Computer Science Department

Professor Kay G. Schulze
Chair

During the 2004-2005 academic year, the Computer Science Department faculty did significant research in the areas of software engineering, robotics, computer algebra, networks, graphics, semantic web, and intelligent tutoring. A number of midshipmen independent research projects were conducted. Midshipmen also participated in summer internships at the Naval Research Laboratory (NRL), the National Security Agency (NSA), Naval Warfare Development Center (NWDC), and the Naval Computer and Telecommunications Area Master Station Atlantic (NCTAMS LANT). One Trident Scholar project and three Bowman Scholar projects were completed. The Computer Science faculty continues to attract grant money and research opportunities from both government and commercial sources.

Sponsored Research

Practical Computing with Semi-Algebraic Sets via Cylindrical Algebraic Computation

Researcher: Assistant Professor Christopher W. Brown
Sponsor: National Science Foundation (NSF)

The purpose of this research was to develop algorithms and produce programs that are able to perform practical symbolic computations with semi-algebraic sets. The primary tool for this was Cylindrical Algebraic Decomposition (CAD), which provides a data-structure for explicitly representing semi-algebraic sets. CAD is a powerful and general tool, which has been implemented several times and already shown itself to be of more than just theoretical value. However, the consensus in the literature is that interesting application problems cannot be solved by current CAD programs within a reasonable amount of time and space. The three principal goals of the project were to extend the theory of CADs to deal efficiently with the types of semi-algebraic sets that arise in applications, to produce efficient algorithms and programs that compute with CADs, and to promote the use of CADs to solve problems in other disciplines.

Imitation Learning of Goal Sequences in Mobile Robots

Researcher: Assistant Professor Frederick L. Crabbe, IV
Sponsor: Office of Naval Research (ONR)

Most studies of imitation learning in robots or other artificial agents concentrate on enabling a robot to learn to repeat individual low-level actions made by a teaching agent. This project continued to expand imitation learning to enable a student robot to learn to identify and perform sequences of high-level sub-goals, each made up of multiple low-level actions. For example, a student agent would follow a teacher agent as the teacher performed a task in order to learn to perform that same task. When the teacher completed each sub-goal in the sequence, the student learned the purpose of each sub-goal as well as when to perform it in the sequence. Work focused on enabling a learning robot to segment the stream of motor commands performed by the teaching robot into conglomerate actions. The learning robot used Bayesian techniques to determine the relative probabilities of various motions in order to determine if one action has ended and another has begun.

High Energy Laser Weapons: Modeling and Simulation, Phase II, Modeling Development.

Researcher: Associate Professor Donald M. Needham
Sponsor: High-Energy Laser Joint Technology Office

Development of one or more end-to-end simulations of laser system performance and effectiveness is fundamental to the goals of the High Energy Laser Joint Technology Office's (JTO) modeling and simulation (M&S) program. One such simulation prospective follows the physics and engineering of a ship's energy starting with energy conversion from the ship's fuel through electrical power generation, electrical generation of laser light, beam transport, etc, and ending with target damage assessment. A fundamental step, proposed by this research, in the process of developing a domain-reusable, end-to-end high energy laser simulation, was to examine an existing model, and focus on the identification of a software system architecture designed to support the inclusion of modeling components needed for the various portions of an end-to-end simulation. The steps in this process included acquiring a suitable high energy laser model, and developing an architecture that isolated and minimized couplings between the software components that implemented the model. Analysis of the resulting architecture focused on increasing its potential for domain-specific reuse so that suitable models for the remaining portions of the end-to-end simulation could be smoothly integrated. Additionally, this work provided guidance to high energy laser modelers on developing software components that implement their models so as to ease integration of their models within an end-to-end simulation.

