Weapons and Systems Engineering Department

Professor Terrence E. Dwan
Chair

Research within the Weapons and Systems Engineering Department continues to provide the faculty with an opportunity to grow professionally and to keep abreast of rapidly advancing systems technology. In addition, every graduating Systems Engineering major participates in research, design, and development projects for the purpose of realizing practical applications of some of the theory which they have studied.

Every faculty member, both civilian and military, either participates in research in areas of interest to the U.S. Navy or supports midshipmen research programs in an advisory capacity. Faculty research areas currently include fuzzy modeling, magnetic bearings, metrology, robotics, ship power systems, and system identification.

This year there were four Trident Scholars in the Weapons and Systems Engineering Department. The scholars engaged in extensive research projects in lieu of several courses. Strong emphasis continues on the faculty-midshipman relationship during the individual research oriented capstone design course. These advisers not only provide support of a technical nature, but also emphasize planning, scheduling, and effective oral and written presentation. Typical examples of midshipmen research projects include development of autonomous carts and boats, automatic target detection, magnetic levitation, and vibration control.

Funding for research continues to be diverse. Sponsors this year included the Naval Academy Research Council (NARC), the Office of Naval Research (ONR), the Naval Research Laboratory (NRL), the Naval Surface Warfare Center (NSWC), and the National Institute of Standards and Technology (NIST).

Sponsored Research

Decentralized Guidance, Navigation, and Control for Platoons of Cooperating Unmanned Underwater Vehicles (UUVs)

Researchers: Assistant Professor Bradley E. Bishop and Assistant Professor Daniel J. Stilwell
Sponsor: Office of Naval Research (ONR)

This project focused on investigation into practical, efficient, and theoretically justified methods for navigation, guidance, and control of platoons/swarms of vehicles. It was conjectured that cooperating vehicles can achieve certain goals that are unattainable by any vehicle alone. The focus of the work was on the particular technical issues imposed by underwater operations, such as limited inter-vehicle communications bandwidth.

The first year of this effort focused on characterizing fundamental and theoretically justified notions of decentralized control for cooperation between vehicles. Computer simulations were developed and used to verify results. The second year is focused on implementing and further refining our results on a platoon of land-based autonomous robots. Throughout the project, Naval Academy midshipmen are involved in the research by implementing theoretical results on real autonomous vehicles. This is occurring in several classes, a seminar course, and numerous senior projects.

H-Infinity Control Theoretic Methods for Antennae

Researchers: Assistant Professor Richard T. O'Brien, Jr.
and Associate Professor Kiriakos Kiriakidis
Sponsor: Office of Naval Research (ONR)

This project investigated two important problems relevant to antennae applications. The filtering problem involves the estimation of received data from noisy measurements as in radar applications. The control problem involves the regulation of the flow of information to and from an antenna as in communication networks. The dynamics of antenna systems are complex and exact mathematical models are difficult or impossible to obtain from first principles. Most of the existing design methods require an accurate model of the system and are unable to accommodate problems of this type. In this project, these two problems were considered in a very general context and the antennae were modeled as uncertain, nonlinear, time-varying systems. Existence of solutions of both problems was addressed for an uncertain nonlinear or time-varying model. Design and synthesis procedures for the filtering and control problems are being developed for linear, time-varying systems with potential extensions to the general problem.

Extended H-Infinity Filtering to Determine Direction-of-Arrival

Researchers: Assistant Professor Richard T. O'Brien, Jr.
and Associate Professor Kiriakos Kiriakidis
Sponsor: Office of Naval Research (ONR)

The direction-of-arrival (DOA) estimation problem for multiple, superimposed sinusoidal signals received by a sensor array was considered. Assuming the number of sources is fixed, the received signal was modeled by a discrete-spatial linear system with a state-space realization parameterized by the DOA's. The estimation problem was formulated as a simultaneous state and parameter estimation in the presence of modeling error and additive noise. In this paper, a parameter estimation algorithm was developed using an extended H-infinity filter. Existing results on reduced-order H-infinity state estimation were used to develop a solution for the DOA estimation problem where the minimum tolerance can be computed from the state-space coefficient matrices. Previously, the DOA estimation problem was solved using a Kalman filter that processed a "snapshot", measurements from all sensors in the array at a given time instant, off-line. In the proposed solution, the DOA estimates are updated on-line as the measurement from each sensor is received.

Uncalibrated Vision-Guided Mobile Robotic Control

Researcher: Assistant Professor Jenelle A. Piepmeier
Sponsor: Naval Academy Research Council (NARC)
and Office of Naval Research (ONR)

Theoretical work focused on the development of control strategies for control of uncalibrated robotic systems using visual feedback from a moving camera. The methods investigated were uncalibrated and required no kinematic models or camera calibration. The work involved simulations of six degree-of-freedom manipulator robots. Results suggested that a Gauss-Newton method utilizing a partitioned Broyden's method for estimation provides the best steady-state tracking behavior. This is the first work to address the uncalibrated visual servoing problem with a moving vision system. Future work will focus on the application of this control scheme on experimental systems. The theory can be easily extended to control of a mobile robot with an on-board vision system, and future work will focus on implementing these control strategies.

LISA Test Platform Disturbance Reduction System (DRS) Simulation Study

Researchers: Associate Professor George E. Piper
and Associate Professor John M. Watkins
Sponsor: NASA/Goddard Space Flight Center

The Laser Interferometer Space Antenna (LISA) Test Package is being proposed to validate the technology required for the LISA mission. The current baseline for the LISA mission consists of three spacecraft flying in formation in a heliocentric orbit. Each spacecraft will contain two proof masses (PM). The LISA mission will observe gravitational waves by precisely monitoring the separation between proof masses of each spacecraft. Detection of gravitational waves requires the proof masses to be undisturbed in the measurement direction. LISA's baseline design calls for a disturbance reduction system on each spacecraft to isolate its proof masses from disturbances to a requisite level. The precision required for monitoring and control of the proof masses pushes the envelope of current technology.

One of the objectives of the proposed Lisa Test Package (LTP) mission will be to test the Disturbance Reduction System (DRS) concept. The LTP mission will consist of a single spacecraft with two proof masses. The two proof masses will be located collinearly along the measurement axis. There are several candidate orbits proposed for the mission including geosynchronous transfer (GTO) orbits, geosynchronous (GEO) orbits, and drift orbits.

The purpose of this study was to develop an analytical model and numerical simulation of the LTP Disturbance Reduction System. The resulting model and simulation is intended for the development and analysis of DRS control strategies. The simulation development consisted of a succession of four models starting with a 2 degrees-of-freedom (DOF) model and concluding with a 9 DOF model. This approach allowed us to investigate the progression of issues that arise with increasing degrees of freedom. The 2 DOF model consisted of single axis motion of two bodies, the spacecraft and a proof mass. It was the simplest model that could used to address the disturbance reduction problem. The 3 DOF model consisted of single axis motion of three bodies, the spacecraft and two proof masses. This model introduced multiple bodies into the disturbance reduction problem. The 6 DOF model consisted of planar motion (X, Y, θ) of two bodies, the spacecraft and a proof mass. It was the simplest model that addressed cross-axis coupling issues. Finally, the 9 DOF model consisted of planar motion (X, Y, θ) of three bodies, the spacecraft and two proof masses. This model addressed cross-axis coupling of multiple bodies in the disturbance reduction problem.

