MASTER OF SCIENCE
IN
ELECTRICAL ENGINEERING

TRANSIENT LOCALIZATION IN SHALLOW WATER ENVIRONMENTS

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In this work, the robustness of a simple, Bartlett-type processor based on matching broadband signal autocorrelation functions is investigated. Measures of robustness to be examined include the size of the localization footprint on the ambiguity surface and the peak-to-sidelobe levels in the presence of environmental mismatch and noise. A full-wave PE model is used to produce broadband replicas. Both model-generated synthetic signals, which provide baseline results, and measured pulses in a shallow water environment are analyzed.

This work suggests that environmental mismatch has a more significant effect on the localization performance than noise. It also suggests that, as long as the noise level is not higher than the signal level, the localization performance will not be significantly affected. This is to be expected, since for white noise the majority of the influence on the autocorrelation function occurs at zero lag which has been removed in the localization algorithms. It is also shown that the autocorrelation matching in the time-domain is generally more useful for smaller bandwidths at low frequencies, which has been observed in previous work, whereas the autocorrelation matching in the frequency-domain is better suited for larger bandwidths and higher frequencies.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Autocorrelation Matching, Transient Localization, Shallow Water

SINGLE-FREQUENCY MEASUREMENTS USING UNDERSAMPLING METHODS

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The objective of this study is to verify the Symmetrical Number System (SNS) undersampling receiver architecture using software and to investigate implementation issues using digital signal processing (DSP) hardware. In the software design, a MATLAB program is written to determine a single sinusoidal input frequency using this receiver architecture. Each channel of the SNS undersampling receiver consists of a low speed ADC, a discrete Fourier transform followed by a constant threshold device to detect the signal's frequency bin. The detected frequency bins are then recombined in an SNS-to-decimal algorithm to recover the frequency of the signal. Error rate performance in a Gaussian noise environment at the input stage is evaluated. In the hardware design, a sinusoidal waveform is digitized, discrete Fourier transformed and

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converted from the SNS format to a decimal value using a single channel digital signal processor. Implementation difficulties and design issues are discussed.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Symmetrical Number System, Symmetrical Folding, Undersampling, Discrete Fourier Transform

ANALYSIS OF REAL TIME EMITTER LOCATION ALGORITHMS FOR TACTICAL ELECTRONIC WARFARE AIRCRAFT

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Geographic location of radar emitters is the process of estimating an emitter's location upon the surface of the earth from direction of arrival (DOA) data for the targeted emitter. The current Emitter Location (EMLOC) algorithm utilized by the Grumman EA-6B Prowler is based on a thesis presented by Mr. Richard Opperman in June 1982. With the advent of increased processing demands on the AN/AYK-14 Tactical Computer as part of recent software upgrades to the AN/ALQ-99 Tactical Jamming System, it was hoped that a Kalman Filter, or Extended Kalman Filter based algorithm, would reduce the processing time and memory requirements for the EMLOC algorithm. This thesis compares the current algorithm and the Kalman/Extended Kalman Filters in a tactical scenario to determine if a change in the current Onboard Flight Program (OFP) should be recommended.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Kalman Filter, Extended Kalman Filter, Location Algorithm

PERFORMANCE ANALYSIS OF DIFFERENTIAL PHASE SHIFT KEYED SIGNALS WITH SELECTION COMBINING AND CONVOLUTIONAL CODING IN FADING CHANNEL

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The performance analysis of a differential phase shift keyed (DPSK) communications system, operating in a Rayleigh fading environment, employing convolutional coding and diversity processing is presented. The receiver is the conventional square-law DPSK receiver using soft-decision convolutional decoding. The computationally efficient union bound technique is utilized to evaluate the system performance.

The coded and uncoded system performances of various diversity combining techniques are evaluated and compared. The combining techniques considered include equal gain combining (EGC), selection combining (SC), and a generalization of SC, whereby two or three signals with the two or three largest amplitudes are noncoherently combined. This generalized method is called second or third order SC and denoted as SC2 or SC3, respectively. Numerical results indicate that coded systems with SC2 and SC3 techniques significantly enhance the bit-error rate (BER) performance relative to that achievable with SC.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Diversity, Convolutional Coding, Decision Decoding, Rayleigh Fading, Numerical Analysis

ROBOTIC MANIPULATION ON A MOVING PLATFORM UTILIZING FORCE SENSING AND SONAR RANGING

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Robotic manipulators are widely used in industry where the environment may be too hostile for workers. However, their application has been limited to an industrial setting where the robot is mounted on a stationary base. It is of great interest to expand the application of the robot manipulator to where it is mounted on an autonomous delivery vehicle. This application would enable the delivery vehicle not only to locate objects in a hostile environment, but also to perform tasks that would entirely remove the human being from the hostile environment. This thesis explores the feasibility of implementing a manipulator on an autonomous vehicle. A Zebra-ZERO Force Control Robot is mounted on a moving platform for feasibility simulations of an autonomous delivery vehicle. The Zebra-ZERO system consists primarily of a robotic arm with six degrees of freedom, a six-axis force sensor mounted at the end of the manipulator, and supporting computer hardware and software. In this thesis, the capability of the Zebra-ZERO system is expanded by integrating it with an external sonar ranging system. The sonar ranging system provides range feedback that is critical for positioning the manipulator while it is mounted on a moving platform. Test results demonstrate that the manipulator mounted on a moving platform is able to compensate for random platform motions and successfully perform various manipulation tasks.

