Computer Science Department

Professor Patrick R. Harrison
Chair

During the 2001-2002 academic year, the Computer Science Department faculty did significant research in the areas of software engineering, robotics, security, computer algebra, and intelligent tutoring. This included the publication of ten papers and nine presentations. A number of independent research projects were conducted with midshipmen in the areas of autonomous control, networks, net centric warfare and robotics. Midshipmen also participated in research in three summer internships at the Naval Research Laboratories and five at the Defense Information Systems Agency. Two new Trident proposals were prepared and approved for the 2002 academic year. The Computer Science faculty continues to attract grant money and research opportunities from a number of government and commercial sources. This year the department has expanded its horizons to include information security as a new area of focus for faculty research and midshipman education.

Sponsored Research

Computing with Semi-Algebraic Sets Using Cylindrical Algebraic Decomposition

Researcher: Assistant Professor Christopher W. Brown
Sponsor: Naval Academy Research Council (NARC)

Cylindrical Algebraic Decomposition (CAD) is a powerful data structure for explicitly representing *Semi-Algebraic Sets* which, roughly speaking, are any geometric object defined by polynomials. Many problems in mathematics, science, and engineering may be phrased as questions about semi-algebraic sets, and CAD is a powerful tool for answering these questions. The ultimate goal of this project is to improve upon the current state of the art in algorithms for using and constructing CAD's so as to increase the range of problems that can be addressed in practice with these methods. This project targets improvements in each of the three main phases of CAD construction (projection, lifting and solution representation) as well as, improvements in the way CAD is used to solve certain application problems and cooperation between CAD and other methods in Computational Real Algebraic Geometry.

Enterprise Computing with .NET, ASP+, C# and SOAP

Researcher: Professor Patrick R. Harrison
Sponsor: Microsoft

The purpose of this research is the development and testing of concepts for Visual Studio .NET and next generation programming environments, tools, help systems and debuggers. This is ongoing and proprietary.

Conference of Information Technology

Researcher: Professor Patrick R. Harrison
Sponsor: Office of Naval Research (ONR)

The goal of this conference is to examine and explore the current and future uses of information technology (IT) in naval operations and the implications for education of midshipmen at the United States Naval Academy.

Development of Bayesian-Based Mechanisms for Real-Time Network Security Systems

Researcher: Assistant Professor Margaret M. McMahon
Sponsor: Naval Academy Research Council (NARC)

Networks are increasingly important in this information age. At many points in network routing, passwords can be captured and an account misused without triggering any alarm. Once admitted, an intruder has all the privileges the account owner enjoys. If there is detection, it is typically after damage to files, systems, or commercial property rights have occurred. Intruders should be uncovered when attempting to gain access, however, authenticating devices at every access point is prohibitively expensive, and prior exchange of passwords may be impractical. This research explores the elements of a real-time dynamic authentication system based on users' behavioral patterns.

These elements protect the system, administer it, contain decision mechanisms and respond to changes in user behavior. Behavior is characterized by the commands used, their order, and the timing between them. Our approach is based on an experimental authentication tool developed at the University of Connecticut. This dynamic approach to user authentication provides intrusion detection, and potential identification. Differences between current input and models stored in the system may indicate a masquerader, an intruder, or a change in a user's behavior or intent.

Reusability Analysis Framework for Shipbuilding Components Modeled in EXPRESS, XML, and Java

Researchers: Associate Professor Donald M. Needham and
Steven A. Demurjian, Sr., Ph.D.
(University of Connecticut, Department of Computer Science and Engineering)
Sponsor: The Electric Boat Corporation, Groton, Connecticut