A Tactical Data Simulator for Network Centric Training Operations at the Naval Academy

Researcher: Assistant Professor David J. Stahl
Sponsor: Department of Defense (DoD) Office of Force Transformation

With initial development completed as a midshipman research project, the Yard Patrol (YP) Tactical Data Simulator (YP-TDS) is an inexpensive commercial-off-the-shelf hardware and software system for simulating sensors, platforms and weapons in real-time across a wide-area network using high frequency (HF) packet radio. The system integrates real sensors with simulated weapons, sensors and ships by means of a multi-terminal command-and-control tactical display having appearance and functionality similar to that of existing warship systems – but intended for use aboard non-commissioned, non-warship vessels in an educational environment. YP-TDS represents an initial effort at embodying the concept of Network Centric Warfare not just in theory, but in actual hands-on practice at the United States Naval Academy (USNA).

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A multiple-actor battle simulation framework has been implemented. Initial operational testing has been successfully completed. Additional software development and creation of pedagogical tools and materials are in progress. The system has been extended to support use in the classroom.

Independent Research

An Investigation into Compromise Actions in Behavior-Based Robotic Systems

Researcher: Assistant Professor Frederick L. Crabbe, IV

This project examined the nature of compromise actions in behavior-based systems. Using Value-Iteration to approximate solutions to the Bellman equation, it determined the comparative advantage to selecting compromise actions when pursuing two appetitive goals. It then used Information Gain to determine in what scenarios compromise behavior provided the greatest benefit.

Applying Soft Computing Techniques to Intrusion Detection

Researcher: Lieutenant Commander Lori L. DeLooze, USN

As more computers are integrated into the Internet, the threat of computer crimes increases and it becomes much more difficult and challenging to predict and prevent computer attacks and malicious intrusions. Soft computing techniques of artificial neural networks and evolutionary computing and fuzzy logic were applied to produce an effective Intrusion Detection System (IDS) to classify attacks by type and characterize the connection according to its behavior. An ensemble of Self-Organizing Maps (SOM) was created, one for each of the four major attack families: Denial of Service, Probe, Remote to Local, and User to Root. A genetic algorithm determined the best possible feature set for the input vectors of the SOMs. After labeling the attack neurons in the SOM, a fuzzy "buffer zone" was formed around them. The ensemble of SOMs detected attacks as well or better than any system in the original Knowledge and Data Discovery 1999 Competition.

The "buffer zone" that surrounds the attack nodes can be used for two purposes. First, the nodes in the neighborhood of the attack nodes characterize the associated connections as either "attack-like" normal connections or "normal-like" attack connections. Each connection will have a value from 0 to 1 for each SOM in the collection. This additional information is very valuable to an analyst when considering a wide range of responsive actions. Second, removing the "buffer zone" from the SOM can amplify the contrast between attacks and other connections. The weights from the nodes remaining after the "buffer zone" is removed can be used to create a reduced rule set that describes the classification of an attack of that type. It was found that the reduced rules can classify attacks as well as or better than the SOM from which they were derived, with a significantly lower false alarm rate.

Meaning for the Masses: Theory and Applications for Semantic Web and Semantic Email Systems

Researcher: Assistant Professor Luke K. McDowell

The Semantic Web envisions a portion of the World-Wide Web in which the underlying data is machine understandable and can, thus, be exploited for improved querying, aggregation, and interaction. To date, however, the growth of the Semantic Web has been stymied by the lack of incentive to create content, and the high cost of doing so. The goal of this project was to enable and motivate non-technical people to both utilize and contribute content for the Semantic Web. As the foundation for this work, three design principles were identified that are essential for producing a successful Semantic Web system - (1) Instant Gratification: provide an immediate, tangible benefit to users, (2) Gradual Adoption: offer clear utility even when the system has few users, and (3) Ease of Use: be simple enough for a non-technical person to use. I then designed mechanisms and theory that support these principles in the construction of two novel systems: Mangrove, a community Semantic Web system, and Semantic Email, a system for leveraging declarative content to automate email-mediated tasks. For the latter, I showed that computing the optimal message handling policy is intractable in general, but identified key restrictions that enable this problem to be solved in polynomial time. Both systems have been fully implemented and deployed in a real-world environment, allowing for reports on practical experience gained with actual users. Overall, this work produced two novel, usable systems, as well as insights and techniques that can direct future Semantic Web systems.

