFACE, WITHOUT CORRESPONDENCE
January 1986

Aloimonos, John
Basu, Anup

University of Rochester DACA76-85-C-0001

Keywords: Motion, Multiple Cameras, Texture, Correspondence

A method is presented for recovery of the three-dimensional translation of a rigidly moving textured object. The novelty of the method consists of the fact that four cameras are used in order to avoid the solution of the correspondence problem. The method seems to be immune to small noise percentages and to have good behavior when the noise increases.

ETL-0476 AD-A183 328

OBSERVATIONS ON MULTI-PEG TOWERS OF HANOI
July 1986

Newman-Wolfe, Richard

University of Rochester DACA76-85-C-0001

Keywords: Towers of Hanoi Problem

A generalization of the classic Towers of Hanoi problem permitting additional work pegs is considered. While the idea is not original, this form of generalization has not appeared in published literature to my knowledge. Several upper bounds and lower bounds are presented for various ranges of extra work pegs, improving on the work of Gacs. A general methodology of attack is also given, producing exact results in many cases.

ETL-0479 AD-A188 186

AN OVERVIEW OF VISION-BASED NAVIGATION FOR AUTONOMOUS LAND VEHICLES 1986
April 1987

Chandran, Sharat
Davis, Larry S.
DeMenthon, Daniel
Dickenson, Swen J.
Gajulapalli, Suresh
Huang, Shie-Rei
Kushner, Todd R.
LeMoigne, Jacqueline
Puri, Sunil
Siddalingaiah, Tharakesh
Veatch, Phillip

University of Maryland DACA76-84-C-0004

Keywords: Vision-Based Navigation, Parallel Algorithms

This report describes research performed during the first two years on the project "Vision-Based Navigation for Autonomous Vehicles" being conducted under DARPA support. The report contains discussion of four main topics: (1) development of a vision system for autonomous navigation of roads and road networks; (2) support of Martin Marietta Aerospace, Denver, the integrating contractor on DARPA's ALV program; (3) experimentation with the vision system developed at Maryland on the Martin Marietta ALV; (4) development and implementation of parallel algorithms for visual navigation on the parallel computers developed under the DARPA Strategic Computing Program-specifically, the WARP systolic array processor, the Butterfly, and the Connection Machine.

ETL-0480 AD-A186 920

AUTOMATED ROUTE FINDER FOR MULTIPLE TANK COLUMNS
September 1987

Benton, John R.

Keywords: Artificial Intelligence, Heuristic Search, Route Planner, IPB (Intelligence Preparation of the Battlefield)

The Automated Route Finder for Multiple Tank Columns computes multiple non-competing paths for columns of tanks. The network of available paths is represented by a graph-theoretic structure. Each arc of the graph has an associated cost which represents the time required to traverse the path corresponding to the arc. A best-first algorithm is used to search the graph in order to find the specified number of optimum paths. The algorithm was implemented on the Symbolics LISP Machine with a color monitor used to display the graph as it is explored. Sample outputs of route finding are included with an analysis of the results. Future enhancements for the system are outlined.

ETL-0481 AD-B117 266L

INTRODUCTION TO THE TERRAIN EFFECTS ON THE INTELLIGENCE *PREPARATION OF THE BATTLEFIELD (IPB)*
September 1987

Mintzer, Olin W.

Keywords: Intelligence Preparation of the Battlefield, Terrain Analysis, Effects of Terrain

This study correlates the effects of terrain with the Intelligence Preparation of the Battlefield (IPB). The five IPB steps are included but the attention is focused on the third step: terrain.

ETL-0482

RESEARCH IN KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM

June 1987

Editors:
Nevatia, R.
Price. K.

University of Southern California

DACA76-85-C-0009

Keywords: Autonomous Land Vehicle, Motion Analysis, Target Detection and Description, Knowledge-Based Vision

This report describes our research in motion analysis and estimation techniques for the period of June 1, 1986, to May 31, 1987. This research is of particular relevance to the DARPA Autonomous Land Vehicle (ALV) program, but should also be of other general utility. Our basic approach to detecting and tracking motion is to extract and match features, such as lines and regions, from a sequence and to generate motion estimates from these. We present one report on matching connected line segments (contours) in a sequence of views. This work assumes relatively small motions between views.

Two approaches to motion based segmentation or grouping are also presented. We also present more results from the general 3-D motion estimation program and discuss a basic integrated system that combines feature extraction, matching and motion estimation.