In order to support interoperability in the Integrated Shipbuilding Environment (ISE), under research investigation at Electric Boat, it is necessary to define shipbuilding components at different levels of abstraction, which support application-to-application interoperability at design and implementation levels. Possible candidates for such abstractions include EXPRESS, XML, and Java, which cover a range of conceptual to development languages. A critical factor in this work is the creation of reusable shipbuilding components and interfaces, at both design and development levels. Current research in reusable components concentrates primarily on the consumer (reuser) perspective instead of the producer perspective. Typically, studies focus on measuring the reuse that a software project has achieved (or how much effort has been saved by reuse) instead of on measuring the degree that an application is reusable for other similar systems that will be built in the future. For instance, in [Lim96], seventeen reuse economic models were compared that measure savings from reuse and return on investment, while in [Poul97], nine similar models were reviewed. While many of these models show a great deal of commonality, there is still less attention given to analyzing reusability during system design and development in order to produce reusable products. However, research efforts have begun to mature as evidenced by the creation of reusable software research groups at universities [Wvu97, Osu98]. *For more information regarding this work, please see the Electric boat grant proposal entitled: "Reusability Analysis Framework for Shipbuilding components Modeled in EXPRESS, XML, and Java" on file in the U.S. Naval Academy Research Office.*

Object-Oriented Support for Distributed Access to Unified Geospatial Data

Researcher: Associate Professor Donald M. Needham
Sponsors: Naval Research Laboratory (NRL) and
Charting, Mapping and Geodesy Branch, Stennis Space Center, Mississippi

Digital geodesic mapping information contained in the Stennis Space Center's Charting and Geodesy Analysis Program's Geospatial Information Database (GIDB) requires frequent feature-level updating and manipulation, activities that object-oriented technology has revolutionized. This work focused on integrating multiple data types (rastor, vector, and text) into the GIDB to create a unified framework for accessing the National Imagery and Mapping Agency's (NIMA) geospatial data. Another focus was the evolution of the GIDB to distributed database architecture to better support users in downloading NIMA data via the Internet. The common Object Request Broker Architecture standard and the Java programming language was used to facilitate the evolution of the GIDB.

Andes: An Active Learning, Intelligent Tutoring System for Newtonian Physics

Researchers: Professor Kay G. Schulze (Computer Science Department)
Professor Robert N. Shelby, Professor Donald J. Treacy, and
Professor Mary C. Wintersgill, (Physics Department)
and Kurt VanLehn (University of Pittsburgh)
Sponsor: Cognitive Sciences Branch, Office of Naval Research (ONR)

The Andes project is developing an intelligent tutoring system for teaching physics to students at the U.S. Naval Academy. It is based on three key ideas: (1) that it should help students with their physics homework rather than take over instruction entirely, (2) that several types of help systems are necessary for effective learning, and (3) principle-based dialog between the students and ANDES is an effective method to give useful advice as a tutor. The project has developed a fairly complete version of the tutoring system, and has conducted several evaluations at the Naval Academy and in laboratories at the University of Pittsburgh. The current research is expanding the scope of the tutor, seeking to increase its acceptance at the Academy and conducting several kinds of evaluations in order to measure and increase the effectiveness of the tutor. ANDES is being cast in a new form to allow the tutor to give better diagnostic advice to the student. This version should be ready for a trial in the fall semester of 2001.

Independent Research

Reinforcement and Social Learning in Robots and Situated Agents Performing A Construction Task

Researcher: Assistant Professor Frederick L. Crabbe

Robots currently are not autonomous because of a general lack of flexibility to adapt to their environment. For example, they are not typically able to pursue multiple goals at once, or switch between goals when appropriate. They also are unable to rapidly adapt to new or changing environments. Such adaptation requires the robot to recognize distinctions in its environment and memorize the optimal responses to the environment, in other words, to learn. While many areas of machine learning are well understood, there remain gaps in that understanding. In particular, two areas of deficiency in current mobile robot systems are learning algorithms that can learn to pursue multiple goals simultaneously, and learning algorithms that take advantage of the full range of social learning (learning from peer or teacher robots in the environment). Multiple-goal learning is important because if a robot is going to manage multiple goals in a dynamic environment, the learning algorithms must take into account multiple goals while learning. Social learning is important because it increases the speed at which learning can take place. It is often much faster for a robot to learn from another robot, rather than learning on its own by trail and error. Recent work has shown some promising results in multiple-goal learning, but the results are not developed mathematically. Additionally, other work has demonstrated the power of social learning, but it has also identified some serious obstacles that need to be overcome.

