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Information Technology Division's Technical Paper Abstracts

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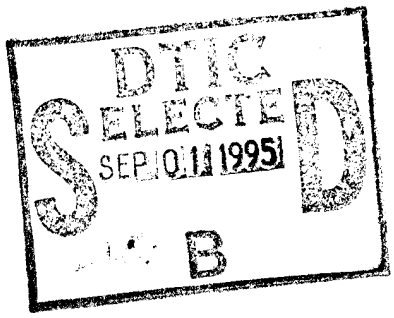
Information Technology Division



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13. ABSTRACT (*Maximum 200 words*)

"Information Technology Division Technical Paper Abstracts 1994" documents the accomplishments of projects at the six branches of the Information Technology Division. The six branches are: Navy Center for Applied Research in Artificial Intelligence (NCARAI) including: computational reasoning for intelligent decision aids, intelligent M4 (multi-media, multi-modal) systems, interface design and evaluation, machine learning, and sensor-based systems; Communication Systems, Center for Computer High Assurance Systems, Transmission Technology, Advanced Information Technology, and Center for Computational Science. Points of contact are indicated for acquiring additional technical information about the projects, and an order form is provided for obtaining copies of the publications abstracted.

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I. INTRODUCTION

The Naval Research Laboratory (NRL) is the corporate laboratory for the United States Navy. NRL employs more than 3700 civilians to conduct research and development programs in a wide range of technical disciplines. More than 750 of these employees hold doctorates, and staff members participate extensively in national and international technical groups. In reporting on its research the laboratory annually publishes over 1000 journal articles, technical papers and reports.

The Information Technology Division (ITD) is one of the largest Divisions at NRL. The technical areas of expertise in ITD include:

Artificial Intelligence
- intelligent simulation
- adaptive control software
- machine learning methods
- robotic vision and control
- interactive systems
- intelligent decision aids
- reasoning under uncertainty

Software
- computer security (COMPUSEC)
- network security
- software assurance
- software specification methodology
- hard real time (HRT) computing
- adaptive software testing methods
- information security (INFOSEC)

Communications
- network simulation
- HF communications
- communication security (COMSEC)
- communications networking

Human-Computer Interaction
- visualization techniques
- metrics and evaluation
- speech communication systems
- human-computer dialog

Decision Support Systems
- parallel processing techniques
- prototyping techniques
- distributed decision support
- distributed simulation

ITD has more than 220 civilian employees organized into six branches: the Navy Center for Applied Research in Artificial Intelligence, Communication Systems, Center for Computer High Assurance Systems, Transmission Technology, Advanced Information Technology, and Center for Computational Science.

Manuscript approved June 23, 1995.

II. NAVY CENTER FOR APPLIED RESEARCH IN ARTIFICIAL INTELLIGENCE CODE 5510

The Navy Center for Applied Research in Artificial Intelligence (NCARAI) is engaged in research and development efforts designed to address the application of artificial intelligence (AI) technology and techniques to critical Navy and national problems. The emphasis at NCARAI is the linkage of theory and application in demonstration projects that use a full spectrum of AI methods.

The technical papers and reports of NCARAI document the accomplishments of projects in computational reasoning for intelligent decision aids, intelligent M4 (multi-media, multi-modal) systems, interface design and evaluation, machine learning, and sensor-based systems. Innovative basic and exploratory research in these areas is made possible by NCARAI's staff of 46 individuals comprising an extraordinary cross section of AI talent from the Government civilian and military sectors, visiting scientists from universities, and consulting scientists from industry. An ongoing seminar series, featuring notable scientists from academic and industrial research communities, as well as the military services, provides an excellent opportunity to exchange information and maintain awareness of current developments.

Persons interested in acquiring additional information about the reported results are encouraged to contact the relevant technical personnel for whom e-mail addresses have been provided.

COMPUTATIONAL REASONING

Title: Research in Advanced Software Technologies at the Naval Research Laboratory: Machine Intelligence and Formal Methods
Author(s): Randall P. Shumaker and Laura C. Davis
E-mail Address: shumaker@itd.nrl.navy.mil or davis@aic.nrl.navy.mil
Citation: Proceedings of the 6th Annual Software Technology Conference, Salt Lake City, UT
Date: April 15, 1994
Report No.: AIC-94-010

Abstract

The Department of Defense is critically dependent upon software, with software representing a very large and rapidly growing fraction of the defense budget. In many respects software engineering methods have improved greatly in the last decade, but demands on these methods to produce ever larger and more complex systems have outpaced these improvements. The Naval Research Laboratory (NRL) Information Technology Division conducts applied research in artificial intelligence and formal methods in software engineering aimed at demonstrating the applicability and effectiveness of advanced software methods to practical problems. Several NRL efforts have matured sufficiently to be distributed for application or further development. While some of these methods represent quite different approaches to software specification, validation and testing than conventional software engineering practice, they are designed to fit within existing frameworks. Each of the systems shares a developmental philosophy -- construct a reusable tool useful within, and compatible with, existing methods of software engineering. This paper describes several of these current efforts and concludes with a discussion of issues in technology transition drawn from our experiences in tool development.

Title: Validating an Embedded Intelligent Sensor Control System
Author(s): Patrick R. Harrison and P. Ann Harrison
E-mail Address: harrison@aic.nrl.navy.mil
Citation: IEEE Expert, 49-53
Date: June 1994
Report No.: AIC-94-023

Abstract

This paper develops a theoretical model for the design of intelligent, real-time, sensor control systems. It then discusses system implementation using this model in the context of what the authors call validation based design. The design and implementation of an actual system using these concepts for sensor control on a high speed jet aircraft is then described. Finally, validation techniques and issues are discussed.

Title: Extension of Off-Nadir View Angles for Directional Sensor Systems
Author(s): D.S. Kimes, P. A. Harrison, and P. R. Harrison
E-mail Address: harrison@aic.nrl.navy.mil
Citation: Remote Sensing of the Environment, Elsevier Publishing
Date: November 1994
Report No.: AIC-94-033

Abstract

A knowledge-based system called VEG was expanded to infer nadir or any off-nadir reflectance(s) of a vegetation target given any combination of other directional reflectance(s) of target for a constant sun angle. VEG determines the best technique(s) to use in an array of techniques, applies the technique(s) to the target data, and provides rigorous estimate of the accuracy of the inference(s). The knowledge-based system VEG facilitates the use of diverse knowledge bases to be incorporated into the inference techniques. In this study, VEG used additional techniques that only use spectral data from the unknown target in a simplistic manner. VEG used spectral data and a normalized difference technique to infer the percent ground cover of the unknown target. This estimate of a percent ground cover of the unknown target along with information on the sun angle were then used to search a historical data base for targets that match the unknown target in these characteristics. This data captured the general shape of the reflectance distribution of the unknown target. This historical information was used to estimate the coefficients of the techniques for the condition at hand and to test the accuracy of the techniques. The tests used in this study were different ones. For example, techniques were tested that make long angular extensions using one, two, or four input view angles to predict an unknown nadir value. Furthermore, a wide variety of unknown targets were tested. The errors (+/-proportional rms) obtained were on the order of 0.15. In addition techniques were tested that use seven or nine multiple view angles to predict the entire hemispherical reflectance distribution of an unknown target. The accuracy of these tests was relatively good considering the relatively dynamic and noisy nature of directional reflectance distributions and the amount of historical data available that closely matches the unknown target.

Title: VEG: An Intelligent Workbench for Analyzing Spectral Reflectance Data
Author(s): P. A. Harrison, P. R. Harrison and D.S. Kimes
E-mail Address: harrison@aic.nrl.navy.mil
Citation: Proceedings of the 1994 Goddard Conference on Space Applications of AI, 193-205, Greenbelt, MD
Date: May 12, 1994
Report No.: AIC-94-048

Abstract

An Intelligent Workbench (VEG) has been developed for the systematic study of remotely sensed optical data from vegetation. A goal of the remote sensing community is to infer physical and biological properties of vegetation cover (e.g. cover type, hemispherical reflectance, ground cover, leaf area index, biomass and photosynthetic capacity) using directional spectral data. Numerous techniques that infer some of these vegetation properties have been published in the literature. A fundamental problem is deciding which technique to apply to the data and then estimating the error bounds on the results. Studies have found that using conventional techniques produced errors as high as 45%.

VEG collects together in a common format technique previously available data from many different sources in a variety of formats. The decision as to when a particular technique should be applied is nonalgorithmic and requires expert knowledge. VEG has

codified this expert knowledge into a rule-based decision component for determining which technique to use. VEG provides a comprehensive interface that makes applying the techniques simple and aids a researcher in developing and testing new techniques. VEG also allows the scientist to incorporate historical databases into problem solving. The scientist can match the target data being studied with historical data so the historical data can be used to provide the coefficients needed for applying analysis techniques. The historical data also provides more accurate error estimates than were previously available. VEG also enables the scientist to try "what-if" experiments on data using a variety of different techniques and historical data sets to do comparative studies or test experimental hypotheses.

VEG also provides a classification algorithm that can learn new classes of surface features. The learning system uses the database of historical cover types to learn class descriptions of one or more classes of cover types. These classes can include broad classes such as soil or vegetation or more specific classes such as forest, grass, and wheat. The classes can also include subclasses based on continuous parameters, e.g. 0-30% ground cover. The learning system uses sets of positive and negative examples from the historical databases to find the most important features that uniquely distinguish each class. The system then uses the learned classes to classify an unknown sample by finding the class that best matches the unknown cover type data. The learning systems also include an option that allows the user to test the system's classification performance.

VEG was developed using object oriented programming, and the current version consists of over 1500 objects.

Title: Application of AI Techniques to Infer Vegetation Characteristics from Directional Reflectance(s)
Author(s): P.R. Harrison and P. A. Harrison
E-mail Address: harrison@aic.nrl.navy.mil
Citation: Proceedings of the Sixth International Symposium on Physical Measurements and Signatures in Remote Sensing, Val D'Isere, France
Date: January 19, 1994
Report No.: AIC-94-049

Abstract

This article reports on the extension of the VEG remote sensing analysis workbench to include the capability to reason about nadir or any off-nadir reflectance(s) of a vegetation target given any combination of other directional reflectance(s) of the target. VEG determines the best techniques in an array of techniques, applies the techniques to the target data, and provides a rigorous estimate of the accuracy of the inferences. In this study, VEG used additional information to make more accurate view angle extension techniques than traditional techniques that only use spectral data from the unknown target. VEG used spectral data and a normalized difference technique to infer the percent ground cover of an unknown target. This estimate of percent ground cover of the unknown target along with information on the sun angle were then used to search a historical data base for targets that matched the unknown target in these characteristics. This historical information was used to estimate the coefficients of the techniques for existing conditions. Extensive testing was done to test the accuracy of the new techniques. The results were very positive for a wide range of problems and are detailed in the report.

Title: Practical Issues in the Development of an Embedded Real-Time Expert System
Author(s): P. A. Harrison, P. R. Harrison and M.A. Parisi
E-mail Address: harrison@aic.nrl.navy.mil
Citation: Proceedings of the Second World Congress on Expert Systems, Lisbon, Portugal, Pergamon Press
Date: January 12, 1994
Report No.: AIC-94-047

Abstract

The paper provides a practical discussion of an overall design concept for real-time intelligent sensor control systems. The discussion focuses on one component of this design concept. This component is an embedded, intelligent, decision aid called the Advice Generator. The application is the sensor control system on the F-14D aircraft. Intelligence is introduced into the sensor management system of the aircraft within a control context. The essence of the design separates control of induction from control of deduction in the sensor management system. The design allows the expert system component to do what expert systems do best, deduce, while overall control of induction is managed by the human (RIO) in the loop. The paper also discusses validation of the Advice Generator component in the context of the design model.

INTELLIGENT M4 SYSTEMS

Title: Eucalyptus: Integrating Natural Language Input with a Graphical User Interface
Author(s): Kenneth Wauchope
E-mail Address: wauchope@aic.nrl.navy.mil
Citation: Naval Research Laboratory Formal Report, NRL/FR/5510--94-9711
Date: February 25, 1994
Report No.: AIC-94-007

Abstract

This report describes Eucalyptus, a natural language (NL) interface that has been integrated with the graphical user interface of the KOALAS Test Planning Tool, a simulated Naval air combat command system. The multimodal, multimedia interface handles both imperative commands and database queries (either typed or spoken into a microphone) while still allowing full use of the original graphical interface. In this way the precision and consistency of direct manipulation is balanced and augmented by the descriptive power and reduced redundancy of NL. The two input media used together yield such powerful interaction techniques as deixis (simultaneous speech and pointing) and the ability to use mouse clicks and verbal referring expressions interchangeably. Finally, the system's discourse handling capability allows abbreviated NL follow-ups (anaphora and ellipsis) to receive full interpretations based on the prior interaction context, whether verbal or graphical.

Title: Human-Machine Dialogue for Multi-Modal Decision Support Systems
Author(s): Elaine Marsh, Kenneth Wauchope and John O. Gurney, Jr.
E-mail Address: marsh@aic.nrl.navy.mil
Citation: AAAI Spring Symposium Series on Intelligent Multi-Media Multi-Modal Systems, Stanford University, Palo Alto, CA.
Date: March 21-23, 1994
Report No.: AIC-94-032

Abstract

In this paper we describe some of the research on multi-modal dialogue being performed in the Interactive Systems group at the Navy Center for Applied Research in Artificial Intelligence at the Naval Research Laboratory. Our concern with multi-modal interfaces arises from our past work in developing general-purpose natural language interfaces that can be applied to a variety of decision support systems. This paper presents two related pieces of work by our group. In the first section (Marsh & Gurney), we describe our basic research in human-machine dialogue for multi-modal interfaces in which we apply discourse modeling to graphical user interfaces (GUIs) to promote multi-modal interactions. In the second section (Wauchope) we discuss an exploratory development effort concentrating on the integration of graphics and natural language with some discourse capability in a fully implemented, multi-modal/multi-media (M4) interface to a simulation-based tactical combat training tool. After presenting these two approaches, we provide with some final remarks.

Title: System Effectiveness of Knowledge-Based Technology: The Relationship of User Performance and Attitudinal Measures
Author(s): Geoffrey S. Hubona and Paul H. Cheney
E-mail Address: hubona@aic.nrl.navy.mil
Citation: Proceedings of the Twenty-Seventh Annual Hawaii International Conference on System Sciences (HICSS-27), vIV, 532-541, IEEE Computer Society Press.
Date: January 4-7, 1994
Report No.: AIC-94-041

Abstract

User satisfaction surveys are frequently used as surrogate measures of system effectiveness in spite of uncertainty whether user perceptions adequately measure system effectiveness. Furthermore, there is conflicting evidence whether effective system use is the cause, or the consequence, of user satisfaction. This study examines the relationship of effectiveness measures in the use of advisory knowledge-based applications. Two objective performance measures and three subjective attitudinal constructs are recorded as users engage in problem solving tasks supported under several interface software conditions. The objectives of the study are to test and validate an attitudinal instrument relevant to system effectiveness, and to determine the relationships of the objective and subjective measures within the context of a general user acceptance model.

Title: A Natural Language Interface For Virtual Reality Systems
Author(s): Stephanie Everett
E-mail Address: severett@aic.nrl.navy.mil
Citation: Internal Report
Date: December 1994
Report No.: AIC-94-046

Abstract

This paper describes a prototype system designed to illustrate the potential usefulness of natural language understanding in speech interfaces to immersive 3D virtual environments. The system uses off-the-shelf speech recognition and synthesis hardware and a general-purpose natural language understanding system developed by NRL. These components are combined to create a flexible and powerful interface to a 3D tactical scenario playback system. Capabilities of the interface system are described, and some relevant research issues are identified.

INTERFACE DESIGN AND EVALUATION

Title: Use of the User Action Notation at the Naval Research Laboratory Human-Computer Interaction Laboratory
Author(s): Joe Chase, Deborah Hix, David Tate, and James Templeman
E-mail Address: library@aic.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5530--94-7488
Date: June 30, 1994
Report No.: AIC-94-015

Abstract

This introduces researchers in the Information Technology Division of the Naval Research Laboratory (NRL) to the User Action Notation (UAN), a notation developed at Virginia Tech for representing the design of the interaction component of interactive systems. This report also presents use of the UAN in describing a variety of unique, innovative interaction techniques to evaluate the notation for its ability to represent such techniques, and explores the possibilities for future research and technology transition with the UAN collaboratively between NRL and Virginia Tech.

Title: Speech and Human Language Technology at the Naval Research Laboratory
Author(s) Helen M. Gigley
E-mail Address: gigley@itd.nrl.navy.mil
Citation: Proceedings of the Human Language Technology Workshop, Merrill Lynch Conference Center, Plainesboro, NJ
Date: March 8-11,1994
Report No.: AIC-94-031

Abstract

Following a brief introduction to the Naval Research Laboratory (NRL), specific ongoing research in speech and human language technology will be presented. Areas of research fall across two laboratories in the Information Technology Division, the Human Computer Interaction Laboratory (HCI) and the Navy Center for Applied Research in Artificial Intelligence (NCARAI). Speech research focuses on narrowband algorithm development and uses human based intelligibility to evaluate success. Demonstrations of results will be played. Navy has been a prominent participant in evaluation of narrowband speech. Current efforts on human-human communication evaluation will provide a basis for new approaches to multi-mode interactions which include speech interfaces. Finally, a video of ongoing efforts at NCARAI on the EUCALYPTUS system which include graphics and spoken language interaction will be shown.

Title: User Modeling -- A Paradigm for Human-Computer Interaction
Author(s) Helen M. Gigley
E-mail Address: gigley@itd.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AIC-94-034

Abstract

How can we use multiple channels of communication to enhance the bi-directional communication between human and machine? This question forms the premise of a new research effort at the Naval Research Laboratory called the Human Machine Dialogue Project. The goal is to use human-human interactions during decision making problem solving to develop human-machine interactions which can maximize the interchange of

information in a beneficial way between the computational counterpart of the team and the user. Aspects being studied include defining new modes of interaction using multi-modal pathways, assessing how and when these are appropriate to use and under what contexts they are best used alone. Evaluation forms a pivotal aspect of the initial study, design, and implementation and is used to determine what is a "better solution" for a given task. The effort assumes that user models provide crucial information about organizational principles that can be instantiated in a module which is independent from an application, a UIMS. How to represent user information, communication information, and application information, what to represent in each, and how to integrate their use is a focal research consideration in the work.