ETL-0483 AD-B119 403L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM, SIXTH QUARTERLY REPORT
November 1987

Hoyer, Gustav R., Editor

Martin Marietta, Denver Aerospace DACA76-84-C-0005

Keywords: Autonomous Land Vehicle, Robotics, Image Understanding, Unmanned Vehicles, Artificial Intelligence, Computer Vision Processing

The Autonomous Land Vehicle (ALV) Sixth Quarterly Report covers program activities between May 31 and August 31, 1987. During this quarter, extensive hardware and software integration activities were performed in preparation for the 1987 demonstration and Technical Status Review (TSR). In hardware developments, installation, integration and testing of all the remaining components of the 1987 reduced computer hardware architecture was completed. In software developments, the final integration, testing and validation of the 1987 Computer Software Configuration Item (CSCI) components was nearly completed. Intensive testing and validation activities focused on the performance of Perception, Reasoning, Control, and Data Transport software components in accordance with the CSCI design. We hosted a meeting of the ALV Vision Working Group on August 20. We supported a visit of personnel from the Hughes AI Center between July 6-17 and August 3-14. We began installation of the Warp Systolic Array Processor on the vehicle. We initiated plans to build a new ALV program facility with an estimated completion date of June 1988.

ETL-0484

DEVELOPMENT OF AUTOMATIC NAMES PLACEMENT SOFTWARE
December 1987

Freeman, Herbert

Battelle Memorial Institute DAAG29-81-D-0100

Keywords: Artificial Intelligence, Automated Cartography, Automated Map Generation

This report describes the development of a software system intended to demonstrate the capability of automatically placing geographic names on maps. The system, which is based on the previously developed AUTOCOR and AUTONAP name placement routines, is designed to label area, line, and point features in 1:24,000 scale United States Geological Survey (USGS) Digital Line Graph (DLG) maps using names extracted from corresponding USGS Geographic Names Information System (GNIS) files. The system performs its task well provided the data in the DLG and GNIS files is of high quality. As is to be expected, the system fails in its task where the correlation between DLG features and GNIS names is unclear, ambiguous, or erroneous. The system was developed for the DEC VAX family computers running under the VMS operating system.

ETL-0485

KNOWLEDGE-BASED VISION TECHNIQUES -- TASK B: TERRAIN AND OBJECT MODELING RECOGNITION

December 1987

Lawton, Daryl T.
Levitt, Tod S.
McConnell, Christopher C.
Nelson, Philip C.
Black, Michael J.
Edelson, Daniel J.
Koitzch, Kerry
Dye, John W.
Binford, Thomas O.
Chelberg, David M.
Kriegman, David J.
Ponce, Jean

Advanced Decision Systems

DACA76-85-C-0005

Keywords: Model-Based Vision System, Terrain Modeling, Schema-Based Reasoning, Perceptual Processing, Image Understanding Tools, Spatial Representation, Hypothesis Management, Navigation, Image-To-Map Matching

This report describes the development and critical components of a model-based vision system for an autonomous vehicle operating in complex, outdoor, dynamic environments using optical, laser, motion, and position sensors. The critical technologies are organized with respect to Object and Event Modeling, Perceptual Processing, Spatial Representation and Reasoning, and the Integration of work in these research areas into modular and transferable components. Key results included the following: (Editor's note: results can be seen on original DD Form 1473 in the published report).

ETL-0486

KNOWLEDGE-BASED ANALYSIS OF SCENE DYNAMICS FOR TARGET MOTION DETECTION, RECOGNITION, AND TRACKING

June 1987

Bhanu, Bir

Honeywell Systems and Research Center

DACA76-86-C-0017

Keywords: Strategic Computing, Qualitative Reasoning and Modeling, Motion Detection, Tracking, Landmark Recognition, Terrain Interpretation, Dynamic Modeling and Matching, Hierarchical Symbolic Grouping, Autonomous Land Vehicle, Dynamic Scene Understanding, Estimation of Vehicle Motion, Multi-spectral Images, Computer Vision

This is the first Annual Report of Honeywell Contract on Scene Dynamics and Object Recognition (DACA76-86-C-0017) sponsored under the DARPA Strategic Computing Computer Vision Program. Our research in Scene Dynamics and Object Recognition is directed towards filling the technology gaps in developing brilliant weapons and smart munitions. The results of our research make a significant technical contribution in vision-controlled navigation/guidance of Autonomous Land Vehicles (ALV's), reconnaissance, surveillance, and other practical military applications such as search and rescue and targeting missions. The topics investigated during the first year of the contract are:

1) Qualitative Reasoning & Modeling for motion detection and tracking
2) Dynamic Model Matching for landmark recognition
3) Hierarchical Symbolic Grouping for interpretation of terrain

The synopsis of technical achievement in each of these technical areas is given below: (Editor's note: synopsis of these technical areas can be seen on original Form DD 1473 in the published report).

ETL-0487

KNOWLEDGE-BASED VISION TECHNIQUES
October 1987

Daily, M. J.
Harris, J. G.
Reiser, K.
Tseng, D. Y.
Olin, K. E.
Vilnrotter, F. M.

Hughes Aircraft Company

DACA76-85-C-0007

Keywords: Computer Vision, Obstacle Detection, Obstacle Avoidance, Virtual Sensors, Knowledge Representation

This report relates the progress for the second year under the KBVT contract. Efforts have been concentrated on autonomous land navigation, in particular obstacle detection and avoidance for off-road maneuvers. Section 1 is an overview of the problem, summary of approach, and the program schedule. The system architecture developed during the first year is presented in Section 2. Development of the rule-based segmentation is described in Section 3. Section 4 discusses processing of the laser range imagery and the development of the Cartesian Elevation Map. Obstacle detection is discussed in Section 5, and the World Modeling System as well as the Synthetic Scanner System are described in Section 6. Section 7 concludes with plans for the third year of technical development.