In this project, two aspects of robot learning are being investigated: learning with multiple goals and social learning in order to improve the autonomous qualities of mobile robots.

Research Course Projects

Underwater Vehicle Competition

Researcher: Midshipman 1/C Jason M. Sebastian, USN
Adviser: Professor Patrick R. Harrison

Midshipman Sebastian was tasked with the specification and implementation of the software as a member of the team developing the underwater vehicle for this year's national competition.

Developing a Joining Algorithm for the Network-Centric Infrastructure in Tactical Targeting Networking Technology

Researcher: Midshipman 2/C Joshua B. Datko, USN
Advisers: Assistant Professor Margaret M. McMahon
and Associate Professor Donald M. Needham

The improvement of shipboard ballistic weaponry that brought about the creation of the battleship in the late 19th century inspired a strategic change throughout the world's navies. This development, coupled with thinkers who envisioned new applications of the technology, like Mahan and his Influence of Seapower Upon History, caused the U.S. Navy to adopt a very different naval strategy. A similar technological revolution is occurring today. Like the technology of the battleship age inspired naval advancement, the information age is changing today's military. This technology is not superior weaponry, as it was in the late 1800's, but a new method of collaborating existing weapons. Current advancements in networking technology are allowing military units to send higher qualities of information with greater rapidity. This has spawned the Network Centric Warfare (NCW) concept, which promises greater battlespace awareness through the use of networking technology.

Although theories of NCW have existed for some time, the development of the necessary NCW-specific protocols and algorithms is still an area of active research. VADM Cebrowski, former Director for space, Information Warfare, Command and Control (N6) commented that, "the structural or logical model of network-centric warfare has emerged. The entry fee is a high-performance information grid that provides a backplane for computing and communications". In November of 2000, the Defense Advanced Research Projects Agency (DARPA) publicly encouraged researchers to develop Tactical Targeting Networked Technology (TTNT) to achieve the NCW vision. TTNT is the infrastructure that is expected to provide the framework for networking warfighting assets through increased bandwidth, on-the-fly reconfigurability, low latency data transfer, and advanced network planning and management. However, before users can access this network, there has to be a detailed sequence of actions to allow users to find and then join the network to ensure smooth connectivity and valid user authorization. The purpose of this research and that of a Trident project during Academic Year 2002 is to develop an algorithm to incorporate users into a network-centric infrastructure, such as a Tactical Targeting Network (TTN), through network discovery, authentication, and service locating methods.

Localization and Map Building in Mobile Robots to Assist Outdoor Military Operations in Urban Terrain

Researcher: Midshipman 2/C Edward H.L. Fong, USN
Adviser: Assistant Professor Frederick L. Crabbe

When a mobile robot is introduced into an unfamiliar environment, it must be able to successfully navigate in its surroundings in order to perform its given tasks. One example would be to assist soldiers and marines in their operations on urban terrain, moving ahead and sending back data such as maps, pictures, or environmental conditions. To do this, a robot must explore its environment, generate some sort of map of the world it "sees," and place itself accurately on that map. This research and a Trident project during Academic Year 2002 is designing and implementing algorithms that provide a robot with the ability to accomplish these tasks while moving around in an unfamiliar, urban environment. We are collaborating with Dr. Alan Schultz's team at the Naval Research Laboratory, which has already incorporated some of these exploration and localization capabilities into a mobile robot located indoors. However, the environment outside differs to a great extent from the laboratory settings in which the team tested the robots. There are differences in elevation, variations in ground composition, and the presence of non-ideal reflective surfaces. When outdoors, the robot must determine in which plane it is traversing (as opposed to the 2-D calculations in the laboratory environment). It must be able to account for ramps, curbs, hills, and ditches, (e.g., realizing that if it is on a negative incline, the "barrier" it sensed in front of it is actually the ground before it instead of an obstacle. When, traversing from smooth pavement to another ground material (i.e., sand), the robot should be able to record and account for such a situation when calculating its position and movement. In addition, the outside environment also contains many objects that are poor reflectors of the robot's sonar pulses (decreasing the effectiveness of its sensors). The primary objective of this research as a future Trident project will be to extend Dr. Schultz's integration of exploration and localization for mobile robots so that it would work robustly in an outdoor setting. The goal will be to develop an algorithm for a mobile robot that would let it explore and map an urban-like environment on its own. Such a robot could prove very useful by searching and gathering information in dangerous and hostile areas.