Title: Eye Tracking in Advanced Interface Design
Author(s) Robert J.K. Jacob
E-mail Address: jacob@itd.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AIC-94-036

Abstract

The problem of human-computer interaction can be viewed as two powerful information processors (human and computer) attempting to communicate with each other via a narrow-bandwidth, highly constrained interface (Tufte, 1989). To address it, we seek faster, more natural, and more convenient means for users and computers to exchange information. The user's side is constrained by the nature of human communication organs and abilities; the computer's is constrained only by input/output devices and interaction techniques that we can invent. Current technology has been stronger in the computer-to-user direction than user-to-computer, hence today's user-computer dialogues are rather one-sided, and the bandwidth from the computer communication medium can help redress this imbalance. This chapter describes the relevant characteristics of the human eye, eye tracking technology, how to design interaction techniques that incorporate eye movements into the use-computer dialogue in a convenient and natural way, and the relationship between eye movement interfaces and virtual environments.

Title: Integrality and Separability of Input Devices
Author(s): Robert J.K. Jacob, Linda E. Sibert, Daniel C. McFarlane, and M. Preston Mullen, Jr.
E-mail Address: jacob@itd.nrl.navy.mil or sibert@itd.nrl.navy.mil
Citation: ACM Transactions on Computer-Human Interaction, v1, n1, 3-26, ACM Press
Date: March 1994
Report No.: AIC-94-037

Abstract

Current input device taxonomies and other frameworks typically emphasize the mechanical structure of input devices. We suggest that selecting an appropriate input device for an interactive task requires looking beyond the physical structure of devices to the deeper perceptual structure of the task, the device, and the interrelationship between the perceptual structure of the task and the control properties of the device. We affirm that perception is key to understanding performance of multidimensional input devices on multidimensional tasks. We have therefore extended the theory of processing of perceptual structure to graphical interactive tasks and to the control structure of input devices. This allows us to predict task and device combinations that lead to better performance and hypothesize that performance is improved when the perceptual structure of the task matches the control structure of the device. We conducted an experiment in

which subjects performed two tasks with different perceptual structures, using two input devices with correspondingly different control structures, a three-dimensional tracker and a mouse. We analyzed both speed and accuracy, as well as the trajectories generated by subjects as they used the unconstrained three-dimensional tracker to perform each task. The results support our hypothesis and confirm the importance of matching the perceptual structure of the task and the control structure of the input device.

Title: Brevity Code Frequencies in AEGIS Team Training Communications
Author(s): Kay Gladwell Schulze, Lisa B. Achille, Astrid Schmidt-Nielsen, and Susan L. Feldman
E-mail Address: schulze@itd.nrl.navy.mil, achille@itd.nrl.navy.mil, or schmidtn@itd.nrl.navy.mil
Citation: NRL Technical Report 9574, Washington, DC: Naval Research Laboratory
Date: February 1994
Report No.: AIC-94-038

Abstract

Communications are a crucial aspect of military decision making. NATO restricted brevity codes are often used in verbal communications of AEGIS team members during training sessions and in the fleet. An understanding of the relationship between brevity code use and communication performance during AEGIS team training is important for brevity code training issues. We recorded the internal Combat Information Center (CIC) communications during AEGIS team training exercises and performed an analysis on speech turns that contained brevity codes. Brevity codes were identified, categorized, and analyzed and on average, 58% of the brevity codes used were used as defined. The remaining were used consistently as ordinary English or in a

manner we designated as "Professional." Brevity codes were categorized as Professional if they were used in a consistent manner by team members in what appeared to be a mutually accepted and consistent meaning different from either the NATO or English meanings.

This title is classified. Under limitations on distribution: DoD & DoD contractors only; test and evaluation; Feb 1994. Other requests shall be referred to : Commanding Officer, NRL

Title: Delivery of Information Through Sound
Author(s): James. A. Ballas
E-mail Address: ballas@aic.nrl.navy.mil
Citation: Auditory Display: Sonification, Audification and Auditory Interfaces, Proceedings, G. Kramer, editor, 79-94, Addison Wesley: Reading MA
Date: April 1994
Report No.: AIC-94-039

Abstract

The potential to deliver information through sound is rapidly expanding with new technology, new techniques, and significant advances in our understanding of hearing. Although these changes raise important new issues about the design of sound delivery systems, there is already a wide range of knowledge scattered through different disciplines about communicating information through nonspeech sound such as sonification. An overview of how sound can deliver information is presented using a framework of linguistic analogies. Areas that will be discussed in some detail include contextual and expectance effects, which operate when tonal sounds as well as realistic sounds are interpreted.

Title: A Software Architecture for Adding New Interaction Techniques to a Command and Control Based Testbed
Author(s): James N. Templeman, Deborah Hix, and Robert J.K. Jacob
E-mail Address: library@aic.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5530--94-7464
Date: March 25,1994
Report No.: AIC-94-040

Abstract

The Human-Computer (HCI) Laboratory at the Naval Research Laboratory (NRL) is developing high-performance interactive computer systems for use in Naval command and control applications. New technology allows computerized systems to make greater use of a person's natural physical, perceptual, and cognitive skills. These systems make it faster and more straightforward for users to access and enter information within the context of time critical, real world situations.

Our work focuses on developing novel interaction techniques-ways of using physical input and output devices to perform user tasks. Previous work has demonstrated the effectiveness of individual interaction techniques. This study is now integrating these techniques into a command and control testbed, that will be tested through empirical user-based evaluation.

Such new capabilities increase the complexity of software development and maintenance requirements of already complex systems. New software architectures must co-evolve with the technology to structure and manage these additional requirements. This report describes the new demands placed on interactive systems and explains how we are addressing this challenge, through development of a flexible software architecture.

Title: Effect of Event Variations and Sound Duration on Identificaion of Everyday Sound
Author(s): James. A. Ballas
E-mail Address: ballas@aic.nrl.navy.mil
Citation: Abstract from the International Conference on Auditory Display, Sante Fe, New Mexico, Addison-Wesley
Date: November 7-9, 1994
Report No.: AIC-94-043

Abstract

Data are presented from two experiments related to accurate identification of everyday sounds: what aspects of a complex sound with several transients are important for accurate identification, and how much of a sound must be heard to identify it. The first experiment was conducted to examine further what parts of a sound contribute to accurate identification, or conversely, confusion and ambiguity. The sounds used were a light switch and stapler and were chosen because they include a pattern of impacts that is somewhat similar. Multiple exemplars of each sound were produced by changing the instruments and circumstances of the event. Results showed that there may be two levels of analysis necessary in selecting and designing a sound for accurate identification. At one level one is concerned with the general type of sound and what other events it can signify. At another level, one is concerned with the details of the sound. Good design of the details can reduce the ambiguity, but in some cases ambiguity cannot be eliminated simply because two different events can legitimately produce the same acoustic pattern.

The second experiment was conducted to get some preliminary data on how much of a sound is needed for its identification. Although in the usual case, one would generate the complete sound, it would be useful to know when sufficient information has been presented for its identification. Forty-one sounds were presented for identification with the duration of the sound successively incremented in 50 ms steps. The results showed that listeners generally needed to hear very little of the sound to make accurate decisions. Accuracy was above 70% for all but three of the 41 test sounds. In general less than half of the sound needed to be heard, and in many cases less than 20% of the sound was needed for an accurate response.

Title: A Paradigm to Assess and Evaluate Tools to Support the Software Development Process
Author(s): James. A. Ballas and Janet L. Stroup
E-mail Address: ballas@aic.nrl.navy.mil or stroup@itd.nrl.navy.mil
Citation: "Integrating Human Factors with Software Engineering," edited by William E. Hefley, Position papers of the Seminar on Integrating Human Factors with Software Engineering, 1994 Annual Meeting of the Human Factors and Ergonomics Society, Nashville, TN, 91-99
Date: October 25 1994
Report No.: AIC-94-044

Abstract

We recently completed an initial study to develop a paradigm for software prototyping tool evaluation. Prototyping tools are used to produce "an executable unit that demonstrates particular aspects of the behavior or functionality of the desired software product" (Lee, Blum, Kanellakis, Crisp, and Caruso, 1994). Our study was conducted with a particular perspective of assessing how the tools support an aspect of software design that has received little attention: exploration of the design space. In order to pursue this perspective, an initial definition of design space exploration was developed and hypotheses were proposed on what outcomes would be observed if a tool supported

design space exploration. Finally, techniques were designed to obtain data to test the hypotheses in a general manner. Data were collected with these techniques during a session in which a particular tool was employed to design software.

Title: A UIMS Architecture for Focus Processing in a Graphical User Interface
Author(s): M.A. Pérez and R.J.K Jacob
E-mail Address: library@aic.nrl.navy.mil
Citation: Presented at AAAI 1994 Spring Symposium Series: Intelligent Multi-Media Multi-Modal Systems Workshop, Stanford University, CA.
Date: March 23, 1994
Report No.: AIC-94-053

Abstract

Today's graphical user interfaces remember little from one transaction to the next; each command exists nearly independently. Humans, however, typically draw on previous elements of a dialogue in their communications. We are seeking to add some of the characteristics of human dialogues to graphical interfaces. This paper describes our research into this problem and our initial results in answering three questions: What are the appropriate analogues of conversational focus in a graphical human-computer conversation? Where does this type of processing best fit within a user interface management system (UIMS) paradigm? What mechanisms can be used to realize it?

Title: The Modechart Toolset User Guide
Author(s): A. Rose, M.A. Pérez and P. Clements
E-mail Address: library@aic.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5540-94-7427
Date: February 14, 1994
Report No.: AIC-94-054 also CHASS-94-028

Abstract

This document describes how to use the Modechart Toolset (MT). MT is a set of tools designed to facilitate the specification, modeling, and analysis of real-time embedded systems using the Modechart language. MT supports the creation, modification, and storage of Modechart specifications. It also supports the analysis of Modechart specifications via a consistency and completeness checker, a simulator and a verifier.

MACHINE LEARNING

Title: Predictive Models Using Fitness Distributions of Genetic Operators
Author(s): John J. Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Workshop on Foundations of Genetic Algorithms 3 (FOGA-95), D. Whitley, editor, Morgan Kaufmann
Date: 1994
Report No.: AIC-94-001

Abstract

An important goal of the theory of genetic algorithms is to build predictive models of how well genetic algorithms are expected to perform, given a representation, a fitness landscape, and a set of genetic operators. This paper attempts to provide pieces of such a theory, in the form of tools that predict the behavior of genetic algorithms based on assumptions concerning the fitness distribution of genetic operators. The fitness distribution of an operator describes the distribution of fitness values of individuals resulting from an operator application as a function of the fitness of the original individual. It is shown that in some cases, the mean of the fitness distribution for genetic operators may be described by simple functions of the fitness of the parents. For these cases, predictive models of population fitness can be derived.

Title: Evolutionary Algorithms in Robotics
Author(s): John J. Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Robotics and Manufacturing: Recent Trends in Research, Education, and Applications, v5, Proceedings of the Fifth International Symposium on Robotics and Manufacturing (ISRAM '94), Mohammad Jamshidi and Charles Nguyen, editors, 65-72, ASME Press: New York
Date: August 14-18, 1994
Report No.: AIC-94-002

Abstract

The field of robotics offers an endless supply of difficult problems, requiring an equally impressive array of methods for their solution. One class of methods that has shown its utility on a number of relevant problems is called Evolutionary Computation. This term applies to computational methods that incorporate principles from biological population genetics to perform search, optimization, and machine learning, and includes a variety of specific formulations with names such as genetic algorithms, evolutionary programming, evolution strategies, and genetic programming. This article presents an overview of evolutionary algorithms, and discusses selected issues concerning their application to robotics.

Title: Learning Robot Behaviors Using Genetic Algorithms
Author(s): Alan C. Schultz
E-mail Address: schultz@aic.nrl.navy.mil
Citation: Intelligent Automation and Soft Computing: Trends in Research, Development, and Applications, v1, Mohammad Jamshidi and Charles Nguyen, editors, Proceedings of the First World Automation Congress (WAC '94) and Fifth International Symposium on Robotics and Manufacturing (ISRAM '94) Manufacturing, 607-612, TSI Press: Albuquerque
Date: August 14-17, 1994
Report No.: AIC-94-003

Abstract

Genetic Algorithms are used to learn navigation and collision avoidance behaviors for robots. The learning is performed under simulation, and the resulting behaviors are then used to control the actual robot.

The approach to learning behaviors for robots described here reflects a particular methodology for learning via a simulation model. The motivation is that making mistakes on real systems may be costly, dangerous, or time consuming. Since learning may require experimenting with behaviors that might occasionally produce unacceptable results if applied to the real world, or might require too much time in the real environment, we assume that hypothetical behaviors will be evaluated in a simulation model (the off-line system). The current best behavior can be placed in the real, on-line system, while learning continues in the off-line system.

The learning algorithm was designed to learn useful behaviors from simulations of limited fidelity. The expectation is that behaviors learned in these simulations will be useful in real-world environments. Previous studies have illustrated that knowledge learned under simulation is robust and might be applicable to the real world if the simulation is more general (i.e. has more noise, more varied conditions, etc.) than the real world environment. Where this is not possible, it is important to identify the differences between the simulation and the world and note the effect upon the learning process. The research reported here continues to examine this hypothesis.

Title: Integrating Reactive, Sequential, and Learning Behavior Using Dynamical Neural Networks
Author(s): Brian Yamauchi and Randall Beer
E-mail Address: library@aic.nrl.navy.mil
Citation: Third International Conference on Simulation of Adaptive Behavior
Date: 1994
Report No.: AIC-94-004

Abstract

This paper explores the use of dynamical neural networks to control autonomous agents in tasks requiring reactive, sequential, and learning behavior. We use a genetic algorithm to evolve networks that can solve these tasks. These networks provide a mechanism for integrating these different types of behavior in a smooth, continuous manner. We applied this approach to three different task domains: landmark recognition using sonar on a real mobile robot, one-dimensional navigation using a simulated agent, and reinforcement-based sequence learning. For the landmark recognition task, we evolved networks capable of differentiating between different landmarks based on the spatiotemporal information in a sequence of sonar readings obtained as the robot circled the landmark. For the navigation task, we evolved networks capable of associating the location of a landmark with a corresponding goal location and directing the agent to the goal. For the sequence learning task, we evolved networks that can learn to generate one of a set of possible sequences based upon reinforcement from the environment. A novel

feature of the learning aspects of our approach is that we assume neither an a priori discretization of states or time nor an a priori learning algorithm that explicitly modifies network parameters during learning. Instead, we expose dynamical neural networks to tasks that require learning and allow the genetic algorithm to evolve network dynamics capable of accomplishing these tasks.

Title: Using a Genetic Algorithm to Search for the Representational Bias of a Collective Reinforcement Learner
Author(s): Helen G. Cobb and Peter Bock
E-mail Address: cobb@aic.nrl.navy.mil
Citation: Third Parallel Problem Solving from Nature -PPSN-III, Yuval Davidor, Hans-Paul Schwefel, and Männer, editors, 576-587, Jerusalem, Israel, Springer-Verlag
Date: October 1994
Report No.: AIC-94-005

Abstract

In reinforcement learning, the state generalization problem can be considered to be the problem of finding a strong and correct representational bias for the learner. The study presented in this paper uses a genetic algorithm based system to evolve a reinforcement learner's representational bias. The State Partitioning Collective Learning System (Sparcle) is a hybrid system that combines a generational GA with a stochastic reinforcement learner called a Collective Learning Automaton (CLA). The primary focus of this study is to investigate the usefulness of the very strong representational biases that the Sparcle system finds for the CLA in terms of two qualities: stability and transferability. The stability of a representational bias is a measure of the quality of an experienced learner's solution, whereas the transferability of a bias measures how well an evolved bias can be transferred to a novice learner. The results presented in the paper show that the usefulness of the CLA's representational bias differs greatly with respect to its stability and its transferability. A representation that can be successfully interpreted by an experienced learner is sometimes inadequate as a representation for a novice learner, due to the fact that a strong representation may integrate knowledge into the representation to such a large extent that only an experienced learner can successfully interpret the representation.

Title: Simple Subpopulation Schemes
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Proceedings of the Third Annual Conference on Evolutionary Programming, Anthony V. Sebald and Lawrence J. Fogel, editors, 296-307, San Diego, CA, World Scientific Publishers
Date: February 24-26, 1994
Report No.: AIC-94-006

Abstract

This paper considers a new method for maintaining diversity by creating subpopulations in a standard generational evolutionary algorithm. Unlike other methods, it replaces the concept of distance between individuals with tag bits that identify the subpopulation to which an individual belongs. Two variations of this method are presented, illustrating the feasibility of this approach.

Title: Assimilating High-Level Advice in Embedded Agents
Author(s): Devika Subramanian and Diana Gordon
E-mail Address: gordon@aic.nrl.navy.mil
Citation: Internal Report
Date: April 1994
Report No.: AIC-94-008

Abstract

In this paper, we address the problem of designing and refining strategies for agents embedded in dynamic, multi-agent worlds. We use high-level advice given by an expert, as well as knowledge of the domain dynamics, to design a parametric action map from an agent's sensors and its internal state to its effectors. A genetic algorithm (GA) refines the action map as the agent dynamically interacts with the environment. We compare the performance of our multistrategy learner against a GA that uses a random initial seed. Our learner converges substantially faster and, in many cases, to a more accurate solution, than a randomly initialized GA in two complex simulated domains and performs well on navigation with a Nomad 200 robot. We experimentally identify and analyze the conditions under which high-level advice can be expected to significantly improve the design of task-level strategies.

Title: Predicting the Performance of Genetic Algorithms
Author(s): John J. Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Invited presentation at the American Geophysical Union 1994 Spring Meeting
Date: May 23-27, 1994
Report No.: AIC-94-009

Abstract

Genetic algorithms are probabilistic optimization techniques based on principles derived from natural population genetics. These algorithms have been used successfully in a variety of problems that are not amenable to traditional optimization methods. As with many heuristic methods, the development of the theoretical foundations of genetic algorithms has proceeded at a slower pace than the progress in the applications of the method. However, there have been some recent developments that may be of interest to users.

A central goal of the theory of genetic algorithms is to understand the relationships among the performance of a genetic algorithm, the problem representation, and the genetic search operators. We are working to develop tools that predict the behavior of genetic algorithms based on properties of the "fitness distribution" of genetic operators. The fitness distribution of an operator describes the expected fitness value of an individual resulting from an operator application, as a function of the fitness of the original individual. It can be shown that in many cases, the fitness distribution for genetic operators may be described by simple functions of the fitness of the parents. For these cases, predictive models of population fitness can be derived.