ETL-SR-1 AD-B119 404L

ARMY TACTICAL TERRAIN DATA REQUIREMENTS FORECAST (FY87-FY93) July 1987

Scott, David J.
Lambert, Robin B.
Nagel, Randall W.
Foshay, William G., Capt
Messmore, Jeffrey A.
Orsinger, Regis J.

Keywords: Digital Terrain Data (DTD), Data Requirements, Forecasts, Future DTD Products, Army Future Systems Requirements

This report documents the results of an initial investigation of the known and anticipated DTD requirements of the Army. The review was limited to those tactical systems with operational DTD requirements prior to FY93. FY93 was chosen as the earliest date when the Army could expect to receive Tactical Terrain Data (TDD) in volume from the DMA modernized production system. TTD is a formal recognized Army digital product designed to meet future information requirements. Subsequent investigations will focus on tactical requirements beyond FY93, as well as non-tactical requirements, e.g. training and simulation applications.

PAPERS

Baldini, Angel. "Astrogeodetic Deflections of the Vertical from Stars Observation with the Danjon Astrolabe, or Similar Instruments." 1986 American Congress on Surveying and Mapping/American Society of Photogrammetry and Remote Sensing (ASCM/ASPRS) Convention, Washington, D.C., 16-21 March 1986. AD-A166 886

Barr, Sam. "Post-Mortem Identification by Means of Comparative Image Analysis of a Tattoo Marking." International Conference on Digital Image Analysis. FBI Academy, Quantico, Virginia, 15-20 June 1986. AD-A179 567

Baussus von Luetzow, Hans. "ETL's Current and Contemplated Geodetic and Related Research and Exploratory Development Program." 10th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 7-10 October 1985.

Baussus von Luetzow, Hans. "Estimation of Gravity Vector Components from Bell Gravity Gradiometer and Auxiliary Data Under Consideration of Topography and Associated Analytical Upward Continuation Aspects." 15th Annual DOD Gravity Gradiometer Review, U.S. Air Force Academy, Colorado, 10-11 February 1987. AD-A188 146

Bernal, Javier (National Bureau of Standards). See Mandel, Betty A.

Breen, Jerry M. See Zimmermann, Bruce B.

Brierly, William B., Jr. "Digital Data Dubbing Capability." Tenth Army Topographic Conference, Fort Belvoir, Virginia, 14-16 October 1987. AD-A188 252

Caldwell, Douglas R. "Using Bar Codes to Enhance Map Products." 11th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1986. AD-A179 697

Caldwell, Douglas R. "The U.S. Army Electronic Map Data (EMD) Initiative." 12th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 209

Caldwell, Douglas R., and Scott, David J. "Soft Map for U.S. Army Electronic Map Background Applications." American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping (ASPRS/ACSM) Fall Convention, Reno, Nevada, 4-9 October 1987. AD-A188 427

Camp, Donald M., and Nagel, Randall W. "Advanced Display System, the Single Crystal-Cathode Ray Tube (SC-CRT) Stereoviewer." 1987 American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping (ASPRS/ACSM) Conference, Baltimore, Maryland, 29 March - 3 April 1987. AD-A183 683

PAPERS (continued)

Capps, Penny R. "AirLand Battlefield Environment (ALBE) Tactical Decision Aid (TDA) Demonstration Program." International GIS Symposium, Crystal City, Virginia, 15-18 November 1987. AD-A189 712

Capps, Penny R. See Tolson, Michael J.

Chen, Pi-Fuay. See Rohde, Frederick W.

DeLoach, Stephen R. "The Potential of the NAVSTAR Global Positioning System for the Corps of Engineers, Civil Works." U.S. Army Corps of Engineers Fifth Remote Sensing Symposium, Ann Arbor, Michigan, 28-30 October 1985.

Desmond, Gregory B. See Edwards, Daniel L.

Dubishar, W. Craig. See Messmore, Jeffrey A.

E-an Zen, (USGS). See Ehlen, Judy.

