

PROJECT SUMMARIES

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

Richard W. Adler, Research Associate Professor
Wilbur R. Vincent, Visiting Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites and Regional Security Operational Centers (RSOCs) worldwide.

SUMMARY: Development of techniques and methodology for identifying and locating radio noise sources of interference to data processing and computer systems at NSG sites worldwide continued. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans, and authoring "Quick-Look" and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A 2-day conference, HF Technical Review of Factors that Affect Performance of Naval Receiving Sites, was organized and was held in Washington DC in May.

OTHER:

Vincent, W.R., Adler, R.W., and Parker, A.A., "The EMI Aspects of Grounds at Receiving and Data Processing Sites," Technical Memorandum, Signal Enhancement Laboratory, Naval Postgraduate School, Monterey, CA, March 1998.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Program Signal Quality Survey NSGA Rota," Quick-Look Report, prepared for COMNAVSECGRU N-44, 10 June 1998.

Vincent, W.R. and Adler, R.W., "System Performance Survey NSGA Naples," Technical Report, prepared for COMNAVSECGRU N-44, March 1998.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Team Survey NSGA Sabana Seca," Technical Report, prepared for COMNAVSECGRU N-44, September 1998.

Vincent, W.R. and Adler, R.W., "Field Exercises on Power-Line-Noise Source-Location Techniques at NSGD San Diego," Data Summary Report, prepared for COMNAVSECGRU N-44, September 1998.

Vincent, W.R., "New Radar Engineers Noise Receiver," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "HF Power-Line-Noise Sensors," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Differential Probe," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Equipotential Ground Experiment," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Cable Tests," prepared for USA INSCOM for presentation at the Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Fusion Lights," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

PROJECT SUMMARIES

Vincent, W.R., "Installation Standards," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Standing Waves on Grounds," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Perry, R., "Motor Controller Status," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Parker, A.A., "Summary of Winter Harbor EMI Problem," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

FIELD STATION RESEARCH AND SUPPORT
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Army Information Security Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Army Regional Security Operational Centers (RSOC) and receiving sites worldwide.

SUMMARY: An EMI survey was conducted at the RSOC, Ft. Gordon, GA. The performance of receiving signals-of-interest at the RSOC was evaluated and the EMI sources observed were documented.

OTHER:

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Quick-Look Report, prepared for USA INSCOM, January 1998.

Vincent, W.R., Adler, R.W., and Parker, A.A., "The EMI Aspects of Grounds at Receiving and Data Processing Sites," Technical Memorandum, Signal Enhancement Laboratory, Naval Postgraduate School, Monterey, CA, March 1998.

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Technical Report, prepared for USA INSCOM, May 1998.

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Quick-Look Report, prepared for USA INSCOM, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

PROJECT SUMMARIES

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

Robert William Ashton, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Annapolis Detachment

OBJECTIVE: Four 100kW buck choppers are currently part of small-scale dc zonal electric distribution system at the Naval Surface Warfare Center (NSWC). The object of this research is to assist in creating two 200kW buck choppers from the existing four 100kW units. This will require hardware changes and major control algorithm modifications. The units are to be paralleled with a non-droop method and share current equally excluding sensor inaccuracies.

SUMMARY: During FY97 the Programmable Universal Controller (PUC) was developed and implemented. The PUC, designed by NSWC personnel, was adopted by this investigator as the second generation controller. The PUC is TMS320 based with ten available 200kHz A/D converters for acquiring sensor information. The PUC uses a computer for interfacing, and many PUCs may be daisy-chained via fiber optic cable. Electrical isolation is accomplished by the use of fiber optic cable to the power section transistor driver board, the computer interface board and all follow-on PUCs. Each PUC can control two converters simultaneously. This required the building of three PUCs, two for NSWC and one for the NPS testbed. Documentation of the PUC had to be generated since little was available from NSWC due to personnel changes.

Two prototype 9kW buck choppers that interface with the PUC were designed, built, and tested. These converters are closely matched so that future paralleling requirements could be implemented. After a PUC was built and tested, assembler code for the TMS320 was developed to run the choppers. The original multi-loop algorithm used in the first generation controller was coded and burned into the EPROMs. The NPS testbed which includes one PC, one PUC, and two 9kW buck choppers was completed. After debugging, the converters were successfully operated at their full-power ratings.

At this point an interface card for the 100kW units at NSWC was designed, cut, populated and tested at NPS. This card is required for local control, several protection features and the special Power Paragon Inc. (PPI) IGBT driver boards. All necessary components for the new controllers were shipped to Annapolis for integration with the power sections. The converters were made operational with the new controllers and were then shipped to PPI, Anaheim, CA for upgrades and permanent hardwiring for parallel operation at 200kW.

During FY98 a new algorithm for paralleling the units without droop was needed and NPS was given the task of developing, testing, and incorporating this new algorithm on the modified power converters. The new algorithm uses a master/slave technique that incorporates current differences in the paralleled units' inductors and outputs to maintain identical current sharing. After successful simulation and hardware testing in the NPS Power Systems Laboratory, the new algorithm was implemented successfully at PPI and the units paralleled 200kW units were shipped back to Annapolis.

PUBLICATIONS:

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," *ISCAS 98*, Vol. III, p. 489, Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," *PESC 98*, Vol. 1, p. 65, Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feedback Linearization Techniques," *Proceedings of PESC 98*, Vol. 1, p. 335, Tokyo, Japan, June 1998.

THESIS DIRECTED:

Floodeen, D.L., "Implementing Desired Control Algorithms for Auxiliary Resonant Commutated Pole PWM Inverters Using Existing DSP Resources," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Energy Conversion)

PROJECT SUMMARIES

KEYWORDS: Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

ADVANCED PROCESSOR AND MEMORY SYSTEMS

Raymond F. Bernstein Jr., Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School Foundation, Inc.

OBJECTIVE: To design large-scale integrated circuits (VLSI) for a vector pipelined processor architecture.

SUMMARY: Two chips are under study in this task. One chip performs the function of interfacing banked memories using permutation-based decoding to a bus. The second chip is a pipelined vector processor that performs radix-r butterfly operations, complex vector addition, and multiplication.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Vector Processor, Pipelining, Digital Signal Processing

NETWORK SIMULATION FOR ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV)

Raymond F. Bernstein Jr., Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Advanced Amphibious Assault Vehicle Technology Center

OBJECTIVE: To simulate the FDDI, CANBus, and Utility bus and their associated computers to stress test the system to determine required improvements in the system.

SUMMARY: The three networks (FDDI, CANBus, Utility bus) used in the AAAV were analyzed. This project began in late November and has been focused on data collection and analysis for this simulation. A simulation of the three networks has been partially developed and will be completed in the following year.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Networks, Network Simulation, FDDI

DESIGN OF IRREDUNDANT SUM-OF-PRODUCTS COMPUTER-AIDED DESIGN (CAD) TOOLS

Jon T. Butler, Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: The goal of this research is to develop improved algorithms for the minimization of irredundant sum-of-products expressions, which are used in almost all CAD tools. Two subgoals are to understand the extent to which a heuristic can fail (produce a large irreducible sum-of-products expression) and why it fails. A goal will be to develop a paradigm by which good heuristics can be produced.

SUMMARY: Initiated a study of Reed-Muller expressions for realizing compactly digital logic functions. This is a collaborative effort with Professor Gerhard Dueck of St. Francis Xavier University, Antigonish, NS, Canada, and two visiting professors at St. Francis Xavier University. Under this joint research project (funded also by NSERC of Canada and St. Francis Xavier University), a fast algorithm was identified for finding the optimum Reed-Muller expansion for symmetric

PROJECT SUMMARIES

circuits. A surprising result of this work is that only two of the 2^{**n} expansions of n -variable functions produce optimum realizations (40% of the functions are optimally realized by the two expansions). Presently, three publications are in progress on this work.

PUBLICATIONS:

Sasao, T. and Butler, J.T., "Worst and Best Irredundant Sum-of-Products Expressions," *IEEE Transactions on Computers*, submitted.

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," *Proceedings of the International Symposium on Multiple-Valued Logic*, pp. 83-88, May 1998.

CONFERENCE PRESENTATIONS:

Butler, J.T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," to be presented at the 29th International Symposium on Multiple-Valued Logic, Freiburg, Germany, 1999.

Butler, J.T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," International Symposium on Multiple-Valued Logic, Fukuoka, Japan, 26 May 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Logic Circuit Design, CAD (Computer-Aided Design), Compact Circuits

THE SIMULATION AND DIGITAL-SIGNAL-PROCESSING (DSP) IMPLEMENTATION OF CLOSED-LOOP AUXILIARY RESONANT COMMUTATED POLE (ARCP) CONTROL ALGORITHMS FOR INVERTER AND BOOST RECTIFIER APPLICATIONS

John G. Ciezki, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: Research engineers at the Navy's government laboratories are actively engaged in producing the hardware elements required for implementing a dc zonal distribution system for the Surface Combatant of the twenty-first century. One of the key components of that system is the Auxiliary Resonant Commutated Pole (ARCP) Inverter which will be used bidirectionally to either create ac from dc or series connected to implement a fixed-frequency to variable-frequency converter. The ARCP is to be controlled by the Power Electronic Building Block Universal Controller (PUC) developed by personnel at the Naval Surface Warfare Center (NSWC). The investigator seeks to develop the control algorithms necessary to implement the closed-loop operation of the ARCP. In particular, it is proposed to use simulation to validate a series of voltage-based and current-based feedback control laws which can then be coded and implemented with the PUC. The control algorithms will be implemented in the stationary and synchronous reference frames and will use pulse-width-modulation and space vector techniques for realizing the switching times. In addition, the investigator will derive a soft-switched boost rectifier algorithm via simulation and aid researchers at NSWC in implementing the derived control using the PUC. The products of this research will consist of a series of technical reports documenting the algorithms and a set of ACSL computer simulation models that will be delivered to NSWC personnel.