Wireless Web Technologies

Researcher: Midshipman 2/C Jess F. Hottenstein, USN
Adviser: Commander Patrick J. Vincent, USNR

At the beginning of the 21st century, the wireless Internet is poised to become a leading form of communication. Wireless communication has evolved rapidly over the last century and has paralleled the development of wired communication. Voice communication was followed by data communication the latter providing a cheaper, more convenient method of transferring information. The technologies currently involved in wireless data transfer are in their infancy, but hold promise for the future. The current state of wireless applications and platforms mirror the undeveloped status of the communication protocols.

The main goal of this research project was to increase the researcher's overall knowledge in the field of wireless networking. Listening to the excited talk surrounding the advent of the wireless web, it is felt that wireless networking will soon be as universal as cellular phones. One can dream of a time when students and workers roam seamlessly to any location and receive information at a rate faster than most people can currently access the Internet in their homes. Indeed by 2005, wireless users should be able to access the Internet as fast as most wired users.

In order to achieve this overall goal, many small goals served as guides for this research. The project began with the basic principles used for wireless communication as the fundamental baseline. The researcher then learned about how the Internet currently works and investigated how wireless data transfer methods are currently used. Finally, the two standards that may be used in the future, Wireless Access Protocol and iMode, were explored.

Publications

Journal (Refereed) Manuscripts

BROWN, C.W., Assistant Professor, "Simple CAD Construction and its Applications," *Journal of Symbolic Computation*, 31(5): pp. 521-547, 2001.

This paper presents a method for the simplification of truth-invariant cylindrical algebraic decompositions (CAD's). Examples are given that demonstrate the usefulness of the method in speeding up the solution formula construction phase of the CAD-based quantifier elimination algorithm. Applications of the method to the construction of truth-invariant CAD's for very large quantifier-free formulas and quantifier elimination of non-prenex formulas are also discussed.

BROWN, C.W. Assistant Professor, "Improved Projection for Cylindrical Algebraic Decomposition," *Journal of Symbolic Computation*, accepted for publication.

McCallum's projection operator for Cylindrical Algebraic Decomposition (CAD) represented a huge step forward for the practical utility of the CAD algorithm. This paper presents a simple theorem showing that the mathematics in McCallum's paper actually point to a better projection operator than he proposes – a reduced McCallum projection. The reduced projection has the potential to not simply speed up CAD computation for problems that are currently solvable in practice, but actually increase the scope of problems that can realistically be attacked via CADs. Additionally, the same methods are used to show that McCallum's projection can be reduced will further when CAD is applied to certain types of commonly occurring quantifier elimination problems.

SCHULZE, Kay G., Professor, SHELBY, R., Professor, TREACY, D.J., Professor, WINTERSGILL, M.C., Professor, Vanlehn, K., and Gertner, A., "Andes: An Intelligent Tutor for Classical Physics," *The Journal of Electronic Publishing*, 6:1, http:/www.press.umich.edu/Sep/06-01/schulze.html 2000. .

Natural sciences are an essential component of the liberal arts educational experience. However, many students find the problem solving skills that are an integral part of any introductory physics course difficult to develop. In particular, working on homework assignments without the benefit of expert feedback is often a frustrating experience. In order to alleviate this situation, one possible remedy is to construct an intelligent tutoring system that is capable of providing immediate feedback and relevant hints to students. One such system is Andes, a coached learning environment for classical physics that has been in development since 1996 by researchers at the Learning Research and Development Center of the University of Pittsburgh and at the United States Naval Academy. This intelligent tutor allows students to solve physics problems in an environment that provides visualization, immediate feedback, and procedural and conceptual help. It runs under both the Windows98 and NT operating systems. Andes consists of an authoring module, developed by the Naval Academy, and a student module, developed by the Learning Research and Development Center. It currently tutors students in the areas of static forces, translational and rotational kinematics, translational and rotational dynamics, energy, and linear and angular momentum.