Title: Feature Selection for Case-Based Classification of Cloud Types: An Empirical Comparison
Author(s): David W. Aha and Richard L. Bankert
E-mail Address: aha@aic.nrl.navy.mil
Citation: Proceedings of the AAAI-94 Workshop on Case-Based Reasoning
Date: July 1994
Report No.: AIC-94-011

Abstract

Accurate weather prediction is crucial for many activities, including Naval operations. Researchers within the meteorological division of the Naval Research Laboratory have developed and fielded several expert systems for problems such as fog turbulence forecasting, and tropical storm movement. They are currently developing an automated system for satellite image interpretation, part of which involves cloud classification. Their cloud classification database contains 204 high-level features, but contains only a few thousand instances. The predictive accuracy of classifiers can be improved on this task by employing a feature selection algorithm. We explain why non-parametric case-based classifiers are excellent choices for use in feature selection algorithms. We then describe a set of such algorithms that use case-based classifiers, empirically compare them, and introduce novel extensions of backward sequential selection that allows it to scale to this task. Several of the approaches we tested feature subsets that attain significantly higher accuracies than those found in previously published research, and some did so with fewer features.

Title: Towards a Better Understanding of Memory-Based Reasoning Systems
Author(s): John Rachlin, Simon Kasif, Steven Salzberg and David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: 1994 International Machine Learning Conference
Date: July 1994
Report No.: AIC-94-012

Abstract

We quantify both experimentally and analytically the performance of memory-based reasoning (MBR) algorithms. To start gaining insight into the capabilities of MBR algorithms, we compare an MBR algorithm using a value difference metric to a popular Bayesian classifier. These two approaches are similar in that they both make certain independence assumptions about the data. However, whereas MBR uses specific cases to perform classification, Bayesian methods summarize the data probabilistically. We demonstrate that a particular MBR system called PEBLS works comparatively well on a wide range of domains using both real and artificial data. With respect to the artificial data, we consider distributions where the concept classes are separated by functional discriminants, as well as time-series data generated by Markov models of varying complexity. Finally, we show formally that PEBLS can learn (in the limit) natural concept classes that the Bayesian classifier cannot learn, and that it will attain perfect accuracy whenever Bayes does.

Title: An Evolutionary Approach to Learning in Robots
Author(s): John Grefenstette and Alan Schultz
E-mail Address: gref@aic.nrl.navy.mil or schultz@aic.nrl.navy.mil
Citation: Machine Learning Workshop on Robot Learning, New Brunswick, NJ
Date: July 13, 1994
Report No.: AIC-94-014

Abstract

Evolutionary learning methods have been found to be useful in several areas in the development of intelligent robots. In the approach described here, evolutionary algorithms are used to explore alternative robot behaviors within a simulation model as a way of reducing the overall knowledge engineering effort. The learned behaviors are then placed into actual robots. This paper presents some initial results of applying the SAMUEL genetic learning system to a collision avoidance and navigation task for mobile robots.

Title: Case-Based Anytime Learning
Author(s): Connie Loggia Ramsey and John Grefenstette
E-mail Address: ramsey@aic.nrl.navy.mil or gref@aic.nrl.navy.mil
Citation: Case Based Reasoning: Papers from the 1994 Workshop, D.W. Aha, editor, Technical Report WS-94-07, AAAI Press: Menlo Park, CA
Date: August 1994
Report No.: AIC-94-016

Abstract

We discuss a case-based method of initializing genetic algorithms that are used to guide search in changing environments. This is incorporated in an *anytime learning* system. Anytime learning is a general approach to continuous learning in a changing environment. A genetic algorithm with a case-based component provides an appropriate search mechanism for anytime learning. When the genetic algorithm is restarted, strategies which were previously learned under similar environmental conditions are included in the initial population of the genetic algorithm. We have evaluated the system by comparing performance with and without the case-based component, and case-based initialization of the population results in a significantly improved performance.

Title: Evolving Robot Behaviors
Author(s): Alan Schultz and John Grefenstette
E-mail Address: schultz@aic.nrl.navy.mil or gref@aic.nrl.navy.mil
Citation: Poster paper at the 1994 Artificial Life Conference
Date: October 1994
Report No.: AIC-94-017

Abstract

This paper discusses the use of evolutionary computation to evolve behaviors that exhibit emergent intelligent behavior. Genetic algorithms are used to learn navigation and collision avoidance behaviors for robots. The learning is performed under simulation, and the resulting behaviors are then used to control the actual robot. Some of the emergent behavior is described in detail.

Title: A Simpler Look at Consistency
Author(s): William M. Spears and Diana Gordon
E-mail Address: spears@aic.nrl.navy.mil or gordon@aic.nrl.navy.mil
Citation: Internal Report
Date: September 1994
Report No.: AIC-94-018

Abstract

One of the major goals of most early concept learners was to find hypotheses that were perfectly consistent with the training data. It was believed that this goal would indirectly achieve a high degree of predictive accuracy on a set of test data. Later research has partially disproved this belief. However, the issue of consistency has not yet been resolved completely.

We examine the issue of consistency from a new perspective. To avoid overfitting the training data, a considerable number of current systems have sacrificed the goal of learning hypotheses that are perfectly consistent with the training instances by setting a goal of hypothesis simplicity (Occam's razor). Instead of using simplicity as a goal, we have developed a novel approach that addresses consistency directly. In other words, our concept learner has the explicit goal of selecting the most appropriate degree of consistency with the training data.

Title: Using Markov Chains to Analyze GAFOs
Author(s): Kenneth A. De Jong, William M. Spears and Diana Gordon
E-mail Address: dejong@aic.nrl.navy.mil, spears@aic.nrl.navy.mil or gordon@aic.nrl.navy.mil
Citation: Foundations of Genetic Algorithms Workshop (FOGA) Estes Park, CO
Date: July 30 - August 2, 1994
Report No.: AIC-94-020

Abstract

Our theoretical understanding of the properties of GAs being used for function optimization (GAFOs) is not as strong as we would like. Traditional schema analysis provides some first order insights, but doesn't capture the effects of representation or the non-linear dynamics of the GA search process. Markov chain theory has been used primarily for steady state analysis of GAs. In this paper we explore the use of transient Markov chain analysis to model and understand the behavior of finite population GAFOs observed while in transition to steady states. This approach appears to provide new insights into GA "hardness" and "deception." Some preliminary results are presented and an initial evaluation of the merits of this approach is provided.

Title: Calibrating, Counting, Grounding, Grouping
Author(s): J. Drapkin, D. Gordon, S. Kraus, M. Miller, M. Nirkhe, and D. Perlis
E-mail Address: gordon@aic.nrl.navy.mil or perlis@cs.umd.edu
Citation: Proceedings of the AAAI 94 Fall Symposium on "Control of the Physical World by Intelligent Agents."
Date: September 1994
Report No.: AIC-94-021

Abstract

Even an "elementary" intelligence for control of the physical world will require extensive knowledge and ability. Among these are ones related to perception, action, and reasoning about "near space:" that region comprising one's body and the portion of space within reach of one's effectors; chief among these are individuation and categorization of

objects. These in turn are made useful in part by the additional capacities to estimate category size, change one's beliefs about categories, and form new categories or revise old categories.

In this position paper we point out some issues in knowledge representation that can arise with respect to the above capacities, and suggest that the framework of "active logics" may be marshaled toward solutions. We conduct our discussion in terms of learning to understand in a semantically explicit way one's own sensori-motor system and its interactions with near-space objects.

Title: A Test of an Unsupervised Machine Learning Procedure Applied to Cloud Classification Data
Author(s): D. Gordon, P. Tag and R. Bakert
E-mail Address: gordon@aic.nrl.navy.mil
Citation: An extended abstract in the Proceedings of the Seventh Workshop on Artificial Intelligence Research in Environmental Science (AIRIES 94) Conference
Date: November 1994
Report No.: AIC-94-022

Abstract

This paper describes the application of the unsupervised learning system Autoclass to a meteorological data set. The data set was developed from satellite imagery of cloud regions. The purpose of the experiments described is to compare cloud classes produced from an unsupervised learning procedure to traditional cloud classes.

Title: Learning Recursive Relations with Randomly Selected Small Training Sets
Author(s): David W. Aha, Stephane Lapointe, Charles X. Ling, and Stan Matwin
E-mail Address: aha@aic.nrl.navy.mil, lapointe@drev.dnd.ca or ling@csd.uwo.ca
Citation: Eleventh International Machine Learning Conference, 12-18, Morgan Kaufmann
Date: July 1994
Report No.: AIC-94-024

Abstract

We evaluate CRUSTACEAN, an inductive logic programming algorithm that uses inverse implication to induce recursive clauses from examples. This approach is well suited for learning a class of self-recursive clauses, which commonly appear in logic programs, because it searches for common sub-structures among the examples. However, little evidence exists that inverse implication approaches perform well when given only randomly selected positive and negative examples. We show that CRUSTACEAN learns recursive relations with higher accuracies than GOLEM, yet with reasonable efficiency. We also demonstrate that increasing the number of randomly selected positive and negative examples increases its accuracy on randomly selected test examples, increases the frequency in which it outputs the target relation, and reduces its number of outputs. We also prove a theorem that defines the class of logic programs for which our approach is complete.

Title: User's Guide to the Navigation and Collision Avoidance Task
Author(s): Diana F. Gordon, Alan C. Schultz, John J. Grefenstette, James Ballas, and Manuel A. Pérez
E-mail Address: gordon@aic.nrl.navy.mil, schultz@aic.nrl.navy.mil, or gref@aic.nrl.navy.mil
Citation: Internal Report
Date: October 1994
Report No.: AIC-94-013

Abstract

This document is the User's Manual for the Navigation and Collision Avoidance task developed at the Naval Research Laboratory. This task, alternatively called the "AUV task," consists of a two-dimensional simulation of an autonomous underwater vehicle (AUV), the agent, that tries to avoid mines and rendezvous with a goal location before exhausting its fuel. Along with two other tasks, this task is part of a common testbed for hybrid models of learning to be developed as part of the Office of Naval Research (ONR) Hybrid Learning Research Initiative. Therefore, this task is designed to be learned by either human subjects or by artificial learning systems. Included with the task is an interface that offers the experimenter easy and flexible task reconfiguration. Furthermore, there are multiple user interfaces for human subjects as well as the option of either joystick or keyboard input for control. All of these options are described in detail in this manual.

Title: Adapting Crossover in Genetic Algorithms
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Internal Report
Date: October 1994
Report No.: AIC-94-019

Abstract

Traditionally, genetic algorithms have relied upon 1 and 2-point crossover operators. Many recent empirical studies, however, have shown the benefits of higher numbers of crossover points. Some of the most intriguing recent work has focused on uniform crossover, which involves on the average $L / 2$ crossover points for strings of length L. Despite theoretical analysis, however, it appears difficult to predict when a particular crossover form will be optimal for a given problem. This paper describes two adaptive mechanisms that decide, as a GA runs, which form is optimal.

Title: Adapting Crossover in Evolutionary Algorithms
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Internal Report
Date: October 1994
Report No.: AIC-94-025

Abstract

One of the major issues in evolutionary algorithms (EAs) is the relative importance of two genetic operators: mutation and crossover. Genetic algorithms (GAs) and genetic programming (GP) stress the role of crossover, while evolutionary programming (EP) and evolution strategies (ESs) stress the role of mutation. The existence of many different forms of crossover further complicates the issue. Despite theoretical analysis, it appears to be difficult to decide a priori which form of crossover to

use, or even if crossover should be used at all, for a given problem. One possible solution to this difficulty is to have the EA be self-adaptive, i.e., to have the EA decide which forms of crossover to use and how often to use them, as the EA attempts to solve the problem. In this paper we describe two adaptive mechanisms for controlling the use of crossover in an EA. The first mechanism assumes that crossover will be used, and chooses between two different forms. The second mechanism is more flexible in that it can also choose to not use crossover. We explore the behaviour of both mechanisms in a number of different situations. Finally, we present an improvement to the adaptive mechanisms. Surprisingly this improvement can also be used to enhance performance in a non-self-adaptive EA.

Title: A Comparative Evaluation of Sequential Feature Selection Algorithm
Author(s): David W. Aha and Richard L. Bankert
E-mail Address: aha@aic.nrl.navy.mil
Citation: Internal Report (To appear as a poster paper at 1995 AI & Statistics Workshop)
Date: November 1994
Report No.: AIC-94-026

Abstract

Several recent machine learning publications demonstrate the utility of using feature selection algorithms in supervised learning tasks. Among these, *sequential feature selection* algorithms are receiving attention. The most frequently studied variants of these algorithms are *forward and backward sequential selection*. Many studies on supervised learning with sequential feature selection report applications of these algorithms, but do not consider variants of them that might be more appropriate for some performance tasks. This paper reports positive empirical results on such variants, and argues for their serious consideration in similar learning tasks.

Title: Automated Identification of Cloud Patterns in Satellite Imagery
Author(s): Richard L. Bankert and David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: Fourteenth Conference on Weather Analysis and Forecasting, Dallas, TX American Meteorological Society
Date: November 1994
Report No.: AIC-94-027

Abstract

At the Naval Research Laboratory progress continues to be made in the development of an automated system, named SIAS (Satellite Image Analysis System) for the interpretation of satellite imagery (Peak and Tag, 1994a). Presented here is a report on the developments specifically related to the cloud pattern identification portion of SIAS (Bankert, 1994a). Recent developments include computation of additional pattern attributes, examination of more specific pattern types, and use of different feature selection routines and identification methods.

The ability of an automated identification procedure to correctly classify various meteorologically significant cloud patterns in satellite imagery will be demonstrated. The level of identification accuracy will be shown to be, among other things, dependent upon proper selection of pattern attributes and identification method.

Title: Genetic Algorithms: A 25 Year Perspective
Author(s): Ken De Jong
E-mail Address: dejong@aic.nrl.navy.mil
Citation: Proceedings of the IEEE World Congress on Computational Intelligence
Date: June 26-July 2, 1994
Report No.: AIC-94-045

Abstract

It's now been more than 25 years since Holland's ideas about robust adaptive systems led to the design and implementation of the first genetic algorithms. It is an opportunity to be reflective about those early beginnings, to assess the progress that has been made, and to identify critical issues that need to be addressed for continued progress in the field.

SENSOR-BASED SYSTEMS

Title: Tripod Operators for Realtime Recognition of Surface Shapes in Range Images
Author(s): Frank Pipitone
E-mail Address: pipitone@aic.nrl.navy.mil
Citation: Proceedings of the NASA Technology 2004 Symposium, Washington DC
Date: November 1994
Report No.: AIC-94-029

Abstract

Tripod operators (TO's) are a versatile class of feature extraction operators for surfaces. They are useful for recognition and/or localization based on range or tactile data. They extract a few sparse point samples in a regimented way, so that N sampled surface points yield only N-3 independent scalar features containing all the pose-invariant surface shape information in these points and no other information. They provide a powerful index into sets of prestored surface representations. A TO consists of three points in 3-space fixed at the vertices of an equilateral triangle and a procedure for making several "depth" measurements in the coordinate frame of the triangle, which is placed on the surface like a surveyor's tripod. TO's can be imbedded in a vision system in many ways and applied to almost any surface shape. Here the focus is an experimental study in which individual TO's are used to search a cluttered range image for one of 25 known shapes, typically in milliseconds, with very few false detections. We believe that this simple way of using TO's, in conjunction with existing triangulation range sensor technology, can be effectively applied to industrial parts recognition tasks, and with additional research to other applications.

Title: Rapid Recognition of Elementary Surface Shapes in Cluttered Range Images Using Tripod Operators
Author(s): Frank Pipitone
E-mail Address: pipitone@aic.nrl.navy.mil
Citation: Proceedings of the Workshop on Machine Vision Applications (MVA 94/IAPR), Kawasaki, Japan
Date: December 1994
Report No.: AIC-94-030

Abstract

Tripod operators (TO's) are a versatile class of feature extraction operators for surfaces. They are useful for recognition and/or localization based on range or tactile data. They extract a few sparse point samples in a regimented way, so that N sampled surface points yield only N-3 independent scalar features containing all the pose-invariant surface shape information in these points and no other information. They provide a powerful index into sets of prestored surface representations. A TO consists of three points in 3-space fixed at the vertices of an equilateral triangle and a procedure for making several "depth" measurements in the coordinate frame of the triangle, which is placed on the surface like a surveyor's tripod. They have complete six DOF isometry invariance and can be imbedded in a vision system in many ways and applied to almost any surface shape. Here the focus is an experimental study in which TO's are used to search a cluttered range image for one of 25 known shapes, typically in milliseconds, with very few false positive detections.

Title: Multi-Source Data Deinterleaving with Neural Networks
Author(s): Behrooz Kamgar-Parsi, Behzad Kamgar-Parsi, and John Sciortino
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: Proceedings of TECOM Artificial Intelligence Symposium, Aberdeen, MD
Date: September 1994
Report No.: AIC-94-028

Abstract

When several data sources are sending asynchronously without any multiplexing conventions, the stream of data from each source will be interleaved in an unpredictable sequence. In such a situation, it would be highly desirable to deinterleave the data streams before attempting further processing. After the application of certain signal processing techniques on the incoming interleaved data stream, one obtains a feature space in which different data sources typically form distinct clusters. It is therefore essential to have a reliable clustering technique to determine: (i) the correct number of sources, and (ii) the correct membership for each datum. The Hopfield-Kamgar neural net clustering technique appears to be the clustering technique of choice for this task. We will explain the main aspects of our technique and briefly discuss alternative neural nets and conventional methods for clustering, and in particular as applied to data deinterleaving.

Title: Learning Natural Thresholds for Object Recognition
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-parsi
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AIC-94-042

Abstract

To determine whether or not an unknown object is a correct match of a given object *P*, current techniques define a threshold value and decide the matter by whether or not the similarity measure exceeds the threshold. The unknown object may deviate from object *P* in many ways. Hence, a given threshold may lead to a correct answer for certain types of deviations but not for others. Humans on the other hand appear to use thresholds that are multi-dimensional and complex. We propose an approach to develop natural thresholds for acceptance/rejection. This is done by attempting to construct decision boundaries at places where the human eye appears to "draw" the line between acceptable (*P*) and unacceptable (not *P*). To this end we have developed a random deformation technique which is capable of automatically generating an infinite number of true and false look-alikes of object *P*, which are then learned by the system. We have applied this technique to a real life problem, namely, distinguishing an approaching aircraft from clouds (or other objects) through its shape. The discriminating power of the system is comparable to that of the human eye.