Automatically Producing Structured Content from Web Pages via Efficiently Indexing and Identifying Relevant Extraction Services

Researcher: Assistant Professor Luke K. McDowell

Most content on the Hyper Text Markup Language (HTML) web is designed for humans to view, rather than for machines to process. To enable greater information aggregation and automation, researchers have invested significant effort in constructing "wrappers" that can automatically, and fairly reliably, extract information from a specific class of web pages and convert it into a structured form that is more amenable to automated usage (*e.g.,* for Semantic Web applications). Unfortunately, it is very difficult to leverage this investment across the Web in general because no automated methods exist for identifying which wrappers could potentially produce useful content from a

given web page of interest. In this project, which has just begun, efforts will be made to (1) identify generic methods for invoking diverse wrappers and processing their results, (2) construct appropriate indices and algorithms for efficiently identifying wrappers of interest based upon document structure, document vocabulary, domain names, and file types, (3) implement a publicly available server to demonstrate the feasibility and usefulness of this approach, and (4) experiment with the scalability and performance of the server under varying conditions. This project also presents a number of interesting opportunities for exploring issues of cooperation, trust, and relevance among a community of wrapper generators and users.

The Andes Project

Researcher: Professor Kay G. Schulze

Classical physics is a prerequisite for virtually all university-level study of science and technology, yet is notoriously difficult for students to learn. The Andes project is an intelligent tutoring system that is intended to be used as a "homework helper" for students taking Physics. This year the project concentrated on expanding the number of problems in the system, particularly in areas traditionally covered in the second semester.

Object-Oriented Method for Interoperability

Researcher: Captain Paul E. Young, USN

This research integrated the previously developed semantic and syntactic correlator modules into the Object Oriented Method for Interoperability (OOMI) Integrated Development Environment (IDE) developed as part of the researcher's dissertation efforts. The objective of the research was to use the current correlator implementation as a baseline for evaluating potential replacement technologies for the correlator.

Trident Scholar Project

Prediction and Improvement of Safety for Software Systems

Researcher: Midshipman 1/C Sean A. Jones, USN
Adviser: Associate Professor Donald M. Needham
Sponsor: Office of Naval Research (ONR) and Bowman Scholar Program

The modern military depends heavily on complex systems in order to fight. As a result, the safety of software executed on computerized systems has become a paramount issue. The transformation of the military's analog combat systems to computer based systems has been plagued by software problems ranging from benign flight simulator issues to smart ships finding themselves dead in the water. The military's interest in increasing automation in order to reduce manpower requirements makes even trivial software safety issues a serious concern. The software engineering community is not well equipped to reduce the safety risks incurred through use of such systems, and it stands to benefit from metrics, analysis tools, and techniques that address software system safety from a design perspective.

The purpose of this project was to propose and develop tools that software engineers can use to address the issue of software safety. The research focused on safety prediction and improvement through the use of software fault trees coupled with "key nodes", a fault tree-based safety metric, and an algorithm for estimating the improvement costs necessary to achieve a targeted level of software safety. The safety prediction metric uses the "key node" property of fault trees. The improvement algorithm is based on the mathematical relationship of nodes in a fault tree. The algorithm yields an estimate of the man-hours necessary to improve a system to a targeted safety value based on cost functions supplied by a component's developer. These metrics and algorithms allow designers to measure and improve the safety of software systems early in the design process, thus allowing for a reduction in costs and an improvement in resource allocation.

Midshipman Research Course Projects

Object-Oriented Method for Interoperability

Researcher: Midshipman 1/C Candace M. Childers, USN
Adviser: Captain Paul E. Young, USN
Sponsor: Bowman Scholar Project

This research integrated the previously developed semantic and syntactic correlator modules into the Object Oriented Method for Interoperability (OOMI) Integrated Development Environment (IDE) developed as part of the adviser's dissertation efforts. The objective of the research was to use the current correlator implementation as a baseline for evaluating potential replacement technologies for the correlator. The midshipman has considered investigating one such potential replacement, the Semantic Web, in her thesis research during her upcoming studies at the Naval Postgraduate School. (This work was published as United States Naval Academy Computer Science Department Technical Report, USNA-CS-TR-2005-06, 2005.)