SUMMARY: The investigator completed work in the following four areas: ARCP inverter control algorithms, PUC C++ routines, dc-dc converter algorithms, and boost rectifier analysis. The investigator first developed a digital simulation of the inverter module using ACSL. Two algorithms were developed to regulate the current out of the inverter and one algorithm was developed to regulate the 3-phase voltage out of the inverter. One final algorithm was developed to regulate the startup and speed control of a 3-phase symmetrical induction machine. All algorithms were validated through simulation and documented as to how they would be implemented using the PUC. In addition, the current-control algorithms were further

PROJECT SUMMARIES

validated using the dSPACE development resources and additional hardware [Frasz, 1998]. To support the rapid determination of control gains for the aforementioned algorithms, various MATLAB programs were written. Programming the PUC with C++ algorithms was unsuccessful due to the memory mapping of the board as found in Floodeen, 1998. Since this endeavor was not possible, the investigator included research into decentralized control of dc-dc converters which is being extended by Moore, 1999. A signal-injection algorithm was identified, analyzed and various MATLAB script files were assembled to facilitate the analysis and selection of gains. The final aspect of the work revolved around the simulation and analysis of a three-phase boost rectifier employing an ARCP topology. A boost converter feedback control was derived, a detailed simulation implemented in both single-phase and three-phase, and a means for transitioning between the three phases established. The work reported here is being extended into a number of thesis projects: paralleling ARCP inverters [Marinac, 1999], de-centralized control of dc-dc converters [Moore, 1999] and current-mode control of dc-dc converters [Hekman, 1999].

PUBLICATION:

Ciezki, J.G. and Ashton, R.W., "The Application of a Customized DSP Board for the Control of Power Electronic Converters in a DC Zonal Electric Distribution System," *Proceedings of the 32nd Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Energy Conversion)

KEYWORDS: Power Electronic Converters, High-Bandwidth Controllers, Power Electronic Building Block

SIGNAL CLASSIFICATION ISSUES USING WAVELET-BASED FEATURES

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Undersea Warfare Center-Newport and Naval Postgraduate School

OBJECTIVES: The goal of the on-going study is to: 1) investigate the application of wavelet-based decompositions to the classification of signals with narrowband characteristics and 2) to conclude a previous investigation applying Wiener filter concepts to wavelet denoising.

SUMMARY: This study conducted during FY98 was split into two parts. First, the application of wavelet-based decompositions to the classification of non-stationary signals with narrowband characteristics were investigated. The literature in this area was reviewed. The Least Discriminant Bases (LDB) scheme was implemented, and the Learned and Willsky's feature extraction scheme and compared their performances when applied to narrowband-like signals. Next, several dimension reduction schemes were considered and a new one called the Mean Separator Neural Network (MSNN) was proposed. Two types of classifiers were considered and compared: classification trees and back-propagation neural networks. Comparisons between different types of dimension reduction and classifiers were conducted both on synthetic and real-world underwater data. Results showed that the MSNN is a viable tool for classification of signals with narrowband characteristics.

Second, the study started during FY97 was concluded which considered the application of Wiener filter concepts to wavelet-based denoising. Results show performances to be quite sensitive to signal types, and that no distinct advantages over wavelet thresholding techniques for a wide range of signals is obtained.

PUBLICATION:

Fargues, M. and Duzenli, O., "Wavelet-Based Feature Extraction Methods for Classification Applications," *Proceedings of the 9th Signal Processing Workshop on Statistical Signal and Array Processing*, pp. 176-179, September 1998.

PROJECT SUMMARIES

THESES DIRECTED:

Forney, F.D., Jr., "Acoustic Noise Removal by Combining Wiener and Wavelet Filtering Techniques," Master's Thesis, Naval Postgraduate School, June 1998.

Cebeci, C., "Denoising of Acoustic Signals Using Wavelet/Wiener Based Techniques," Master's Thesis, Naval Postgraduate School, June 1998.

Duzenli, O., "Classification of Underwater Signals Using Wavelet Based Decompositions, Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Software)

KEYWORDS: Wavelet, Classification

FEATURE EXTRACTION FOR SIGNAL CHARACTERIZATION IN CLASSIFICATION APPLICATIONS

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force

OBJECTIVES: The goal of the study is to extend a dimension reduction scheme considered in previous work and to consider its applications to classification applications.

SUMMARY: In a previous study a new dimension reduction scheme was proposed to reduce the dimension of the feature space generated to characterize signal classes. This initial scheme, called the Mean Separator Neural Network, was designed to distinguish between two classes only. In this work, the scheme was extended to more than two classes. The results obtained were compared to other types of dimension reduction techniques proposed in the literature. Next, a simple decision scheme was proposed which can be used with the MSNN to generate a complete classifier at a cheap computational cost. Simulations to compare classification performances were conducted both on synthetic and underwater data. Results show our proposed overall classification scheme to have performances similar to those obtained with more expensive schemes on the data considered.

PUBLICATION:

Fargues, M. and Duzenli, O., "Dimension Reduction Issues in Classification Applications," *Proceedings of the 32nd Asilomar Conference on Signals, Signals, and Computers*, November 1998.

THESIS DIRECTED:

Duzenli, O., "Classification of Underwater Signals Using Wavelet Based Decompositions," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Software)

KEYWORDS: Wavelet, Classification

PROJECT SUMMARIES

DESIGN OF A MICROELECTRONIC CONTROLLER AND TACTOR INTERFACE INTEGRATED CIRCUIT (IC) FOR THE TACTILE SITUATIONAL AWARENESS SYSTEM

Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Naval Aerospace Medical Research Laboratory

OBJECTIVE: To develop a wearable (small, lightweight, and low power) microelectronic controller for the Tactile Situational Awareness System (TSAS) developed by the U.S. Naval Aerospace Medical Research Laboratory (NAMRL). To develop a specification for the tactor interface and to design a custom digital integrated circuit for communicating with the tactor.

SUMMARY: TSAS is a new combat aviation situational awareness system, developed by NAMRL that allows aircraft avionics systems to communicate directly with the pilot through the use of touch using a device called a tactor. The specification of an interface standard for tactors has been successfully completed. The design of a wearable (small, lightweight, and low power) microelectronic controller for TSAS has been completed. The components required to construct the controller are on order. The design of a tactor interface integrated circuit to allow the controller to communicate with an array of up to 256 tactors has been completed. The chip has been fabricated and tested but did not work due to fabrication errors. The design is being submitted again to obtain a working part.

THESIS DIRECTED:

Luke, B., "Design of a Microelectronic Controller with MIL-STD-1553 Bus Interface," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: Wearable Computing, Microelectronics, Tactile Communications

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Space Systems Academic Group
Sponsor: National Security Agency

OBJECTIVE: To develop circuit designs and mask layout techniques that improve the radiation tolerance of digital integrated circuits fabricated with standard, commercial, bulk CMOS processes for use in low-earth orbit spacecraft and high altitude aircraft.

SUMMARY: Work is concentrating in two areas. First, reducing subthreshold, gate, end-around leakage current which is caused by radiation-induced charge in the field oxide along the edge of the conducting channel of the transistor. This effort has been very successful. Second, compensating for shifts in threshold voltage that are caused by radiation-induced charge in the gate oxide. To date this effort has been promising but the work is still in progress and conclusive data is not yet available.

PUBLICATION:

Fouts, D.J., Noe, S.S., Lum, G.K., Lambley, A.S., and McKerrow, G.R., "Second-Layer Polysilicon Structures for Gate End-Around Leakage Current Compensation in Bulk CMOS ICs," *IEEE Transactions on Nuclear Science*, submitted.

PROJECT SUMMARIES

THESIS DIRECTED:

McKerrow, G.R., "Design Rules for Radiation-Tolerant CMOS ICs Fabricated with Commercial Bulk Processes," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control, and Communications, Electronic Warfare

KEYWORDS: Radiation-Hardened Electronics, Space Electronics

THE MILITARY APPLICATION OF MEO AND ICO COMMERCIAL SATELLITE SYSTEMS

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Vicente Garcia, National Security Agency Cryptologic Chair

Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: To produce a model that is capable of accommodating the less initial needs and requirements of U.S. MILSATCOM by utilizing the services provided by MEO and ICO satellite systems.

SUMMARY: A comprehensive model architecture consisting of ICO, Teledesic, and GBS was developed. This model accommodated narrowband, wideband, and broadcast requirements of U.S. MILSATCOM in addition to the communication needs of a model UN peacekeeping mission. The application of these systems to U.S. MILSATCOM coincided with the U.S. defense doctrine of a CONUS-based military with the capability of rapid global power projection to respond to crises throughout the global arena. Instead of investing heavily in new satellite systems, the U.S. military could use the forthcoming commercial LEO and MEO systems to meet the information requirements of tactical commanders.

PUBLICATION:

Kakavas, I., Ha, T.T., and Garcia, V., "The Military Applications of MEO and ICO Commercial Satellite Systems," Naval Postgraduate School Technical Report, NPS-EC-98-014, 15 September 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MEO, ICO, MILSATCOM

PROCESSING OF RADAR SIGNALS USING CORRELATION AND WAVELET CONCEPTS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: Investigate wavelet processing of second order statistics obtained from frequency agile radars with variable pulse repetition frequency (PRF).

SUMMARY: Radar characteristics of systems of interest were obtained. Typical attributes of representative electronic signatures were simulated using MATLAB. Initial results indicated that the correlation-based approach was not suitable for pulsed signals. This result was in contrast to the results obtained when dealing with constant envelope signals (i.e., fre-

PROJECT SUMMARIES

quency hopped signals). Work is in progress concentrating on using the wavelet transform directly in the time domain. One student is involved in the research.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: Radar Signals, Signal Detection/Classification, Identification

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop and investigate the properties of a wavelet based approach in detecting and classifying digital modulated signals. A wavelet transform, replacing the traditional Fourier transform in the computation of the time-frequency distribution, is used to obtain a scale-time/delay distribution. Also transformations of the generated distribution to its co-domains will be addressed.

SUMMARY: Wavelets were used to identify the modulation type of digital communication signals. In addition, parameters of interest were extracted. The processing is based on the 2-dimensional instantaneous correlation function. Both domains, time and delay, were used to in the wavelet based analysis. Based on simulation, processing performance versus signal-to-noise ratio was obtained.

PUBLICATION:

Hippenstiel, R., Fargues, M., Khalil, N., and Overdyk, H., "Processing of Second Order Statistics via Wavelet Transforms," Naval Postgraduate School Technical Report, NPS-EC-98-005, 20 February 1998.

CONFERENCE PRESENTATION:

Hippenstiel, R.D. and Fargues, M.P., "Processing of Second Order Statistics Via Wavelet Transforms," SPAWAR, Chantilly, VA, 7 April 1998.