Title: Quantization Error in Regular Grids: Triangular Pixels
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-parsi
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AIC-94-051

Abstract

Quantization of the image plane into pixels introduces an error in any quantity computed from the image. Digital processing of images requires quantizing the image

plane into pixels. This spatial quantization introduces an error in any quantity computed from the image. The regular polygons that tile a 2D plane are triangles, squares, and hexagons. In previous papers we treated square and hexagonal pixels. Here we derive closed-form, analytic expressions for the average error and the error distribution function due to triangular pixel quantization, for any function of an arbitrary number of independent variables in the linear approximation. These quantities are essential in examining the intrinsic sensitivity of image processing algorithms. We, also, find the result that for all possible cases $0.99<E_T/E_S<1.13$, where E_T and E_S are the expected errors in triangular and square pixel quantizations.

Title: Model-based Pattern Recognition with Multilayer Neural Networks
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AIC-94-052

Abstract

We propose a model-based pattern recognition approach using multilayer neural networks to overcome certain shortcomings of the conventional techniques. In conventional model-based pattern (or object) recognition approaches one finds the best match between the pattern of interest and the patterns stored in a database to identify the pattern (or search a scene in order to detect a given pattern). Shortcomings of this approach are that: (i) it may be time consuming to search for the best match or the nearest neighbor, (ii) the best match may not be the correct match leading to erroneous results. Using multilayer networks we propose an approach so that the system is able to decide (with great confidence) whether the pattern of interest is a correct match of the encountered pattern or a correct member of its class. Thus, not only misclassification is unlikely, but also the search terminates as soon as a correct match is found, i.e. without a need to first find the best match. In essence the purpose of our approach is to make it possible for a model-based vision system to perform more like a human eye. The suggested approach does, in fact, attempt to construct decision boundaries at places where the human eye appears to "draw" the line between acceptable and unacceptable patterns. We have applied this technique to a real life problem; the discriminating power of the proposed technique appears to be comparable to that of the human eye. We note that this is a new application for multilayer networks, because in their common pattern recognition applications, they too cannot decide whether the closest class is the correct class.

Title: Distribution and Moments of the Weighted Sum of Uniform Random Variables, with Applications in reducing Monte Carlo Simulations
Author(s): Behzad Kamgar-Parsi, Behrooz Kamgar-Parsi and Menashe Brosh
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: In press. Journal of Statistical Computation and Simulation
Date: 1994
Report No.: AIC-94-050

Abstract

We derive analytical expressions for the distribution function and the moments of the weighted sum $Y=\sum_i{}^n{}_{=1}\, a_i X_i$, *where* X_i are independent random variables with non-identical uniform distributions, for an arbitrary number of variables N, and arbitrary

coefficient values a_i. These results are the generalizations of those for the regular sum of uniform random variables. Using the results, we examine the inadequacy of the central limit approximation for finite N. We also discuss the savings in the cost of computing properties of the weighted sum using these results *vs.* Monte Carlo simulations. We give an example of the application of the weighted sum to analyzing the effects of digitization error in computer vision.

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Title: Ordinal Optimization by Means of Standard Clock Simulation and Crude Analytical Models
Author(s): Craig M. Barnhart, Jeffrey E. Wieselthier, and Anthony Ephremides
E-mail Address: barnhart@itd.nrl.navy.mil
Citation: 33rd IEEE Conference on Decision and Control, Lake Buena Vista, FL
Date: December 14-16, 1994
Report No.: CS-94-001

Abstract

In this paper we apply the ideas of ordinal optimization and the technique of Standard Clock (SC) simulation to the voice-call admission-control problem in integrated voice/data multihop radio networks. This is an important problem in networking that is not amenable to a satisfactory analysis by means of the usual network modeling techniques. We develop and efficient simulation model based on the use of the SC approach, which permits the simultaneous simulation of a large number of admission-control policies, thereby reducing computation time significantly. We then demonstrate the effectiveness of ordinal-optimization techniques, which provide a remarkably good ranking of admission-control policies after relatively short simulation runs, thereby facilitating the rapid determination of good policies. Moreover, we demonstrate that the use of crude and inaccurate analytical and simulation models can provide highly accurate policy rankings that can be used in conjunction with ordinal-optimization methods, provided that they incorporate the key aspects of system operation.

Title: Reed-Solomon Coding Performance with Errors and Erasures Decoding on a Rayleigh Fading Channel
Author(s): Paul J. Crepeau and Karen W. Halford
E-mail Address: crepeau@itd.nrl.navy.mil
Citation: Proceedings: MILCOM '94
Date: October 1994
Report No.: CS-94-002

Abstract

In this paper we present analytical results for a specific case of message transmission over a Rayleigh fading channel using NCMFSK and RS coding with errors and erasures decoding. Results show that errors and erasures decoding provides a 4 dB coding gain compared to errors-only (hard decision) decoding. Furthermore, we show that the ratio of erasures to errors must be nearly 20:1 to achieve minimum, message error probability. Finally, we show that this choice of decoding strategy maximized Ro, the cutoff rate parameter of the coding channel.

Title: Integrated Computer Aided Design Practices As Demonstrated On A Fin-Line Device
Author(s): J.A. Molnar
E-mail Address: molnar@itd.nrl.navy.mil
Citation: IETE Technical Review
Date: April 1994
Report No.: CS-94-003

Abstract

The integration of circuit simulation with numerical simulation of electromagnetic structures is examined in the application to a fin-line attenuator design. Numerical modeling of the electromagnetic structure provides the benefit of visualizing the structure and examining the propagation of electromagnetic fields, an aspect that is absent

from circuit simulation computer packages. Associated with the benefits is the ability to export design information to circuit simulators for improved computation efficiency. The disadvantage remains that numerical modeling of complex structures is computationally intensive.

Title: Ordinal Optimization of Admission Control in Wireless Multihop Integrated Networks via Standard Clock Simulation
Author(s): Jeffrey E. Wieselthier, Craig M. Barnhart, and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Proceedings of INFOCOM '94, Conference on Computer Communications, Part One, v1, pp29-38.
Date: June 12-16, 1994
Report No.: CS-94-004

Abstract

In this report we apply the ideas of ordinal optimization and the technique of Standard Clock (SC) simulation to the voice-call admission-control problem in integrated voice/data multihop radio networks. We first describe the use of the SC approach on sequential machines, and quantify the speedup in simulation time that is achieved by its use in a number of queueing examples. We then develop an efficient simulation model for wireless integrated networks based on the use of the SC approach, which permits the rapid parallel simulation of a large number of admission-control policies. This model is an extension of the basic SC approach in that it incorporates fixed-length data packets, whereas SC simulation is normally limited to systems with exponential interevent times. Using this model, we demonstrate the effectiveness of ordinal-optimization techniques, which provides remarkably good ranking of admission-control policies after relatively short simulation runs, thereby facilitating the rapid determination of good policies. Moreover, we demonstrate that the use of crude, inaccurate analytical and simulation models can provide highly accurate policy rankings that can be used in conjunction with ordinal-optimization methods, provided that they incorporate the key aspects of system operation.

Title: A New Look at Double Error Correcting BCH Codes
Author(s): P.J. Crepeau
E-mail Address: crepeau@itd.nrl.navy.mil
Citation: Seminar - Communication Systems Laboratory at the University of Virginia
Date: April 1994
Report No.: CS-94-005

Abstract

When three raw channel errors are made on a binary symmetric channel that uses a double error correcting BCH code, the received data will either fall in an erroneous decoding sphere or it will fall in the interstitial region between decoding spheres. In this presentation we give a new construction that clearly shows why the error locator polynomial has two roots in the former case and has (with rare exception) no roots in the latter case. This construction employs the addition table of the code's Galois field, viewing the solution of the error locator polynomial as a search of squares of the addition table similar to the motion of a knight on a chess board. This shows that errors falling within decoding spheres are undetectable, but errors falling in the interstitial region are largely detectable. The results have application in finding the probability of undetected message error for codes that try simultaneously to correct and detect errors.

Title: Discrete-Event-Dynamic-System-Based Approaches for Control in Integrated Voice/Data Multihop Radio Networks
Author(s): C.G. Cassandras and Vibhor Julka
E-mail Address: library@aic.nrl.navy.mil
Citation: NRL Memorandum Report No. 7601
Date: December 7, 1994
Report No.: CS-94-006

Abstract

We report accomplishments and new directions in our effort to develop and apply discrete-event-dynamic-system-based techniques for the transmission scheduling problem in Radio Networks (RN). First, we examine this problem in the context of data traffic in general topology networks. Next, we look at the scheduling problem when processing packetized voice calls, where Grade-of-Service (GOS) requirements are quite different. For data traffic, we formulate an optimization problem for the allocation of transmission time slots to different competing nodes and present a gradient-based algorithm suitable for on-line implementation without any assumptions on the nature of the data traffic processes. Examples illustrating the adaptive features of our approach and comparing it to other schemes are included. For voice traffic, we formulate the optimal scheduling problem as a stochastic discrete resource allocation problem, which is combinatorially hard. We describe a technique for transforming this to a continuous optimization problem and develop algorithms for minimizing the blocking probability of packetized voice traffic.

Title: Book Review of "The Collected Papers of Claude Shannon"
Author(s): P.J. Crepeau
E-mail Address: crepeau@itd.nrl.navy.mil
Citation: Computing Reviews, v35, n12, ACM Press
Date: December 1994
Report No.: CS-94-007

Abstract

Claude Shannon is one of the towering intellectual figures in twentieth century scientific thought. Shannon, now in his late seventies and living quietly in Massachusetts, has been away from the scientific mainstream for more than two decades. While his reputation as spiritual father and pioneer of the information age has continued with uninterrupted vitality, many of the new generation of teachers and scientists have never actually read his key papers and their knowledge of the man is based on second-hand classroom anecdotes residing somewhere on the border between myth and reality. Neil Sloane and Aaron Wyner have now removed any uncertainty concerning Shannon and his enormous scientific contribution by gathering a wealth of information and presenting it in this wonderful volume.

Title: Schemes for Reliable Message Delivery in NATO Improved Link Eleven (NILE) Networks
Author(s): M.J. Chung and D.G. Kallgren
E-mail Address: kallgren@itd.nrl.navy.mil
Citation: NRL Formal Report, NRL/FR/5520--94-9729
Date: September 30 1994
Report No.: CS-94-008

Abstract

This report describes different schemes to provide reliable radio communication in HF ECCM and UHF ECCM media. There are five potential schemes that may provide reliable communication: Automatic Retransmission, Block Acknowledgment, Selective Acknowledgment, Repeat Request, and Stronger Coding. However, only three are studied in detail: Automatic Retransmission, Block Acknowledgment, Selective Acknowledgment. There are four performance measures that are used to evaluate each scheme: message delay, protocol delay, efficiency and message reliability. The performance analysis shows indistinctly defined operating regions, with a different scheme preferred for each region.

Title: A Mini-Product-Form-Based Solution to Data-Delay Evaluation in Wireless Integrated Voice/Data Networks
Author(s): J.E. Wieselthier, C.M. Barnhart and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Internal Report
Date: September 1994
Report No.: CS-94-009

Abstract

In this paper we consider the evaluation of data-packet delay in wireless integrated voice/data networks. In networks that support voice in the classical circuit-switched fashion, the voice occupancy process satisfies a product-form solution under reasonable modeling assumptions. Although this product-form solution provides an accurate characterization of equilibrium voice-traffic behavior, it does not directly provide a method to evaluate data-packet delay. The crudest, but most simple, approximate model assumes that each link is an M/D/I system with service rate equal to the average residual capacity of the link. Although useful for ordinal optimization, this model yields highly inaccurate delay estimates. However, examination of each link separately in a manner that incorporates interaction with the rest of the network permits us to take advantage of the wireless nature of the network and obtain a three-flow characterization of each link, which also satisfies a product-form solution and is hence termed a "mini-product-form" solution. By matching the values of these flows, which are natural to the wireless network, to the average values obtained from the product-form solution of the entire network, we obtain a three-dimensional Markov chain characterization of the voice occupancy state on the link, which permits a simpler evaluation of data-packet delay. A further reduction is possible by converting the three-dimensional chain to a single-dimensional one. In all cases there is remarkable agreement with exact behavior (obtained via simulation) and usually improved accuracy as compared to the well-known reduced-load approximation or to other crude models.

Title: Functional, Electrical, and Mechanical Description of the W-Band Noise Measurement System and the NRL W-Band VXI Module
Author(s): J.A. Molnar and T.V. Mai
E-mail Address: molnar@itd.nrl.navy.mil
Citation: NRL Formal Report, NRL/FR/5520-94--9745
Date: September 30, 1994
Report No.: CS-94-010

Abstract

Development of systems employing technology operating at millimeter wave frequencies is increasing as system designers exploit the advantages of this frequency band over lower frequency microwaves. Testing of these systems is essential to ensure proper functioning. A measurement system for the W-band frequency range (75 - 100 GHz) was developed. The system uses a VXI bus mainframe. An instrument controller and three instruments are inserted into the empty mainframe slots. Two of the instruments are commercially available; a power meter and a 4 - 12.4 GHz signal generator. The third instrument was developed at NRL to provide W-band capability. The instrument incorporates several functions: signal generator, noise source and frequency measurement down converter. The signal generator is accurate to +10 Hz, with 1 mW maximum power output and AM, FM and pulse modulation capability. The noise source provides an ENR 15>dB. The measurement down converter translates the frequency to facilitate noise and spectral analysis. Software resident in the instrument controller integrates and controls the functionality of the instruments while providing a simple interface for the user. The mechanical, electrical, and electronic details of the W-band signal generation module are presented and explained. Software developed to demonstrate the capabilities of the integrated system is discussed.

Title: An Integrated Knowledge Acquisition and Database Management System
Author(s): C.B. Barclay and J.A. Molnar
E-mail Address: molnar@itd.nrl.navy.mil
Citation: NRL Formal Report,, NRL/FR/5520--94-9733
Date: August 26, 1994
Report No.: CS-94-011

Abstract

Fault Isolation System Knowledge Bases (FISDM) is a menu driven database interface that was developed to enhance the acquisition and management of knowledge acquired for FISDM. This software was of general purpose and could be accessed on any ASCII terminal. FISDMPro enhanced the basic FISDM software by providing a Graphical User Interface (GUI) and Expert System to aid knowledge base creation. FISDMPro was developed with the GUI development tool TAE (Transportable Application Engine). The Expert system portion of FISDMPro uses the C Language Integrated Production System (CLIPS) expert system engine, and rules were developed that govern the creation of the major components of a FIS knowledge base. The Interface now presents a graphical method of creating the knowledge base simply defining modules as blocks and providing interconnections between graphical method of creating the knowledge base by simply defining modules as blocks and providing interconnections between the blocks. The interconnections are governed by the physical interrelations of the modules, and the expert system generates rules relating to the interconnections. A presentation of the capabilities is shown along with the discussion of the software dynamics.

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[ ] **CS-94-011** An Integrated Knowledge Acquisition and Database Management System, *C.B. Barclay and J.A. Molnar*

IV. CENTER FOR COMPUTER HIGH ASSURANCE SYSTEMS CODE 5540

The Center for Computer High Assurance Systems performs research and develops technology in areas supporting military requirements for communication security (COMSEC) and computer security (COMPUSEC). Emphasis is given to the development of concepts, architectures, analysis techniques and methodology that exploit appropriately the opportunities available through systematic consideration of the total security problem and its impact on communication and computer systems. The Center provides leadership and is the Navy's lead laboratory for research and development of COMPUSEC technology and evaluation techniques. Areas of activity include development of information security devices, subsystems and system technology through the conceptual, analysis and experimentation, and proof-of-concept phases. The Center works closely with Navy system developers and with the National Security Agency.

Title: Confidentiality in a Replicated Architecture Trusted Database System: A Formal Model
Author(s): O. Costich, J. D. McLean, and J. P. McDermott
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Proceedings. IEEE Computer Security Foundations Workshop VII, IEEE CS Press, 60-65
Date: June 1, 1994
Report No.: CCHAS-94-001

Abstract:

Unlike previous approaches to developing a trusted database system, the replicated architecture approach provides access control at a high level of assurance through replication of data and operations. We present a model of the SINTRA replicated architecture trusted database system which shows how the logical (users') view of the system and its security policy is translated into the physical structure and operations of the SINTRA system. We formalize the intended security policy for replicated architecture and demonstrate that a high level of assurance can be obtained solely from replication with virtually no change to the structure of the underlying database systems or the security kernel.

Title: The SINTRA Data Model: Structure and Operations
Author(s): O. Costich, M. H. Kang and J. N. Froscher
E-mail Address: mkang@itd.nrl.navy.mil
Citation: Proceedings of the 8th Annual IFIP WG 11.3 Working Conference on Database Security, Bad Salzdetfurth, Germany
Date: August 1994
Report No.: CCHAS-94-002

Abstract:

Relational database systems are based on a powerful abstraction: the relational data model with the relational algebra and update semantics. If the database design (i. e., the way the data is organized) satisfies criteria provided by this foundation, users have assurance that they can retrieve information in a consistent, predictable way. Multilevel secure database systems must not only provide assurance that information is protected based on its sensitivity, but should be based on a data model as sound and complete as the conventional relational model. In this paper, we present a data model with a relational algebra and update semantics for a multilevel secure database system whose protection mechanisms are provided by the replicated architecture. The approach is to systematically describe the effects of treating security labels as data and to define explicitly the semantics of these data labels for relational database operations. We also briefly compare the SINTRA data model to earlier ones from the Sea View project and their derivations.

Title: A Practical Approach to High Assurance Multilevel Secure Computing Service
Author(s): J. N. Froscher, M. H. Kang, J. P. McDermott, O. Costich, and C. E. Landwehr
E-mail Address: froscher@itd.nrl.navy.mil
Citation: Proceedings of the Tenth Annual Computer Security Applications, Orlando, FL
Date: December 1994
Report No.: CCHAS-94-003

Abstract:

Current projects to provide MLS computing services rarely seem to exploit advances in related fields. Specifically, the concepts of data distribution, replication, and

interoperation are currently receiving much attention in the commercial database system sector but have yet to be applied to the delivery of MLS computing services. This paper explains how these concepts might be applied to help deliver MLS computing services relatively quickly and cheaply, and how they can ease integration of legacy systems and new technology into future MLS cooperative, distributed computing environments.

Title: Multiple-query Optimization at Algorithm-level
Author(s): M. H. Kang, H. Dietz, and B. Bhargava
E-mail Address: mkang@itd.nrl.navy.mil
Citation: Data & Knowledge Engineering, v14, n1, 57-75
Date: November 1994
Report No.: CCHAS-94-004

Abstract:

The database multiple-query optimization can be achieved by analyzing multiple-query sequences at a level below that used by current optimizers, but above the low-level executable code. In this paper, the concept of the "algorithm-level" representation of a database program is defined and optimization techniques that can be applied to the algorithm-level representation are discussed. Some techniques extend existing concepts, while others are new. In this paper, we also show multiple-query optimization can be performed across the update queries.