Eastes, John W. (USAETL); Salisbury, John W. (USGS); and Hapke, Bruce (University of Pittsburgh). "Usefulness of Weak Bands in Midinfrared Remote Sensing of Particulate Planetary Surfaces." *Journal of Geophysical Research*, 1987, Vol. 92, NOB1, pp. 702-710. AD-A179 669

Edwards, Daniel L. "CAPIR/DEM: A Collection System for Geographically Based Digital Elevation Data." *Geographic Information Systems (GIS) in Government* Workshop, Springfield, Virginia, 10-13 December 1985. [This paper was also presented at the 1986 American Congress on Surveying and Mapping/American Society for Photogrammetry and Remote Sensing (ACSM/ASPRS) Convention, Washington, D.C., 16-21 March 1986.] AD-A167 471

Edwards, Daniel L.; Schoppmann, Michael W.; and Desmond, Gregory B. "Terrain Data Base Generation for Autonomous Land Vehicle Navigation." International Society for Photogrammetry and Remote Sensing (ISPRS) Commission II Symposium, Baltimore, Maryland, 26-30 May 1986. AD-A187 869

Ehlen, Judy (USAETL), and E-an Zen, (USGS). "Petrographic Factors Affecting Jointing in the Banded Series, Stillwater Complex, Montana." *Journal of Geology*, 1986, Vol. 94, pp. 575-584. AD-A179 618

Golden, Robert J., 1st Lt. "Battlefield Environmental Effects Software (BEES): An Overview." 12th Annual DOD Mapping, Charting & Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 144

Greczy, Lazlo. "AirLand Battlefield Environment (ALBE) Demonstration." 11th Annual DOD Mapping, Charting & Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1986. AD-A187 975

Hapke, Bruce (University of Pittsburgh). See Eastes, John W.

PAPERS (continued)

Hardaway, G. Michael. "The Quick Response Multicolor Printer (QRMP) System." 12th Annual DOD Mapping, Charting & Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 140

Hardaway, G. Michael, and Porter, Elizabeth. "The Terrain Analyst Work Station." Geographic Information Systems (GIS) in Government Workshop, Springfield, Virginia, 10-12 December 1985. AD-A166 798

Hardaway, G. Michael. See Porter, Elizabeth.

Herrmann, Richard A. "Army Requirements for Digital Topographic Data." Eighth Annual Army Topographic Conference, Fort Belvoir, Virginia, 30 September - 2 October 1985. AD-A155 164

Hevenor, Richard. See Rohde, Frederick W.

Howard, Theodore W. "A Digital Terrain Data (DTD) Production Initiative." Tenth Army Topographic Conference, Fort Belvoir, Virginia, 14-16 October 1987. AD-A188 164

Jorgensen, Thomas. See Kurtz, Keith.

Kurtz, Keith, and Jorgensen, Thomas. "GIS-Based Applications with a Worldwide Database." Geographic Information Systems (GIS) in Government Workshop, Springfield, Virginia, 10-13 December 1985. AD-A166 825

Lambert, Robin B. See Mattson, Kathleen M.

Lane, Gerald R. (USATACOM). See Leighty, Robert D.

Leighty, Robert D. (USAETL), and Lane, Gerald R. (USATACOM). "DARPA ALV Summary." Intelligent Systems for Army Logistics Support and Combat Engineering Symposium, Fort Belvoir, Virginia, 25-27 March 1986. AD-A167 472

Leighty, Robert D. (USAETL), and Lane, Gerald R. (USATACOM). "Developing Technologies for Army Autonomous Land Vehicles." 1986 Army Science Conference, West Point, New York, 17-20 June 1986. AD-A187 972

Lukes, George E. "Automated Screening of Reconnaissance Imagery." 1986 Army Science Conference, West Point, New York, 17-20 June 1986. AD-A187 974

Lukes, George E. "A Review of Computer-Assisted Photo Interpretation Research at USAETL." SPIE Los Angeles '87 Symposium, Los Angeles, California, 16 January 1987. AD-A183 034

Lukes, George E. (USAETL), and Raggam, Hannes (Technical University and Graz Research Center). "Implementation of Map-To-Image Correspondence for Synthetic Aperture Radar Image Analysis." 1986 American Congress on Surveying and Mapping/American Society of Photogrammetry and Remote Sensing (ASCM/ASPRS) Convention, Washington, D.C., 16-21 March 1986. AD-A166 791

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Mandel, Betty A. (USAETL); Witzgall, Christoph; and Bernal, Javier (National Bureau of Standards). "Non-Linear Contour-To-Grid Digital Interpolation." 11th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1986. AD-A180 632

Marth, Richard B. "The Terrain Analyst Work Station." 10th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 7-10 October 1985. AD-A167 473

Marth, Richard B. "Digital Topographic Support System (DTSS)." 12th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 304

Mattson, Kathleen M., and Lambert, Robin B. "Fulda Gap Video Disc--A Tactical Decision Aid." 54th MORS, Fort McNair, Washington, D.C., 24-26 June 1986. AD-A187 973

Messmore, Jeffrey A., and Scott, David J. "An Army Strategy for the 1990's." 1987 American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping (ASPRS/ACSM) Conference. Baltimore, Maryland, 29 March - 3 April 1987. AD-A179 569

Messmore, Jeffrey A., and Dubishar, W. Craig. "The Evolution of Tactical Terrain Data (TTD)." 12th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 165

Nagel, Randall W. See Camp, Donald M.

