MASTER OF SCIENCE
IN
APPLIED MATHEMATICS

LOSSLESS COMPRESSION USING BINARY NECKLACE CLASSES AND MULTIPLE HUFFMAN TREES

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In this thesis, we present two lossless compression approaches. Our Rotational Tree Approach (RTA) is based upon mathematics developed by Fredricksen. RTA uses the rotations associated with binary necklace classes to disperse source bit strings to a forest of Huffman encoding trees. Our Indexed Tree Approach (ITA) also uses a Huffman forest, but disperses bit strings via a simpler mechanism based upon the first few bits of each string. For text compression, we find RTA to be competitive with standard Huffman encoding while ITA is generally superior by a small margin of 1% – 3%. Both approaches owe their (limited) success to decreased modeling overhead as compared to standard Huffman encoding. Compression results against the Canterbury Corpus test suit and complete Java implementation code are included as appendices.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Lossless Data Compression, Discrete Mathematics, Analysis of Algorithms, Huffman coding, Rotational Tree, Index Tree

FINITE ELEMENT MODELING OF THE RAH-66 COMANCHE HELICOPTER TAILCONE SECTION USING PATRAN AND DYTRAN

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The United States Army contracted Boeing-Sikorsky to develop the RAH-66 Comanche, a new, armed reconnaissance helicopter that features stealth technology designed to improve survivability when operating in hostile environments. Ballistic testing is required on any new technology, to include the Comanche, prior to fielding. Computer-based simulations are being employed to reduce the requirements for expensive live fire testing. This thesis uses computer programs called PATRAN and DYTRAN from MSC Software Corporation to build the model and simulate the effects of an explosive round detonating in the Comanche tailcone section. This thesis describes in great detail the process of creating and modifying the model in PATRAN to most accurately depict the Comanche tailcone section and creating the input decks for DYTRAN to run the analysis. A test case involving an explosion with a high amount of explosive energy, or specific internal energy (SIE) was simulated. From this test, several results are shown to display

the capabilities of DYTRAN. These results, when compared with live fire data, can be used to validate the computer-based simulation in order to reduce the requirements of expensive live fire testing.

DoD KEY TECHNOLOGY AREA: Air Vehicles, Computing and Software, Materials, Processes, and Structures, Modeling and Simulation

KEYWORDS: Comanche, Ballistic Modeling, PATRAN, DYTRAN, Tailcone

A COMPREHENSIVE STATISTICAL ANALYSIS OF SUBSTANCE ABUSE PATTERNS AND TRENDS WITHIN THE UNITED STATES ARMY

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The United States Army's Center for Substance Abuse Programs relies on a broad based approach to combat substance abuse. Certain factors, however, have been associated with a soldier's involvement with substance abuse. They include age, race, gender, military occupation specialty, and rank.

A statistical analysis of recent drug and alcohol use/abuse patterns would permit the Army to target services and programs toward those most at risk for developing substance abuse related problems. Additionally, a model that could profile the typical enrollee into the Army's Substance Abuse Program, ASAP, would be a valuable predictive mechanism for future abuse trends within the Army.

This study supports the United States Army's Center for Substance Abuse Programs' efforts to improve the identification of those most at risk for substance abuse. This study provides a detailed statistical analysis on current substance abuse patterns within the United States Army and civilian society, and presents a mathematical model of ASAP enrollments.

DoD KEY TECHNOLOGY AREAS: Biomedical, Manpower, Personnel, and Training

KEYWORDS: Substance Abuse, Alcoholism, Drug Abuse, DUI, DWI, United States Army, Cluster Analysis, Time Series

ATTRACTOR BASINS OF VARIOUS ROOT-FINDING METHODS

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Real world phenomena commonly exhibit nonlinear relationships, complex geometry, and intricate processes. Analytic or exact solution methods only address a minor class of such phenomena. Consequently, numerical approximation methods, such as root-finding methods, can be used.

The goal is, by making use of a variety of root-finding methods (Newton-Rhapson, Chebyshev, Halley and Laguerre), to gain a qualitative appreciation on how various root-finding methods address many prevailing real-world concerns, to include, how are suitable approximation methods determined; when do root finding methods converge; and how long for convergence?

Answers to the questions were gained through examining the basins of attraction of the root-finding methods. Different methods generate different basins of attraction. In the end, each method appears to have its own advantages and disadvantages.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Basin of Attraction, Numerical Methods, Complex Polynomials

MAGNETIC FIELD ESTIMATION USING OPTIMAL LOCATIONS OF NEAR FIELD SENSORS

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The objective of this thesis is to theoretically investigate optimal placement of magnetic field sensors near the surface of a submarine in order to predict the magnetic field at a greater distance and reduce error in off board field predictions.

A steel spheroidal shell of uniform thickness with a distribution of magnetic dipoles on the center axis is used to model a submarine. The dipoles inside the shell and induced magnetization in the material of the shell both contribute to the magnetic fields everywhere in space. Computer simulations are preformed in two stages using Matlab programming. The first stage is to compute the magnetic fields using spherical harmonic expansions in each of the three regions. The expansion coefficients are found by enforcing continuity of the tangential fields and normal flux density at the inner and outer boundaries of the shell. The second stage of the simulation adds noise to the computed vector fields at the hypothetical sensors located just outside the shell and uses the noisy "measured" fields to estimate the expansion coefficients in the exterior region. The estimated coefficients are used to construct a predicted field at larger distances from the shell. Accuracy of this method is evaluated by comparison of the predicted and original computed fields.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles – Ships and Watercraft, Modeling and Simulation

KEYWORDS: Magnetic Signature, Spheroidal Magnetic Shell, Optimal Field Estimation