Title: Architectural Impact on Performance of a Multilevel Database System
Author(s): M. H. Kang and J. N. Froscher
E-mail Address: mkang@itd.nrl.navy.mil
Citation: Proceedings. Tenth Annual Computer Security Applications, Orlando, FL
Date: December 1994
Report No.: CCHAS-94-005

Abstract:

There are many known approaches for multilevel secure database systems. Since protection and assurance are the primary concerns in MLS databases, performance has often been sacrificed. Motivated by performance concerns, a replicated architecture approach which uses a physically distinct backend database management system for each security level is being investigated. This is a report on the behavior and performance issues for the replicated architecture approach. Especially, we compare the performance of the SINTRA (Secure Information Through Replicated Architecture) MLS database system to that of a typical conventional (non-secure, single-level) database system. After observing the performance bottlenecks for the SINTRA, we present solutions that can alleviate them.

Title: Achieving Database Security through Data Replication: The SINTRA Prototype
Author(s): M. H. Kang, J. N. Froscher, J. P. McDermott, O. Costich, and R. Peyton
E-mail Address: mkang@itd.nrl.navy.mil
Citation: Proceedings. 17th National Computer Security Conference, Baltimore, MD,
Date: October 1994
Report No.: CCHAS-94-006

Abstract:

There are several proposed approaches for multilevel secure (MLS) database systems which protect classified information. The SINTRA (Secure Information Through Replicated Architecture) database system, which is currently being prototyped at

the Naval Research Laboratory, is a multilevel trusted database system based on a replicated data approach. This approach uses physical separation of classified data as a protection measure. Each database contains data at a given security level and replicas of all data at lower security levels. Project goals include good performance and full database capability. For practical reasons (e.g., ease of evaluation, portability) the SINTRA database system uses as many readily-available commercial components as possible. In this paper, security constraints and the rationale for the SINTRA prototype are described. We also present the structure and function of each component of the SINTRA prototype: the global scheduler, the query preprocessor, and the user interface. A brief description of the SINTRA recovery mechanism is also presented.

Title: Using Object Modeling Techniques To Design MLS Data Models, in Security for Object-Oriented Systems
Author(s): M. H. Kang, O. Costich, and J. N. Froscher
E-mail Address: mkang@itd.nrl.navy.mil
Citation: Springer-Verlag, London
Date: 1994
Report No.: CCHAS-94-007

Abstract:

The expressiveness of the data model has a significant impact on the functionality of the resulting database system. The more general the data model, the less need be lost when the conceptual model is mapped onto a particular data model. In this paper, we explain how MLS data models can lead to a loss of database functionality or the inability to model some real world phenomena if data models are not kept general and independent of other considerations. We also present our positions with respect to developing MLS data models for MLS database systems using the object modeling technique.

Title: A Taxonomy of Computer Program Security Flaws
Author(s): C. E. Landwehr, A. R. Bull, J. P. McDermott, and W. S. Choi
E-mail Address: landwehr@itd.nrl.navy.mil
Citation: ACM Computing Surveys, v26, n3, 211-254
Date: September 1994
Report No.: CCHAS-94-008

Abstract:

An organized record of actual flaws can be useful to designers, implementors, and evaluators of computer systems. This paper provides a taxonomy for computer program security flaws together with an appendix that carefully documents 50 actual security flaws. These flaws have all been described previously in the open literature, but in widely separated places. For those new to the field of computer security, they provide a good introduction to the characteristics of security flaws and how they can arise. Because these flaws were not randomly selected from a valid statistical sample of such flaws, we make no strong claims concerning the likely distribution of actual security flaws within the taxonomy. However, this method of organizing security flaw data can help those who have custody of more representative samples to organize them and to focus their efforts to remove and, eventually, to prevent the introduction of security flaws.

Title: Hidden Safety Requirements in Large-scale Systems
Author(s): C. E. Landwehr
E-mail Address: landwehr@itd.nrl.navy.mil
Citation: IFIP transactions A (Computer Science and Technology), Volume A-53, 295-302
Date: August 1994
Report No.: CCHAS-94-009

Abstract:
To avoid hidden safety problems in future large scale systems, we must be able to identify the crucial assumptions underlying the development of their components and to enunciate straightforward rules for safe component interconnection.

Title: The B2/C3 problem: How Big Buffers Overcome Covert Channel Cynicism in Trusted Database Systems
Author(s): J. P. McDermott
E-mail Address: mcdermott@itd.nrl.navy.mil
Citation: Proceedings of the 8th Annual IFIP WG 11.3 Working Conference on Database Security, Bad Salzdetfurth, Germany
Date: August 1994
Report No.: CCHAS-94-010

Abstract:
We present a mechanism for communication from low to high security classes that allows partial acknowledgments and flow control without introducing covert channels. By restricting our mechanism to the problem of maintaining mutual consistency in the replicated architecture database systems, we overcome the negative general results in this problem area. A queuing theory model shows that big buffers can be practical mechanisms for real database systems.

Title: Covert Channels -- Here to Stay?
Author(s): I. S. Moskowitz and M. H. Kang
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: Proceedings: COMPASS '94, Gaithersburg, MD, IEEE Press, 235-243
Date: June 1994
Report No.: CCHAS-94-011

Abstract:
We discuss the difficulties of satisfying high-assurance system requirements without sacrificing system capabilities. To alleviate this problem, we show how trade-offs can be made to reduce the threat of covert channels. We also clarify certain concepts in the theory of covert channels. Traditionally, a covert channel's vulnerability was measured by the capacity. We show why a capacity analysis alone is not sufficient to evaluate the vulnerability and introduce a new metric referred to as the "small message criterion."

Title: Discussion of a Statistical Channel
Author(s): I. S. Moskowitz and M.H. Kang
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: Proceedings of the IEEE Information Theory and Statistics Workshop
Date: 1994
Report No.: CCHAS-94-012

Abstract:
This paper deals with a new type of covert channel problem that arose when we designed a multilevel secure computer system, using a quasi-secure, asynchronous, communication device called the Pump. We call this new type of covert channel a statistical channel. It is our hope to get feedback from experts who work in the intersection of information theory and statistics.

Title: An Experience Modeling Critical Requirements
Author(s): C. N. Payne, A. P. Moore, and D. M. Mihelcic
E-mail Address: payne@itd.nrl.navy.mil
Citation: Proceedings: COMPASS '94, Gaithersburg, MD, IEEE Press, 245-256
Date: June 1994
Report No.: CCHAS-94-013

Abstract:
Previous work at NRL demonstrated the benefits of a security modeling approach for building high assurance systems for particular application domains. This paper introduces an application domain called "selective bypass" that is prominent in certain network security solutions. We present a parameterized modeling framework for the domain and then instantiate a confidentiality model for a particular application, called the External COMSEC Adapter (ECA), within the framework. We conclude with lessons we learned from modeling, implementing and verifying the ECA. Our experience supports the use of the application based security modeling approach for high assurance systems.

Title: An Epistemic Logic of Situations
Author: P.F. Syverson
E-mail: syverson@itd.nrl.navy.mil
Citation: Theoretical Aspects of Reasoning About Knowledge (TARK 1994), Ronald Fagin (editor), Pacific Grove CA, Morgan Kaufmann Pub. Inc., 109-121
Date: March 1994
Report No.: CCHAS-94-014

Abstract
In this paper we present a first order epistemic logic that incorporates the essentially finite character of what is actually known by any knower. Our logic and language allows us to represent familiarity with individuals including individual situations. It is also a logic of limited awareness in the manner of [Fagin & Halpern 88]. It is adequate for the syntactic characterization of the shared-situation account of common knowledge. Finally, it is sound and complete with respect to the presented semantics.

Title: On Unifying Some Cryptographic Protocol Logics
Author(s): P.F. Syverson and P. van Oorschot
E-mail: syverson@itd.nrl.navy.mil
Citation: Proceedings of 1994 IEEE Computer Society Symposium on Research in Security and Privacy, IEEE Computer Society Press, 14-28
Date: May 1994
Report No.: CCHAS-94-015

Abstract

We present a logic for analyzing cryptographic protocols. This logic encompasses a unification of four of its predecessors in the BAN family of logics, namely those given in Gong, Needham, and Yahalom (1990), Abadi and Tuttle (1991), van Oorschot (1993), and BAN itself (Burrows, Abadi, and Needham 1989). We also present a model-theoretic semantics with respect to which the logic is sound. The logic herein captures all of the desirable features of its predecessors and more; nonetheless, it accomplishes this with no more axioms or rules than the simplest of its predecessors.

Title: A Taxonomy of Replay Attacks
Author: P.F. Syverson
E-mail: syverson@itd.nrl.navy.mil
Citation: Proceedings of the 1994 Computer Security Foundations Workshop (CSFW 7), IEEE Computer Society Press, 187-191
Date: June 1994
Report No.: CCHAS-94-016

Abstract

This paper presents a taxonomy of replay attacks on cryptographic protocols in terms of message origin and destination. The taxonomy is independent of any method used to analyze or prevent such attacks. It is also complete in the sense that any replay attack is composed entirely of elements classified by the taxonomy. The classification of attacks is illustrated using both new and previously known attacks on protocols. The taxonomy is also used to discuss the appropriateness of particular countermeasures and protocol analysis methods to particular kinds of replays.

Title: The NRL Protocol Analyzer: An Overview
Author: C.A. Meadows
E-mail: meadows@itd.nrl.navy.mil
Citation: Proceedings of the 2nd Conference on the Practical Applications of Prolog, Association for Logic Programming
Date: April 1994
Report No.: CCHAS-94-017

Abstract

The NRL Protocol Analyzer is a special-purpose verification tool, written in Prolog, that has been developed for the analysis of cryptographic protocols that are used to authenticate principals and services and distribute keys in a network. In this paper we give an overview of how the Analyzer works and describe its achievements so far. We also show how our use of the Prolog language benefited us in the design and implementation of the Analyzer.

Title: A Model of Computation for the NRL Protocol Analyzer
Author: C.A. Meadows
E-mail: meadows@itd.nrl.navy.mil
Citation: Proceedings of 1994 Computer Security Foundations Workshop, IEEE Computer Society Press
Date: June 1994
Report No.: CCHAS-94-018

Abstract

In this paper we develop a model of computation for the NRL Protocol Analyzer by modifying and extending the model of computation for Burroughs, Abadi, and Needham (BAN) logic developed by Abadi and Tuttle. We use the results to point out the similarities and differences between the NRL Protocol Analyzer and BAN logic, and discuss the issues this raises with respect to the possible integration of the two.

Title: Three Systems for Cryptographic Protocol Analysis
Author(s): R. Kemmerer, C.A. Meadows and J. Millen
E-Mail: meadows@itd.nrl.navy.mil
Citation: Journal of Cryptology, v7, n2
Date: Spring 1994
Report No.: CCHAS-94-019

Abstract

Three experimental methods have been developed to apply formal methods to the security verification of cryptographic protocols of the sort used for key distribution and authentication. Two of these methods are based on Prolog programs, and one is based on a general-purpose specification and verification system. All three combine algebraic with state-transition approaches. For purposes of comparison, they were used to analyze the same example protocol with a known flaw.

Title: Tradeoff Areas in Secure System Development
Author: C.A. Meadows
E-mail: meadows@itd.nrl.navy.mil
Citation: Proceedings of CSESAW '94, Naval Surface Warfare Center
Date: July 1994
Report No.: CCHAS-94-020

Abstract

In this paper we identify several areas in which the satisfaction of security requirements can affect the cost and performance of a system, and describe what is known about tradeoffs in these areas. The areas we investigate include both features offered by the system and the procedures that are involved in building the system.

Title: Formal Requirements for Key Distribution Protocols
Author(s): P. Syverson and C.A. Meadows
E-mail: syverson@itd.nrl.navy.mil or meadows@itd.nrl.navy.mil
Citation: Proceedings of Eurocrypt '94, (IACR)
Date: May 1994
Report No.: CCHAS-94-021

Abstract

We discuss generic formal requirements for reasoning about two party key distribution protocols, using a language developed for specifying security requirements for security protocols. Typically earlier work has considered formal analysis of already developed protocols. Our goal is to present sets of formal requirements for various contexts which can be applied at the design stage as well as to existing protocols. We use a protocol analysis tool we have developed to determine whether or not a specific protocol has met some of the requirements we specified. We show how this process uncovered a flaw in the protocol and helped us refine our requirements.

Title: The Feasibility of Quantitative Assessment of Security
Author: C.A. Meadows
E-mail: meadows@itd.nrl.navy.mil
Citation: Proceedings of DCCA4, Springer-Verlag
Date: 1994
CCHAS Report No.: CCHAS-94-022

Abstract

We discuss the feasibility of quantitative assessment of security, and outline several areas in which quantitative assessment may be possible and of practical use.

Title: The Need for a Failure Model for Security
Author: C.A. Meadows
E-mail: meadows@itd.nrl.navy.mil
Citation: Proceedings of DCCA4, Springer-Verlag
Date: 1994
CCHAS Report No.: CCHAS-94-023

Abstract

We discuss the necessity and practicality of constructing a failure model of security similar to that for fault-tolerance.

Title: Mechanically Verifying Safety and Liveness Properties of a Delay Insensitive Circuits
Author: D.M. Goldschlag
E-mail: goldschl@itd.nrl.navy.mil
Citation: Formal Methods in System Design, v5, n3, 207-225, Kluwer Academic Publishers
Date: December 1994
CCHAS Report No.: CCHAS-94-024

Abstract:

This paper describes, by means of an example, how one may mechanically verify delay insensitive circuits on an automated theorem prover. It presents the verification of both the safety and liveness properties of an n-node delay insensitive FIFO circuit. The proof system used is a mechanized implementation of Unity on the Boyer-Moore prover.

This paper describes the circuit formally in the Boyer-Moore logic and presents the mechanically verified correctness theorems. The formal description also captures the protocol that the circuit expects its environment to obey and specifies a class of suitable initial states.

This paper demonstrates how a general purpose automated proof system for concurrent programs may be used to mechanically verify both the safety and liveness properties of arbitrary sized delay insensitive circuits.

Title: A Formal Model of Several Fundamental VHDL Concepts
Author: D.M. Goldschlag
E-mail: goldschl@itd.nrl.navy.mil
Citation: Proceedings of COMPASS'94, 9th Annual Conference on Computer Assurance, 177-181, IEEE Computer Society Press
Date: June 27 through July 1, 1994
CCHAS Report No.: CCHAS-94-025

Abstract:

This paper presents a formal model of several fundamental concepts in VHDL including the semantics of individual concurrent statements, and groups of those statements, resolution functions, delta delays, and hierarchical component structuring. Based on this model, several extensions to VHDL are proposed, including non deterministic assignments and unbounded asynchrony. Non-determinism allows the specification of environments and of classes of devices. This model naturally captures the meaning of composition of VHDL programs.

Title: Simple Timing Channels
Author(s): I.S. Moskowitz and A. Miller
E-mail Address: moskowit@itd.nrl.navy.mil
Citation: IEEE Computer Society Technology Committee on Security and Privacy Conference, 56-64, Oakland, CA.
Date: May 16-18, 1994
Report No.: CCHAS-94-026

Abstract:

We discuss the different ways of defining channel capacity for certain types of illicit communication channels. We also correct some errors from the literature, offer new proofs of some historical results, and give bounds for channel capacity. Special function techniques are employed to express the results in closed form. We conclude with examples.

Title: Detailed Operational Concept for the JTIDS Key Management System
Author(s): S. S. Shah
E-mail Address: shah@itd.nrl.navy.mil
Citation: NRL Formal Report, NRL/FR/5540--94-9709
Date: March 25, 1994
Report No.: CCHAS-94-027

Abstract:

The Joint Tactical Information Distribution System (JTIDS) requires cryptographic initialization of its communications security (COMSEC) equipment. The OPTASK LINK message provides the cryptographic initialization requirements for JTIDS. Yet the daily task of managing these requirements, associating them to crypto

variables (i.e., keys), and loading the crypto variable into the JTIDS COMSEC equipment is time consuming and labor intensive. Therefore, an advanced key management system is being developed for Navy JTIDS that will use newly developed key management and key distribution devices (i.e., a Data Transfer Device (DTD) and a dedicated PC running key management user application software) to perform JTIDS cryptographic initialization. This new key management system will also use the Thornton KGV-8B crytographic device, which supports future Navy key fill protocols and BLACK key distribution. This report provides a detailed description of the functions, features, and processes of the new JTIDS key management system. It also presents a detailed operational concept of the system as it would function in the Navy operational environment.

Title: Modechart Toolset User's Guide
Author(s): A.T. Rose, M.A. Pérez, and P.C. Clements
E-mail Address: library@aic.nrl.navy.mil
Citation: NRL Memorandum Report, NRL/MR/5540--94-7427
Date: February 14, 1994
Report No.: CCHAS-94-028 also AIC-94-054

Abstract:

This document describes how to use the Modechart Toolset (MT). MT is a set of tools designed to facilitate the specification, modeling, and analysis of real-time embedded systems using the Modechart language. MT supports the creation, modification, and storage of Modechart specifications. It also supports the analysis of Modechart specifications via a consistency and completeness checker, a simulator and a verifier.

Title: A Toolset for Developing Real-Time Systems
Author(s): C. Heitmeyer
E-mail Address: heitmeye@itd.nrl.navy.mil
Citation: Proceedings of the NATO Advanced Study Institute on Real Time Computing
Date: October 1994
Report No.: CCHAS-94-029

Abstract:

We describe a prototype toolset whose goal is to provide comprehensive support for constructing verifiably correct real-time systems. The toolset has two purposes: 1. to demonstrate and evaluate the utility of formal methods for developing real-time systems; and 2. to obtain information needed to build production-quality CASE tools supporting the methods. Two formal methods that underlie the toolset are the Modechart language and a mechanical verifier. Modechart is a graphical language for expressing a system's timing behavior that is derived from Statechart and the concept of modes. In Modechart, the time that a system can remain in a selected mode is defined by delays and deadlines. The Modechart verifier determines whether a timing assertion can be derived from a set of Modechart specifications. Each timing assertion, expressed in a form of first-order logic called Real-Time Logic (RTL), is a logical statement of the properties that must hold for the specifications to be considered correct. The verifier classifies each assertion as valid or invalid. The toolset software is coded in C and C++ and runs on Sun workstations. The toolset's user interface software was developed using OpenWindows and the DevGuide toolkit. The toolkit provides C programs for the windows, menus, scrollbars, and other standard widgets required by the toolset's user interface software.