Norvelle, F. Raye. "UNAMACE Software Improvements." 11th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1986. AD-A183 684

Orsinger, Regis J. "Army Digital Terrain Requirements." Navy's Digital Mapping, Charting and Geodesy Data Testbed Interest Group. Washington, D.C., 22 June 1987. AD-A188 253

Porter, Elizabeth. "Human Factors Design Considerations for the Next Generation GIS." Geographic Information Systems (GIS) in Government Workshop, Springfield, Virginia, 10-13 December 1985.

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PAPERS (continued)

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Porter, Elizabeth. See Hardaway, G. Michael.

Opitz, Bruce. See Quick, John, Maj.

Quick, John, Maj., and Opitz, Bruce. "New Topographic Material Update." 11th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1986. AD-A179 613

Raggam, Hannes (Technical University and Graz Research Center). See Lukes, George E.

Rinker, Jack N. See Satterwhite, Melvin R.

Rohde, Frederick W. "Radar Descriptors for the Classification of Terrain Features." 1986 Army Science Conference, West Point, New York, 17-20 June 1986. AD-A188 145

Rohde, Frederick W.; Chen, Pi-Fuay; and Hevenor, Richard. "Automated Radar Image Analysis Research in Support of Military Needs." 11th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 8-10 October 1987. AD-A179 615

Rose, Barbara. "The Feasibility of Automating Rapid Response Terrain Analysis Studies." 1987 American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping (ASPRS/ACSM) Conference, Baltimore, Maryland, 29 March - 3 April 1987. AD-A188 458

Rosenthal, Richard L. See Zimmermann, Bruce B.

Salisbury, John W. (USGS). See Eastes, John W.

Satterwhite, Melvin R., and Rinker, Jack N. "Effect of the Reflectance Spectra of Vegetation and their Digital Classification." 1986 Army Science Conference, West Point, New York, 17-20 June 1986. AD-A188 143

Schoppmann, Michael W. See Edwards, Daniel L.

Scott, David J. See Caldwell, Douglas R.

Scott, David J. See Messmore, Jeffrey A.

Sither, Mark A. "Terrain Analyst Work Station (TAWS) Demonstrations." 1987 American Society of Photogrammetry and Remote Sensing/American Congress on Surveying and Mapping (ASPRS/ACSM) Conference, Baltimore, Maryland, 29 March - 3 April 1987. AD-A188 139

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Straub, Michael C. "The Quick Response Multicolor Printer (QRMP) System." Tenth Army Topographic Conference, Fort Belvoir, Virginia, 14-16 October 1987. AD-A188 140

Tolson, Michael J. "AirLand Battlefield Environment (ALBE) Tactical Decision Aid (TDA) Demonstration Program." 12th Annual DOD Mapping, Charting and Geodesy Conference, Cameron Station, Alexandria, Virginia, 20-22 October 1987. AD-A188 210

Tolson, Michael J., and Capps, Penny R. "AirLand Battlefield Environment (ALBE) Tactical Decision Aid (TDA) Demonstration Program." Tenth Army Topographic Conference, Fort Belvoir, Virginia, 14-16 October 1987. AD-A188 166

Witzgall, Christoph (National Bureau of Standards). See Mandel, Betty A.

Zimmermann, Bruce B.; Rosenthal, Richard L.; and Breen, Jerry M. "Geographic Information Systems in Robotic Vehicles." Geographic Information Systems (GIS) in Government Workshop, Springfield, Virginia, 10-13 December 1985. AD-A166 859

TITLES

TITLES (continued)

TITLES (continued)

TITLES (continued)

CORPORATE AUTHORS

PERSONAL AUTHORS

PERSONAL AUTHORS (continued)

AD NUMBERS

APPENDIX -- TITLES

1953-1985

TITLE	REPORT NO.	YEAR
Accuracy of Cartometric Data	AD-810 496	1966
Accurate Emphemeris Time Determination and Geocentric Stations Position from Photographs of the Moon Against Stellar Background	ETL-RN-72-4	1972
Acousto-Optic Technology for Topographic Feature Extraction and Image Analysis	ETL-0256	1981
Acquisition and Evaluation of Thermal Standard Data	ETL-0218	1980
Adjunct Development Test II (DT II) of Position and Azimuth Determining System AN/USQ-70	ETL-0217	1980
Advanced Continuous Tone Plate and Process Compatible with Present Military Lithographic Reproduction Equipment and Practices	ETL-0056	1975
Advanced Edit System	ETL-0295	1983
Advanced Feature Symbolization for Three Dimensional Views	ETL-0223	1980
Advanced Methods for the Calibration of Metric Cameras		1968
Advanced Radar Topographic Application	ETL-CR-73-2	1973
Advanced Satellite Hardware/Software System Study	ETL-0225	1980
Advanced Satellite Tracking Instrumentation Study		1968
Advanced Study of a Position and Azimuth Determining System (Final)	AD-844 930L	1968
Advanced Study of a Position and Azimuth Determining System (Addendum)	AD-848 369L	1968
Advanced Study of a Position and Azimuth Determining System (Supplement)	AD-861 446L	1969
Advanced Techniques for the Reduction of Geodetic SECOR Observation (Final)	AD-640 238	1966
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TITLE	REPORT NO.	YEAR
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Application of Hierarchical Data Structures to Geographical Information Systems	ETL-0301	1982
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Application of Inertial Techniques to Surveying	AD-805 156	1966
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TITLE	REPORT NO.	YEAR
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Color Ink-Jet Demonstration Program	ETL-0196	1979
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Digital Cartographic Study and Benchmark	ETL-0168	1978
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Errors in Automatic Pass Point Mensuration Using Digital Techniques	ETL-0232	1980
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Evaluation and Comparison of Terrain Classification Methods (Type III)	AD-845 338L	1968
Evaluation and Test of a Five-Color Electrostatic Printing Machine for the Reproduction of Topographic Maps and Charts	25-TR	1965
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Evaluation and Test of a Single-Color Electrostatic Printing Machine for the Reproduction of Topographic Maps and Charts	19-TR	1964
Evaluation of a New Electrostatic Recording Medium	ETL-0102	1977
Evaluation of a Xerographic Process for Preparing Zinc Oxide-Silicone, Binder-Type Lithographic Plates	1545-TR	1958
Evaluation of Automatic Mapping APQ as a Radar Mapping System	31-TR	1966
Evaluation of Coherent Radar Photography	18-TR	1963