Graphical Programming System for Embedded Microprocessors

Researcher: Associate Professor Carl E. Wick
Sponsor: National Institute of Standards and Technology (NIST)

Embedded microprocessors are often programmed in assembly language in order to best match complex control algorithms with limited processor speed and storage space. Higher-level languages like "C" have appeal for programming because they are somewhat more "natural" and "conversational" than assembly language, but these facilities are provided at the expense of speed and program size. This project aims toward a different direction in programming; one that is more graphically oriented, which can take advantages of both approaches - ease of programming while still keeping the flexibility and efficiency of assembly language for small embedded microprocessors.

Office of Naval Research (ONR) Afloat Lab

Researcher: Assistant Professor Edwin L. Zivi
Sponsor: Office of Naval Research (ONR)

The Afloat Lab is a test platform for new technologies intended for shipboard use. Formerly classified as a Yard Patrol craft and used to train midshipmen, the Afloat Lab has the same machinery, electronics, and navigation systems as the Navy's large fleet ships which makes it an ideal test platform.

The Afloat Lab provides a realistic shipboard environment for an innovative self-healing communications network that can route message traffic around breaks and allows critical shipboard systems to keep functioning. The fault tolerant communication network was developed and demonstrated by a Navy / contractor team including:

1. Assistant Professor Edwin L. Zivi

   U.S. Naval Academy Weapons and Systems Engineering Department
2. Adept Systems, network fragment healing for ANSI-709.1 LonTalk Networks
3. Anteon Inc., system integrator
4. Naval Surface Warfare Center, Carderock Division
5. United States Naval Academy and Small Craft Repair Facility

Following successful underway network fragment healing demonstrations (to the Chief of Naval Research, RADM Jay M. Cohen), YP-679 has acquired a broader role as an ONR technology demonstration craft. For more information, see the ONR Afloat Lab web page http://www.onr.navy.mil/events/afloat/default.asp

Naval Combat Survivability

Researcher: Assistant Professor Edwin L. Zivi
Sponsor: Naval Surface Warfare Center (NSWC)

As a result of mandated crew size reductions, control of integrated power generation, distribution, propulsion, and weapons systems must be highly automated. These systems must continuously support the tactical mission with minimal human intervention. The Naval Combat Survivability requirements are a direct result of the transfer of casualty response duties from manpower intensive engineering and damage control teams to automation. To replace human senses and muscle, an automated power system must provide continuous power and situational awareness.

Under combat conditions, battle damage is a reality. The tempo and lethality of modern warfare requires a robust warship that "fights through" battle damage. An Integrated Power System must function continuously despite major disruptions in both the power system and the associated automation. This disruption is not a discrete event; rather it evolves and expands with time. Throughout the damage progression, the automation must effectively sequence an effective casualty recovery. The close spatial and temporal clustering of combat casualty events and concurrent damage to both the power system and the automation, severely challenge conventional fault masking and fault recovery procedures.

The Naval Surface Warfare Center is funding collaborative research through the Energy Systems Analysis Consortium (ESAC), comprised of Purdue University, the University of Missouri-Rolla, the University of Wisconsin-Milwaukee, the U.S. Naval Academy, the Naval Postgraduate School, and the University of Urbana-Champaign. Reduced scale AC and DC testbed systems have been installed at Purdue University and University of Missouri-Rolla. This research focuses on experimentally validated non-linear stabilizing control algorithms.

Electric Power Network Efficiency and Security (EPNES)

Researcher: Assistant Professor Edwin L. Zivi
Sponsor: Office of Naval Research (ONR)

Control system requirements for highly automated and survivable future electric warships have been articulated to stimulate and unify interdisciplinary research conducted under the joint National Science Foundation / Office of Naval Research (NSF/ONR) Electric Power Networks Efficiency and Security (EPNES) initiative. This ONR challenge problem focuses on continuity of control for interdependent shipboard engineering and damage control systems under hostile conditions. The mission statement for these Hull, Mechanical, Electrical & Damage Control (HME&DC) systems may be summarized as: Provide continuous mobility, power, and thermal management for shipboard combat systems despite major disruptions involving cascading failures. This challenge problem is prototypical of analogous complex, interdependent systems including the national power grid, military and civilian infrastructure, and transport systems. These nonlinear, distributed, heterogeneous, variable structure systems contain dynamically interdependent subsystems. Mission/life critical system integrity and fault tolerance requirements demand dependable continuity of service. Innovative, dependable, and affordable control system architectures, strategies, algorithms, methods and tools are sought. After a brief problem statement and discussion of shipboard control systems, the ONR control challenge problem and reference system are presented.

Independent Research

Distributed Heterogeneous Simulation

Researcher: Assistant Professor Edwin L. Zivi

Complex, interactive systems such as the Navy's Integrated Power System require a suite of modular, simulation and control system design tools. Shipboard finite inertia power systems are complex with 100 to 1000 states, numerically stiff with eigenvalues ranging from -0.1 to $-1x10^6$, nonlinear, and variable structure. These simulations require modular, numerically efficient, simulation and control system design tools. Power quality, signature, and electro-magnetic interference studies require detailed, waveform level analysis. Meanwhile, system transient and stability studies require reduced order models, which retain the essential nonlinear and variable structure, attributes of detailed, waveform level models. Moreover, control system design algorithms require simplified, continuous models that are typically linearized. U. S. Navy Integrated Power System experience indicates that numerical performance, model modularity, and the availability of realistic models continue to constrain the development of complex, interactive system simulations.

In collaboration with P.C. Krause and Associates, a heterogeneous, distributed simulation research facility has been installed at the U.S. Naval Academy. This simulation facility is composed of five, high performance multiprocessor workstations connected by an ANSI/IEEE 1596-1992 Scalable Coherent Interface. This facility is being used to investigate stabilizing control for nonlinear, variable structure, integrated power systems, subjected to large scale, combat induced disturbances.

Research Course Projects

Robotic Rescue: Investigation into Components of an Urban Search and Rescue Robot

Researcher: Midshipman 2/C Bryan M. Hudock, USN
Adviser: Assistant Professor Bradley E. Bishop

The difficulties in recovering the survivors of a collapsed structure are numerous, as was seen in the September 11th disaster. A robot is the best answer to the problem of quickly locating people trapped inside such a treacherous environment. Two main problems were addressed for this application. The primary goal was developing the morphology of a robot to allow consistent movement in such an unstable, irregular, and confined environment. The secondary goal was to investigate techniques by which the robot could be controlled through the application of evolutionary methods. Some of the topics addressed include genetic algorithms, morphological equivalents found in nature, and current research in evolved robotic behavior.

Bang-Bang Control of a Double Integrator System

Researcher: Midshipman1/C Michael G. Vasek, USN
Adviser: Assistant Professor Richard T. O'Brien, Jr.