A Comparison of Metrics for Software Safety Prediction

Researcher: Midshipman 1/C Sean A. Jones, USN
Adviser: Associate Professor Donald M. Needham

This project provided a detailed look into how a complex software system is designed, and what metrics are available for predicting the safety of such systems. This work resulted in a control system embedded within United States Naval Academy's MidSTAR I satellite scheduled for launch aboard a National Aeronautics and Space Administration (NASA) mission in FY07. The project included the design, construction, and testing of a software control system for the MidSTAR I satellite with a focus on software reuse and reduction of maintenance costs. (This work was published as United States Naval Academy Computer Science Department Technical Report, USNA-CS-TR-2005-05, 2005.)

Low Level Segmentation for Imitation Learning Using the Expectation Maximization Algorithm

Researcher: Midshipman 1/C Andrew D. Warner, USN
Adviser: Assistant Professor Frederick L. Crabbe, IV
Sponsor: Bowman Scholar Program

Imagine a robot that is able to develop skills on its own, without being programmed directly. This robot would be invaluable in any business, factory, or laboratory. Unfortunately, this problem, known as inductive learning, is very difficult, and has several varieties. One such is imitation learning. The overall process of imitation learning begins with one robot observing another robot performing a task. The watcher then breaks down, or segments, the demonstrating robot's actions into basic actions called planning units. Next, the observing robot uses the planning units to create a plan that accomplishes the required task. The execution of a successful plan demonstrates that the robot has correctly implemented an inductive learning process. The scope of this research does not allow the problem of imitation learning to be discussed in its entirety; however, it does investigate an important subset of the larger problem. This project focused on the segmentation of the data, specifically how to break it up into the steps that provide the building blocks of the robots ultimate plan. (This work was published as United States Naval Academy Computer Science Department Technical Report, USNA-CS-TR-2005-04, 2005.)

Publications

Journal (Refereed) Manuscripts

McDOWELL, Luke K., Assistant Professor, (co-author), "Semantic Email: Theory and Applications," *Journal of Web Semantics*, 2(2): 153-183, 2004.

> This paper investigated how the vision of the Semantic Web can be carried over to the realm of email. We introduced a general notion of semantic email, in which an email message consists of an RDF query or update coupled with corresponding explanatory text. Semantic email opens the door to a wide range of automated, email-mediated applications with formally guaranteed properties. In particular, this paper introduced a broad class of semantic email processes. For example, consider the process of sending an email to a program committee (PC), asking who will attend the PC dinner, automatically collecting the responses, and tallying them up. We defined both logical and decision-theoretic models where an email process is modeled as a set of updates to a data set on which we specify goals via certain constraints or utilities. We then described a set of inference problems that arise while trying to satisfy these goals and analyze their computational tractability. In particular, we showed that for the logical model it is possible to automatically infer which email responses are acceptable with respect to a set of constraints in polynomial time, and for the decision-theoretic model it is possible to compute the optimal message-handling policy in polynomial time. We concluded by describing our publicly available implementation of semantic email.

Conference Proceedings

BROWN, Christopher W., Assistant Professor, (co-author), "Algorithmic Methods for Computing Threshold Conditions in Epidemic Modeling," *Proceedings of Computer Algebra in Scientific Computing (CASC 2004)*, 2004, pp. 51-60.

> The calculation of threshold conditions for models of infectious diseases is of central importance for developing vaccination policies. Frequently coupled systems of ordinary differential equations are used as models and the computation of threshold conditions can be reduced to the question of stability of the disease free equilibrium. We showed how the computations of threshold conditions for such models can be done fully algorithmically by using techniques of quantifier elimination for real closed fields and related simplification methods for quantifier-free formulas.

CRABBE, Frederick L., Assistant Professor, "Optimal and Non-Optimal Compromise Strategies in Action Selection," *Proceedings of the 8th International Conference on Simulation of Adaptive Behavior (SAB),* Los Angeles, CA, 2004, pp. 233-242.