Title: A General Theory of Composition for Trace Sets Closed Under selective Interleaving Functions
Author(s): J.D. McLean
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Proceedings of the 1994 IEEE Symposium on Research Security and Privacy, IEEE Computer Society Press, 79-93
Date: 1994
Report No.: CCHAS-94-030

Abstract:

This paper presents a general theory of system composition for "possibilistic" security properties. We see that these properties fall outside of the Alpern-Schneider safety/liveness domain and hence, are not subject to the Abadi-Lamport Composition Principle. We then introduce a set of trace constructors called "selective interleaving functions" and show that possibilistic security properties are closure properties with respect to different classes of selective interleaving functions. This provides a uniform framework for analyzing these properties and allows us to construct a partial ordering for them. We present a number of composition constructs, show the extent to which each preserves closure with respect to different classes of selective interleaving functions, and show that they are sufficient for forming the general hook-up construction. We see that although closure under a class of selective interleaving functions is generally preserved by product and cascading, it is not generally preserved by feedback, internal system composition constructs, or refinement. We examine the reason for this.

Title: Assurance Risk Assessment, and Fuzzy Logic
Author(s): J.D. McLean
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Proceedings of the 17th National Computer Security Conference, Baltimore, MD, 483-486
Date: 1994
CCHAS Report No.: CCHAS-94-031

Abstract:

To evaluate the effectiveness of techniques used to build secure systems some sort of quantitative measure of penetration resistance is desirable. However, fuzzy logic is the wrong way to go since a single fuzzy metric of system security hides the information that was used to generate the metric and since there is an inherent danger of giving quantitative fuzzy metrics more credence than they really deserve. Certainly with respect to confidentiality, and possibly with respect to integrity and availability as well, information theoretic approaches, though not perfect, are more suitable.

Title: Security Models
Author(s): J.D. McLean
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Encyclopedia of Software Engineering , John Wiley and Sons Inc.
Date: 1994
CCHAS Report No.: CCHAS-94-032

Abstract:

The term "security model" has been used to describe any formal statement of a system's confidentiality, availability, or integrity requirements. In this article we focus on the primary use of security models, which has been to describe general confidentiality requirements. We then give pointers to security model work in other areas.

Title: Quantitative Measures of Security
Author(s): J.D. McLean
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Preprints of the Fourth International Working Conference on Dependable Computing for Critical Applications, San Diego, CA
Date: 1994
CCHAS Report No.: CCHAS-94-033

Abstract:

One of the most striking properties of the "Trusted Computer System Evaluation Criteria" and its international successors is that none of these documents contain any attempt to relate their evaluation levels to a measure of how much effort must be expended to break into a system. As a consequence, it's impossible to evaluate rationally the marginal benefit of spending the extra money necessary to obtain a higher rating than a lower one. One reason for this gap between evaluation levels and cost of system penetration is the difficulty of quantifying penetration costs. In this paper I hope to shed some light on the questions of what is needed, what we have, and what would be useful to have in the future.

Title: The Generalized Railroad Crossing: A Case Study in Formal Verification of Real-Time Systems
Author(s): C.L. Heitmeyer and N. Lynch
E-mail Address: heitmeye@itd.nrl.navy.mil
Citation: Proceedings, 15th IEEE Real-Time Systems Symposium
Date: December 7-9, 1994
CCHAS Report No.: CCHAS-94-034

Abstract:

A New Solution to the Generalized Railroad Crossing problem, based on time automata, invariants and simulation mappings, is presented and evaluated. The solution formally shows the correspondence between four system descriptions: an axiomatic specification, an operational specification, a discrete system implementation, and a system implementation that works with a continuous gate model.

Title: The Generalized Railroad Crossing: A Case Study in Formal Verification of Real-Time Systems
Author(s): C.L. Heitmeyer and N. Lynch
E-mail Address: heitmeye@itd.nrl.navy.mil
Citation: NRL Memorandum Report 7619, Washington, D.C
Date: 1994
CCHAS Report No.: CCHAS-94-035

Abstract:

A new solution to the Generalized Railroad Crossing problem, based on timed automata, invariants and simulation mappings, is presented and evaluated. The solution formally shows the correspondence between four system descriptions: an axiomatic specification, an operational specification, a discrete system implementation, and a system implementation that works with a continuous gate model. The details of the proofs, which were omitted from the conference paper due to lack of space, are included.

Title: The Role of HCI in CASE Tools Supporting Formal Methods
Author(s): C.L. Heitmeyer
E-mail Address: heitmeye@itd.nrl.navy.mil
Citation: Proceedings, Workshop on Software Engineering and Human-Computer Interaction, Sorrento, Italy
Date: May 16-17, 1994
Report No.: CCHAS-94-036

Abstract:
This paper describes a number of issues in human-computer interaction that arose in two projects which are developing CASE tools to support formal methods. It also proposes a research agenda.

Title: CAROL (CES2300) Phase II Rooftop Test Results
Author(s): P.M. Jenket
E-mail Address: jenket@itd.nrl.navy.mil
Citation: NRL Memorandum Report NRL/MR/5540--94-7477
Date: September 30, 1994
Report No.: CCHAS-94-037

Abstract:
This report describes the results of testing performed on the CES2300 Communications Exploitation System. Tests were performed at the Harris Corp. Complex in Melbourne, Florida in December of 1991.
(The REPORT is CLASSIFIED SECRET)

Title: Design Documentation for the SINTRA Preprocessor
Author(s): Myong H. Kang and Rodney Peyton
E-mail Address: mkang@itd.nrl.navy.mil
Citation: NRL Memorandum Report NRL/MR/5540--94-7640
Date: December 12, 1994
Report No.: CCHAS-94-038

Abstract:
The SINTRA database system is a multilevel trusted database management system based on the replicated architecture [FrM89, Kan94]. The replicated architecture approach uses a physically distinct backend database management system for each security level. Each backend database contains information at a given security level and all data from lower security levels. The system security is assured by a trusted frontend which permits a user to access only the backend database system which matches his/her security level.

The SINTRA database system consists of one trusted frontend (TFE), several untrusted backend database systems (UBD) and several User Interface Stations (UIS). The role of the TFE includes user authentication, directing user queries to the backend, and maintaining data consisting among backends, etc. Each UBD can be any commercial off-the-shelf database system and each UIS can be any system supporting Unix, X11 and TCP/IP.

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[ ] **CCHAS-94-001** Confidentiality in a Replicated Architecture Trusted Database System: A Formal Model, *O. Costich, J. D. McLean, and J. P. McDermott*

[ ] **CCHAS-94-002** The SINTRA Data Model: Structure and Operations, *O. Costich, M. H. Kang and J. N. Froscher*

[ ] **CCHAS-94-003** A Practical Approach to High Assurance Multilevel Secure Computing Service, *J. N. Froscher, M. H. Kang, J. P. McDermott, O. Costich, and C. E. Landwehr*

[ ] **CCHAS-94-004** Multiple-query Optimization at Algorithm-level, *M. H. Kang, H. Dietz, and B. Bhargava*

[ ] **CCHAS-94-005** Architectural Impact on Performance of a Multilevel Database System, *M. H. Kang and J. N. Froscher*

[ ] **CCHAS-94-006** Achieving Database Security through Data Replication: The SINTRA Prototype, *M. H. Kang, J. N. Froscher, J. P. McDermott, O. Costich, and R. Peyton*

[ ] **CCHAS-94-007** Using Object Modeling Techniques To Design MLS Data Models, in Security for Object-Oriented Systems, *M. H. Kang, O. Costich, and J. N. Froscher*

[ ] **CCHAS-94-008** A Taxonomy of Computer Program Security Flaws, with Examples, *C. E. Landwehr, A. R. Bull, J. P. McDermott, and W. S. Choi*

[ ] **CCHAS-94-009** Hidden Safety Requirements in Large-scale Systems, *C. E. Landwehr*

[ ] **CCHAS-94-010** The B2/C3 problem: How Big Buffers Overcome Covert Channel Cynicism in Trusted Database Systems, *J. P. McDermott*

[ ] **CCHAS-94-011** Covert Channels -- Here to Stay?, *I. S. Moskowitz and M. H. Kang*

[ ] **CCHAS-94-012** Discussion of a Statistical Channel, *I. S. Moskowitz and M.H. Kang*

[ ] **CCHAS-94-013** An Experience Modeling Critical Requirements, *C. N. Payne, A. P. Moore, and D. M. Mihelcic*

[ ] **CCHAS-94-014** An Epistemic Logic of Situations, *P. Syverson,*

[ ] **CCHAS-94-015** On Unifying Some Cryptographic Protocol Logics, *P. Syverson and P. van Oorschot*

[ ] **CCHAS-94-016** A Taxonomy of Replay Attacks, *P. Syverson*

[ ] **CCHAS-94-017** The NRL Protocol Analyzer: An Overview, *C.A. Meadows*

[ ] **CCHAS-94-018** A Model of Computation for the NRL Protocol Analyzer, *C.A. Meadows*

[ ] **CCHAS-94-019** Three Systems for Cryptographic Protocol Analysis, *R. Kemmerer, C.A. Meadows and J. Millen*

[ ] **CCHAS-94-020** Tradeoff Areas in Secure System Development, *C.A. Meadows*

[ ] **CCHAS-94-021** Formal Requirements for Key Distribution Protocols, *P. Syverson and C.A. Meadows*

[ ] **CCHAS-94-022** The Feasibility of Quantitative Assessment of Security, *C.A. Meadows*

[ ] **CCHAS-94-023** The Need for a Failure Model for Security, *C.A. Meadows*

[ ] **CCHAS-94-024** Mechanically Verifying Safety and Liveness Properties of a Delay Insensitive FIFO Queue, *D.M. Goldschlag*

[ ] **CCHAS-94-025** A Formal Model of Several Fundamental VHDL Concepts, *D.M. Goldschlag*

[ ] **CCHAS-94-026** Simple Timing Channels, *I.S. Moskowitz and A. Miller*

[ ] **CCHAS-94-027** Detailed Operational Concept for the JTIDS Key Management System, *S. S. Shah*

[ ] **CCHAS-94-028** Modechart Toolset User's Guide, *A.T. Rose, M.A. Pérez, and P.C. Clements*

[ ] **CCHAS-94-029** A Toolset for Developing Real-Time Systems, *C. Heitmeyer*

[ ] **CCHAS-94-030** A General Theory of Composition for Trace Sets Closed Under-selective Interleaving Functions, *J.D. McLean*

[ ] **CCHAS-94-031** Assurance Risk Assessment, and Fuzzy Logic, *J.D. McLean*

[ ] **CCHAS-94-032** Security Models, *J.D. McLean*

[ ] **CCHAS-94-033** Quantitative Measures of Security, *J.D. McLean*

[ ] **CCHAS-94-034** The Generalized Railroad Crossing: A Case Study in Formal Verification of Real-Time Systems, *C.L. Heitmeyer and N. Lynch*

[ ] **CCHAS-94-035** The Generalized Railroad Crossing: A Case Study in Formal Verification of Real-Time Systems, *C.L. Heitmeyer and N. Lynch*

[ ] **CCHAS-94-036** The Role of HCI in CASE Tools Supporting Formal Methods, *C.L. Heitmeyer*

[ ] **CCHAS-94-037** CAROL (CES2300) Phase II Rooftop Test Results, *P.M. Jenket*

[ ] **CCHAS-94-038** Design Documentation for the SINTRA Preprocessor, *Myong H. Kang and Rodney Peyton*

V. TRANSMISSION TECHNOLOGY
CODE 5550

The Transmission Technology Branch conducts a research and development program directed toward the improvement of information transmission and reception between surface, air, submerged and space platforms. The Branch mission includes understanding and developing approaches to satisfy the need for affordable, efficient and robust dissemination of combat management information. In support of this goal, the Branch investigates all aspects of the process of information transfer including the development of state-of-the-art transmission equipment as well as research into antennas and channel propagation phenomena. Emphasis is placed on those aspects of transmission technology that permit adaptation to inhospitable natural or man-made environments. In addition, the Branch conducts research and development in support of signal intercept and related intelligence system projects. Areas of activity include; (1) Wideband HF architecture and RF system engineering, (2) Communication channel characterization including Arctic communication issues, (3) Intercept system analysis, development, and prototype evaluation, (4) Satellite and space communication technology and (5) Research into wideband and compact antenna systems.

Title: Enhancement of Stimulated Electromagnetic Emission during Two Frequency Ionospheric Heating Experiments
Author(s): Paul A. Bernhardt, Leonard S. Wagner, Joseph A. Goldstein, V. Yu. Trakhtengerts, E. N. Ermakova, V. O. Rapoport, G. P. Komrakov, and A. M. Babichenko
E-mail Address: goldstein@itd.nrl.navy.mil or wagner@itd.nrl.navy.mil
Citation: Physical Review Letters, v72, n18, 2879-2882
Date: May 2, 1994
Report No: TT-94-001

Abstract:
We have discovered that stimulated electromagnetic emission (SEE), excited by a powerful electromagnetic (EM) wave (pump 1) in the ionosphere, can be enhanced by a second high power EM wave (pump 2) with a higher frequency. For frequency separations near 0.4 MHz, the downshifted SEE in a 40 kHz band below the frequency of pump 1 is increased by 2 dB when pump 2 is turned on. We theorize that a second EM wave generates plasma irregularities that facilitate the mode conversion of electrostatic waves to yield enhanced EM emissions from pump 1.

Title: Correlation of High Latitude Ionospheric Disturbances with Geomagnetic Activity
Author(s): Leonard S. Wagner and Joseph A. Goldstein
E-mail Address: goldstein@itd.nrl.navy.mil or wagner@itd.nrl.navy.mil
Citation: MILCOM '94 Conference Proceedings
Date: October 2-5, 1994
Report No: TT-94-002

Abstract:
A series of measurements of the characteristics of the HF skywave radio channel were conducted on a near-vertical-incidence-skywave (NVIS) path in the vicinity of Fairbanks, Alaska in May of 1988. The location of the path was such that it was subauroral during the daytime but near or within the auroral oval at night, depending on the level of magnetic activity. Signal parameters derived from these measurements included signal amplitude, delay-spread and Doppler-spread. Signal amplitude, Doppler spread and NVIS oblique ionograms were used to assess the degree of irregularity of the ionospheric medium and the nature of the reflection/scattering process. Comparison with available indices of magnetic activity, as well as locally measured magnetograms, provided a means for correlating geomagnetic activity with disturbed ionospheric conditions. Both daytime and nighttime measurements showed a strong correlation between the intensity of magnetic activity and the degree of ionospheric disturbance especially as manifested in changes in signal Doppler-spread.

Title: Encoded Speech Intelligibility Improvement in the F/A-18 Noise Environment Using Spectral Subtraction Preprocessing
Author(s): David A. Heide
E-mail Address: heide@itd.nrl.navy.mil
Citation: Proceedings of the 5th International Conference on Signal Processing Applications and Technology, Volume II
Date: October 18-21, 1994
Report No: TT-94-003

Abstract:
Recently, there has been significant interest in reducing the data rate of voice communication links used by the F/A-18 Navy fighter/attack aircraft. Because of the extremely noisy environment of the F/A-18, a 16.0 kilobit per second (KBPS)

continuously variable slope delta (CVSD) encoding scheme is currently used for the voice encoding. Because of the U.S. Navy's dependence on a limited number of narrowband communication links, it would be advantageous to use a lower data-rate voice encoder such as the 2.4 kbps LPC-10 (linear predictive coding with 10 coefficients) to support more voice links. Unfortunately, even present day versions of this algorithm have been judged to be unacceptable because of the distortions introduced by the noisy F/A-18 environment. What is needed is a compromise between the 2.4 and 16.0 kbps encoding schemes that maintains acceptable speech intelligibility. The compromise developed at the Naval Research Laboratory utilizes the 4.8 kbps Code Excited Linear Predictor (CELP) voice encoder, currently being deployed in secure office-to-office communication. While the 4.8 kbps CELP voice encoder has performed remarkably well in noise-free environments, this performance has not translated over to extremely noisy environments associated with the F/A-18 aircraft. The main interest of this report is the development of a noise canceling preprocessor to the CELP voice encoder that improves the intelligibility of the noisy speech to an acceptable level.

While many noise reduction techniques were investigated, the best results were accomplished by first reducing the noise through spectral subtraction and then enhancing the important resonant formats of the speech. The results indicated that when the noise cancellation preprocessor was added to the CELP encoder, the DRT intelligibility scores were improved by a significant 5.0 points, making the speech much more acceptable for possible use in the F/A-18.

This report discusses:

- principle research objectives
- problems with the F/A-18 noise environment
- algorithm requirements
- performance evaluation issues
- speech presence detector
- noise coefficient update rate
- noise reduction algorithm
- results
- conclusions

Title: Arctic Propagation Phenomena at VHF and UHF for a BLOS Path
Author(s): Edward J. Kennedy and Michael A. Rupar
E-mail Address: kennedy@itd.nrl.navy.mil or rupar@itd.nrl.navy.mil
Citation: BLOS (Beyond Line-of-Sight) Conference Proceedings
Date: August 2-4, 1994
Report No: TT-94-004

Abstract:

A system to study BLOS propagation has been implemented on the northern Alaskan coastline. Signal strength measurements are taken of radiated signals from beacons operating in the VHF and UHF frequency bank. These measurements have been conducted continuously since September 1993. The distance between the beacon transmitters and receiver is 30 miles, and is, geometrically, a diffraction path. These measurements are correlated with local environmental conditions and with weather information from the U.S. Navy's NODDS system. The path is coastal/maritime, with open water during a portion of the year, leading to wide variation in the near-surface atmospheric properties. Enhanced signal strengths are observed frequently although at levels below free space. Some correlation has been observed with both temperature and season.

Title: Speech Analysis and Synthesis Based on Pitch-Synchronous Segmentation of the Speech Waveform
Author(s): George S. Kang and Lawrence J. Fransen
E-mail Address: kang@itd.nrl.navy.mil or fransen@itd.nrl.navy.mil
Citation: Naval Research Laboratory Report, NRL/FR/5550--94-9743
Date: November 9, 1994
Report No: TT-94-005

Abstract:

Currently, the most frequently-used speech model is an electric analog of the human speech production system where the vocal tract is an all-pole filter implemented by the linear predictive coder (LPC). Although the LPC model is computationally efficient, it has some drawbacks: (1) intelligibility of the female voice is significantly lower than the male voice, (2) acoustic environmental noise significantly degrades the intelligibility of encoded speech, and (3) familiar voices become difficult to recognize after they have been encoded. These weaknesses stem from the inability of LPC to estimate the parameters of the model accurately. In order to do so, we would need the information of both the input signal to the model (excitation signal from the glottis that pumps air into the vocal tract) as well as the output signal from the model (the speech waveform). Unfortunately, we have no access to the input signal. As a result, the parameters derived from the output signal alone often misrepresent the model.