The double integrator system has been of interest for many years and was used extensively to illustrate minimum-time and minimum-fuel controllers. The double integrator system is one of the most fundamental systems within control theory and has many applications such as spacecraft rotation, low-friction applications and systems undergoing translation and rotation. While many controllers exist for the double integrator system, most require measurements of position and velocity. Furthermore, the position-only controllers do not provide acceptable performance or robustness. In this paper, a bang-bang control algorithm was developed for a double integrator system using position feedback.

Trident Scholar Projects

Steering Control Compensation of Accelerating Vehicle Motion

Researcher: Midshipman 1/C Steven R. Burns, USN
Advisers: Assistant Professor Richard T. O'Brien, Jr.
and Assistant Professor Jenelle A. Piepmeier
Sponsor: Office of Naval Research (ONR)

A dangerous and common situation during highway automotive use is the emergency turning/braking (ETB) maneuver. An ETB maneuver is defined by full application of the brakes combined with a significant steering input from the driver. To date, there has been no known development of a dedicated driver assistance controller for this common situation. The proposed ETB controller assists the driver in maintaining control over the vehicle during the ETB maneuver.

The ETB controller and similar vehicle subsystem development is limited as a result of the high material cost and space intensiveness of full-size vehicle testing. Normally, physical testing of automotive components is cost and space prohibitive at small research facilities. The use of scale-model vehicle testing in automotive engineering is a recent innovation and, therefore, the development of a scale-model platform is a significant contribution to this field.

The scale-model platform components include a treadmill, scale-model vehicle assembled from kit, vision system, desktop computer, and sensor suite. The treadmill and scale-model vehicle simulate the road and vehicle, respectively, while the camera system provides position and orientation data to the vehicle controllers. Utilizing sensor data, the computer maintains the vehicle's position on the treadmill in a closed-loop system, while the treadmill speed controller functions in a parallel open loop.

A mathematical model of a vehicle has been developed and a scale-model vehicle platform constructed. The ETB controller prototype has been designed using Linear Quadratic optimal control methods and simulated. The effects of various vehicle parameters have been studied using the computer simulation.

The system concept tested in this project will assist the driver in controlling the vehicle during the ETB maneuver, decreasing the likelihood of accident and increasing driver control over the vehicle, by controlling the aspects of the ETB maneuver that are beyond the driver's control, and normally go uncontrolled.

Stability Analysis of a Nonlinear System Stabilizing Controller for an Integrated Power System

Researcher: Midshipman 1/C Daniel F. Chiafair, USN
Adviser: Assistant Professor Edwin L. Zivi
Sponsor: Office of Naval Research (ONR)

Future electric warships will contain one integrated electrical power infrastructure for propulsion, ship's service, and weapons systems. This integrated power system (IPS) must provide continuous power to mission and life critical systems, including during major combat battle damage disruptions. Today's warships are constructed with segregated mechanical propulsion and electric power systems. The existing ship service electrical system is not very robust: because the system is very tightly coupled, a single casualty can disrupt the entire system causing a total loss of electrical power. Even though the mechanical propulsion system may be in perfect working condition, it cannot provide any electrical power to the ship. An integrated power system will be deployed on future naval combatants to resolve this problem. The key advantage of an electronically controlled, integrated power system is the ability to actively control the flow of power throughout distribution systems. The system requires sophisticated control algorithms and automation infrastructure to maintain power and, if necessary, re-route power to critical systems. The ultimate goal of integrating active, survivable control algorithms into an integrated, solid-state power distribution system will be to maintain power continuity during major, combat induced casualties.

This research investigated a novel nonlinear systems stabilizing control strategy and associated stability assessment tools recently proposed by Sudhoff. Using a MATLAB-based DC stability toolbox, nonlinear stability augmentation of a prototype DC Zonal Electrical Distribution System (DC-ZEDS) was investigated with respect to changes in system parameters and system structure. The results indicate that significant improvements in system stability can be achieved using innovative control strategies and algorithms.

Underwater Gliders: Measurement Methods and Analysis

Researcher: Midshipman 1/C Benjamin A. Drew, USN
Adviser: Associate Professor Carl E. Wick
Sponsor: Office of Naval Research (ONR)

This research investigated some variable parameters of miniature underwater gliders. Underwater gliders are devices that are propelled by gravity force or by force provided by displacement of water. These natural forces are converted to forward motion by the interaction of wings and body on the water medium. The researcher has studied different configurations of wings and body in several constructed miniature prototype gliders. Studies were conducted in both water and in air (wind tunnel testing). Data from these tests are presented, and an analysis and comparison of vehicles was made. Finally, a design for a recirculation tank is presented; the device acts like a wind tunnel in water. This experimental apparatus was constructed in an effort to reconcile differences seen between gliding experiments and wind tunnel experiments using the constructed gliders.

Active Control of Fan Noise in Ducts Using Magnetic Bearings

Researcher: Midshipman 1/C Jonathan P. Nelson, USN
Advisers: Associate Professor John M. Watkins
and Associate Professor George E. Piper
Sponsor: Office of Naval Research (ONR)

The objective of this project was to investigate global noise attenuation of narrow band fan noise in an air duct through the use of magnetic bearings. An axial flow fan creates tonal noise related to its rotational rate. Additional noise exists due to harmonics of this frequency as well as turbulent airflow. In addition to conventional brush bearings to support the fan shaft radially, this project used an active magnetic thrust bearing to control axial movement. The thrust bearing primarily functioned as an active sound control actuator.

Active sound control is the method of achieving destructive interference of sound waves by outputting a secondary wave of equal amplitude and frequency, 180 degrees out of phase with the primary wave. An error microphone was positioned in the duct to provide feedback to a Digital Signal Processor (DSP), which contained the active sound control program, while a performance microphone tested for global sound control at various points along the duct. Instead of using a secondary speaker, this project used the fan itself to collocate the primary and secondary sound sources. Therefore, global sound control throughout the duct was theoretically possible. This project demonstrated this global control of noise experimentally.

Midshipman Design Projects

Grease Lightening

Researchers: Midshipmen 1/C Jonathan V. Ahlstrom, Leslie D. Boegel
and Michael G. Vasek, USN
Adviser: Commander David T. Bailey, USN

Crew Laser Timer

Researchers: Midshipmen 1/C Joshua A. Alms and William C. Jones, USN
Adviser: Lieutenant Paul J. Frontera, USN

Turtle Tracker
Researchers: Midshipmen 1/C Jason Anderson and Amanda M. James, USN
Adviser: Commander Bradley D. Taylor, USNR

Golf Ball Retreiver
Researchers: Midshipmen 1/C Brigitte M. Aungier and John M. Coates, USN
Adviser: Lieutenant Commander Nicholas F. Budd, USN

Scrolling Message Board
Researchers: Midshipmen 1/C Brett B. Bayer, Jodie D. Gadwa, Scott A. Halverson, John J. Houston and Michael S. Mieres, USN
Adviser: Commander Juan A. Navarrete, USN

Autonomous Underwater Vehicle
Researchers: Midshipmen 1/C Lori J. Bentzel, Christian Diaz, David B. Myers, Robert P. Nelson, Michael A. Schaal and Douglas W. Szwarc, USN
Adviser: Lieutenant Commander Fredric D. Forney, USN

Rebreather
Researchers: Midshipmen 1/C Robert R. Bocek and Justin K. Peters, USN
Adviser: Lieutenant Ann C. Chamberlain, USN