> Devising a solution to the action selection problem rests on a definition of which actions are preferable over others. Among many properties suggested for action selection mechanisms, one prominent one is the ability to select compromise actions, i.e., actions that are not the best to satisfy any active goal in isolation, but rather compromise between the multiple goals. This research performed a mathematical and experimental analysis of compromise behavior in an attempt to determine exactly how much compromise behavior aids an animat. It concludes that optimal compromise behavior is a small improvement over non-compromise behavior, but commonly proposed easy to compute compromise mechanisms are worse than non-compromise behavior. It further analyzed the properties of situations when compromise behavior is distinctly better than non-compromise behavior.

Firkin, E. C., and McMAHON, M. M., Assistant Professor, "Architecture for a Truly Integrated Defense Network", *Proceedings of the 9th Command and Control Research and Technology Symposium (CCRTS) 2004*, Coronado, CA, June 2004, and in *Proceedings of Ninth International Command and Control Research and Technology Symposium (ICCRTS)*, 2004.

> Undoubtedly the National Capital Region (NCR) of the United States of America is the most important piece of real estate in the entire world. That being said it also has no current Integrated Defense System (IDS) where a team of decision makers can evaluate real-time information and make an informed decision as to what defensive action to undertake. There are several extremely lethal capabilities to include United States Army Air Defense Artilery (ADA), United States Air Force fighter aircraft and United States Customs helicopters protecting National Capital Region (NCR) and they are fed information from Federal Aviation Administration (FAA) and United States Army Sentinel radars but again that information is not interconnected into a real-time picture of the entire defense that can be directed and operated from an effective Command and Control node. Command authorities at the local, state, federal, and Department of Defense (DoD) level must have a responsive network providing interoperability. Our nation's capital decision makers need a "Warfare Centric Network" which allows them to integrate diverse capabilities into a system that allows them to speak and share information in a common language. Much as a United States Navy Carrier Battle Group shares common track numbers, sensor updates and intelligence information as if they were a single system, the NCR's complete defense needs to operate as a single identity.

Firkin, E. C., and McMAHON, M. M., Assistant Professor, "Coalition Transformation: An Evolution of People, Processes, and Technology to Enhance Interoperability", *Proceeding of the 9th International Command and Control Research and Technology Symposium (ICCRTS 2004)*, 2004.

> The tragic events of 9-11, terrorist hostage situations in Russia, Philippines, and recent cancellations of several international civilian air flights have brought the world closer in forming an alliance pitting industrialized nations against the less technically advanced but extremely dedicated international terrorists. The ability to operate as independent nations in this fight against loosely defined organizations requires a tightly netted collaboration of military and inter-governmental organizations working as a single entity while maintaining some level of national independence. Through the use of a demonstrated Network-Centric Warfare (NCW) solution, called Tactical Component Network (TCN), countries can exchange information among designated mission-centric groups with the data's owner determining the allowable distribution and its fidelity. Networks can use a local environment for small real-time operations or a global hub network integrating coalition partners in an integrated network of sensors and shared intelligence information. TCN allows individual nations stove-piped systems to share data, common pictures and intelligence information for any region of interest. The TCN architecture has successfully been demonstrated by the United States military in a variety of stressing applications and the same infrastructure can support multi-national applications to facilitate the detection and neutralization of terrorists.

Lawler, G. Lieutenant, USN, and YOUNG, Paul E., Captain, USN, "Approaching Interoperability from the Bottom Up: A Lattice Structure for the Object-Oriented Method for Interoperability (OOMI)", *15th Institute of Electrical and Electronics Engineering, Inc. (IEEE) International Workshop on Rapid Systems Prototyping Conference Proceedings*, 2004, pp. 135-142.

> Software prototyping often incorporates existing components and systems with newly developed code in order to rapidly achieve the goals of the prototyping effort. Unfortunately, heterogeneities among component systems often make system interoperability difficult, potentially reducing the benefit of such an approach. Achieving interoperability among heterogeneous system components is necessary in order to take advantage of the benefits that the use of existing elements brings to prototype development. The predominant approach to achieving interoperability among heterogeneous components involves the development of an intermediate representation. An example is Young's Object-Oriented Method for Interoperability (OOMI), which produces a bottom-up model for the resolution of heterogeneity among component systems. This paper describes how to manage the complexity of the bottom-up approach

through the use of self-similar components that support scalability, and a lattice structure that limits complexity.