This report has introduced a new speech model which characterizes the speech waveform itself instead of the speech production mechanism. The speech waveform is made of a collection of the disjoint waveforms, each representing a pitch cycle, and is structurally analogous to a motion picture made of a collection of stationary frames. We have described a new method of speech analysis and synthesis that involves segmenting and analyzing individual pitch waveforms, then replicating and concatenating them to generate the output speech. We carefully avoid mixing two disjoint waveforms, just as two adjacent frames of a movie picture would not be mixed in photographic processing.

Once individual pitch waveforms are segmented, they may be subjected to either transformation for the purpose of speech alteration or encoding for the purpose of speech compression. One application of speech alteration is for generating continuous speech by concatenating raw speech segments (words or phrases) with prosodies. With the increased use of man-made speech in tactical voice message systems and virtual reality environments, such a speech generation tool is highly desirable. The speech encoding application is, of course, for implementing speech processors operating at low data rates (2400 b/s or less). According to speech intelligibility tests, our new 2400 b/s encoder outperforms the 2400-b/s LPC; namely, the intelligibility of female speech is two points better in a quiet environment and five points better in a noisy environment. In a noisy environment, it is even superior to the Codebook-Excited Linear Predictor (CELP) operating at twice the data rate. Since a majority of tactical platforms are noisy (e.g., helicopter, high-performance aircraft, tank, destroyer, etc.), our 2400-b/s speech encoding technique will make tactical voice communication more effective; and, it will become an indispensable capability for future C4I.

Title: Electromagnetic Spectrum Occupancy Study of a Potential Transmitter Site for the HF Active Auroral Research Program (HAARP)
Author(s): Joseph A. Goldstein, Edward J. Kennedy and Monroe Y. McGown
E-mail Address: goldstein@itd.nrl.navy.mil, kennedy@itd.nrl.navy.mil, or mcgown@itd.nrl.navl.mil
Citation: Naval Research Laboratory Report, NRL/MR/5554--94-7622
Date: September 30, 1994
Report No: TT-94-006

Abstract:

This report presents the results of measurements conducted by the Naval Research Laboratory in May and June 1993. The purpose of the measurements was to ascertain the radio frequency occupancy in the immediate vicinity of the proposed High Frequency Active Auroral Research Program (HAARP) facility to be constructed in the Gakona, Alaska area. The HAARP facility will consist of a large planar array of antennas excited by phased high power transmitters operating in the lower portion of the HF band (2.8 to 8 MHz). The existing electromagnetic spectrum usage in the vicinity of Gakona was measured in order to assess the potential for electromagnetic interference problems arising from the HAARP facility. The measurements covered the frequency spectrum from 2 MHz to 1000 MHz. Data was collected for a period of 17 days in May and early June 1993. There are a large number of users in the HF band and data shows a normal diurnal pattern of energy increase in the lower portion of the band in the nighttime hours. The number of users decreases with increasing frequency because the propagation path at higher frequencies is dependent upon line-of-sight signal paths. Gakona is a very rural area and is separated by hilly terrain from surrounding residential and commercial activities. Above the HF band, the most prominent signal identified is a 152 MHz transient signal that saturates the signal path of our measurement apparatus. The signal is so strong that it produces harmonics throughout the measurement band and distorts the display of the data. Another strong feature that is sometimes observed is a 450 MHz signal.

Title: A Laboratory Prototype HF Repeater for Relocatable Over-the-Horizon-Radar
Author(s): Adrian S. Eley
E-mail Address: eley@itd.nrl.navy.mil
Citation: NRL Formal Report , NRL/FR/5550--94-9742
Date: December 1994
Report No: TT-94-007

Abstract:

The Relocatable Over-the-Horizon Radar (ROTHR) is a high frequency radar that uses ionospheric refraction of the transmitted and reflected signal in the detection of aircraft at long ranges. Variability in the effective height of the ionosphere, however, makes it difficult to measure target range and azimuth accurately. Radar repeaters placed at known positions provide a means of locating targets in the radar coverage area. Characteristics that are important to the design of such a repeater are its abilities to recognize and repeat one of a number of given ROTHR waveforms, to produce a return that simulates a target with low transmit power, and to produce a distinct signal that can be recognized as a specific repeater.

This report addresses the development of a laboratory prototype repeater that was evaluated in field tests using the path between the ROTHR site at the Naval Security Group Activity-Northwest, Virginia and Ramey, Puerto Rico. This evaluation demonstrated successfully that waveform recognition based on the radar waveform repetition frequency was possible and that less than 0.5 Watt of repeater transmitter power was adequate for signal recognition at the ROTHR receiver site. Further, tests showed that the repeater can be recognized by retransmitting the received signal with a small frequency offset.

Title: TESPEX 2: Data Telemetry and Acquisition
Author(s): Timothy L. Krout , Jon Jannucci, Joseph Goldstein, et al.
E-mail Address: goldstein@itd.nrl.navy.mil
Citation: 23rd Annual International Meeting, Sonar Technology Panel (GTP-9), TTCP, Proceedings
Date: November 8-11, 1994
Report No: TT-94-008

Abstract:

This paper discusses the satellite vertical line array (VLA) systems used during TESPEX 2. The 4-channel VLA and 32-channel VLA systems are discussed. Emphasis is given to the 32-channel system, a superset of the 4-channel system. The 32-channel VLA is discussed in four sections:

- The in-water components (hydrophone array, data acquisition unit (DAU), and umbilical cable) performed the functions of digitization and formatting of the acoustic signals.
- Three signal processing and recording systems, located on a buoy, a ship, and on shore, performed data formatting, storage to recording devices, and data dissemination to scientists.
- The satellite communication system performed data telemetry.
- The buoy, including the generator and weather station, provided protection, cooling, and power, for the electronics necessary for at-sea data collection and transmission.

Limitations of the current system are discussed as are plans for enhancements to the system.

TESPEX 2 utilized two acoustic data acquisition systems: a 32-channel vertical line array with satellite telemetry to shore, and a 4-channel vertical line array with in-buoy recording. The systems were deployed approximately 3.5 km apart, north of Darwin, Australia, at the nominal position 10°S latitude and 130°E longitude, to collect acoustic data from June 14 through July 4, 1994. The data collected on these systems will be used by scientists involved in TTCP to determine whether significant passive sonar performance gains using new processing techniques [1,2] that capitalize on environmental complexity in coastal water can be realized. Scientific results of the experiment are presented in [3], [4]. This paper discusses the VLA systems used in the experiment and planned enhancements that will extend the capabilities of these systems.

The VLA systems used in TESPEX 2 were unique in that neither system required a ship to remain in the vicinity of the receiver. The 32-channel VLA (VLA-32) system utilized satellite communication to relay acoustic data from the experiment site to a laboratory in Darwin where scientists received and processed the data and controlled the operation of the system. The 4-channel VLA systems used in-buoy recording to eliminate the need to dedicate a ship as a receiver platform. This arrangement freed the source ship from limitations typically imposed by line-of-sight communications or tethered receive arrays, yet still provided the scientists real-time access to a subset of the acoustic data and control of the VLA-32 system.

This paper discusses both VLA systems used during TESPEX 2, with emphasis on the VLA-32 system. The VLA-4 system is discussed first, with the discussion limited to differences from the TESPEX 1 system. The VLA-32 system is then discussed in four sections describing:

- the in-water components, consisting of the array, data acquisition unit (DAU), and umbilical cable,
- the signal processing and recording systems, one located on the buoy, one on the FRV Southern Surveyor, and one on shore at the Northern Territory University in Darwin, Australia,
- the satellite communication system, and
- the buoy, including the generator and weather station.

Title: Noise Cancellation for CELP Voice Encoders in an F/A-18 Noise Environment
Author(s) D. A. Heide
E-mail Address: heide@itd.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: TT-94-009

Abstract

Because of the severe noise environment in the Navy's F/A- 18 jet aircraft, it has always been very difficult to achieve highly intelligible speech using low data rate voice encoders such as the 2.4 kbps LPC-I0. As a result, all voice encoding has been done with a high data rate 16.0 kbps CVSD algorithm. The main focus of this research was to develop a technique that could retain the acceptable intelligibility of the high rate encoders while still significantly lowering the data rate required. To achieve these results, a noise cancellation pre-processor was developed to be used in tandem with the new 4.8 kbps CELP encoder that is being implemented in the STU-III.

While many noise reduction techniques were investigated, the best results were accomplished by first reducing the noise through spectral subtraction and then enhancing the important resonant formats of the speech. The results indicated that when the noise cancellation pre-processor was added to the CELP encoder, the DRT intelligibility scores were improved by a significant 5.0 points, making the speech much more acceptable for possible use in the F/A- 18.

1994 TECHNICAL REPORT ORDER FORM
Transmission Technology, Code 5550

[ ] **TT-94-001** Enhancement of Stimulated Electromagnetic Emission during Two Frequency Ionospheric Heating Experiments, *Paul A. Bernhardt, Leonard S. Wagner, Joseph A. Goldstein, et al.*

[ ] **TT-94-002** Correlation of High Latitude Ionospheric Disturbances with Geomagnetic Activity, *Leonard S. Wagner and Joseph A. Goldstein*

[ ] **TT-94-003** Encoded Speech Intelligibility Improvement in the F/A-18 Noise Environment Using Spectral Subtraction Preprocessing, *David A. Heide*

[ ] **TT-94-004** Arctic Propagation Phenomena at VHF and UHF for a BLOS Path, *Edward J. Kennedy and Michael A. Rupar*

[ ] **TT-94-005** Speech Analysis and Synthesis Based on Pitch-Synchronous Segmentation of the Speech Waveform, *George S. Kang and Lawrence J. Fransen*

[ ] **TT-94-006** Electromagnetic Spectrum Occupancy Study of a Potential Transmitter Site for the HF Active Auroral Research Program (HAARP), *Joseph A. Goldstein, Edward J. Kennedy and Monroe Y. McGown*

[ ] **TT-94-007** A Laboratory Prototype HF Repeater for Relocatable Over-the-Horizon-Radar, *Adrian S. Eley*

[ ] **TT-94-008** TESPEX 2: Data Telemetry and Acquisition, *Timothy L. Krout , Jon Jannucci, Joseph Goldstein, et al.*

[ ] **TT-94-009** Noise Cancellation for CELP VOice Encoders in an F/A-18 Noise Environment, *D.A. Heide*

VI. ADVANCED INFORMATION TECHNOLOGY CODE 5580

The Advanced Information Technology Branch of the Information Technology Division develops and implements cutting edge hardware and software solutions for Navy problems in a number of application areas. Current research and development thrusts include:

- parallel and distributed hardware, software and display technologies;
- novel signal processing techniques directed primarily toward the exploitation of massively parallel systems;
- development of hardware independent systems for developing and porting code for parallel processing systems;
- design and implementation of reactive and interactive control systems;
- development of technologies for decision support systems and prototyping of all varieties of decision systems including tactical decision aids and mission planning;
- exploration and demonstration of new methods for data management including data fusion, design and navigation of database systems, and correlation and tracking of current and historical information; and display technologies for visual management of all of the above applications.

The technical programs in the Branch include some basic research (6.1), a substantial exploratory development program (6.2) and a continuing effort to field technology through a succession of advanced technology demonstrations (6.3a). The Branch draws on expertise in computer science, mathematics, operations research, electrical engineering and physics.

Title: Determinacy of Generalized Schema II
Author(s): Richard S. Stevens
E-mail Address: stevens@ait.nrl.navy.mil
Citation: SIAM Journal on Computing
Date: 1994
Report No.: AT-94-001

Abstract

Karp and Miller's computation graphs have been widely studied because they are a useful abstraction of multiprocessor computation. A system has the determinacy property if whenever the same set of input streams is entered into the system the resultant output is the same set of output streams. Karp and Miller showed that computation graphs have this property; Woo, Smith, and Agrawala showed that data flow schema, a generalization of computation graphs, also have the property of determinacy. An earlier paper, co-authored by this author, defined the multiple component system model (MCSM), a more general model with the determinacy property, and proved some properties about deadlocking MSCMs. This paper investigates the asymptotic behavior of MCSMs which do not deadlock.

Title: Time-Domain Visualization of Electromagnetic and Acoustic Wave Fields Computed with a Cellular Automaton Algorithm on a Parallel Computer
Author(s): James B. Cole, Rudolph A. Krutar and Susan K. Numrich
E-mail Address: cole@ait.nrl.navy.mil
Citation: IEEE Visualization 94 Conference
Date: October 17-21, 1994
Report No.: AT-94-002

Abstract

We demonstrate animated visualization of wave fields computed using a parallel time-domain finite difference algorithm in the form of a cellular automaton. The cellular automaton approach takes full advantage of the power of parallel processing and can support on-line animation that depict evolving two- or three-dimensional wave fields. In this way heuristic information that is normally unavailable with other techniques is conveyed to the user. Display parameters can be easily adjusted to explore interesting features. This technique is an ideal tool to study transient and near field processes.

Title: Visualizing Noisy Underwater Acoustic Range Images
Author(s): Behzad Kamgar-Parsi and Behrooz Kamgar-Parsi
E-mail Address: behzad@ait.nrl.navy.mil
Citation: Proceedings of IEEE Visualization '94
Date: October 17-21, 1994
Report No.: AT-94-003

Abstract

Range images are traditionally represented as 2D gray scale images, where brightness encodes depth. Visually more informative are 3D perspective displays, notably surface rendering. However, the appearance of a rendered surface can be severely affected by sensor noise, much more so than the 2D gray scale image. Indeed, even moderate levels of noise may produce artifacts in a 3D image that can obscure small features and interfere with shape perception. In this paper we present examples of underwater range images obtained by a high resolution imaging sonar, and examine the effects, and the side effects, of a sequence of inexpensive 3D image transforms that can significantly reduce the noise level and enhance small features.

Title: A Prototype System for the Evaluation of Interdependent Routing Algorithms for Military Aircraft
Author(s): Ranjeev Mittu
E-mail Address: mittu@ait.nrl.navy.mil
Citation: Precision Strike Technology Symposium JHU/APL
Date: October 1994
Report No.: AT-94-004

Abstract

The problem of safely routing military aircraft through areas of high threat density has been important to strike mission planners for many years (and will probably continue to be important in the future). The need for effective algorithms to route these aircraft is clear; in a theater wide strike operation, resources may become scarce, not only by enemy air/ground fire, but also due to the complexity of the logistics. In other words, the main goal of a force level planner should be to coordinate strikes against targets, and not be overly concerned with diminishing resources. This paper will describe a prototype system that has been developed by NRL to test a suite of interdependent routing algorithms.

Title: Advanced Technology for Precision Strike Planning
Author(s): James B. Hofmann and Dennis Carroll
E-mail Address: hofmann@ait.nrl.navy.mil
Citation: MORSS 94 Symposium Proceedings, *Abstract only*
Date: June 6-10, 1994
Report No.: AT-94-005

Abstract

A top-down functional analysis of the needs of a force level air strike planner is performed. These areas include definition, assessment, planning and execution. Opportunities for the application of advanced technology are examined in the areas of target analysis, interdependent platform routing, options selection and resource allocation and visualization and evaluation of competing plans. An end to end system for the assessment and planning phases is described. Operations research approaches to the target analysis, allocation and routing areas are also delineated. High-end computer graphics for visualization, target analysis and preview/evaluation functions is examined. To test the concept, a complex training scenario was used. The results are presented.

Title: Weapon-Target Allocation for Force-Level Strike Planning
Author(s): Ray Jakobovits, Dennis Carroll Metron and James Hofmann
E-mail Address: hofmann@ait.nrl.navy.mil
Citation: MORSS 94 Symposium Proceedings, *Abstract only*
Date: June 6-10, 1994
Report No.: AT-94-006

Abstract

This paper describes the application of optimization technology to force-level strike warfare planning. The problem is to generate a strike concept that integrates tactical aircraft and cruise missile strikes from multiple bases, while simultaneously considering both attack of assigned targets and suppression of implied targets (threats). The use of optimization techniques enables the planning cycle time to be compressed as

well as consideration of alternative plans under different planning assumptions. The problem is formulated and solved as a nonlinear, nonseparable integer programming problem. The paper describes the problem formulation and algorithm as implemented and demonstrated in an advanced technology prototype. Plan management issues and recent extensions of the approach to distributed planning environments are also discussed.

Title: High-Resolution Underwater Acoustic Imaging
Author(s): Behzad Kamgar-Parsi
E-mail Address: behzad@ait.nrl.navy.mil
Citation: 1994 Naval Research Laboratory Review, 105-108
Date: May 1994
Report No.: AT-94-007

Abstract

The capability to image underwater objects with high resolution, such that small features of about 1 centimeter can be resolved, is important in many Navy and commercial applications. These applications include identifying objects, manipulating valves, and inspecting pipes for cracks or barnacle build up. Cameras and lasers have high resolution but fail at centimeter ranges in turbid water-a common condition in coastal waters or in waters disturbed by people.

Acoustic signals, however, propagate in turbid water with little degradation, thus sonars are the only real alternative for imaging in such conditions. In joint efforts, University of Washington Applied Physics Laboratory, Naval Explosive Ordnance Disposal Technology Center, and NRL have developed and tested underwater systems for three-dimensional (3-D) imaging from distances of several meters. The systems use a lens to focus incoming sound waves, thereby eliminating the beam forming electronics used in traditional forward-looking sonars. Hence, they are relatively compact and light. The lens technology is not new [1], but recent advances in desktop computing and visualization now make it possible to process and display the large amount of data in real time. We describe two of the prototypes and present examples of images reconstructed from data taken from stationary and moving platforms.

Title: Progress and Problems in Ocean Visualization
Author(s): Lawrence J. Rosenblum and Behzad Kamgar-Parsi
E-mail Address: behzad@ait.nrl.navy.mil
Citation: Data Visualization: Research Issues, Applications and Future Directions, 435-454, Academic Press
Date: 1994
Report No.: AT-94-008

Abstract

The ocean is a complex, inhospitable medium for remote sensing. Satellites and planes use radar systems and other devices to sense the ocean's surface. Remarkably, although radar signals penetrate the surface by only a few centimeters, both ocean bottom and mid-ocean phenomena such as internal waves can be seen by the radar. Investigating the underlying physics is an important current area of research. Below the surface, the high density of water compared with air makes most sensors inoperable, limiting us to acoustics and, at close ranges in clear water, optics and lasers. The comparatively low

acoustical frequencies result in sparse measurements and low resolution. Overcoming these limitations is the challenge of applying visualization techniques to ocean data sets. This paper presents examples of some of the successes and limitations of visualization in the ocean environment and concludes with a discussion of data visualization problems for the discipline.