Blimp
Researchers: Midshipmen 1/C Jeb Bolen and Kurtis W. Johnson, USN
Adviser: Major Darin J. McCloy, USMC

Cooperative Autonomous Robots
Researchers: Midshipmen 1/C Erik A. Boyce, Jeremy J. Braud and David B. Thomas, USN
Adviser: Lieutenant Commander Michael J. Clayton, USN

RC Power Glove
Researchers: Midshipmen 1/C Joshua H. Bringhurst and Michael C. Smith, USN
Adviser: Major Randy P. Broussard, USAF

Systems Ball
Researchers: Midshipmen 1/C Fred P. Burke and Barcley W. Stamey, USN
Adviser: Lieutenant Pierre Hilaire, USN

Automated Jar Opener
Researchers: Midshipmen 1/C Scott C. Carr, Joseph J. Lauman and Brian J. Schall, USN
Adviser: Lieutenant Commander Fredric D. Forney, USN

Systems Ball
Researchers: Midshipmen 1/C Steven Carter, Matthew M. Mariano and Steve C. Reis, USN
Adviser: Lieutenant Robert C. Bandy, USN

Autonomous Plane
Researchers: Midshipmen 1/C Andrew J. Chauvin, Jonathan W. Gandy and Brandon D. Smith, USN
Adviser: Lieutenant Michael J. Supko, USN

Donkey Kong Autonomous Robots
Researchers: Midshipmen 1/C Jason L. Chen and Corey S. Doney, USN
Adviser: Lieutenant Commander Craig M. Payne, USN

Automatic String Tuner
Researcher: Midshipman 1/C Michael J. Cregge, USN
Adviser: Commander David T. Bailey, USN

My Dog Is Old and Lazy
Researchers: Midshipmen 1/C Justin P. Davis and Matthew M. Pianetta, USN
Adviser: Commander Jay A. Gutzler, USNR

Snake Robot
Researcher: Midshipman 1/C Jeffrey G. Dean, USN
Adviser: Major Todd W. Ferry, USMC

Automated Lawnmower
Researchers: Midshipmen 1/C Timothy K. Fischer, Derrick S. Hunt and William R. White, USN
Adviser: LCDR Charles B. Lynch, USN

Automated Windshield Wiper
Researchers: Midshipmen 1/C Daniel E. Fournier, Adam Q. Hocutt and Michael A. Liguori, USN
Adviser: Major Randy P. Broussard, USAF

Automated Bartender
Researchers: Midshipmen 1/C Kevin R. Friel and Chad H. Harvey, USN
Adviser: Captain Gary D. Noble, USNR

Autonomous Snake
Researchers: Midshipmen 1/C Thomas C. Genest and Trey D. Oats, USN
Adviser: Captain Gary D. Noble, USNR

Driving Assistant
Researchers: Midshipmen 1/C Ahmad M. Ghaffar and Ian J. Kirschke, USN
Adviser: Major Darin J. McCloy, USMC

Auto Caddy
Researchers: Midshipmen 1/C Stuart C. Grazier and Jonathan E. Page, USN
Adviser: Commander Allison Webster-Giddings, USN

Accoustically-Controlled Vessel
Researcher: Midshipman 1/C William M Guheen, USN
Adviser: Lieutenant Ann C. Chamberlain, USN

Aquatic Display
Researchers: Midshipmen 1/C Kenneth A. Haik, Matthew G. Horton, Erin C. Kellogg and Zachary B. Mitchell, USN
Adviser: Commander David T. Bailey, USN

Cooperative Robots
Researchers: Midshipmen 1/C Jason A. Hickle, Courtney L. Holland, Timothy W. Johnson and James C. Southerton, USN
Adviser: Lieutenant Commander Charles B. Lynch, USN

Roberto Intelligente
Researchers: Midshipmen 1/C Rugaba M. Kanani, Eric J. Olsson and Antonio Valle, USN
Adviser: Lieutenant Michael J. Supko, USN

Systems Ball
Researchers: Midshipmen 1/C Matthew F. Kavanagh and Joshua P. Zelfer, USN
Adviser: Major Randy P. Broussard, USAF

USNA Battle Bot
Researcher: Midshipman 1/C Andrew S. Lathrop, USN
Adviser: Major Darin J. McCloy, USMC

Cheese-Bot
Researchers: Midshipmen 1/C Ryan R. Long and Wesley N. Slagle, USN
Adviser: Commander Jay A. Gutzler, USNR

Robo-Waiter
Researchers: Midshipmen 1/C Samuel K. Nakamine, Brandon Otto and Jacob J. Tomlin, USN
Adviser: Lieutenant Robert C. Bandy, USN

Mobile Robotics
Researchers: Midshipmen 1/C Christopher W. Newport and Stephen M. Troy, USN
Adviser: Major Todd W. Ferry, USMC

Urban Search and Rescue
Researchers: Midshipmen 1/C Sean L. Ponder and Bryan P. Reed, USN
Adviser: Lieutenant Commander Craig M. Payne, USN

Automated YP
Researcher: Midshipman 1/C Gary C. Ross, USN
Adviser: Commander Bradley D. Taylor, USNR

Autonomous Foosball Table
Researcher: Midshipman 1/C Matthew V. Speicher, USN
Adviser: Commander Juan A. Navarrete, USN

3rd and Long
Researchers: Midshipmen 1/C Marlon D. Terrell and Alan L. Thompson, USN
Adviser: Commander Allison D. Webster-Giddings, USN

Publications

Conference Proceedings

AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor, Waltrip, Bryan C., and Koffman, Andrew D., "The Design and Self-Calibration of Inductive Voltage Dividers for an Automated Impedance Scaling Bridge," *Proceedings of the Instrumentation and Measurement Technology Conference* (*IMTC)*, Anchorage, AK, May 2002, pp. 1191-1195.

At the National Institute of Standards and Technology (NIST) over the past several years, there has been an effort to improve the impedance measurement services of 2-terminal (2T), 3-terminal (3T) and 4-terminal pair (4TP) standard capacitors, resistors, and inductors, with respect to accuracy, range of impedance, and range of frequency. The effort has involved building new measurement systems to scale the primary realizations of the Farad, Ohm and Henry using classical bridge techniques and, more recently, digital sampling and processing techniques, where appropriate.

The primary realization of the Farad at NIST is based on the calculable capacitor, a cross-capacitor whose capacitance (approximately 0.5 pF) can be found from a single length measurement, as described in the published literature. The frequency dependent characteristics of 4TP resistance standards are based on calculable 100 W and 1000 W resistors. At frequencies of 1000, 1592 and 15920 Hz, highly accurate manual bridges are then used to scale these values of capacitance and resistance to levels appropriate to support present capacitance and resistance measurement services. While these bridges are highly accurate and relatively wideband, they allow only for the comparison of like impedances, *i.e.*, capacitors may only be compared to other capacitors. The primary realization of the Henry at NIST is through a Maxwell-Wien bridge, and, more recently, a digital impedance comparison bridge, which relate known values of resistance and capacitance to inductance.