McDOWELL, Luke K., Assistant Professor, (co-author), "The Specification of Agent Behavior by Ordinary People: A Case Study," *Proceedings of the 3rd International Semantic Web Conference*, 2004, pp. 182-197.

The development of intelligent agents is a key part of the Semantic Web vision, but how does an ordinary person tell an agent what to do? One approach to this problem is to use Resource Description Framework (RDF) templates that are authored once but then instantiated many times by ordinary users. This approach, however, raises a number of challenges. For instance, how can templates concisely represent a broad range of potential uses, yet ensure that each possible instantiation will function properly? And how does the agent explain its actions to the humans involved? This paper addressed these challenges in the context of a case study carried out on our fully-implemented system for semantic email processes. We described how high-level features of our template language enable the concise specification of flexible goals. In response to the first question, we showed that it is possible to verify, in polynomial time, that a given template will always produce a valid instantiation. Second, we showed how to automatically generate explanations for the agent's actions, and identified cases where explanations can be computed in polynomial time. These results both improved the usefulness of semantic email and suggested general issues and techniques that may be applicable in other semantic agent systems.

McMAHON, M. M., Assistant Professor, "A Hub-and-Spoke Network for Global Network-Centric Applications", *Proceedings of Parallel and Distributed Processing Techniques and Applications (PDPTA 2004)*, 2004, pp 97-102.

The hub-and-spoke architecture use in networks dates to the early telecommunications central switching office. The benefits of this architecture are only beginning to be explored in network-centric global applications. In a hub-and-spoke network, the hub can serve multiple roles: a translator between communication formats, a subscription manager, multi-level data access controller, and a data repository. The hub extends existing local network technology by allowing interaction between dissimilar and distant systems. Disaster relief and incident response are examples of operations that require dissimilar, previously uncoordinated agencies to collaborate under dynamic and rapidly changing circumstances. These types of operations can benefit from the support of network-centric applications. This article described a hub that performs global networking, the implementation efforts to date, and the plans for future work. Initial performance data when using a Low Earth Orbit (LEO) satellite system as a spoke is also presented.

McMAHON, M. M., Assistant Professor, "A Component-Based Application Development, Test, and Evaluation Environment for Network Applications", *Proceedings of Software Engineering Research and Practice (SERP2004)*, 2004, pp 760-765.

Large-scale construction typically depends on the use of prefabricated components. Software system developers can use the same approach to build applications by using existing, documented, and tested components. New applications can be developed by combining third-party components with existing components. Current literature does not suggest that there is focus on test and evaluation within the environment itself, which is especially evident when the application requires dynamic input for realistic testing. Component suite developers provide a set of extensible, reusable, dependable components. To facilitate an expandable base of third-party developers and customers, the need for a network-accessible development, test, and evaluation environment has evolved. This paper describes the design of a component-based application development and test environment that addresses the needs of both developers and their customers, using the Internet to connect the users to development, integration, and test resources. We present the design, the supporting constraints, and design decisions.

McMAHON, M. M., Assistant Professor and Firkin, E.C., "Performance of a Hub-Based Network-Centric Application over the Iridium Satellite Network", Lecture Notes in Computer Science, Springer-Verlag GmbH, Volume 3421 / 2005 Title: Networking – International Competition Network (ICN) 2005: *Proceedings of the 4th International Conference on Networking Part II*, 2005, p. 575.

The hub-and-spoke architecture of a star network dates to the telecommunications central switching office. However, its benefits are only beginning to be explored in network-centric global applications. The hub facilitates interaction between dissimilar and distant systems. It serves multiple roles: translator between communication formats; subscription manager; multi-level data access controller; and data repository. A network application has expectations of latency. Network-centric application developers need to understand the underlying performance of the spokes used to communicate with the hub. This understanding becomes more difficult when commercial spokes are used. This paper describes the requirements for a hub that performs global networking, the implementation efforts to date, and the plans for future work. It addresses the methods used to gain insight into the performance of spokes when they are implemented by commercial network services. Results are presented for an example spoke technology, the Iridium satellite network.