DoD TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: Wavelets, Time Frequency Distributions, Signal Detection/Classification

EVALUATION AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING (PMHT) ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport

OBJECTIVE: To improve shallow water tracking of quiet submarines using sensor fusion and an advanced PMHT algorithm.

SUMMARY: Traditional multiple hypothesis tracking algorithms seek to enumerate all possible combinations of measurement-to-track data associations, maintaining a goodness of fit score for each association. Because computers have finite memories and the combinatorial possibilities of assigning even a few time sets of measurements to different possible

PROJECT SUMMARIES

combinations of tracks quickly becomes astronomical, all possible hypotheses cannot be maintained over time. Hence, only the most likely subset of hypotheses is maintained, and tracks, associations, and hypotheses themselves are increased and pruned over the course of an engagement to maintain an acceptable memory load. Hence, multiple hypothesis algorithms have been limited in their applications. Doctor Roy Streit and colleagues at NUWC have developed a new approach to multiple hypothesis target tracking that features a probabilistic approach to the measurement-to-track assignment problem. The PMHT algorithm circumvents the need for enumeration of measurement-to-track assignments, as well as pruning.

This algorithm is still under development, and extensions to critical practical areas is ongoing. Here at the Naval Postgraduate School, the Principal Investigator has conducted research into the extension of the algorithm to cluttered environments, specifically for tracking active sonar targets. Also, an investigation into the attribute-augmented assignment problem has been undertaken, and the modified algorithm has been compared with other existing tracking and assignment algorithms. This past year's effort focused on statistical attributes and the use of multiple maneuver models to aid tracking.

PUBLICATIONS:

Dunham, D.T. and Hutchins, R.G., "Tracking Multiple Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," *Studies in Probabilistic Multi-Hypothesis Tracking and Related Topics*, Vol. SES-98-01, Roy L. Streit, (ed.), Chapter 14, Naval Undersea Warfare Center Division, Newport, RI, 1998.

Hutchins, R.G. and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," *Studies in Probabilistic Multi-Hypothesis Tracking and Related Topics*, Vol. SES-98-01, Roy L. Streit (ed.), Chapter 15, Naval Undersea Warfare Center Division, Newport, RI, 1998.

Hutchins, R.G. and Dunham, D.T., "Evaluation and Extensions of the Probabilistic Multi-Hypothesis Tracking Algorithm to Cluttered Environments," Naval Postgraduate School Technical Report, NPS-EC-98-015, January 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Sensors, Modeling and Simulation

KEYWORDS: Kalman Filters, Sensor Fusion, Multi-Target Tracking, Littoral Warfare

DEVELOPMENT OF PARABOLIC EQUATION MODEL OVER ROUGH SURFACE

Ramakrishna Janaswamy, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Center-San Diego and Naval Postgraduate School

OBJECTIVE: To explore alternate methods for fast prediction of radio propagation over rough ocean surface in the presence of ducting.

SUMMARY: The Navy is interested in assessing the effect of wind-driven roughness on the low grazing angle radio propagation over the ocean surface. The effect of roughness can be studied by looking at the equivalent impedance produced by the rough surface for the specular wave. An integral equation first needs to be solved before one can calculate the specular wave. The integral equation used earlier suffered from ill conditioning for large surface deviations. An extended integral equation based on Tikhonov's regularization scheme was considered to remove the ill conditioning. The regularization scheme significantly extended the range of applicability to larger wave heights. It was, however, demonstrated that choosing the regularization parameter was not a trivial task.

PROJECT SUMMARIES

PUBLICATION:

Janaswamy, R., "A Curvilinear Coordinate Based, Split-Step Parabolic Equation Method for Propagation Predictions Over Terrain," *IEEE Transactions on Antennas, Propagation*, Vol. 46, No. 7, pp. 1089-1097, July 1998.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Tropospheric Propagation, Rough Surfaces

COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: The objective of this research is to investigate the suitability of using several existing computational electromagnetics (CEM) codes in modeling antenna problems to predict the antenna's performance when it is in its operational environment; that is, when installed on a platform with other objects near it or in its field of view.

SUMMARY: Several off-the-shelf CEM codes have been used to model a wide range of antenna problems. They include simple dipoles and slots as well as microstrip patches and horns. These codes are well suited to the evaluation of antenna gain and pattern characteristics under various operational conditions. The purpose of this research was to demonstrate some of the features of the codes that are of use in the design and analysis of antennas on complex structures. The performance of individual elements and arrays of elements on complex structures has been computed using electromagnetic patch codes.

Many of the codes are derivatives of RCS prediction codes, and have been thoroughly validated. Furthermore, pre- and post-processing tools have been developed to generate geometry models and visualize data. Several military and civilian applications were presented in a master's thesis. They include antennas on an F-18, Cessna 172, and a communications pod under the wing of an F-18.

PUBLICATION:

Jenn, D.C., "Performance Evaluation of Antennas Installed on a Joint Standoff Weapon (JSOW) Captive Air Training Missile (CATM)," Naval Postgraduate School Technical Report, NPS-EC-98-008, 10 March 1998.

THESIS DIRECTED:

Calusdian, J., "Evaluation of Low-Gain Antennas on Aircraft," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Array Antennas, Computational Electromagnetics

PROJECT SUMMARIES

CORRELATION INTERFEROMETRY DIRECTION FINDING (CIDF) REFLECTOR ANTENNA

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Beny Neta, Professor

Department of Mathematics

Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this investigation was to study the application of the correlation interferometry direction finding algorithm to beamforming for a wide field of view reflector antenna, using computer simulation.

SUMMARY: This research was a preliminary investigation of the application of correlation signal processing to aperture antennas. Correlation is equivalent to matched filtering. In this application the result is spatial filtering. Processing a signal incident on an antenna in this way results in compression of the antenna beam solid angle and permits the angle of arrival of the incident signal to be determined. Thus, correlation signal processing can be employed to determine angle of arrival within the wider field of view of the antenna. Using this approach, one can simultaneously achieve both a wide instantaneous field of view and the ability to more precisely determine the angle of arrival.

Three aperture antennas were investigated; a high gain parabolic dish with Yagi feed, a high gain conical horn antenna fed from circular waveguide excited with an electric field probe, and an open ended circular waveguide, also excited with an electric field probe. In the case of the parabolic dish, the incident field was sampled at 36 points around the periphery of the dish. For the horn, the incident field was sampled at 24 points around the mouth of the horn. The field incident on the open ended waveguide was sampled at 16 points in the plane of the aperture using short dipoles that were arbitrarily located in the aperture plane at distances up to 6 times the radius of the waveguide. The results obtained for these three structures show that the beam solid angle of an aperture antenna can be successfully compressed and that the angle of arrival of an incident signal can be determined by sampling the incident field as described.

The most obvious application of the technique described here is signals intelligence where there is a requirement to geolocate intercepted signals.

PUBLICATION:

Knorr, J.B. and Neta, B., "Signal Processing for Aperture Antenna Beam Compression," Naval Postgraduate School Technical Report, NPS-EC-98-016, September 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Electronic Warfare, Modeling and Simulation, Sensors

KEYWORDS: Antennas, Beam Compression, Correlation Interferometry Direction Finding

MONOLITHIC MICROWAVE INTEGRATED CIRCUIT (MMIC) RECEIVER FOR AIR TRAFFIC COLLISION AVOIDANCE

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsor: Michigan Technological University

OBJECTIVE: The objective of this project was to construct a low cost receiver for a small aircraft traffic collision avoidance system using monolithic microwave integrated circuit technology.

SUMMARY: Although traffic collision avoidance systems (TCAS) systems have been developed for commercial aircraft, affordable systems for small aircraft are still not available. The focus of this project was to design and construct a low cost TCAS receiver using monolithic microwave integrated circuit (MMIC) technology. A receiver was designed using two commercially available ICs such that a hard limited output was produced for transponder inputs from other aircraft in the range from 0.25 to 40 nautical miles. The first IC served as a downconverter which translated the 1090 MHz aircraft

PROJECT SUMMARIES

transponder signal to an intermediate frequency of 50 MHz. The second IC was a logarithmic amplifier that provided the hard limited output. These were mounted on a printed circuit board that used microstrip circuitry as necessary for the RF and for LO signal frequency control. The receiver was powered by a single 5 Volt supply and required a current of about 100 mA. The total cost of the parts used to build the receiver was under \$25, excluding the printed circuit board which would be inexpensive to mass produce. The receiver is being tested and will be modified as necessary to achieve the desired performance during 1999. The receiver will be integrated with other TCAS subsystems at Michigan Technological University.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors

KEYWORDS: Air Traffic Collision Avoidance, TCAS

TIME DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To develop a toolbox model for signal intercept in the time domain including the signal sources, communication channels and receivers.

SUMMARY: Models of digital communication systems have been developed and implemented using Matlab/Simulink Communications Toolbox. The ability to detect and extract information in the presence of wideband noise and interference was verified via Monte Carlo type simulations in the time domain.

THESES DIRECTED:

Tsiridis, K., "Time Domain Simulation of MFSK Communications System Performance in the Presence of Wideband Noise and Co-Channel Interference," Master's Thesis, Naval Postgraduate School, December 1998.

Erdogan, V., "Time Domain Simulation of MPSK Communications System Performance in the Presence of Wideband Noise and Co-Channel Interference," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Communications, Modeling and Simulation

ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop electromagnetic eigen-analysis software to electromagnetically characterize complex metallic platforms such as aircraft and ships.

SUMMARY: New capability has been developed for the electromagnetic eigen-analysis code EIGEN in order to enable faster eigen-analysis of wire grid models of electrically large metallic platforms. This includes faster matrix fill routines,

PROJECT SUMMARIES

iterative eigen-solver implementation, and 3D visualization of results. In addition, the visual graphical user interface (GUI) has been developed.

OTHER:

Lebaric, J., EIGEN 5.2 Electromagnetic Eigen-Analysis MATLAB Software

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Computational Electromagnetics, Antennas

HANDS-ON SHORT COURSE ON COMPUTER MODELING AND SIMULATION IN ELECTROMAGNETICS, COMMUNICATIONS AND RADAR

Jovan Lebaric, Visiting Associate Professor

Robert Vitale, Microwave Lab Director

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Crane Division

OBJECTIVE: To introduce the uses of commercial software MATHCAD, MATLAB, SIMULINK, Communications Toolbox, and NEC-WinPro for computer-based modeling and simulation in the areas of applied electromagnetics, communications, and radar.