An automated, high-accuracy impedance scaling bridge to compare 2T, 3T and 4TP standard capacitors, resistors, and inductors over the 20 Hz to 1 MHz frequency range is presently under development. This impedance scaling bridge is being developed to improve present impedance measurement services, as well as to extend these services to support recent improvements in the accuracy and stability of commercially available capacitance meters, LCR meters and impedance standards. An initial design of the bridge has been constructed and tested with promising results. A detailed discussion of the bridge is given in the published literature. The bridge was designed according to proven coaxial bridge techniques, but includes additional circuitry and measurement methods that allow for the comparison of unlike impedances, *i.e.*, a capacitor can be directly compared to a resistor. A preliminary error analysis of the bridge components indicates that the major source of error is due to the ratio and phase error of the reference inductive voltage dividers (IVDs).

This paper discussed the development of improved IVDs for this bridge and the development of a system to self-calibrate the IVDs.

AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor, Waltrip, Bryan C., and Koffman, Andrew D., "A Capacitance Measurement System Using an IVD Bridge," *Proceedings of the National Conference of Standard Laboratories (NCSL)*, Washington DC, July 2001. (CD-ROM)

A new system to characterize the magnitude and phase characteristics of 1 pF to 1 uF capacitance standards over the 50 Hz to 100 kHz frequency range is described. The system has been developed to provide measurement support for LCR meters and general impedance measurement services. It consists of an inductive voltage divider (IVD) bridge capable of accurately comparing two capacitance standards and a set of 1 pF to 1 nF capacitance standards with known magnitude and phase characteristics. Details of the measurement system will be given, along with preliminary measurement results and major sources of error.

AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor, Waltrip, Bryan D., Koffman, Andrew C., and PIPER, George, E., Associate Professor, "A Lecture on Accurate Inductive Voltage Dividers", *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Montreal, Canada, June 2002. (CD-ROM)

An attempt was made to demonstrate the art of making a very accurate inductive voltage divider. The challenge was to present the material to undergraduate students. First, the electromagnetic induction was introduced and magnetic field and its flux was presented so that the fundamental principle on which transformers work is explained. The next step was the ideal transformer definition. A real transformer was presented in such a way that each performance point of the idea transformer was matched with practical realization. Techniques used to achieve the performance closest to the idea case were explained in much detail. The state-of-the-art methods of two-stage transformer and reducing load of inter-winding capacitances were introduced.

BISHOP, Bradley E., Assistant Professor and STILWELL, Daniel J., Assistant Professor, "On the Application of Redundant Manipulator Techniques to the Control of Platoons of Autonomous Vehicles," *Proceedings of the 2001 Institute for Electrical and Electronic Engineering (IEEE) Conference on Control Applications*, September 2001, pp. 823–828.

In this paper, we discuss the parallelism between redundant manipulator control and the control of platoon-level functions for systems of autonomous vehicles. We cast the platoon formation problem in an analogous manner to traditional redundancy resolution, and discuss techniques for control of the platoon. We develop a novel technique for the controlling the null space of the platoon Jacobian matrix such that certain tasks projected onto the null space can be achieved with locally maximal system resources, and demonstrate techniques for task synthesis under the redundant manipulator framework. We present simulation results for platoons of four vehicles, demonstrating the fundamental characteristics of the proposed scheme and providing one possible task set.

BROUSSARD, Randy P., Major, (USAF) and Assistant Professor, *"Wavelet Preprocessing for High Range Resolution Radar Classification,"* Institute for Electrical and Electronic Engineering *(*IEEE) Transactions on Aerospace and Electronic Systems, October 2001, Vol. 37, No. 4, pp. 1321-1332.

A wavelet denoising scheme to aid an automatic target recognition (ATR) system in recognizing aircraft from high range resolution radar (HRR) signatures was developed. A template matching classification technique is used with templates formed from synthetically generated signatures. The goal of the classification system is to achieve classification accuracy equivalent to that obtained with measured HRR signatures. Results suggest that a large portion of HRR signature content is none discriminatory. The wavelet denoising process removes the nondiscriminatory information, thereby leading to remarkable increases in classification accuracy. Results are shown for HRR signatures from six aircraft.

BURNS, Steven R., Midshipman 1/C, (USN), O'BRIEN, Richard T., Jr., Assistant Professor, and PIEPMEIER, Jenelle A., Assistant Professor, "Steering Controller Design Using Scale-Model Vehicles," *Institute for Electrical and Electronic Engineering* (*IEEE) Southeastern Symposium on System Theory*, Huntsville, AL, March 2002. (CD-ROM)

A scale-model, experimental apparatus is developed to design and evaluate steering controller designs. The controller is designed using Linear Quadratic optimal control methods on a standard four-state vehicle model. The apparatus simulates the human driver using a scale-model vehicle, a treadmill, and a vision system.

DWAN, Terrence E., Professor, PIPER, George E., Associate Professor, WICK, Carl E., Associate Professor, and BISHOP, Bradley E., Assistant Professor, "Systems Ball – A Creative Capstone Design Experience," *Proceedings of Frontiers in Education Conference 2001 Annual Conference*, Reno, NV, October 2001, ISBN 0-7803-6671-9, pp. F3G-1 – F3G-4.

This paper describes the experiences of a design competition that has been successfully used in a senior-level capstone design course. The capstone design course is an integral component of the Systems Engineering

Curriculum at the U.S. Naval Academy. In this course, students must define a project in which they will research, design, build, and test a prototype. To provide a catalyst for this design process, the Systems Engineering Department has sponsored a popular design competition called the Systems Ball. Students choosing the Systems Ball as their design project, team together to build vehicles that partake in a combative version of basketball. For the past 10 years the Systems Engineering faculty have found the Systems Ball to be an effective and fun way to guide multiple student teams through the design process while stimulating their creativity.

KIRIAKIDIS, Kiriakos, Associate Professor, "Optimal Nonlinear Filters based on the Takagi-Sugeno Fuzzy Model," *Proceedings of the Institute for Electrical and Electronic Engineering (IEEE) International Conference on Fuzzy Systems*, Honolulu, HI, May 2002. (CD-ROM)

This article treats the estimation of the output of interest for a class of nonlinear plants that admit the Takagi-Sugeno (TS) fuzzy model. Based on such model, we propose the synthesis of a filter whose estimation error is less than a prescribed fraction of the disturbance, by measure of the Euclidean norm. We also address the optimization of the filter's performance.

KIRIAKIDIS, Kiriakos, Associate Professor and Gordon, Diana, "Supervision of Multiple-Robot Systems," *Proceedings of the American Control Conference*, Arlington, VA, June 2001, pp. 2117-2118.

Teams of miniature robots (land-based, airborne, or submerged) constitute a new breed of robotic systems where the issue of controlled behavior arises naturally. At the highest level, the dynamics of such systems are event-driven. Herein, we consider multiple-robot systems whose robot units go offline upon the occurrence of certain events. To supervise such event-varying structure, we propose an adaptive supervisory control method.

KIRIAKIDIS, Kiriakos, Associate Professor and BISHOP, Bradley E., Assistant Professor, "On the Analysis of Uncertain Hybrid Systems with Estimated-State Feedback," *Proceedings of the 2001 American Control Conference*, June 2001, pp. 212–216.