Title: Challenges in the IV&V of C2E Software
Author(s): Kurt Askin, Kenneth W. Pitts, James E. Coolahan, et al.
E-Mail Address: askin@ait.nrl.navy.mil
Citation: ADPA Conference, USAF Academy, Colorado Springs, CO.
Date: March 22-25, 1994
Report No.: AT-94-009

Abstract

The software to be incorporated in the Command and Control Element (C2E) of the National Missile Defense segment is planned to be developed in an evolutionary manner, with emphasis on software reuse (including the use of Commercial-off-the-shelf software), in a cost-constrained environment. Each of these three characteristics of the development process pose challenges to the independent Verification and Validation (IV&V) effort that must be conducted to ensure that the C2E software will function as intended when deployed. This paper discussed the multi-stage IV&V process that will be necessary to accommodate the evolutionary development approach, the challenge resulting from the desire to incorporate reused software while maintaining a system that can be trusted to work reliably when called upon, and the techniques to be employed to minimize the amount of software that must undergo more detailed (and thus more costly) IV&V testing.

Title: European Activities in Virtual Reality
Author(s): Jose Encarnacao, Matin Gobel and Lawrence Rosenblum
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: Monthly Column, "Visualization Blackboard", IEEE Computer Graphics and Applications, v14, n1, 66-74
Date: January 1994
Report No.: AT-94-010

Abstract

Virtual reality...Rarely has a technology so entranced the human imagination. The idea of entering a computer-generated space with a reality of its own enthralls many and frightens some. Yet the short- and long-term usefulness of the technology seems clear. Applications include: training; simulation; concurrent engineering; telecommunications; telepresence; scientific visualization; education; medicine; and entertainment.

This article surveys European activities and funding for virtual reality (VR) with two caveats: First, nearly a year separates writing and publication. For most scientific fields, this publication delay for survey material would be minimal; for VR significant changes might have since occurred in some programs. We took advantage of the revision period to upgrade our information and the references as much as possible. Second, some long-standing, significant European efforts go unmentioned as outside the scope of our short survey or as duplicates of others included here. Despite the limitations, we believe this sampling of Europe's leading efforts collectively gives an accurate snapshot of current European activity.

Title: Support Tools for the Processing Graph Method
Author(s): Roger Hillson
E-Mail Address: Hillson@ait.nrl.navy.mil
Citation: Proceeding of the 5th International Conference, Signal Processing & Technology (ICSPAT 94)
Date: October 18-21, 1994
Report No: AT-94-011

Abstract

The Navy has developed a data flow method for programming networks of processors. This approach, called the Processing Graph Method (PGM), is now being used to develop signal processing applications for the Navy's second-generation tactical signal processor. At the Naval Research Laboratory, a unified set of software tools has been developed to facilitate PGM programming. A Macintosh-based Graphic Entry Workstation can be used to iconically capture processing graphs which are then automatically translated into Signal Processing Graph Environment Notation. The Processing Graph Support Environment is a set of Ada software utilities for compiling, linking, and executing the processing graphs; it includes a large, user-extensible library of signal processing primitives. A new effort is underway to develop a Processing Graph Method Tool to facilitate the migration of PGM to various hardware architecture.

Title: Using the Hough Transform and the Fourier Transform to Detect Broadband Multipath Interference Patterns in Lofargram Images
Author(s): Becky Popp
E-Mail Address: popp@ait.nrl.navy.mil
Citation: Proceedings of ICASSP-95, Detroit Michigan
Date: May 8-17, 1995
Report No.: AT-94-012

Abstract

Earlier research showed that an extended Hough Transform is effective in detecting broadband multipath interference patterns in acoustic Lofargrams. By combining the Hough transform and the Fourier transform the processing gain is improved. Broadband multipath interference patterns are formed on a Lofargram when signals are received via multiple paths from a broadband acoustic source moving with constant velocity and depth. An interference pattern can be closely approximated by a family of hyperbolas. The Hough transform is used to perform line integrations over candidate families of hyperbolas. After the transform, the Hough output data corresponding to the family of hyperbolas matching an interference pattern contains periodic components. The Fourier transform is performed over the Hough output data with resulting peak value(s) corresponding to the interference pattern(s). Resulting parameters provide information which can be used to aid in source location. We derive the theoretical processing gain, present processing gain measurements from processing synthetic and real acoustic Lofargrams, and provide estimates of source range and depth.

Title: Cyberpower 2000: The Information Revolution
Author(s): Tamara Luzgin
E-Mail Address: luzgin@ait.nrl.navy.mil
Citation: Internal Report
Date: 1994
Report No.: AT-94-013

Abstract

The Persian Gulf War inaugurated a new era in international relations, global security, and modern warfare. It introduced the notion that state-of-the-art command and control (C2) can achieve and maintain unity of force and unity of command and that superior command and control must have the capability to utilize and exploit information as both a resource and a weapon. The focus of this paper is to postulate how information must evolve to provide for and support the war fighting capabilities that will be required in the 21st century. This paper proposes that information possesses the capacity to evolve into automated knowledge as technological advances provide the means to process more complex forms of automated information and that automated information possesses a power potential that is enhanced with each evolutionary cycle as automated information becomes transformed into automated knowledge. By utilizing and exploiting the interaction between automated information and automated decision making, information power becomes transformed into knowledge power which becomes transformed into cyberpower. Cyberpower represents the utility of automated knowledge, its residual power potential, and its potential to evolve into advanced forms of knowledge. The concept of cyberpower is defined as the inherent power derived from the synergistic interaction of automated information and knowledge, advanced autonomous decision systems and processors, and advanced computers to create and utilize automated meta-knowledge. This paper postulates that cyberpower is both advanced knowledge and the power of advanced knowledge and that automated knowledge possesses cyberpower and is created by cyberpower.

Title: A Nearly Exact Second Order Finite-Difference Time-Domain Wave Propagation Algorithm on a Coarse Grid
Author(s): James B. Cole
E-Mail Address: cole@ait.nrl.navy.mil
Citation: Computer in Physics, v8, n6, 1-5
Date: November/December 1994
Report No.: AT-94-014

Abstract

We introduce a new second order finite-difference time-domain (FDTD) algorithm to solve the wave equation on a coarse grid with a solution error less than 10-4 that of the conventional one. Although the computational load per time step is greater, it is more than offset by a large reduction in the number of grid points needed, while maintaining high accuracy, as well as by a reduction in the number of iterations. In addition, boundaries can be more accurately characterized at the subgrid level. This algorithm is based on a second-order finite-difference Laplacian that is nearly isotropic with respect to the wave propagation direction. Although optimum performance is achieved at a fixed frequency, the accuracy is still much higher than that of a conventional FDTD algorithm over "moderate" bandwidths.

Title: Data Consolidation and Connected Components
Author(s): Joseph B. Collins
E-Mail Address: collins@ait.nrl.navy.mil
Citation: DFS-94 Technical Proceedings
Date: October 25-28, 1994
Report No.: AT-94-015

Abstract

We describe a new database function we call consolidation. This function performs a basic data fusion operation of abstraction and aggregation. The user specifies the attributes that serve as identifiers of the abstract objects and executes a SELECT/GROUP BY query with a SQL-type syntax. The records making up the fused objects are linked by common identifier values. Mathematically, the function is equivalent to finding the connected components, a transitive closure operation, of the specified records using only those identifying relations, or links, specified.

Title: Observation on Operational Jointness
Author(s): Tamara Luzgin
E-Mail Address: luzgin@ait.nrl.navy.mil
Citation: Joint Forces Quarterly, Institute for National Strategic Studies
Date: October 1994
Report No.: AT-94-016

Abstract

The July symposium on Joint Operations offered an interesting survey of the joint operations community which revealed that, in addition to the acceptance of and progress in implementing jointness, there remains a lack of consensus within the military community on the utility and operational practicality of operational jointness, on the benefits to be expected, and the effects of jointness on Service culture and performance. Efforts to implement operational jointness and a Joint Task Force (JTF) structure are beset by fundamentally chronic and nettlesome problems. Representative among these appear to be polarization within the community, Service parochialism and competition, structuring the JTF as a dual-use force, and unrealistic goals and expectations.

This article examines the major aspects of these problems and offers suggestions and recommendations for possible solutions. The article also examines some of the more prominent features of the national security environment and assesses their impact on implementing jointness in the future force and standing the Joint Task Force. The conclusion drawn is obvious: the process of implementing operational jointness and standing up a Joint Task Force will continue to be difficult. Consistent national and Congressional support for what is perceived as upgrades to a military force that has no purpose or mission is at best uncertain. The revolution in military affairs, the evolving national security strategy, and the lackluster effort to redefine and realign military roles and mission have seriously undermined the ability of the military community to define and conduct joint operations. Changing roles and missions combined with declining defense budgets exacerbate the traditional interservice competition and increase protectionism, seriously impacting the ability of the Services to work together to stand up a Joint Task Force and to transform the Atlantic Command into the JTF of the future. Because Service components will seek to protect their war fighting assets and their dominance in traditional mission areas, each Service will seek to claim its fair share of the action in each Joint Task Force mission and to demonstrate the importance of its presence, the superiority of its war fighting capabilities, and its utility.

Title: Research Issues in Scientific Visualization
Author(s): L. Rosenblum, Guest Editor
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: Monthly Column, "Visualization Blackboard", IEEE Computer Graphics and Applications, v14, n2, 61-85
Date: March 1994
Report No.: AT-94-017

Abstract not available. Column only.

Title: Research Issues in Volume Visualization
Author(s): Arie Kaufman, Karl Heinz Hohne, Wolfgang Kruger, et al.
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: Monthly Column, "Visualization Blackboard", IEEE Computer Graphics and Applications, v14, v2, 64-67
Report No.: AT-94-018

Abstract not available. Column only.

Title: Visualization Blackboard Department
Author(s): L. J. Rosenblum, Editor
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: IEEE Computer Graphics and Applications
Date: bi-monthly, 1991-1994
Report No.: AT-94-019

Abstract not available. Column only.

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[ ] **AT-94-001** Determinacy of Generalized Schema II, *Richard S. Stevens*

[ ] **AT-94-002** Time-Domain Visualization of Electromagnetic and Acoustic Wave Fields Computed with a Cellular Automaton Algorithm on a Parallel Computer, *James B. Cole, Rudolph A. Krutar and Susan K. Numrich*

[ ] **AT-94-003** Visualizing Noisy Underwater Acoustic Range Images, *Behzad Kamgar-Parsi and Behrooz Kamgar-Parsi*

[ ] **AT-94-004** A Prototype System for the Evaluation of Interdependent Routing Algorithms for Military Aircraft, *Ranjeev Mittu*

[ ] **AT-94-005** Advanced Technology for Precision Strike Planning, *James B. Hofmann and Dennis Carroll*

[ ] **AT-94-006** Weapon-Target Allocation for Force-Level Strike Planning, *Ray Jakobovits, Dennis Carroll Metron and James Hofmann*

[ ] **AT-94-007** High-Resolution Underwater Acoustic Imaging, *Behzad Kamgar-Parsi*

[ ] **AT-94-008** Progress and Problems in Ocean Visualization, *Lawrence J. Rosenblum and Behzad Kamgar-Parsi*

[ ] **AT-94-009** Challenges in the IV&V of C2E Software, *Kurt Askin, Kenneth W. Pitts, James E. Coolahan, et al.*

[ ] **AT-94-010** European Activities in Virtual Reality, Jose *Encarnacao, Matin Gobel and Lawrence Rosenblum*

[ ] **AT-94-011** Support Tools for the Processing Graph Method, *Roger Hillson*

[ ] **AT-94-012** Using the Hough Transform and the Fourier Transform to Detect Broadband Multipath Interference Patterns in Lofargram Images, *Becky Popp*

[ ] **AT-94-013** Cyberpower 2000: The Information Revolution, *Tamara Luzgin*

[ ] **AT-94-014** A Nearly Exact Second Order Finite-Difference Time-Domain Wave Propagation Algorithm on a Coarse Grid, *James B. Cole*

[ ] **AT-94-015** Data Consolidation and Connected Components, *Joseph B. Collins*

[ ] **AT-94-016** Observation on Operational Jointness, *Tamara Luzgin*

[ ] **AT-94-017** Research Issues in Scientific Visualization, *L. Rosenblum, Guest Editor*

[ ] **AT-94-018** Research Issues in Volume Visualization, *Arie Kaufman, Karl Heinz Hohne, Wolfgang Kruger, et al.*

[ ] **AT-94-019** Visualization Blackboard Department, *L. J. Rosenblum, Editor*

VII. CENTER FOR COMPUTATIONAL SCIENCES CODE 5590

The Center for Computational Science, Code 5590, conducts research and development to further the advancement of computing and communications systems to solve Navy problems. The Branch accomplishes this mission through a balanced focus on service, research, and development. The Center is committed to investigating and developing leading edge technologies to establish an advanced computational environment that will benefit all research areas. The Branch studies new technologies to evaluate their potential. Promising technologies are further developed, enhanced, and transitioned to production systems. The Branch's operational efforts provide for a computing environment that emphasizes reliability, high performance, and user productivity. In the area of research and development the Branch develops and implements new technologies, both hardware and software, to solve Navy problems in diverse application areas. Current thrusts include: parallel and distributed hardware, software and display technologies; signal processing techniques directed toward exploitation of massively parallel systems; development of hardware architecture independent systems for developing and porting code for parallel processing; and development of high-speed networks.

In the area of operational support, the Center provides shared high performance computing and networking resources and related services, including user support and training, for NRL, Navy, and DoD interdisciplinary research efforts. The Branch manages and operates NRL's shared massively parallel supercomputer, vector mini-supercomputer, central file server/archiver, and scientific visualization systems. The Branch has responsibility for the laboratory's local area network and external connections to network and computer systems world-wide. The Branch also provides laboratory ADP logistic support by identifying ADP requirements and securing and administering contractual support for lab-wide or multiple buys of ADP systems, software and services.

Title: On Commonalities in Signal Design for Non-Gaussian Channels
Author(s): Nhi-Anh Chu
E-mail Address: chu@cmvax.nrl.navy.mil
Citation: 28th Annual Conference on Information Science & Systems, Communications, Computer Control & Signal Processing,
also a Naval Research Laboratory Report, NRL/FR/5591-94-0002
Date: February 3, 1994
Report No.: CCS-94-001

Abstract

Signal waveform design is a critical aspect in the overall design of a communication or radar system. If the channel happens to be non-Gaussian, few analytic results exist. Johnson and Orsak have previously applied a particular Large Deviation result to derive the asymptotically optimal signal waveform for detectors optimized to the Neyman-Pearson criterion. In this work we generalize these results to derive the signal waveforms which are simultaneously optimal with respect to the minimum probability of error, the mini-max, and the Neyman-Pearson criteria. We show that for a large class of non-Gaussian statistics, there exist only two asymptotically optimal signal waveforms; one impulsive while the other is constant in amplitude. The impulsive waveform is optimal when the tails of the noise density fall off faster than the tails of the Gaussian density. Conversely, the constant amplitude waveform is optimal when the tails of the noise density fall off slower than those of the Gaussian. To establish these results we have shown that under each of the three optimality criteria, the asymptotic performance for small signals is essentially determined by the signal energy, while for large signals, the performance is determined by a non-Euclidean metric which varies with respect to the tails of the noise density function. To support these results, we offer simulations for a variety of non-Gaussian channels. In each case, the asymptotic theory holds strikingly well even for decidedly non-asymptotic regimes.

Title: Visualizing Time Dependent Data From Molecular Dynamics Simulations Using AVS
Author(s): Upul R. Obeysekare, Chas J. Williams and Robert O. Rosenberg
E-mail Address: library@aic.nrl.navy.mil
Citation: AVS '94 Conference Proceedings
Date: March 1994
Report No.: CCS-94-002

Abstract

We addresss the relevant issues involved in visualizing time dependent data from molecular dynamics simulations using AVS. To enhance the existing visualization capabilities of these databases, we developed a suite of AVS modules. This module suite addresses important factors such as importing data, filtering data to extract subdomains, picking individual atoms for highlighting, selecting atoms for monitoring dynamics using trajectories, and generating animations for studying the dynamics of the whole system.

Title: Real-Time Visual Control of Numerical Simulations
Author(s): U.R. Obeysekare, F.F. Grinstein, Chas J. Williams, and G. Patnaik
E-mail Address: library@aic.nrl.navy.mil
Citation: Visualization '94
Date: October 1994
Report No.: CCS-94-003

Abstract

We address relevant issues and difficulties involved in the practical implementation of real-time visualization (RTV) with emphasis on interactive control of numerical simulations. Important issues governing the implementation of this technique such as network data transfer speeds, architecture neutral implementation, visual programming environment across heterogeneous computer architectures, and user-interface design for visual control of the simulation are being addressed. Strategies to overcome difficulties associated with the implementation of the concept are analyzed in the context of the two-dimensional simulation of a high speed jet flow under AVS environment.

Title: Connection Machine Software Conversion of the Navy TOPS Model
Author(s): Paul B. Anderson and Michael A. Young
E-mail Address: anderson@cmf.nrl.navy.mil or myoung@cmf.nrl.navy.mil
Citation: Naval Research Laboratory Report, NRL/MR/5590-94-0005
Date: March 22, 1994
Report No.: CCS-94-004

Abstract

The introduction of highly parallel machines with peak performance significantly exceeding the Cray machines has sparked interest in running scientific models on these new architectures. This report describes a software conversion, of the Navy model called TOPS, starting with a Cray Y-MP/8 version in Fortran 77 and ending with a Fortran 90 version for the Connection Machine CM-5. Data mapping, conversion planning, and performance points of view are considered.

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[ ] **CCS-94-001** On Commonalities In Signal Design for Non-Gaussian Channels, *Nhi-Anh Chu*

[ ] **CCS-94-002** Visualizing Time Dependent Data From Molecular Dynamics Simulations Using AVS, *Upul R. Obeysekare, Chas J. Williams and Robert O. Rosenberg*

[ ] **CCS-94-003** Real-Time Visual Control of Numerical Simulations,*U.R. Obeysekare, F.F. Grinstein, Chas J. Williams, and G. Patnaik*

[ ] **CCS-94-004** Connection Machine Software Conversion of the Navy TOPS Model, *Paul B. Anderson and Michael A. Young*