SUMMARY: A 5-day hands on workshop was held at NSWC Crane to introduce applications of commercially available mathematical and engineering software to problems of antenna design and communications and radar systems modeling and simulation. The topics included both the theory and algorithm development and implementation.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Modeling and Simulation, Electromagnetics, Antennas, Radar

CLASSIC DIAMONDBACK UNIVERSAL MAST SLEEVE ANTENNA STUDY

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To determine the antenna options and parameters for designing an antenna system for the universal mast sleeve.

SUMMARY: The antenna classes that satisfy the electrical performance requirements (power, bandwidth, polarization, and beamwidth) and still conform to the space restrictions of the universal mast have been identified and their performance limitations identified and quantified.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Antennas, Communications

PROJECT SUMMARIES

PROJECT GUSTY ORIOLE

Herschel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

RADM Thomas C. Betterton, USN (Ret), Naval Space Technology Chair

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing, and communications of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and for SS4041 and SS4051, Military Space Systems and Technologies.

SUMMARY: Investigated algorithms and architectures of systems for the production, distribution, and analysis of tactical information. Investigated architectures of space-borne computer systems. Investigated operational problems concerned with the employment of tactical information for decision making and targeting. Planning a multi-source maritime situational awareness experiment for early 1999. Planned the inclusion of a major space system architecture study in SS4051 in winter 1999.

PUBLICATION:

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," *MILCOM98 Classified Conference Record*, MITRE Corp., Bedford, MA, October 1998.

CONFERENCE PRESENTATION:

Loomis, H.H., Jr. and Betz, J. "Low Probability of Intercept Communications (U)," MILCOM98 Classified Session, MITRE Corp., Bedford, MA, October 1998.

THESES DIRECTED:

Strozzo, P.G., "Detection and Classification of Digital Communication Signals Using Second and Higher Order Cyclostationary Features (Parts I & II) (U)," Master's Thesis, Naval Postgraduate School, June 1998.

Galina, J., "Maritime Situational Awareness-Dedicating the On-Board Processor for a Space Based Solution," Master's Thesis, Naval Postgraduate School, September 1998.

Jackson, A.K., "An Architecture for Maritime Situational Awareness," Master's Thesis, Naval Postgraduate School, September 1998.

Dines, S., "Space Based Information Operations," Master's Thesis, Naval Postgraduate School, December 1998.

Mateo, N., "The Effects of Time Varying Doppler on Cyclic Spectral Analysis," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Sensors

KEYWORDS: Tactical Information, Maritime Situational Awareness

PROJECT SUMMARIES

ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Engineering Logistics Office and Naval Postgraduate School

OBJECTIVE: Develop models for efficient processing of compressed video and imagery observed over an ATM network. Establish a testbed high-speed network within NPS for testing and evaluation of networked video and imagery.

SUMMARY: The initial components for an ATM high-speed video network were identified, procured, installed, and configured resulting in a significant upgrade to the ECE department's networking laboratory facilities. The development of this lab has already benefited students in the EC3850 class. A commitment was obtained from NELO to cover the remaining shortfall in initial proposed DFR funding. The initial taxonomy and algorithms to be used in the analysis of video bitstreams has been developed. Additionally, software from interested DoD agencies was been acquired and installed. The final stage of this project involved designing and configuring an application using combined video and imagery to test the installation. The work resulted in the collaborative thesis of LTs Karl Thomas and Shawn Lobree.

THESIS DIRECTED:

Thomas, K.O. and Lobree, S.W., "A Demonstration and Analysis of Requirements for Maritime Navigation Planning," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

IT-21 VULNERABILITY ASSESSMENT

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop models and simulations of IT-21 specific standards-based digital communications networks using MIL3's OPNET network modeling software environment. Determine infrastructure constraints and vulnerabilities based on simulated results. This work is part of a continuing project with NELO.

SUMMARY: Two subprojects have been identified in relation to this project: 1) IT-21 standards-based software modeling for susceptibility analysis and 2) hardware simulation and testing. With respect to the first topic, a baseline simulation model has been developed of a projected IT-21 standards-based network. Additionally, two initial attack simulations have been developed and are under evaluation. Under the second subproject, a simulated IT-21 compliant wide area network (WAN) has been constructed in the Advanced Networking Laboratory using the SX-14 data channel simulator. Actual vulnerability analysis will begin upon arrival an Adtech AX/4000 test system (scheduled delivery Mar 99). Work on this project began in November 98.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

PROJECT SUMMARIES

WIRELESS LOCAL AREA NETWORK (LAN) ANALYSIS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Develop models for the assessment of wireless LAN performance over non-standard distances. Provide guidance and consultation on future initiatives in wireless LAN research.

SUMMARY: The OPNET Modeler network simulation tool will be used to simulate radio frequency (RF) environments where wireless LANs may be implemented. Issues relating to receiver sensitivity and performance in noisy environments will be examined. Work on this project began in November 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: 802.11, ATM, Wireless, LAN, High Speed Networking

INTERNETWORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Develop methods for non-traditional analysis of computer network topologies, specifically those affiliated with the Internet. Recommend means for advanced use of network information in information operations. This work is part of a continuing project with the NSA.

SUMMARY: This project examines computer network topologies and operations in support of national security interests and is largely classified in nature. Recent initiatives within the NSA have produced highly unique data requiring more powerful analysis techniques. The initial stages of this research involved identifying key participants with a potential interest in this information. Additionally, specific areas for investigation were identified for further pursuit by NPS students. Finally, LT Eric Herbert completed his thesis in one of these areas, modeling telecommunications of financial data communications, in September 98. This work was presented at NSA in August 98. Ongoing work involves identifying new NPS students for thesis research in the remaining areas of interest and continued analysis of network trends.

CONFERENCE PRESENTATION:

McEachen, J.C., "Modeling Financial Transaction Networks," 1998 W Executive Council Seminar, National Security Agency, Ft. Meade, MD, 26 August 1998.

THESIS DIRECTED:

Herbert, E.W., "Telecommunications Vulnerability Analysis of Financial Transactions," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Internet, Counternarcotics, Network Analysis

PROJECT SUMMARIES

MODELING AND SIMULATION OF ATM TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Conduct analysis and evaluation of ATM facilities focusing on vulnerability identification and isolation through development of comprehensive large-scale digital communications network models using MIL3's OPNET network modeling software environment. This work is part of a continuing project with NELO.

SUMMARY: Analysis of a large-scale ATM network began by considering operation in a heterogeneous source environment. Specifically, a model examining the performance of a two-stage queuing system was developed, fed by a multiplexed Constant Bit Rate (CBR) source and a Poisson distributed source. The resulting D+M/D/1 waiting time tail distribution was approximated analytically using a weighted M/D/1 queuing system and used to verify the behavior of a computer model simulation. Cell loss encountered in the second stage is then observed for a variety of interarrival rates from the Poisson source. The work to date has presented a solid analytic foundation that will be further examined through theoretical analysis. Much of the queuing analysis of this project has also been applied to the design of a high-speed network interface.

PUBLICATION:

Batson, M.S. and McEachen, J.C., "Analysis Cell Loss in an ATM High-Speed Network Interface," Naval Postgraduate School Technical Report, NPS-EC-99-001, December 1998.

THESIS DIRECTED:

Batson, M.S., "Loss Performance in an ATM Cell Capture Environment," Master's Thesis, Naval Postgraduate School, December 1998.

OTHER:

Data Communication Analysis Tools Suite (DCATS). A new version of software protocol analysis tools consolidated at the request of a sponsor (NELO) and forwarded via DCS, 10 July 1998. These software tools allow near-real-time analysis of a large variety of data communication protocols in a user-friendly X-window based environment.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: IEEE Circuits and Systems Society

OBJECTIVE: Leveraging off cutting edge Internet technology, develop a network-centric system that facilitates the fundamental processes of conference organization and planning.

SUMMARY: Professional society conferences — such as the IEEE International Symposium on Circuits and Systems (ISCAS) or the IEEE Military Communications Conference (MILCOM) — are the primary mechanism for exchanging ideas on cutting edge research of vital interest to DoD. This project has identified and encapsulated the collaboration

PROJECT SUMMARIES

processes associated with organizing such conferences and created a system for researcher interaction on a global scale via the Internet.

Recent advances in database and networking technology allow the traditional processes for conference collaboration to be migrated to an on-line environment. Specifically, the recent development of Multi-part MIME encoding, Adobe Portable Document Format (PDF) and Open Database Connectivity (ODBC) worldwide web (WWW) gateways led to the implementation of a prototype system which allowed thousands of conference participants to submit documents using standard WWW browsing software for on-line consideration and review. Further, the review process itself as well as presentation scheduling, receipt verification and acknowledgement, and system administration are all facilitated with this system. Traditionally, this had been a highly labor intensive exercise involving several exchanges via postal mail and considerable expense. Some on-line conference organization systems have been implemented in the past, but none have approached the extent and robustness of the current effort.

PUBLICATION:

Coffman, J.W. and McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment," *Proceedings of the 1998 International Symposium on Circuits and Systems*, Vol. IV, pp. 33-36, Monterey, CA, June 1998.

CONFERENCE PRESENTATION:

McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment," 1998 International Symposium on Circuits and Systems, Monterey, CA, 1 June 1998.

THESIS DIRECTED:

Coffman, J.W., "A Paradigm for Conference Collaboration Across a Globally Networked Environment," Master's Thesis, Naval Postgraduate School, March 1998.

OTHER:

ISCAS '98 WWW, E-mail, and Database Servers (<http://iscas.nps.navy.mil/>). A suite of servers was installed and configured for use by the ISCAS organizing committee and participants. These services included mass e-mail announcements, e-mail for committee members, paper submission, review dissemination and collection, scheduling, database access, and program generation. Records on over 3000 individuals were maintained. Over 1200 papers were collected and reviewed. The WWW site was visited over 5 million times as of December 1998.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Database, Internet, Common Gateway Interface, Worldwide Web (WWW), Networking

UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC-142 COMMUNICATION SYSTEM

**Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Marine Corps Systems Command**

OBJECTIVE: To design and develop a prototype uninterruptable power supply. The result would be an improved power distribution panel that will provide the capability to manually switch between two ac sources, to the HMMWV dc battery/alternator or other dc sources. This would be accomplished with no interruption in the AN/MRC-142 communication system operation.