In this paper, we present an analysis technique for hybrid linear systems using observers for state feedback control. We present a stability proof for such systems under sector bounded dynamic uncertainties, and discuss the implications of observer feedback for hybrid systems.

O'BRIEN, Richard T., Jr., Assistant Professor and WATKINS, John M., Associate Professor, "A Streamlined Approach for Teaching Root Locus Compensator Design," *Proceedings of the Conference on Decision and Control*, Orlando, FL, December 2001, pp. 3224-3229.

In this paper, classical root locus compensator design methods are streamlined with the objective of simplifying the computational procedures. The proposed methods place less emphasis on compensator synthesis and allow for more emphasis on compensator selection. The design procedures for four standard compensators are developed from a design procedure for the PD compensator. A numerical example is included.

PIEPMEIER, Jenelle A., Assistant Professor, Gumpert, B., and Lipkin, H. "Uncalibrated Eye-in-Hand Visual Servoing," *Institute for Electrical and Electronic Engineering (IEEE) International Conference on Robotics and Automation*, Washington, D.C., May 2002, pp. 568-573.

This paper presents uncalibrated control schemes for vision-guided robotic tracking of a moving target using a moving camera. These control methods are applied to an uncalibrated robotic system with eye-in-hand visual feedback. Without a priori knowledge of the robot's kinematic model or camera calibration, the system is able to track a moving object and maintain the desired features. These control schemes estimate the system Jacobian as

well as changes in target features due to target motion. Four novel strategies are simulated, and a variety of parameters is investigated with respect to performance.

PIEPMEIER, Jenelle A., Assistant Professor, and Morgan, Peter A., "Uncalibrated Vision-Based Mobile Robot Control," *American Society of Civil Engineers (ASCE) Space and Robotics 2002 Conference*, Albuquerque, NM, March 2002, pp. 388-395.

This article presents experimental results for vision-based mobile robot control using a fixed camera. A commercially available vision system is used to identify the robot position and a moving goal position. With little a priori knowledge, the control method estimates the system model on-line and does not require calibrated camera or mobile robot parameters. Results demonstrating the control of two very different mobile robots using the same controller highlight the flexibility of the approach.

PIEPMEIER, Jenelle A., Assistant Professor and Morgan, Peter A., "Uncalibrated Vision-Based Control of Two-Wheeled Mobile Robots," *International Mechanical Engineering Conference and Exposition (IMECE) 2001*, New York City, NY, November 2001. (CD-ROM)

A quasi-Newton method with Jacobian estimation is used to control a mobile robot utilizing visual feedback. The method is uncalibrated, requiring no camera calibration or known robot kinematics. Given a proper task configuration, the robot can be controlled such that it follows a moving target. This paper investigates the appropriate task configurations that result in a controllable system.

PIEPMEIER, Jenelle A., Assistant Professor, and O'BRIEN, Richard T., Jr., Assistant Professor, "On the Recruitment of Female Students to the Systems Engineering Department at the U.S. Naval Academy," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Albuquerque, NM, June 2001. (CD-ROM)

The Weapons and Systems Engineering Department at the U.S. Naval Academy is seeking to increase the number of female students enrolled as systems engineering majors. Currently, the 7% of approximately 345 students are female midshipman, which is below the national average of women engineering students (19%). This is not surprising within the unique environment of a military service academy with only 15% of the total student body comprised of females. Given the high caliber of the student body, it is believed that a number of female students who possess the ability to succeed do not choose an engineering major. The authors seek to identify the reasons capable female students are not choosing the Systems Engineering major. The authors conducted a discussion session with the junior and senior female Systems Engineering majors. The students filled out a questionnaire and generated several useful suggestions. This paper presents the results of this discussion, looks at the unique factors that affect the students in choosing a major at the Naval Academy, and proposes several recruitment strategies.

PIEPMEIER, Jenelle A., Assistant Professor, KNOWLES, Kenneth A., Professor and BISHOP, Bradley E., Assistant Professor, "Using MATLAB for Robotics Instruction," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Montreal, Canada, June 2002. (CD-ROM)

An effective undergraduate robotics course will have strongly coupled laboratory and classroom components. It is important that the students experience the application of classroom theory. Often, this application is transparent when using the vendor supplied programming environments. For example, Cartesian move commands will move the robot to a desired point in the workspace without a need for explicit solution of the inverse kinematics problem by the student. Programming environments such as MATLAB, Maple, or C\C++ have long provided an ideal simulation environment for studying kinematic or dynamic robotic models. Environments such as MATLAB are especially ideal for engineering students with limited programming expertise. By taking advantage of the serial port capabilities in MATLAB's Release 12 and later versions, along with the ability to compile existing C\C++ code under the MATLAB shell, the instructor can devise assignments that allow the student to easily model and

control robotic systems in the MATLAB environment. This paper discusses two approaches and representative laboratory assignments.

PIPER, George E., Associate Professor, WATKINS, John M., Associate Professor, AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor, and WICK, Carl E., Associate Professor, "Design of an Electronic Muffler - A DSP Based Capstone Design Project," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Albuquerque, NM, June 2001. (CD-ROM)

Active control of noise has been an emerging technology for the past two decades. Active noise control (ANC) is an attractive means to achieve large amounts of noise reduction in a small package, particularly at low frequencies, where passive noise control may be impractical. While the concept of ANC has long been established, the technological means for implementing ANC have only recently become available. With the advent of high-speed digital signal processors (DSPs) and modern signal processing methods, ANC is now becoming a reality.

This paper presents an interesting undergraduate design project involving ANC. In their capstone engineering design course students designed and built a prototype ANC system that successfully demonstrated the concepts of an electronic muffler. The heart of the project centered on the popular Analog Devices' SHARC DSP evaluation module (EVM). In this paper we discuss ANC concepts and the electronic muffler, the students design project, and the pedagogical outcome.

PIPER, George E., Associate Professor, WATKINS, John M., Associate Professor, Leitner, Jesse, and Markley, Landis, "On the Control Design of the Disturbance Reduction System for the LISA Mission," *Proceedings of the 2002 American Institute of Aeronautics and Astronautics (AIAA) Guidance, Navigation, and Control Conference*, Monterey, CA, June 2002. (CD-ROM)

The Laser Interferometer Space Antenna (LISA) mission will consist of a three spacecraft formation acting as a large interferometer. The spacecraft formation will measure the distortion of space caused by passing gravitational waves. Each spacecraft will contain two shielded proof masses that define the optical arms of the interferometer. To mitigate the effects of external disturbances, the LISA Disturbance Reduction System will control the spacecraft to fly drag-free trajectories with reference to their respective proof masses. This paper investigates control design issues associated with the LISA Disturbance Reduction System (DRS). In particular, this paper presents a 2 degrees-of-freedom (DOF) model representing a spacecraft with a single proof mass. With this model, key control design issues are identified. A Linear Quadratic Gaussian (LQG) controller design is then presented to illustrate the feasibility of the DRS control concept. A 3 DOF model is used to explore the DRS implications of a spacecraft with two proof masses.