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Evaluation of Color Test Photography for Military Geographic Analysis: A Literature Review	ETL-TR-70-6	1970
Evaluation of Components for Some Elevation-Determining Systems	AD-407 297L	1963
Evaluation of Conventional Correlation Methods When Matching Infrared Imagery to Panchromatic Imagery	ETL-0195	1979
Evaluation of Experimental Xerographic Process for Lithographic Platemaking	1417-TR	1955
Evaluation of High Precision SHORAN-Controlled Photography	1484-TR	1957
Evaluation of Land Use Techniques for Processing MGI	AD-817 124L	1967
Evaluation of Multiband and Color Aerial Photography for Selected Military Geographic Intelligence in a Subtropical Desert Environment	54-TR	1970
Evaluation of Offset Collotype Printing for the Field Reproduction of Aerial Photographs	1465-TR	1956
Evaluation of Pointing to a Sharp Edge	AD-668 260	1968
Evaluation of Published Criteria for Identifying Metamorphic Rocks on Air Photos: Two Case Studies in the Northeastern United States	ETL-0326	1983
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Evaluation of Single and Multicolor Map and Chart Reproduction Equipment	ETL-0080	1976
Evaluation of the Method of Determining Parallax from Measured Phase Difference	ETL-0145	1977
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Experimental Correlator Studies	AD-374 450L	1966
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Feasibility of Using Optical Power Spectrum Analysis Techniques for Automatic Feature Classification from High Resolution Thermal, Radar, and Panchromatic Imagery	ETL-0186	1979
Feasibility Study for an All-Weather Surveying Signal Light	37-TR	1968
Feasibility Study for Field Generation of Input for Radar Scene Generation from DLMS Terrain and Elevation Data	ETL-0203	1978
Feasibility Study of a Quick Response Multicolor Printer (QRMP)	ETL-0242	1980
Feasibility Test of a Proposed 3-D Radar System	AD-349 882L	1964
Feasibility Test Program for Measurement of Gravity Anomaly Changes Using 2 MICRO-g Accelerometer in the Inertial Platform	ETL-CR-74-16	1974
Feature Analysis and Reduction of Laws Texture Measure	ETL-0343	1983
Feature Component Reduction Through Divergence Analysis	ETL-0305	1982
Feature Extraction Assessment Study, Final Report	ETL-0377	1984
Feature Extraction of the Illiac IV	ETL-0191	1979
Feature Tagging	ETL-0227	1980
FEED Evaluation	ETL-0322	1983
FEED Software Documentation	ETL-0335	1983
Fictitious Data Generator for Analytical Aerotriangulation	AD-640 799	1965
Field Artillery Plotting Equipment	1421-TR	1955
Final Report, Development of Mirror Stereoscope	1382-TR	1954
Final Report on Stable Cartographic Bases	1542-TR	1958
Final Report, Study of Digital Matching of Dissimilar Images	ETL-0244	1980
Finite Element Models of the Earth's Gravity Field Phase IV	ETL-0198	1979
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Fixed and Multiple Frequency Angle Measurements with 35-GHz Microwaves	33-TR	1966
Floodplain Tree Species: A Bibliographic Literature Search with Abstracts	ETL-0193	1979
Flux Valve Heading Reference System	ETL-0134	1977
Forced Dynamics of Asymmetric Spacecraft	ETL-0039	1976