DoD KEY TECHNOLOGY AREA: (Other Robotics)

KEYWORDS: Control, Zebra-ZERO, Force Sensor, Sonar Ranging, Robot Manipulator

THEATER BALLISTIC MISSILE DEFENSE–MULTISENSOR FUSION, TARGETING, AND TRACKING TECHNIQUES

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The Gulf War illustrated how important ballistic missile defenses have become to the United States. The study of intercepting Theatre Ballistic Missiles (TBMs) in their boost phase was prompted by concerns about the widespread dissemination of submunitions and the differentiation of decoys from actual warheads released early in the missile's midcourse flight. Boost Phase Intercept (BPI) would alleviate this problem by destroying the enemy's ballistic missile in the missile's launch phase, thereby causing the lethal payload and debris from the engagement to fall back on the aggressor. This thesis focuses on the development of missile tracking algorithms to be used in the boost phase of TBMs. A missile encounters significant changes in velocity, acceleration, and direction during the boost phase, making it difficult to track. Extended Kalman filter (EKF), Alpha-Beta-Gamma filter, and Interacting Multiple Model (IMM) filtering techniques are developed to determine the missile tracking accuracy of TBMs during boost phase. Simulation results and actual TBM profiles from test data are presented to verify the tracking accuracy utilizing different filtering techniques.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Kalman Filter, Alpha-Beta-Gamma Filter, Interacting Multiple Models, Theater Ballistic Missile Defense

PERFORMANCE ANALYSIS OF A SLOW FREQUENCY HOPPED, NONCOHERENT BINARY FREQUENCY-SHIFT KEYING COMMUNICATION SYSTEM WITH RATE 1/2 CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DETECTION OVER A RICEAN FADING CHANNEL WITH PARTIAL-BAND NOISE JAMMING

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A performance analysis of a slow frequency-hopped, noncoherent binary frequency-shift keying (SFH/NCBFSK) communication system with rate 1/2 convolutional coding and soft decision Viterbi detection in the presence of partial-band noise jamming is performed. The effect of additive white Gaussian noise is also considered. The analysis is performed for both a non-fading channel and a Ricean fading channel. The system's performance is severely degraded by partial-band noise jamming. By way of comparison the analysis is also performed when the system utilizes hard decision Viterbi detection and for a system utilizing noise-normalized combining with soft decision Viterbi detection. In both cases a significant increase in the system's immunity to the effects of partial-band noise jamming is achieved.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Spread Spectrum Communications, Digital Communications, Partial-band Jamming, Fading Channel, Frequency-Hopped Spread Spectrum Communications

INTEGRATION OF MARTES AND PAT CRYPTOLOGIC TOOLKITS FOR THE INFORMATION WARRIOR

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A number of Cryptologic tools have been created over the past two decades to assist in national intelligence gathering tasks. Among the current tools being used to aid NSA Cryptologic efforts are the MARTES and PAT software programs. This thesis will begin by discussing a need for such software tools in the world today. After examining the MARTES and PAT software toolkits to understand exactly how they perform their respective Cryptologic functions, detailed examples of MARTES and PAT processing and analysis will follow, showing the effectiveness of each program. The final discussion will examine why MARTES should integrate the PAT program into its available toolkits. Logistic and operational issues associated with such an integration will also be explored before recommending future areas of study.

KEYWORDS: MARTES, PAT, TINKERTOY, SIGINT, Cryptology, National Security Agency

DoD KEY TECHNOLOGY AREA: Other (lnformation Operations)

THE VLSI IMPLEMENTATION OF A GENERALIZED IMMITTANCE CONVERTER SWITCHED CAPACITOR FILTER

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In this research, the design and VLSI implementation of a digitally programmable active analog filter, based on the Generalized Immittance Converter (GIC) circuit, are presented. The programmable features include the filter type (band-pass, high-pass, low-pass or notch), the center or cut-off frequency, and the quality factor. Switched capacitor networks are used to implement resistances. The design was first simulated and then implemented on a wire-wrap board and tested. The circuit was then modeled and re-simulated using the Cadence Design Tools software package. Once the modeled circuit passes all design rule checks the final chip design was then submitted for fabrication. This research project will help provide a knowledge base for using Cadence software for VLSI CMOS design. Once the chip has been fabricated and tested it will provide a base for further development of stray insensitive VLSI design of analog circuits.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Switched Capacitor, Generalized Immittance Converter, VLSI, Cadence

RADAR CROSS SECTION REDUCTION: GEOMETRIC CONTROL OF DISCONTINUITIES USING SERRATED EDGES

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The objective of this thesis is to investigate and evaluate the effectiveness of radar cross section (RCS) reduction by means of the geometric control of discontinuities using serrated edges. Although the use of serrated edges for RCS reduction can be clearly seen on stealth aircraft such as the Northrop B-2, and was mentioned in several papers and references, not much data on the reduction magnitude, the associated geometry, or the design methodology are available in the open literature. Parameters of interest include the number of basic serration cells (triangles) required per wavelength, and the aspect ratio of the triangles that form the zig zags. An infinitely thin metallic plate is considered for the analysis. The RCS of such a plate with serrated edges is computed and compared against the RCS of a plate of the same sized without serrated edges. The infinitely thin assumption is valid if the wing of the aircraft, which is represented by the plate, is thin compared to the wavelength. The results obtained show significant reduction in RCS.

KEYWORDS: Radar Cross Section, Edge Diffraction, Method of Moments

DoD KEY TECHNOLOGY AREA: Electronics