SCHULZE, Kay G., Professor, SHELBY, R., Professor, TREACY, D.J., Professor, WINTERSGILL, M.C., Professor, and Vanlehn, K., "Andes: An Active Learning, Intelligent Tutoring System for Newtonian Physics," in A. Jimoyiannis (Ed.) *Themes in Education*, 1:2, pp. 115-136, Leader Books, Athens, Greece.

A trend that has been emerging more strongly in the last decade has been to question the role and content of physics in contemporary higher education. Although the majority of students should study physics, most of them will not become professional physicists or engineers. Efforts have been made within the physics education community to make the subject more accessible to the average student. In addition, it is well known that students appear to learn more when personal tutoring is available as they attempt to solve homework problems. The artificial intelligence community has developed systems that try to tutor students in mathematics, chemistry and computer programming.

Andes is an intelligent tutoring system in classical physics that has been in development by researchers at the Learning, Research, and Development Center (LRDC) at the University of Pittsburgh and the United States Naval Academy since 1996. It allows students to solve physics problems in an environment that provides visualization, immediate feedback, procedural help, and conceptual help. It currently tutors students in static forces, translational and rotational kinematics, translational and rotational dynamics, work and energy, and linear and angular momentum. The system encourages the student to draw free body diagrams, when appropriate, and to enter the equations necessary to solve the problem. It allows them to ask for hints, both in terms of what they have done incorrectly as well as when they have reached an impasse and do not know how to proceed.

Andes is comprised of an expert model and a student environment. The expert model, developed by the researchers at the Naval Academy, incorporates the physics domain knowledge and pedagogical strategies that are the foundation of Andes. The student environment, developed by the LRDC, incorporates the interface (called the Workbench), the student assessment, and the help system.

After having used Andes with a limited number of students at the Naval Academy over a three-year period, it was used in a formal study in the fall of 1999. The statistical and anecdotal results of this study are reported in this paper.

Conference Proceedings

BROWN, C.W., Assistant Professor, "Improved Projection for CAD's of $\mathbf{R}^2$," *Proceedings of the International Symposium on Symbolic and Algebraic Computation*, July 2000, pp. 137-153.

This paper presents an improved projection operator for the construction of CAD's of $\mathbf{R}^2$. It is shown that, typically, it suffices to include in projection only leading coefficients (along with discriminants and resultants) rather

than all coefficients. Cases in which the leading coefficient alone does not suffice can be dealt with, in a sense, even more efficiently. Generalizing the improved projection operator to dimension greater than three is a topic of ongoing research.

CRABBE, F.L., Assistant Professor, and Dyer, M.G., "Observation and Imitation: Goal Sequence Learning in Neurally Controlled Construction Animats: VI_MAXSON, *Proceedings of the 6th International Conference on Simulation of Adaptive Behavior*, September 2000, pp.373-382.

We report on an under-explored animat learning problem, that of learning sequences of goals, and present an algorithm for solving it using observation and imitation. The presentation introduces the problem as well as a neural agent control architecture we use as a framework in which to use the algorithm. We demonstrate that, by using the algorithm, a learning agent can learn to satisfy a sequence of goals by observing the actions of a teaching agent, and later imitate the teaching agent.

CRABBE, F.L. Assistant Professor, "Multiple Goal Q-Learning: Issues and Functions," *Proceedings of the International Conference on Computational Intelligence for Modeling, Control and Automation*, accepted; to appear in September 2001.

This paper addresses the concerns of agents using reinforcement learning to learn to achieve multiple goals. It proves that an algorithm based on acting upon the maximal goal at any one time will not always produce the Maximal Expected Utility for the agent. The paper then examines the type of function approximator necessary for the agent and concludes that bi-linear function is the best compromise between expressive power and speed of learning.