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Forecast for the 1970's in Mapping,Charting, and Geodesy Research and Development	TN-70-2	1970
Formulas for Computing Atmospheric Refraction for Objects Inside or Outside the Atmosphere	RN-8	1963
Formulation of a Space Oblique Mercator Map Projection	ETL-0131	1977
Fort Belvoir Text Placement System, Final Technical Report	ETL-0199	1979
Fourier Transform Autocorrelation	ETL-0184	1979
Frequency Dependence of Backscatter from Rough Surfaces (An Experiment with Broad-Spectrum Acoustic Waves)	AD-847 275	1968
Full View Holograms	ETL-CR-70-1	1970
Further Investigation of an Electronic Angle-Measuring Device	ETL-TR-74-1	1973
Further Study of Digital Matching of Dissimilar Images	ETL-0385	1985
Gamma-Ray Spectrometer Study	ETL-0008	1975
General Climatological Guide to Daily Freezing Conditions: Frost Days, Ice Days, and Freeze-Thaw Days, A	ETL-0287	1982
General Noniterative Solution of the Inverse and Direct Geodetic Problems	RN-11	1963
General Programming on a Parallel Processor	ETL-0062	1976
Geocentric Position and/or Orbital Parameters with Star Satellite Photography from a Single Camera Station	CR-102-1	1963
Geodetic Control by Means of Astronomic and Torsion Balance Observations and the Gravimetric Reduction of Levelling	AD-672 491	1967
Geodetic Control without Triangulation, Trilateration, or Gravity Data and Gravimetric Reduction of Levelling		
1st Interim Report	AD-447 994L	1964
2nd Interim Report	AD-461 100L	1965
3rd Interim Report	AD-477 474	1965
Geodetic SECOR		1962
Geodetic SECOR Ground Equipment		1964
Geodetic SECOR Satellite	ETL-TR-74-6	1974
Geodetic SECOR Wide-Band RF Subsystem		1967
Geodetic SECOR Wide-Band RF Subsystem for SECOR Ground Equipment Sets	AD-804 780L	1967
Geodetic SECOR Wide-Band System		1966
Geodetic Spacecraft		1961
Geodimeter, Models I and II	1495-TR	1957
Geographic Modelling of Insurgency Resources	AD-848 723L	1969
Geographic Modelling of Insurgency Resources, Appendix	AD-851 896L	1969

TITLE	REPORT NO.	YEAR
Geoid Representation from Satellite-Determined Coefficients	AD-634 541	1966
Geologic Evaluation of Radar Imagery from Darien Province, Panama	AD-853 884	1969
Geometric Simultaneous Multistation Determination, with Constraints, Using Data from Geodetic Satellites	RN-22	1967
Geometrical Quality of Lunar Mapping by Photogrammetric Methods	RN-9	1962
Geomorphic Evaluation of Radar Imagery of Southeastern Panama and Northwestern Columbia	ETL-CR-71-2	1971
Geopotential Determination from Satellite to Satellite Tracking and Satellite Altimetry	ETL-CR-74-21	1975
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Gigas-Zeiss Digital Control Unit	ETL-ETR-73-1	1973
Gradiometer-Aided Rapid Gravity Survey System	ETL-0112	1977
Graphic Arts Symbol Generating Hardware for a Gerber Plotting System	ETL-CR-74-14	1974
Graphic Data Handling Techniques	AD-659 807	1967
Gravimetric Geodesy Free of Density Estimates through Analysis of Discrete Gravity Data	RN-12	1963
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Gravity Study Program, Interim Report	ETL-0253	1981
Hail and Its Distribution	ETL-SR-73-3	1973
Hexagonal Data Base Study	ETL-0338	1983
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High Resolution Orthophoto Output Table (HIROOT)	AD-856 731L	1969
High Resolution Orthophoto Output Table	ETL-ETR-72-3	1972
High Speed Disc Memory and a Color Image Display for a Small Computer	AD-878 975L	1970
High-Speed, Large-Format Film Writer Methodologies and Design Study	ETL-0389	1985
High Speed Parallel Sensing Scheme	ETL-0119	1977
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TITLE	REPORT NO.	YEAR
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Holographic Optical Elements With Low Q-Factors	ETL-0123	1977
Holographic Ray Tracing and Spot Diagrams	ETL-0052	1975
Holographic Stereogram Display Techniques for the Viewing and Mensuration of Stereo Photogrammetric Imagery	ETL-CR-74-2	1973
Holographic Terrain Displays	ETL-0083	1976
Holography and Stereoscopy	ETL-CR-72-2	1972
Horizontal Gradients of Gravity in Geodesy	AD-672 492	1964
Horizontal Gradients of Gravity in S.W. Ohio	AD-672 489	1967
Hot Weather Testing of 10-Second Direction Theodolite with Universal Tribrach and Universal Tripod, Astronomical Attachment, Universal Sun Compass, Lensatic Compass, and Wrist Compass Air Photo Patterns	1289-TR	1953
Image Alignment and Correlation System	ETL-0237	1980
Image-Based Approach to Mapping, Charting, and Geodesy	ETL-0366	1982
Image Correlation on a Parallel Processor	ETL-0061	1976
Image Enhancement by Chemical Intensification	ETL-0014	1975
Image Processing for Visual Navigation of Roadways	ETL-0406	1985
Image-Processing Precision and Affecting Relative Orientation	ETL-RN-71-6	1971
Image Scanner Technology Study	ETL-0137	1978
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Inertial Positioning System Test Data Summary Report	ETL-0028	1975
Inertial Survey Applications to Civil Works	ETL-0309	1983
Inertial Survey Equipment (GEISHA)	AD-814 051	1963
Inferential Techniques for Soil Depth Determinations, Part I: *Coleogyne ramossissima* Torr. (Black-Brush)	ETL-0036	1975
Inferential Techniques for Soil Depth Determinations, Part II: *Artemisia filifolia* Torr. (Sand Sagebrush)	ETL-0176	1979
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Instrument to Measure the Tilt of Large Structures, An	ETL-0313	1983
Instrumentation for Color Aerial Photography	ETL-RN-70-1	1970
Intelligent Advisors for Cross-Country Route Planning	ETL-0365	1984
Interactive Digital Correlation Techniques for Automatic Compilation of Elevation Data	ETL-0272	1981
Interactive Digital Image Processing for Terrain Data Extraction	ETL-0241	1980
Interactive Digital Image Processing for Terrain Data Extraction, Phase 2	ETL-0277	1981
Interactive Digital Image Processing for Terrain Data Extraction, Phase 3	ETL-0294	1982
Interactive Digital Image Processing for Terrain Data Extraction, Phase 4	ETL-0348	1983
Interactive Digital Image Processing for Terrain Data Extraction, Phase 5	ETL-0374	1984
Interactive Digital Image Processing Investigation	ETL-0172	1978
Interactive Digital Image Processing Investigation, Phase II	ETL-0221	1980
Interactive Image Analysis System Design	ETL-0312	1982
Interactive Knowledge-Based Cartographic Feature Extraction	ETL-0273	1981
Interagency Energy and Environmental Survey		1977
Interferometer Data Reduction Study	AD-503 143L	1969
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Interpolation of Deflections from Horizontal Gravity Gradients	AD-672 490	1967
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Interpretation of Radar Imagery for Terrain Analysis in Tropical Environments		1968
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Investigation and Evaluation of Planigon Lens Distortion Characteristics	1472-TR	1957
Investigation, Experiments, and Study of Electron Beam Recorder (EBR) Techniques for Map Production	ETL-CR-73-15	1973
Investigation of Bjerhammar's New Gravity Reduction Method	AD-460 404	1964
Investigation of Cartographic Pressplate Recording from Digital Data	ETL-0043	1976