PROJECT SUMMARIES

SUMMARY: The research project tasks can be summarized as follows: 1) analyze and study the current existing AN/MRC-142 power distribution panel; 2) design and develop an uninterruptable power supply that will convert the selected ac source to 28v dc according to specifications, respond to monitor signals and initiate or terminate HMMWV charging, manual override switch for selection between either ac generator, automate switching between either generator and the HMMWV batteries, display panel for monitoring of the UPS operations, and protect against overvoltage of the ac generators; 3) modify the existing PDP to accommodate the above design within the same panel; and 4) complete implementation and testing of the developed UPS according to the enclosed specifications.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: AN/MRC-142 Marine Communication System, Uninterruptable Power Supply, Computer Modeling

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: To study the space radiation effects on state-of-the-art solar cells, including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells and develop radiation hardened analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating the new laser annealing technique on GaAs and InP solar cells, and irradiating solar cells using the NPS Linear Accelerator and measuring their characteristics using the newly developed Solar Simulator facilities. Other tasks are to investigate radiation effects on different electronic devices and radiation testing of analog VLSI chips previously designed and fabricated using the NPS Linear Accelerator. Major research thrusts: annealing of radiation-damaged solar cells, investigating of laser annealing techniques for radiation damaged solar cells, and radiation tolerant ASIC and analog IC design, implementation, and testing.

PUBLICATION:

Pieper, R. and Michael, S., "Using PSPICE to Model the Cooling Performance of Convection Surfaces," *Proceedings of the 30th Southeastern Symposium on System Theory*, Morgantown, WV, pp. 85-90, March 1998.

THESIS DIRECTED:

Wilbur, M.J., "The VLSI Implementation of a GIC Switched Capacitor Filter," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Environmental Effects)

KEYWORDS: Space Radiation Effects, Satellites, Annealing, Radiation Hardened, Computer Modeling

PROJECT SUMMARIES

ENHANCED ELECTRO-MAGNETIC (EM) RADIATION SOURCE IMAGING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVE: This continuing research seeks to develop enhanced back-propagation algorithms for improved imaging of radiation sources using near-field measured data. Important technical issues involve discovery and development of the most useful technique for implementation with measured data. The form of this transformation is an issue, with integral equation and differential equation (e.g., finite element) based approaches possible, as well as hybrid methods. On-surface descriptions of signature sources can include physical currents or, more generally, equivalent currents (useful for apertures and volume sources such as penetrable composite materials). Algorithm robustness is an important consideration for real-world operation. Error propagation to source images induced by noise and inaccuracies in acquired data requires detailed quantification. A technique is currently being explored which uses wavelet basis decomposition of image data coupled with singular-value decomposition for adaptive inversion.

SUMMARY: This effort supports future ship survivability by furthering the evolution of measurement procedures and data processing for ship EM signature characterization. Accurate localization and identification of radiation sources from both scattering (RCS) and emitters is essential for their mitigation in the design, construction and maintenance of future low-observable platforms operating in an increasingly sophisticated enemy sensor environment.

PUBLICATION:

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 3, Office of Naval Research, Code 334, September 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Imaging, Back-Propagation, Diffraction Limit

IMPULSE ANTENNA MODELING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The goal of this task is to investigate the impulse radiation characteristics of specified antenna structures.

SUMMARY: Initial wire-grid numerical modeling of antenna structures has been completed using frequency-stepping. Impulse source modeling has been approached independently from both frequency- and time-domains to form Thevenin equivalent circuits for impulsive sources. Responses from these distinct source models have been shown to agree. Impulse response characterization of antenna structures is accomplished via inverse transformation of an equivalent circuit.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Impulse Response, Antenna Modeling

PROJECT SUMMARIES

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: The goal of this project was to perform engineering design for efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

SUMMARY: A Method-of-Moments numerical model was developed as an aid to search for optimum geometrical dimensions and resistive tapers to achieve the challenging 10 MHz operation criterion, given the antenna size constraint. Several prototype TEM horns were modeled and performance evaluations conducted. Design specifications were provided to the Army Research Lab for fabrication and testing.

THESIS DIRECTED:

Adamiak, D.V., "Transient Field Visualization for Ultra-Wideband Antenna Design," Master's Thesis, December 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-Wideband, Impulse Antennas, TEM Horns

WIDEBAND LOW-PROFILE COMMUNICATION ANTENNA DESIGN

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Research Office

OBJECTIVE: A finite element algorithm was developed for use in designing omnidirectional wideband VHF communication antennas having low-drag blister type profiles for use on helicopters.

SUMMARY: An analysis tool has been created for use in the design of efficient wideband VHF omnidirectional antennas for employment on Army helicopters. Dielectric loading can be used to optimize impedance matching and antenna pattern over a desired range of frequency. Tapered feed and flare sections, without dielectric loading, provide impedance matching over ultra-wide bandwidths. The finite-element solution uses the coupled-azimuthal potential field formulation with mesh termination by the field-feedback technique. This software tool allows designers to optimize performance while constraining the antenna's physical profile through use of inhomogeneous lossy dielectric loading.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Wideband, Finite Elements, Antenna Design

IMPROVEMENT IN ANTI-SHIP CRUISE MISSILE (ASCM) THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The first continuing objective is to develop signal processing routines to improve effectiveness calculations (miss distance) for ship board self-defense systems against incoming anti-ship cruise missiles (ASCM) using hardware-in-the-loop (HIL) simulators. A second continuing objective is to support N91's ASCM Simulator Validation Working Group

PROJECT SUMMARIES

with the development of software routines that automatically extract Electronic Warfare Integrated Reprogrammable Database (EWIRDB) parameters from simulator characterization data obtained in the Naval Research Laboratory (NRL) Central Target Simulator (CTS) anechoic chamber facility.

SUMMARY: A centralized time-space-position information (TSPI) architecture that integrates real-time INS, GPS, and targeting data from captive-carry missile seekers has been developed and the software delivered (Centralized TSPI Software Version 1.0). In this architecture, the local sensors onboard the captive-carry aircraft transmit all recorded data to a centralized algorithm for absolute targeting. Geodetic displays on a Mercator projection provide a complete pictorial presentation of the field test experiment using only the sensors onboard the captive-carry aircraft. That is, the processing is independent of any external range sensors, thereby ensuring all target platforms may participate in the testing without having to contribute positional information to the absolute targeting algorithms. To help support N91's ASCM simulator validation effort, software to extract EWIRDB parameters from the simulator's CTS characterization data was delivered (Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) Version 3.0).

PUBLICATIONS:

Pace, P.E., Nishimura, B.H., Morris, W.M., and Surratt, R.E., "Effectiveness Calculations in Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 34, No. 1, pp. 124-136, January 1998.

Pace, H. and Pace, P.E., "Frequency Management for the 21st Century," *Journal of Electronic Defense*, Vol. 21, No. 1, pp. 21-25, January 1998.

Pace, P.E. and Burton, G.D., "Anti-Ship Cruise Missiles: Technology, Simulation and Ship Self-Defense," *Journal of Electronic Defense*, Vol. 21, No. 11, pp. 51-56, November 1998.

CONFERENCE PRESENTATIONS:

Pace, P.E. and Burton, G.D., "Automatic Extraction of EWIRDB Parameters from Threat Missile Simulators," 66th Military Operations Research Society Symposium, Monterey, CA, 25 June 1998.

Pace, P.E. and Nash, M.D., "A Novel Independent Sensor Fusion Algorithm for Time-Space-Position Information in Captive-Carry Missile Simulator Experiments," 66th Military Operations Research Society Symposium, Monterey, CA, 25 June 1998.

THESES DIRECTED:

Burton, G.D., "Automatic Extraction of Threat Simulator Critical Parameters Version 3.0 (U)," Master's Thesis, Naval Postgraduate School, September 1998.

Nash, M.D., "A Centralized Time-Space-Position Information Architecture for Absolute Targeting in HIL Captive-Carry Missile Simulator Experiments (U)," Master's Thesis, Naval Postgraduate School, September 1998.

Goncalves, W.A., "Computer Modeling of Captive-Carry Missile Simulator Experiments," Master's Thesis, Naval Postgraduate School, September 1998.

OTHER:

Pace, P.E. and Nash, M.D., "Centralized TSPI Software Version 1.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 28 August 1998.

PROJECT SUMMARIES

Pace, P.E. and Burton, G.D., "Automatic Extraction of Threat Simulator Critical Parameters Software Version 3.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 28 August 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Modeling and Simulation

KEYWORDS: Time-Space-Position Information, Captive-Carry, Sensor Fusion, EWIRDB, Hardware-in-the-Loop, Missile Simulation, Effectiveness Calculations

DIGITAL TARGET IMAGING ARCHITECTURES

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Research Laboratory and Naval Postgraduate School

OBJECTIVE: The investigation into the development and testing of several digital target imaging architectures and devices to generate realistic 2.5 ft resolution SAR, ISAR and HRR radar returns is carried out.

SUMMARY: The architectures generate complex imaging and profiling radar returns utilizing modern digital and Digital RF Memory (DRFM) technology. Modeling and simulation techniques were used first to define the required performance parameters and expected imaging results. Using the results of the study, the best architecture was selected and a prototype FPGA was constructed using a NRL 10K50 GPIOP card in order to demonstrate the concept and quantify the amount of resources required for image generation.

CONFERENCE PRESENTATION:

Pace, P.E. and Yeo, S-Y., "Pipelined Digital Image Synthesizers," Technology Cooperation Program, Technical Panel 3 - EW Systems, Naval Postgraduate School, 3 September 1998.

THESIS DIRECTED:

Yeo, S-Y., "A Digital Image Synthesizer for ISAR Counter-Targeting," Master's Thesis, Naval Postgraduate School, September 1998.

PATENT:

Pace, P.E., Surratt, R.E., and Yeo, S-Y., "Radar Image Synthesizer Architecture," Patent Disclosure NC 79,429.

OTHER:

Pace, P.E. and Yeo, S.-Y., "Image Synthesizer Prototype FPGA Design Software Version 1.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 3 September 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Digital RF Memories, FPGA, ISAR, Counter-Targeting

PROJECT SUMMARIES

EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAY

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force

OBJECTIVE: To theoretically and experimentally investigate direction finding antenna architectures employing symmetrical number system encoding techniques to provide instantaneous angle of arrival estimates over a wide field of view and wide frequency range.