TAYLOR, Bradley D., Commander (USNR), and Muftic, Sead, "Remote Method Security in a Distributed Processing Architecture Supporting Generic Security Objects," *Instrumentation, Controls and Automation in the Power Industry, The Instrumentation, Systems, and Automation Society*, San Diego, CA, Volume 45, ISA, June 2002. (CD-ROM)

The paper reviews existing real-time distributed processing and controls engineering systems, using generic secure objects, remote computing security methods and network communication, finding most supply effective means within their domain. Despite potentially significant benefits from integration of these domains, the paper claims that this has not occurred due to entrenched interests refusing to endorse a common set of security extensions to Java RMI. Recent development of mobile agents provides an additional means of improving security in a closed network environment connected to the open Internet. The solution provides extensive novel architectural components for real-time controls of a system for a distributed processor network, using adapted Java RMI and Mobile Agent methods and proposes communication and security protocols to accomplish such an instantiation.

WATKINS, John M., Associate Professor, Lee, Ken, Hernandez, Carlos, Blumenstock, Ken, and Schepis, Joe, "Adaptive Auto-Balancing Control of Magnetic Bearings for an Optical Chopper," *Proceedings of the American Control Conference*, Arlington, VA, June 2001, pp. 1298-1303.

In this paper, we show how adaptive notch filters and magnetic bearings can be utilized for auto-balancing of an optical chopper. This optical chopper is required to operate between 4800 and 5200 RPM (rotations per minute) for five years in space. Life testing of the ball bearings in the optical chopper has indicated potential failure of the bearings after three to four years due to lubrication break down. The goal of this research is to investigate the feasibility of replacing the ball bearings with magnetic bearings. By using magnetic bearings to suspend the optical chopper, friction between the bearings and the rotor, and associated failures, can be eliminated. Initial testing using standard feedback controllers, however, showed excessive wobble in the chopper due to mechanical imbalances. By using adaptive notch filters based on the LMS (least mean squares) algorithm, we show how this wobble can be significantly attenuated. Experimental results are presented.

WICK, Carl E., Associate Professor, and STILWELL, Daniel J., Assistant Professor, "A Miniature Low-Cost Autonomous Underwater Vehicle," *Marine Technology Society / Institute for Electrical and Electronic Engineering (MTS/IEEE) Oceans 2001 Conference Proceedings*, Honolulu, HI, November 2001, pp. 423-428, ISBN 0-933957-28-9.

This paper announces the development of a prototype miniature low-cost autonomous underwater vehicle (AUV). The vehicle was designed to explore technology for one-way military applications, including minefield mapping/ tagging, and cooperative underwater activities with similar units, but could also find application in shallow water mapping and remote sensing. The prototype vehicle measures approximately 24 inches long (61cm) by 3.5 inches in diameter (8.9cm), displacing approximately 7 lbs (3.3kg). We present the physical design of this vehicle, or findings from initial testing, including the performance of inexpensive sensors used for vehicle navigation.

STILWELL, Daniel J., Assistant Professor, WICK, Carl E., Associate Professor, and BISHOP, Bradley E., Assistant Professor, "Small Inertial Sensors for a Miniature Autonomous Underwater Vehicle," *Proceedings of the Institute for Electrical and Electronic Engineering (IEEE) Joint International Conference on Control Applications*, Mexico City, Mexico, September 2001, pp. 841-846, ISBN: 0-7804-6735- 9.

Testing and algorithm development are addressed for the guidance system of a low-cost (disposable) miniature autonomous underwater vehicle. The requirements of low-cost and small size necessitate the use of low-cost and low-performance inertial sensors. Mechanized calibration routines are developed to address high drift rates in gyro calibration coefficients, and compass/gyro stabilization methods are investigated to address susceptibility of the compass to magnetic interference.

ZIVI, Edwin L., Assistant Professor, and PIEPMEIER, Jenelle A., Assistant Professor, "Dynamic System Animation within a SIMULINK Laboratory Environment," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Albuquerque, NM, June 2001. (CD-ROM)

Recent innovations in the animation of student developed, laboratory simulations have been found to significantly improve student understanding and enthusiasm. This animation can be implemented using MATLAB s-functions that are typically called from a SIMULINK simulation. These rudimentary animations have been found to be relatively easy to construct and well received by students. General observations and recommendations are developed from specific examples, hints, and experiences. Runtime animation has been found to be a valuable complement to the existing capability to visually construct the simulation model. S-function animations have been found to be composed of two primary elements: reusable interface/initialization "boilerplate" and animation specific graphics. To date, animations have been developed solely as part of faculty course preparation. These animations have been found to efficiently leverage MATLAB's high level programming features to provide an effective teaching tool.

ZIVI, Edwin, Assistant Professor, and PIEPMEIER, Jenelle A., Assistant Professor, "The Implementation of a Classroom Laboratory Paradigm," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition,* Montreal, Canada, June 2002. (CD-ROM)

This paper describes a novel classroom design used in the Systems Engineering Department at the United States Naval Academy to more strongly couple the classroom and laboratory experiences for undergraduate systems engineering students. The Systems Engineering Department has replaced two roughly equally sized rooms dedicated separately as a laboratory and a classroom with one lab-classroom equal to roughly one and a half times the size of the pre-renovation rooms. Designed for roughly twenty students, the lab-classroom is designed to integrate course-specific engineering laboratory equipment with the traditional lecture environment. The coupling of the physical environments serves to blur the distinction between formerly disparate events including: lecture, computer modeling and simulation, and hardware implementation. Lab-classroom can be dedicated to specific disciplines within the major such as control systems, robotics, environmental engineering, communications, and microprocessors. In addition, our lab-classroom are equipped with a variety of multimedia tools to facilitate student learning. For example, now one single room houses traditional desks, chalk boards, multimedia equipment, as well as ten robotic workstations including computers and vision systems. The paper discusses several of the lab-classroom activities that this new physical layout enables as well as faculty and student response.

Technical Reports

O'BRIEN, Richard T., Jr., Assistant Professor and KIRIAKIDIS, Kiriakos, Associate Professor, "Extended H-Infinity Filtering to Determine Direction of Arrival (DOA)," Office of Naval Research End-of-the-Year Report, September 2001**.**

The direction-of-arrival (DOA) estimation problem for multiple, superimposed sinusoidal signals, received by a sensor array is considered. Assuming the number of sources is fixed, the received signal is modeled by a discrete-spatial linear system with a state-space realization parameterized by the DOA's. The estimation problem is formulated as a simultaneous state and parameter estimation in the presence of modeling error and additive noise. In this paper, a parameter estimation algorithm is developed using an extended H-infinity filter. Existing results on reduced-order H-infinity state estimation are used to develop a solution for the DOA estimation problem where the minimum tolerance can be computed from the state-space coefficient matrices. Previously, the DOA estimation problem was solved using a Kalman filter that processed a "snapshot", measurements from all sensors in the array at a given time instant, off-line. In the proposed solution, the DOA estimates will be updated on-line as the measurement from each sensor is received.

ZIVI, Edwin L., Assistant Professor, "Office of Naval Research (ONR) Control Challenge Problem," ONR / NSF EPNES Control Challenge Problem Website, http://www.usna.edu/EPNES/, 20 January 2002.