McMAHON, M.M., Assistant Professor, Ammar, R.A., and Sholl, H.A., "Proposed Structure of a Network Security System Using Dynamic Authentication," *14th International Conference on Parallel and Distributed Computing Systems*, Dallas, TX, accepted, to appear August 2001.

Networks are increasingly important for communicating and for commerce in everyday life. Passwords are vulnerable at many points in network routing, and allow a masquerading intruder to misuse an account without triggering any alarm. Once admitted, an intruder has all the privileges enjoyed by the account owner. Even if misuse is detected, it is typically after damage to files, systems, commercial property, or privacy has occurred. Intruders should be uncovered while attempting to gain access. Authenticating devices at every access point is logistically impractical; prior exchange of passwords may be unfeasible.

This research explored the elements of a real-time dynamic authentication system based on users' behavioral patterns. User behavior is characterized by the commands used, their order, and the timing between them. This dynamic approach to user authentication provides intrusion detection, and potential identification using Bayes' theorem. Differences between current input and models stored in the system may indicate a masquerader, an intruder, or a change in an authorized user's intent.

Our work focused on refining and defining metrics of an approach for dynamic user authentication. We investigated the influence of sample size and state space on our ability to recognize the presence of individuals using a computer system.

McMAHON, M.M., Assistant Professor and Sholl, H.A., "Influence of State Size on User Models in a Network Security System," *13th International Conference on Parallel and Distributed Computing Systems*, Las Vegas, Nevada, August 8-10, 2000.

Networks are increasingly important for communicating and for commerce in everyday life. Passwords can be captured at many points in network routing, allowing a masquerading intruder to misuse an account without triggering any alarm. Once admitted, an intruder has all the privileges enjoyed by the account owner. Even if misuse is detected, it is typically after damage has occurred. Intruders should be uncovered while attempting to gain access.

Differences between a user's current input and stored models may indicate an intruder's presence. We focused on refining the state models used in dynamic user authentication. We investigated the influence of state machine size to recognize the presence of individuals logged into a computer system by their order of invoking UNIX commands and the timing between invocations. The decision was based on the conditional probability of the user given a string of commands and the timing between those commands. In our experiments, user models' state space was defined to include 25, 50, 75 and 100 percent of all states encountered in the training set. Results showed that using a percentage of the states present in the training set, rather than selecting one value for all user models, may yield better recognition.

NEEDHAM, D.M. Associate Professor, and Demurjian, S., "Producing Reusable Components: A Domain-and-Organization-Specific Perspective," *Proceedings of the ACM/SIGSOFT Symposium on Software Reusability (SSR'01)*, Toronto, Canada, May 18-20, 2001, pp. 41-50.

Developing reusable object-oriented software requires a designer to determine how to structure a software system so as to achieve the necessary functionality, while at the same time increasing the reuse potential of the software. We introduced a set of reusability metrics intended to be iteratively applied during the design and implementation parts of the software life-cycle to help guide the production and identification of reusable components. Component identification centers on the application's domain, with reuse focusing specifically on an organization's future systems. Our approach requires the developer to subjectively categorize classes, identify component boundaries, and specify where components are related. Our metrics provide reuse valuations on the couplings between components. Based upon the results of applying our metrics, we provide refactoring guidelines to increase the separation between components in a manner that improves component reusability. In this research, we included an application of our metrics to a commercial object-oriented framework.

NEEDHAM, D.M., Associate Professor, Wilson, R., and Shaw, K., "An Analysis of a CORBA-Based Approach to Accessing Geospatial Information via the Internet," *20th IEEE International Performance, Computing, and Communications Conference (IPCCC 2001)*, Phoenix, AZ, April 4-6, 2001, pp. 236-243.

Access to the National Imagery and Mapping Agency's (NIMA's) Vector Product Format data is essential to the evolution of digital mapping products. Currently, users of NIMA data must have software to view the data resident on their own computer systems, and must obtain the data on CD-ROM or other storage media. This paper examines the design of an object-oriented (OO) digital mapping database prototype, called the Geospatial Information Database (GIDB). The GIDB provides accessibility to NIMA mapping data over the Internet in a CORBA-compliant manner. We describe a software solution to create a thin client product to enable viewing and manipulation of NIMA mapping data, and utilize n-tier concepts for data manipulation on the server side. We discuss difficulties encountered during the modeling and implementation stages of our development of the GIDB, as well as examine improvements made to increase the efficiency of our system.