SUMMARY: A new interferometer direction finding (DF) array architecture based on the optimum symmetrical number system (OSNS) has been examined. OSNS arrays are capable of unambiguous high resolution DF over a wide bandwidth and field of view with as few as three elements, with multiple baseline options. OSNS Acoustic arrays were also investigated as well as symmetrical number system ADC architectures. A three-element DF array was designed, fabricated and tested at 8.5 GHz to verify the OSNS antenna concepts experimentally.

PUBLICATIONS:

Pace, P.E., Styer, D., and Akin, I.A., "A Folding ADC Employing a Robust Symmetrical Number System with Gray-Code Properties," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, TPA14-7, 1 June 1998.

Pace, P.E., Styer, D., and Ringer, W.P., "Optimum SNS-to-Binary Conversion Algorithm and FPGA Realization," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, TAA14-11, 1 June 1998.

Jenn, D.C. and Pace, P.E., "Symmetrical Number System Phase Sampled Interferometer Direction Finding Antennas," Naval Postgraduate School Technical Report, NPS-EC-98-003, 20 February 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "Symmetrical Number System Phase Sampled DF Antenna Architectures," *Proceedings of the IEEE Antennas and Propagation Society International Symposium*, Atlanta, GA, 21 June 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "High Resolution Wideband Direction Finding Arrays Based on Optimum Symmetrical Number System Encoding," *IEEE Electronics Letters*, Vol. 34, pp. 1062-1064, June 1998.

CONFERENCE PRESENTATIONS:

Pace, P.E., Styer, D., and Akin, I.A., "A Folding ADC Employing a Robust Symmetrical Number System with Gray-Code Properties," IEEE International Symposium on Circuits and Systems, Monterey, CA, TPA14-7, 1 June 1998.

Pace, P.E., Styer, D., and Ringer, W.P., "Optimum SNS-to-Binary Conversion Algorithm and FPGA Realization," IEEE International Symposium on Circuits and Systems, Monterey, CA, TAA14-11, 1 June 1998.

Jenn, D., Pace, P.E., and Powers, J.P., "High-Resolution Acoustic Arrays Using Optimum Symmetrical-Number-System Processing," 24th International Symposium on Acoustical Imaging, Santa Barbara, CA, 23 September 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "Symmetrical Number System Phase Sampled DF Antenna Architectures," IEEE Antennas and Propagation Society International Symposium, Atlanta, GA, 21 June 1998.

THESIS DIRECTED:

PROJECT SUMMARIES

Hatziathanasiou, T.N., "Optimum Symmetrical Number System Phase Sampled Direction Finding Antenna Architectures," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Symmetrical Number Systems, Phase Sampling Interferometer Arrays, Direction Finding Antennas

METHODS FOR PERFORMANCE ANALYSIS OF HEAT DISSIPATING STRUCTURES

Ron J. Pieper, Visiting Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: Apply techniques based on electrical engineering principles to problems of transient and static heat flow in structures designed for heat dissipation.

SUMMARY: Studies were conducted in three areas: 1) An approximate method of analysis of double stack cold plates based on an assumption that an adiabatic point exists along the structure was proposed, 2) A more general method of analysis of double stack cold plates, which covers all regimes of operation, was developed, and 3) A demonstration that the electronic simulation package PSPICE can be employed to study cold plate structures was reported. In the latter case heat dissipating structures, which would not be, solvable analytically, can be performance evaluated using the methods discussed. This is part of an ongoing effort.

PUBLICATIONS:

Pieper, R.J. and Kraus, A.D., "Design and Analysis of Double Stack Cold Plates Covering All Conditions of Asymmetric Heat Loading," *American Association of Mechanical Engineers (ASME) Journal of Electronic Packaging*, Vol. 120, pp. 296-301, September 1998.

Pieper, R.J. and Kraus, A.D., "Cold Plates with Asymmetric Heat Loading," *International Journal of Microelectronics Packaging*, Vol. 1, pp. 115-129, 1998.

Pieper, R.J. and Michael, S., "Using PSpice to Model the Cooling Performance of Convective Surfaces," *Proceedings of the 30th Southeastern Symposium on System Theory*, pp. 85-89, March 1998.

CONFERENCE PRESENTATION:

Pieper, R.J. and Michael, S., "Using PSpice to Model the Cooling Performance of Convective Surfaces," 30th Southeastern Symposium on System Theory, Morgantown, WV, 11-13 March 1998.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Electronics

KEYWORDS: Electronics, Fin Structures, Modeling

PROJECT SUMMARIES

PHOTONIC SAMPLING ARCHITECTURES FOR MICROWAVE SIGNAL COLLECTION AND ANALYSIS

John P. Powers, Professor

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: This project continues the investigation into photonic sampling of wideband signals using mode-locked lasers and examines the subsequent process of analog-to-digital conversion. It continues an experimental evaluation of an optical sampling fiber laser. Also investigated is the development of optical signal processing architectures for oversampling sigma-delta modulation in order to relax the laser's jitter and optical pulsewidth requirements.

SUMMARY: This research involved the construction of a low-power, sigma mode-locked fiber laser for possible use on mobile signal collection platforms. Measurements were made and algorithms developed in order to quantify the performance characteristics that are important for direct sampling of wideband antenna signals. These include low frequency and high frequency pulse-to-pulse time uncertainty (temporal jitter), amplitude uncertainty (amplitude jitter), pulse repetition frequency, and pulsewidth. The fiber laser demonstrated a PRF of 16 GHz, pulsewidth of 7.2 ps, amplitude noise less than 1%, time jitter of 386 fs and the ability to be harmonically mode-locked at twice the modulation frequency using only 200 mW of diode pump power in the optical amplifier. Also, a novel fiber lattice accumulator design for integrated optical digital antenna technology has been designed. The fiber lattice design uses phase modulation to produce the proper interference between the input optical pulse and the recirculating optical pulse in order that they may be coherently combined. In this manner, the accumulation takes into account the sign of the sampled bipolar antenna signal. The fiber lattice performance has been numerically evaluated within a first-order optical digital antenna phase coherent simulation. The error in antenna performance for several input signals has also been quantified.

PUBLICATIONS:

Butler, J.M., Pace, P.E., and Powers, J.P., "Experimental Results of a Low-Power Sigma Mode-Locked Fiber Laser for Applications in Mobile Sampling of Wideband Antenna Signals," *Proceedings of the 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, to be published 16 February 1999.

Pace, P.E., Bewley, S.A., and Powers, J.P., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," *Proceedings of the 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, to be published 16 February 1999.

Pace, P.E. and Powers, J.P., "Photonic Sampling of RF and Microwave Signals," Naval Postgraduate School Technical Report, NPS-EC-98-009, 16 March 1998.

CONFERENCE PRESENTATIONS:

Butler, J.M., Pace, P.E., and Powers, J.P., "Experimental Results of a Low-Power Sigma Mode-Locked Fiber Laser for Applications in Mobile Sampling of Wideband Antenna Signals," 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Santa Barbara, CA, 18 February 1999.

Pace, P.E., Bewley, S.A., and Powers, J.P., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Santa Barbara, CA, 19 February 1999.

THESES DIRECTED:

Butler, J.M., "Construction and Measurement of an Actively Mode-Locked Sigma Laser," Master's Thesis, Naval Postgraduate School, June 1998.

PROJECT SUMMARIES

Bewley, S.A., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Other (Optics)

KEYWORDS: Mode-Locked Fiber Lasers, Wideband Signal Sampling, Optical Sigma Delta, Fiber Lattice Architectures

AIRPLATFORM SURVIVABILITY ENHANCEMENT

R. Clark Robertson, Professor

Frederick Levien, Senior Lecturer

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Aircraft Division

OBJECTIVE: The objectives for this project are to evaluate the effectiveness of combining countermeasures with low-observable technology, both in the RF and IR domain, to evaluate the effectiveness of an IR-TALD in enhancing air platform survivability, and to investigate the GITSIMS and MOSAIC programs' individual ability to model IR tactical engagement scenarios.

SUMMARY: It is well known through both simulation and field tests that IR flare countermeasures can be effective in reducing the vulnerability of aircraft to incoming IR missile seekers. Smart missiles employing sophisticated CCM (counter-countermeasure) tracking algorithms can reduce or even eliminate the flare's effectiveness. Nonetheless, another gambit for the aircraft designer is the employment of designs which would either reduce IR signature or redistribute the power in the IR signature to make the aircraft less vulnerable. This parametric study demonstrates the level of synergism between the employment of both decoy flares and the employment of stealthy IR reduction methods. The effects of IR signature reduction for a large number of one-on-one simulation engagements using MOSAIC have been completed. Preliminary results indicate that IR signature reduction does not significantly increase the effectiveness of IR flares.

CONFERENCE PRESENTATIONS:

Copeland, B., Pieper, R., Robertson, C., Levien, F., and Buczynski, P., "IR-Signature Dependent Effectiveness of Flare Countermeasures," to be presented at the Advanced Technology Electronic Defense Systems (ATEDS) 1999 Symposium, Monterey, CA, 16-18 March 1999.

Alvarado, L., Robertson, C., and Levien, F., "A Methodology for Conducting a Cost Effectiveness Analysis Study of the Integration of Low Observables and Electronic Warfare in Air Vehicle Design," to be presented at the Advanced Technology Electronic Defense Systems (ATEDS) 1999 Symposium, Monterey, CA, 16-18 March 1999.

THESIS DIRECTED:

Alvarado, O.L., "Determination of a Methodology for Conducting a Cost Effectiveness Analysis Study of the Integration of Low Observables (LO) in Electronic Warfare (EW) in Air Vehicles (AV) Design," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY: Electronic Warfare

KEYWORDS: Electronic Countermeasures, IR Countermeasures, Low-Observable Technology

PROJECT SUMMARIES

FAST FREQUENCY-HOPPED DIGITAL COMMUNICATION

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to determine the electronic counter-countermeasures (ECCM) potential of fast frequency-hopped (FFH), noncoherent M-ary frequency-shift keyed (MFSK) and FFH differential phase-shift keyed (DPSK) communication systems over super high frequency (SHF) and extremely high frequency (EHF) satellite communication links under conditions of worst case hostile electronic countermeasures (ECM) and fading channels.