McMAHON, M. M., Assistant Professor, and Rathburn, R., "Measuring Latency in Iridium Satellite Constellation Data Services", *Proceedings of the 10th International Command and Control Research and Technology Symposium*, 2005, paper 233.

The use of Satellite Communications (SATCOM) has become essential to operations in both Afghanistan and Iraq. In particular, the Iridium satellite constellation has demonstrated its usefulness and flexibility. It has had significant impact on how operations are conducted.

Iridium provides users both voice and data services. There are two approaches to sending data over the Iridium network: a circuit-switched data service and message-switched data service. Use of the circuit-switched data service requires the overhead of a setup in the same manner as a voice call. There are two message-switched data services: Short Burst Data (SBD) and Short Message Service (SMS). Our testing involves the SBD message-switched data service, which is optimized for high capacity and efficiency when sending small amounts of data through the Iridium network.

While there are many users for these services, little information can be found about their actual performance in fielded systems. The best sources of information are specifications or modeling of the performance of these services. We perceived that understanding the underlying network performance was needed and established experiments to capture that performance. We present results from both circuit-switched data service and message-switched SBD data service. We also address insights into the use of these services.

NEEDHAM, Donald M. Associate Professor, and ECKSTRAND, Eric (Ensign, USN), "Analyzing a High Energy Laser Modeling and Simulation Framework," *Proceedings of the International Conference on Software Engineering Research and Practice (SERP 2004), Volume II*, 2004, pp. 580-586.

End-to-end high energy laser simulations model a laser's intensity starting with the originating power conversion through to final illumination on target. Such simulations benefit from a modularized architecture in which a component of a software simulation framework, such as a module that computes a laser's wavefront propagation, can be modified or replaced with minimal impact to the rest of the framework. In this work, a framework's underlying component model was integrated with an existing laser propagation model. The feasibility of incorporating legacy laser wavefront propagation modeling codes into a framework was examined.

NEEDHAM, Donald M. Associate Professor, "Interdisciplinary Teams for Embedded Software Systems," *Proceedings of the International Conference on Software Engineering Research and Practice (SERP 2004), Volume I*, 2004, pp. 17-20.

This paper presented the design and development activities of several projects undertaken by interdisciplinary teams of undergraduate students at the United States Naval Academy. Each team included students from a variety of academic backgrounds, including aerospace engineering, computer science, mechanical engineering, oceanography, and systems engineering. The teams developed, tested, and deployed embedded control systems for Autonomous Underwater Vehicles (AUVs), and Unmanned Aerial Vehicles (UAVs). This paper analyzed the impact of working with interdisciplinary teams of students, the effect of course sequencing on multi-term projects, and how knowledge of a variety of disciplines impacts the effectiveness of interdisciplinary teams.

STAHL, David J., Assistant Professor, NEEDHAM, Donald M., Associate Professor, and LENNERTON, Mark J., Major, USMC, "An Overview of Modeling and Simulation in the Computer Science Department at United States Naval Academy", *Proceedings of the Society for Computer Simulation (SCS)*, 2005, pp. 171-178.

The United States Naval Academy's Computer Science Department actively involves midshipmen in a variety of modeling and simulation efforts. This paper described current work in the areas of network-centric command-and-control, high energy laser end-to-end simulation, and virtual environments for military training.

VanLehn, K., Bhembe, D., Chi, M., Lynch, C., SCHULZE, K., Professor, SHELBY, R., Professor Emeritus (USNA Physics Department), Tayor, L., TREACY, D., Professor (USNA Physics Department), Weinstein, A., and WINTERSGILL, M. C., Professor (USNA Physics Department), "Implicit Versus Explicit Learning of Strategies in a Non-procedural Cognitive Skill," *Proceedings of the 7th Conference on Intelligent Tutoring Systems*, 2004, pp. 521-530.