Control system requirements for highly automated and survivable future electric warships are presented herein to stimulate and unify interdisciplinary research conducted under the joint NSF/ONR Electric Power Networks Efficiency and Security (EPNES) initiative 1,2. This ONR challenge problem focuses on continuity of control for interdependent shipboard engineering and damage control systems under hostile conditions. The mission statement for these Hull, Mechanical, Electrical & Damage Control (HME&DC) systems may be summarized as: provide continuous mobility, power, and thermal management for shipboard combat systems despite major disruptions involving cascading failures. This challenge problem is prototypical of analogous complex, interdependent systems including the national power grid, military and civilian infrastructure, and transport systems. These nonlinear, distributed, heterogeneous, variable structure systems contain dynamically interdependent subsystems. Mission/life critical system integrity and fault tolerance requirements demand dependable continuity of service. Innovative, dependable, and affordable control system architectures, strategies, algorithms, methods and tools are sought. After a brief problem statement and discussion of shipboard control systems, the ONR control challenge problem and reference system are presented.

Presentations

BISHOP, Bradley E., Assistant Professor and STILWELL, Daniel J., Assistant Professor, "On the Application of Redundant Manipulator Techniques to the Control of Platoons of Autonomous Vehicles," 2001 Institute for Electrical and Electronic Engineering (IEEE) Conference on Control Applications, Mexico City, Mexico, September 2001.

BISHOP, Bradley E., Assistant Professor, "Redundant Manipulator Analogs in Robot Swarm Control," Mechanical Engineering Division, Drexel University, Philadelphia, PA, January 2002.

DWAN, Terrence E., Professor, PIPER, George E., Associate Professor, WICK, Carl E., Associate Professor, and BISHOP, Bradley E., Assistant Professor, "Systems Ball – A Creative Capstone Design Experience," 2001 Frontiers in Education Conference, Reno, NV, October 2001.

KIRIAKIDIS, Kiriakos, Associate Professor, and BISHOP, Bradley E., Assistant Professor, "On the Analysis of Uncertain Hybrid Systems with Estimated-State Feedback," 2001 American Controls Conference, Arlington, VA, June 2001.

KIRIAKIDIS, Kiriakos, Associate Professor, "Supervision of Multiple-Robot Systems," 2001 American Controls Conference, Arlington, VA, June 2001.

KIRIAKIDIS, Kiriakos, Associate Professor, "Optimal Nonlinear Filters Based on the Takagi-Sugeno Fuzzy Model," Institute for Electrical and Electronic Engineering (IEEE) Conference International Conference on Fuzzy Systems, Honolulu, HI, May 2002.

O'BRIEN, Richard T., Jr., Assistant Professor, "A Streamlined Approach for Teaching Root Locus Compensator Design," Conference on Decision and Control, Orlando, FL, December 2001.

PIEPMEIER, Jenelle A., Assistant Professor, "On the Recruitment of Female Students to the Systems Engineering Department at the U.S. Naval Academy," American Society for Engineering Education (ASEE) Annual Conference and Exposition, Albuquerque, NM, June 2001.

PIEPMEIER, Jenelle A., Assistant Professor, "Uncalibrated Vision-Based Control of Two-Wheeled Mobile Robots," 2001 International Mechanical Engineering Conference and Exposition (IMECE), New York City, NY, November 2001.

PIEPMEIER, Jenelle A., Assistant Professor, "Uncalibrated Vision-Based Mobile Robot Control," American Society of Civil Engineers (ASCE) Space and Robotics 2002, Albuquerque, NM, March 2002.

PIEPMEIER, Jenelle A., Assistant Professor, "Uncalibrated Eye-in-Hand Visual Servoing," Institute for Electrical and Electronic Engineering (IEEE) Conference International Conference on Robotics and Automation, Washington, DC, May 2002.

PIEPMEIER, Jenelle A., Assistant Professor, KNOWLES, Kenneth A., Professor and BISHOP, Bradley E., Assistant Professor, "The Use of MATLAB for Robotic Control in an Undergraduate Robotics Laboratory," American Society for Engineering Education (ASEE) Annual Conference and Exposition, 1520 Computers in Education Poster Session, Montreal, Canada, June 2002.

PIPER, George E., Associate Professor, "Design of an Electronic Muffler - A DSP Based Capstone Design Project," American Society for Engineering Education (ASEE) Annual Conference and Exposition, Albuquerque, NM, June 2001.

PIPER, George E., Associate Professor and WATKINS, John M., Associate Professor, "LISA Test Platform Disturbance Reduction System Simulation Study," NASA/Goddard Space Flight Center, Greenbelt, MD, September 2001.

STILWELL, Daniel J., Assistant Professor, WICK, Carl E., Associate Professor and BISHOP, Bradley E., Assistant Professor, "Small Inertial Sensors for a Miniature Autonomous Underwater Vehicle," 2001 Institute for Electrical and Electronic Engineering (IEEE) Conference on Control Applications, Mexico City, Mexico, September 2001.

STILWELL, Daniel J., Assistant Professor, and WICK, Carl E., Associate Professor, "Multi-Vehicle Navigation, Guidance, and Control," AUVSI Second Annual Ground, Sea, and Air Conference, Washington, DC, February 2002.

TAYLOR, Bradley D., Commander (USNR), "Remote Method Security in a Distributed Processing Architecture Supporting Generic Security Objects," Instrumentation, Controls and Automation in the Power Industry, Volume 45, The Instrumentation, Systems, and Automation Society (ISA), San Diego, CA, June 2002.

Waltrip, Bryan C., AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor and Koffman, Andrew D., "A Capacitance Measurement System Using an IVD Bridge," National Conference of Standard Laboratories (NCSL), Washington DC, July 2001.

Waltrip, Bryan C., Koffman, Andrew D., and AVRAMOV-ZAMUROVIC, Svetlana, Associate Professor, "The Design and Self-Calibration of Inductive Voltage Dividers for an Automated Impedance Scaling Bridge," Instrumentation and Measurement Technology Conference (IMTC), Anchorage, AK, May 2002.

WATKINS, John M., Associate Professor, "Adaptive Auto-Balancing Control of Magnetic Bearings for an Optical Chopper," 2001 American Control Conference, Arlington, VA, June 2001.

WICK, Carl E., Associate Professor and STILWELL, Daniel J., Assistant Professor, "A Miniature Low-Cost Autonomous Underwater Vehicle," Marine Technology Society / Institute for Electrical and Electronic Engineering (MTS/IEEE) Oceans 2001 Conference, Honolulu, HI, November 2001.

ZIVI, Edwin L., Assistant Professor, "Integrated Power System Simulation and Control Challenges," 2001 Virtual Test Bed Annual Review, Charleston, SC, July 2001.

ZIVI, Edwin L., Assistant Professor, "Electric Power Network Efficiency and Security ONR Control Challenge Problem," Institute for Electrical and Electronic Engineering (IEEE) Conference Power Society, Winter Annual Meeting, New York, NY, January 2002. (NSF invited speaker)

ZIVI, Edwin L., Assistant Professor, "Electric Power Network Efficiency and Security ONR Control Challenge Problem," Energy Systems Analysis Consortium Annual Meeting, Purdue University, West Lafayette, IN, March 2002.