SUMMARY: The performance degradation resulting from both partial-band barrage noise interference and multi-tone interference of orthogonal, noncoherent frequency-hopped, M-ary frequency-shift keyed receivers (FH/MFSK) was investigated. Extension of the results to FH/DPSK was trivial. The effect of thermal and other wideband noise was not neglected. Furthermore, the channel was modeled as a Ricean fading channel, and both the information signal and the interference signal were assumed to be affected by channel fading. Both band and independent multitone interference were considered. Performance was evaluated by obtaining a union bound on the probability of bit error, and receiver performance was compared with exact results for band multitone interference of a noncoherent FH/MFSK receiver under comparable circumstances. Except for the case of Rayleigh fading of the signal, the union bound was very tight for those cases that can be compared with exact results. The advantages of the union bound approach were twofold. First, the union bound approach yielded a solution that is far less computationally intensive than that obtained with the exact approach. Second, the union bound approach allowed numerical results to be obtained for interference conditions that were not amenable to exact analysis, such as independent multitone interference of FH/MFSK. When rate convolutional coding with Viterbi was used, contrary to conventional wisdom, performance was superior with hard decision decoding as opposed to soft decision decoding when partial-band noise jamming was present.

PUBLICATION:

Tedesso, T.W. and Robertson, R.C., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding in the Presence of Partial-Band Noise Jamming," *Proceedings of the IEEE Military Communications Conference*, Vol. 2, pp. 484-488, 1998.

CONFERENCE PRESENTATION:

Tedesso, T.W. and Robertson, R.C., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding in the Presence of Partial-Band Noise Jamming," 1998 IEEE Military Communications Conference, Boston, MA, 18-21 October 1998.

THESIS DIRECTED:

Tedesso, T.W., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding and Soft Detection Viterbi Detection Over a Ricean Fading Channel with Partial-Band Noise Jamming," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Spread Spectrum, Frequency-Hopping, Partial-Band Jamming

PROJECT SUMMARIES

GEOLOCATION IMPROVEMENTS AT LOW LATITUDES

Rasler W. Smith, Research Assistant Professor

Richard W. Adler, Research Associate Professor

Gus K. Lott, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To determine temporal and spatial extent of ionospherically induced radiowave scintillation in the equatorial region and ascertain the deleterious effects of the scintillation on geolocation.

SUMMARY: The experiment observed equatorial-region ionosphere total electron content (TEC) derived from Global Positioning System (GPS) signals using receivers on Oahu, Christmas Island, and Rarotonga. VHF transequatorial propagation from Hawaii to Rarotonga was simultaneously measured. Analysis showed that a moving second moment of vertical-equivalent TEC strongly correlates to each VHF transequatorial radio propagation event. The research also develops equations that show the potential errors in time, frequency, and angle used in geopositioning solutions.

PUBLICATION:

Smith, R.W., Adler, R.W., and Lott, G.K., "Scintillation Prediction and Geolocation at Low Latitudes," Naval Postgraduate School Technical Report, NPS-EC-98-007, March 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Geolocation, Scintillation

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

Department of Electrical and Computer Engineering

Sponsor: Advanced Maritime Projects Office

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and related processing, time-domain analysis, and data fusion for Beartrap post-mission analysis.

SUMMARY: The system is being developed based on commercial off the shelf technology: PentiumPro-based PC with Windows NT operating system. The user interface is being developed using Microsoft Visual C++; all processing algorithms are being coded in the C++ language as well.

During 1998, several new user interface screens have been designed. Software for reading data from analog tape has been completed and interfaced to the hardware. An algorithm for expanding narrowband lines and viewing these with high resolution was implemented and a set of various graphical analysis tools and views were implemented and brought into the system. Work on the target tracker continued and is near completion.

THESES DIRECTED:

Kohl, C.A., "Development of a Narrowband Zoom Processing Capability Using Commercial Processors," Master's Thesis, Naval Postgraduate School, June 1998.

Minyard, J.D., "Development of Analysis Tools and Incorporation of Commercial Digital Signal Processors in a Signal Analysis Graphical User Interface," Master's Thesis, Naval Postgraduate School, June 1998.

PROJECT SUMMARIES

OTHER:

The research is producing software for delivery to the sponsor. A pre-beta version of the software has already been delivered. A demonstration of the current software was conducted at the November 1998 meeting of the Beartrap mission specialists.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Other (Signal Processing)

KEYWORDS: Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

MULTI-SENSOR DATA FUSION FOR THE VESSEL TRAFFIC SERVICES SYSTEM

Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Coast Guard

OBJECTIVE: To develop data fusion algorithms based on fuzzy association techniques for use in the USCG vessel traffic system upgrade project.

SUMMARY: Vessel Traffic System (VTS) receives data from multiple sensors of different types: multiples radars, differential global positioning system based ADS receivers, acoustic sensors, and synthetically generated standard routes. Multiple sensors tracking the same target generate a large amount of redundant data. Here we have developed a data association algorithm based on fuzzy clustering-mean approach to fuse data from multiple sensors. The algorithm is being tested using field-recorded data (from Puget Sound, WA).

PUBLICATIONS:

Aziz, A., Tummala, M., and Cristi, R., "A Time Series of Decisions Approach in Detection Systems," *Proceedings of 32nd Asilomar Conference on Signals, Systems, and Computers*, 1-4 November 1998.

Aziz, A., Tummala, M., and Cristi, R., "Fuzzy Logic Data Association Approach in Multisensor Multitarget Data Fusion," *Proceedings of IASTED International Conference on Signal and Image Processing*, 28-31 October 1998.

Midwood, S., Glenn, I., and Tummala, M., "Multisensor Data Fusion Algorithm for the USCG's Vessel Traffic Services," *Proceedings of 1998 IEEE International Conference on Circuits and Systems*, June 1998.

Aziz, A., Tummala, M., and Cristi, R., "Fuzzy Logic Data Correlation Approach in Multisensor-Multitarget Tracking Systems," accepted for publication, *Journal of Signal Processing*, July 1999.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors

KEYWORDS: Data Fusion, Fuzzy Logic, Multiple Sensors

PROJECT SUMMARIES

PHASE ADJUSTMENT CONTROL FOR LORAN-C APPLICATIONS

Murali Tummala, Professor

Roberto Cristi, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

OBJECTIVE: To develop algorithms for estimation and control of time difference error in LORAN-C receivers to replace the existing CALOC system.

SUMMARY: This work is part of Coast Guard's Loran-C re-engineering effort, both transmitter and receiver units. A stochastic model has been investigated, which accommodates short term (on the order of seconds) as well as long-term (on the order of hours) influences of disturbances. A multiresolution Kalman filter algorithm will be used to evaluate the effectiveness of the model.

PUBLICATION:

Cristi, R., Tummala, M., and France, F.M., "Algorithms for LORAN-C Time Difference Error Minimization," Naval Postgraduate School Technical Report, NPS-EC-98-002, January 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Time Difference Error, Stochastic Model, Kalman Filter

TRAFFIC CHARACTERIZATION AND SCHEDULING ISSUES IN MULTIMEDIA WIRELESS NETWORKS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To develop traffic models for multimedia information and algorithms for scheduling of such traffic over wireless networks.

SUMMARY: In this effort, we developed traffic models for low bit rate video. Also extensively studied the scheduling of multimedia traffic cells over a wireless ATM network. This work is of interest to Code D8805, Communications and Information Systems Department, SPAWAR Systems Center, San Diego.

PUBLICATION:

Parker, R.E. and Tummala, M., "Modeling of H.263 Encoded Low-Bit-Rate Video Traffic for Tactical Video Conferencing Applications," *Proceedings of 32nd Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, 1-4 November 1998.

DISSERTATION DIRECTED:

Uziel, A., "Channel Allocation in Wireless Integrated Services Networks for Low-Bit-Rate Applications," Doctor of Philosophy Dissertation, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Wireless Communication Networks, Asynchronous Transfer Mode, Integrated Services Digital Networks, Video Traffic, Video Teleconferencing

PROJECT SUMMARIES

RELOCATABLE REGIONAL SATELLITE-BASED TACTICAL MOBILE TELEPHONE NETWORK

Don Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Space Command

OBJECTIVE: Provide planning/decision guidance for meeting future tactical, assured-access, narrowband communications surge requirements in regional operations. The proposed system(s) would supplement the very limited surge capacity of existing/planned assets based on fixed-location satellite constellations (e.g., UFO, DSCS, Milstar). This is a continuing project.

SUMMARY: This is an interim report since this project will not be completed until 30 June 1999 when the students involved in the research have completed their thesis research. Studies are being conducted in several areas: 1) mobile user requirements definition, 2) large antenna design, 3) waveform, 4) link budget, and 5) on-orbit thruster design. Part of the research is classified at the TS/SCI level and cannot be included here.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MILSATCOM, Mobile Satellite Service (MSS), Surge

SINGLE EVENT UPSET (SEU) IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford, Assistant Professor
Douglas Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To harden digital gallium arsenide (GaAs) integrated circuits to space radiation by re-engineering the initial semiconductor wafer.

SUMMARY: The program has developed GaAs semiconductor wafers, which provide radiation hardness to single event upsets (or soft errors), induced by cosmic radiation. A buried low temperature grown Gallium Arsenide (LT GaAs) buffer layer epitaxy is grown on a GaAs wafer. The wafer is substituted in commercial GaAs foundries to provide radiation hardened integrated circuits. The buffer layer increases recombination to eliminated excess carriers produced from ionizing radiation. The last year of this program has investigated improving the stability of the LT GaAs buffer layer for semiconductor manufacturing, and performing radiation experiments. Work in 1998 improved performance of the Motorola GaAs process by 20%, and showed that processing temperatures up to 700°C can be tolerated without compromising transistor parameters.

PUBLICATION:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," *Proceedings of the 1998 EIA/IEEE GaAs Reliability Workshop*, Atlanta, GA, November 1998.

CONFERENCE PRESENTATION:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M.,

PROJECT SUMMARIES

Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," 1998 EIA/IEEE GaAs Reliability Workshop, Atlanta, GA, November 1998.

THESES DIRECTED:

Devers, J., "Frequency Dependence of Single Event Upsets in Gallium Arsenide Metal Semiconductor Field Effect Transistors," Master's Thesis, Naval Postgraduate School, June 1998.

Mason, C., "Characterization of Heterojunction Insulated Gate Field Effect Transistors," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Materials, Processes, and Structures, Manufacturing Science and Technology, Modeling and Simulation

KEYWORDS: Gallium Arsenide, Radiation Effects, Semiconductors

**RADIATION HARDNESS ANALYSIS OF InP AND SiGe
TECHNOLOGIES FOR SPACE APPLICATIONS
Todd Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force**

OBJECTIVE: To investigate the radiation hardness of InP and SiGe state-of-the-art electronic technologies for use in military space environments.