SCHULZE, Kay G., Professor, Vanlehn, K., Freedman, R., Jordan, P., Murray, C., Osan, R., Ringenberg, M., Rose, C., SHELBY, R., Professor, TREACY, D., Professor, Weinstein, A., and WINTERSGILL, M., Professor, "Fading and Deepening: The Next Steps for Andes and Other Model-Tracing Tutors," *Proceedings of the 5th International Conference*, ITS 2000, Montreal, Canada, 2000.

Model tracing tutors have been quite successful in teaching cognitive skills; however, they still are not as competent as expert human tutors. We propose two ways to improve model-tracing tutors and in particular the Andes physics tutor. First, tutors should fade their scaffolding. Although most model tracing tutors have scaffolding that needs to be gradually removed (faded), Andes' scaffolding is already "faded," and that causes student modeling difficulties that adversely impact its tutoring. A proposed solution to this problem was presented. Second, tutors should integrate the knowledge they currently teach with other important knowledge in the task domain in order to promote deeper learning. Several types of deep learning are discussed, and it is argued that natural language processing is necessary for encouraging such learning. A new project, Atlas, is developing natural language based enhancements to model tracing tutors that are intended to encourage deeper learning.

Presentations

BROWN, Christopher W., Assistant Professor, "Improved Projection for CAD's of $\mathbf{R}^2$," International Symposium on Symbolic and Algebraic Computation, July 2000.

BROWN, Christopher W., Assistant Professor, "Cylindrical Algebraic Decomposition and Simple Descriptions of Semi-Algebraic Sets," Applications of Real Algebraic Geometry Outside Mathematics, Rennes, France, June 16, 2001.

CRABBE, F.L., Assistant Professor, "Observation and Imitation: Goal Sequence Learning in Neurally Controlled Construction Animats: VI-MAXON," 6th International Conference on Simulation and Adaptive Behavior, Paris, France, September 14, 2000.

McMAHON, M.M., Assistant Professor, "Influence of State Size on User Models in a Network Security System," 13th International Conference on Parallel and Distributed Computing Systems, Las Vegas, NV, August 8-10, 2000.

McMAHON, M.M., Assistant Professor, chaired Session 7B "Network Security and Fault Tolerant Systems," 13th International Conference on Parallel and Distributed Computing Systems, Las Vegas, NV, August 9, 2000.

NEEDHAM, D.M., Associate Professor, "Producing Reusable Components: A Domain-and-Organization-Specific Perspective ACM Symposium on Software Reusability (SSR'01)," Toronto, Canada, May 19, 2001

NEEDHAM, D.M., Associate Professor, "An Analysis of a CORBA-Based Approach to Accessing Geopatial Information Via the Internet," 20th IEEE International Performance, Computing and Communications Conference (IPCCC 2001), Phoenix, AZ, April 6, 2001.

NEEDHAM, D.M., Associate Professor, "Analyzing Domain & Organization-Specific Reusability for Shipbuilding Components," Integrated Shipbuilding Environment Phase II (ISE-2), Arlington, VA, November 2, 2000.

NEEDHAM, D.M., Associate Professor, "Reuse Potential in XML Designs," University of Connecticut, Storrs, Connecticut, October 13, 2000.

NEEDHAM, D.M., Associate Professor, "Reusability Analysis for Shipbuilding Components Modeled in XML and Java," Electric Boat Corporation, Groton, Connecticut, June 28, 2000.

NEEDHAM, D.M., Associate Professor, "XML Support for Object-Oriented Reuse," The University of Connecticut, Storrs, Connecticut, June 12, 2001.

SCHULZE, K.G., Professor, SHELBY, R., Professor, TREACY, D., Professor, and WINTERSGILL, M., Professor, "Andes: A Tutoring System for Classical Physics," American Association of Physics Teachers, Guelph, Ontario, July 15, 2000.