University physics is typical of many cognitive skills in that there is no standard procedure for solving problems, and yet a few students still master the skill. This suggests that their learning of problem solving strategies is implicit, and that an effective tutoring system need not teach problem solving strategies as explicitly as model-tracing tutors do. In order to compare implicit vs. explicit learning of problem solving strategies, we developed two physics tutoring systems, Andes and Pyrenees. Pyrenees is a model-tracing tutor that teaches a problem solving strategy explicitly, whereas Andes uses a novel pedagogy, developed over many years of use in the field, which provides virtually no explicit strategic instruction. Preliminary results from an experiment comparing the two systems were reported.

Book Chapters

NEEDHAM, Donald N., Associate Professor, Caballero, R., Demurjian, S., Eickhoff, F., Mehta J., and Zhang, Y., "A Reuse Definition, Assessment, and Analysis Framework for User Markup Language (UML)," Advances in User Markup Language/Extensible Markup Language (UML/XML) Based Software Evolution, H. Yang (ed.) IRM Press, 2005, pp 281-302.

Software engineers seeking to improve design reusability stand to benefit from tools that precisely measure the potential and actual reuse of software artifacts to achieve domain-specific reuse for an organization's current and future products. This book chapter examined a formal framework for reusability assessment of development-time components and classes via metrics, refactoring guidelines, and algorithms. We considered the reuse definition, assessment, and analysis of a UML design, prior to the existence of code. We included dependency tracking in use case and class

diagrams in support of reusability analysis and refactoring for UML. We discussed the integration of these extensions into the UML tool Together Control Center to support reusability measurement from design to development.

Technical Reports

BROWN, Christopher W., Assistant Professor, "The McCallum Projection, Lifting, and Order-Invariance, United States Naval Academy Computer Science Department Technical Report, ISNA-CS-TR-2005-02, 2005.

The McCallum Projection for Cylindrical Algebraic Decomposition (CAD) produces a smaller projection factor set than previous projections; however it does not always produce a sign-invariant CAD for the set of input polynomials. Problems may arise when a (k+1)-level projection factor vanishes identically over a k-level cell. According to McCallum's paper, when this happens (and k+1 is not the highest level in the CAD) we do not know whether the projection is valid, i.e., whether or not a sign-invariant CAD for the set of input polynomials will be produced when lifting is performed in the usual way. When the k-level cell in question has dimension 0, McCallum suggests a modification of the lifting method that will ensure the validity of his projection, although to my knowledge this has never been implemented. In this paper we give easily computable criteria that often allow us to conclude that McCallum's projection is valid even though a projection factor vanishes identically over a cell. We also improve on McCallum's modified lifting method. We have incorporated the ideas contained in this paper into Quantifier Elimination by Cylindrical Algebraic Decomposition (QEPCAD), the most complete implementation of CAD. When McCallum's projection is invalid because of a projection factor not being order-invariant over a region on which it vanishes identically, at least a warning message ought to be issued. Currently, QEPCAD may print warning messages that are not needed, and may fail to print warning messages when they are needed. Our implementation in QEPCAD ensures that warning messages are printed when needed, and reduces the number of times warning messages are printed when not needed. Neither McCallum's modified lifting method nor our improvement of it have been implemented in QEPCAD - the design of the system would make implementing such a feature quite difficult.

CRABBE, Frederick L., Assistant Professor, "The United States Naval Academy Computer Science Department Technical Report Series Information and Guide," United States Naval Academy Computer Science Department Technical Report, ISNA-CS-TR-2005-01, 2005.

In January of 2005, the Computer Science Department at the United States Naval Academy launched its own technical report series. The management of submissions and queries is performed automatically with Python scripts. This document describes how the system works and how it should be used to submit technical reports and retrieve reports already submitted.

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We present a system that enables a robot to learn to plan through demonstration and imitation. An imitator acquires planning operators by observing a demonstrator, segmenting the demonstrator's actions into planning steps, and learning the preconditions and effects of the operators. When the imitator tries to execute its own plans, it learns to perform the operations through reinforcement learning and corrects errors in the previously learned operator effects.

Presentations at Professional Meetings and Conferences

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