SUMMARY: Experiments utilized femto-second lasers with photo-conductive sampling probes to measure the first recorded radiation induced in-situ voltage transients internal to an integrated circuit operating at 10 GHz. Facilities at the University of Michigan's Center of Ultrafast Science were utilized for the laser experiments and computer modeling of the underlying charge transport mechanisms were performed at NPS. The 1998 research examined studied the Hughes Research Laboratories InP-based Heterojunction bipolar processes. Test structures in IBM's SiGe process were designed and fabricated and are to be tested in 1999.

PUBLICATIONS:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," *Proceedings of the 1998 EIA/IEEE GaAs Reliability Workshop*, Atlanta, GA, November 1998.

David, G., Yun, T., Crites, M., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "Absolute Potential Measurements Inside Microwave Digital ICs Using a Micromachined Photoconductive Sampling Probe," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 46, No. 12, December 1998.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., Yun, T., Crites, M., Meyer, S., Bustamante, M., Thomas, S., III, and Elliott, K., "Measurements of Laser Induced SEE Voltage Transients in InP HBT Logic," *Proceedings of the 11th Annual Single Event Effects Symposium*, Manhattan Beach, CA, 23 April 1998.

David, G., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "DC-to-mm-Wave Absolute Potential Measurements Inside Digital Microwave ICs Using a Micromachined Photoconductive Sampling Probe," *IEEE MTT-S International Microwave Symposium Digest 1998*, New York: IEEE, pp. 1333-1336, 1998.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," 1998 EIA/IEEE GaAs Reliability Workshop, Atlanta, GA, November 1998.

David, G., Yun, T., Crites, M., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "Absolute Potential Measurements Inside Microwave Digital ICs Using a Micromachined Photconductive Sampling Probe," IEEE International Symposium on Microwave Technology, Baltimore, MD, June 1998.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., Yun, T., Crites, M., Meyer, S., Bustamante, M., Thomas, S., III, and Elliott, K., "Measurements of Laser Induced SEE Voltage Transients in InP HBT Logic," 11th Annual Single Event Effects Symposium, Los Angeles, CA, April 1998.

THESES DIRECTED:

Cochran, F., "Single Event Analysis of AlInAs/GaInAs/InP Heterojunction Bipolar Transistors," Master's Thesis, Naval Postgraduate School, June 1998.

Mayfield, T., "Characterization of InGaAs/AlInAs Heterojunction Bipolar Transistors," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures, Modeling and Simulation

KEYWORDS: Radiation Effects, Indium Phosphide, Gallium Arsenide

TIME RESOLVED SINGLE EVENT EFFECT STUDIES IN SILICON ON INSULATOR (SOI)

Todd Weatherford, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Air Force Research Laboratory

OBJECTIVE: To measure single event transients in very high speed digital circuits fabricated with silicon on insulator (SOI) technologies with ion and laser facilities. The picosecond transients will be compared to circuit and device simulations.

SUMMARY: The program will start to examining SOI circuits fabricated in MIT Lincoln Laboratory's 0.25 um and 0.11 um semiconductor process in early 1999. We expect to expand these measurements to SPAWAR's SOI process. Circuits provided by MIT/LL with additional circuits designed by NPS will be studied at two facilities: a) University of Michigan's Center for Ultrafast Science utilizing their in-situ photoconductive probe and lasers and b) the Sandia Microbeam facility for examine heavy ion induced transients. Both facilities can ionize charge in sub-micron diameter tracks by utilizing < 5 um optical fibers or ion beams with apertures < 3 um. The purpose is to determine the similarities and differences for using a laser to simulate heavy ion induced transients, and also to determine if the external measurement capabilities of the Sandia system are as accurate in comparison to the Michigan system. Students will assist in modeling the mechanisms for these transients in Technology Computer Aided Design (TCAD) and in performing the experiments.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Space Vehicles

KEYWORDS: Silicon-On-Insulator, Single Event Upsets, Picosecond Transients

PROJECT SUMMARIES

LOW-BAND HARM ASSESSMENTS AND EVALUATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: To provide initial analysis and assessments of low-band HARM Guidance System architectures and designs and enabling technologies and products.

SUMMARY: The HARM missile guidance section provides basic band HARM system concept is a next step in the evolution of HARM missile development. At low frequencies, unique and application specific signals and potential unintentional signals exist, which have not been exploited for HARM applications. The HARM missile can be improved by exploiting these new signal opportunities.

DoD KEY TECHNOLOGY AREAS: Sensors, Missiles, Guidance, Targeting

KEYWORDS: Guidance System, RF Receiver, Video Processor, Signal Extraction, Parameter Extraction, Low-Band, Antenna

ECONOMICAL SAR/ISAR SYSTEM DEVELOPMENT FOR UNMANNED AERIAL VEHICLE (UAV) APPLICATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop new innovative and economical SAR/ISAR techniques for potential UAV applications. Emphasis is on using new SAR/ISAR waveforms and new concept SAR/ISAR processing techniques.

SUMMARY: SAR/ISAR sensors are key surveillance and targeting assets for Navy airborne missions. High resolution and high fidelity SAR images are required to meet surveillance and target detection requirements. Without these long-range SAR sensors, our key warfare information and military response capabilities are severely restricted for modern warfare scenarios and even peacetime missions.

The proposed Virtual-Aperture MTI/SAR/ISAR concept provides SAR surface target mapping, ISAR ship-target detected moving targets on SAR maps. This new SAR concept uses economical COTS products for generating moderate instantaneous bandwidth waveforms, digital sampling with low-speed A/D converters and signal processing with relatively low-speed DSPs.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Radar, Surveillance, Targeting)

KEYWORDS: SAR, ISAR, DSP, Hopped-Frequency, Chirped, MTI, Virtual Aperture Processing

WIRELESS DAMAGE CONTROL COMPUTER NETWORKS

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To investigate the feasibility of deploying a wireless computer network aboard submarines for damage control communications.

PROJECT SUMMARIES

SUMMARY: The effect of a mostly metallic submarine environment on wireless communications and mitigating methods were examined. The overall requirements and specifications for a submarine wireless network were derived. These requirements were then matched against capabilities of existing commercial products in the mobile computing and wireless networking industries. A proof of concept system was developed and evaluated in both laboratory and submarine environments. Testing results demonstrated that a low-cost, high-performance wireless local area network for use in submarines was achievable using existing technologies.

THESIS DIRECTED:

Debus, S.M., "Feasibility Analysis for a Submarine Wireless Computer Network Using Commercial-Off-the-Shelf Components," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Damage Control, Wireless Computer Networks

ACCURATE CONTROL OF MANIPULATORS USING INERTIAL SENSORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Science Foundation

OBJECTIVE: To investigate control and coordination of robot manipulators using inertial sensors.

SUMMARY: A small INS/GPS navigation system (SANS) was developed and tested. It consisted of a low-cost small-size inertial measurement unit (IMU), a DGPS, and TCM-2 digital compass. Data were collected and processed by an AMD 586DX133 based PC/104 computer. Estimation software was based on an asynchronous Kalman filter. This sensor system and a Zebra-Zero 6-DOF manipulator were mounted on a moving platform. Testing results demonstrated that the manipulator mounted on a moving platform was able to compensate for random platform motions and successfully perform various manipulation tasks.

PUBLICATION:

Yun, X., Hernandez, G.C., Bachmann, E.R., McGhee, R.B., and Healey, A., "An Integrated GPS/INS Navigation System for Small AUVs Using an Asynchronous Kalman Filter," *Proceedings of 1998 IEEE Symposium on Autonomous Underwater Vehicle Technology (AUV '98)*, Draper Laboratory, Cambridge, MA, 20-21 August 1998.

THESES DIRECTED:

Raphael, R.A., "Robotic Manipulation on a Moving Platform Utilizing Force Sensing and Sonar Ranging," Master's Thesis, Naval Postgraduate School, March 1998.

Hernandez, G.C., "An Integrated GPS/INS Navigation System for Small AUVs Using an Asynchronous Kalman Filter," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: INS, GPS, AUV, Navigation, Kalman Filter

PROJECT SUMMARIES

TRACTION CONTROL OF AUTONOMOUS ALL-TERRAIN ROBOTIC VEHICLES

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this project is to investigate traction control of the Shepherd mobile robot.

SUMMARY: Shepherd is a four-wheel-drive and four-wheel-steer autonomous ground vehicle developed at NPS for land mine search purposes. When the vehicle travels on off-road surfaces, its traction can be improved by monitoring the percentage of slip of each wheel and by actively adjusting driving torques distributed to four wheels. This project studied estimation methods for determining the amount of wheel slip and active traction control algorithms for improving the vehicle's maneuverability on rough terrains. A traction control algorithm was developed for intelligently distributing driving torques among different wheels of a robotic vehicle based on the amount of wheel slip. A comprehensive simulation study on the effectiveness of the traction control algorithm was conducted. An inertial navigation system was integrated and tested on the Shepherd mobile robot.

PUBLICATIONS:

Sarkar, N. and Yun, X., "Traction Control of Wheeled Vehicles Using Dynamic Feedback Approach," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '98)*, pp. 413-418, Victoria, Canada, 13-17 October 1998.

Yun, X., Latt, K., and Glennon, J.S., "Mobile Robot Localization Using the Hough Transform and Neural Network," *Proceedings of the 1998 IEEE ISIC/CIRA/ISAS Joint Conference on the Science and Technology of Intelligent Systems*, pp. 393-400, Gaithersburg, MD, 14-17 September 1998.

CONFERENCE PRESENTATION:

Yun, X., "Mobile Robot Localization Using the Hough Transform and Neural Network," 1998 IEEE ISIC/CIRA/ISAS Joint Conference on the Science and Technology of Intelligent Systems, Gaithersburg, MD, 14-17 September 1998.

THESES DIRECTED:

Leonardy, T., "Implementation and Evaluation of an INS System for the Shepherd Rotary Vehicle," Master's Thesis, Naval Postgraduate School, December 1997.

Glennon, J.S., "Feature-Based Localization of Mobile Robots Through Hough Transform and Unsupervised Learning Network," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Other (Robotic Technology)

KEYWORDS: Traction Control, Autonomous Vehicles