TITLE	REPORT NO.	YEAR
Investigation of Continuous Photoconductive Layer Arrays	ETL-0011	1975
Investigation of Discrete Function Technology for Topographic Sciences	ETL-0162	1978
Investigation of Electro-Acoustic Technology for Topographic Application	ETL-0160	1978
Investigation of Extrema in Digital Images for Texture Analysis	ETL-0210	1979
Investigation of Fusion and Fixation Disparity Limits for Photogrammetry	AD-625 217	1965
Investigation of Linear Transformations for Automatic Cartographic Analysis	ETL-0181	1979
Investigation of Multiband Photographic Techniques, Vol. I	AD-479 300L	1965
Investigation of Multiband Photographic Techniques, Vol. III		1965
Investigation of Photographic Mapping Detail and Data Encoding	AD-286 715	1962
Investigation of Techniques to Generate Contours from Stereo Pairs	ETL-0029	1975
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Investigations Related to the Establishment of a World Geodetic System	AD-697 163	1969
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KANDIDATS	ETL-CR-71-3	1971
Knowledge-Based Images Analysis	ETL-0258	1981
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TITLE	REPORT NO.	YEAR
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Light, Target for Ranging Pole	1402-TR	1955
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TITLE	REPORT NO.	YEAR
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Measurement Techniques of Electrical Parameters of Surface Materials in the X-Band Region	ETL-0304	1982
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TITLE	REPORT NO.	YEAR
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Multi-Image Pattern Recognition: Ideas and Results	AD-863 596	
Multiparametric Figures of Equilibrium: Curvature of the Plumb Line	AD-603 073	1964
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Multipower Army Stereoscope	12-TR	
Multisensor Approaches for Determining Deflections of the Vertical	ETL-0314	1983
Multisensor Study of Plant Communities at Horsefly Mountain, Oregon	AD-698 098	1969
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TITLE	REPORT NO.	YEAR
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2nd Interim Report	AD-422 227	1963
3rd Interim Report	AD-432 243	1963
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TITLE	REPORT NO.	YEAR
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2nd Interim Report	AD-265 036	1961
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Photomap Reproduction System		1965
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TITLE	REPORT NO.	YEAR
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Potential Sand and Dust Source Areas	ETL-SR-72-1	1972
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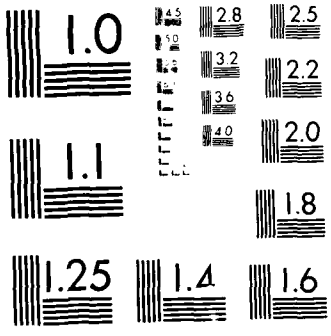

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