General Research Topic Areas

Data Base Technology

- Data Warehousing
- XML Applications
- Information Retrieval
- Data Mining
- Knowledge Management
- Agent Technology

Other Computer Engineering

- Real Time Simulation
- Object-Oriented Design and Programming (w/Java & C++)
- Real Time Embedded Systems
- High Speed Data Stream Encoding

Signal processing

- DSP programming
- Reduced Rank Beamforming methods
- Efficient Beamforming implementation
- Unique signal vector beamforming concepts
- Transducer Array design and signal processing (beamforming/spatial filtering)
- Image Processing and analysis
- Computer aided detection and classification
- Three dimensional, volumetric image data processing and visualization
- Gradient-sensing techniques with large-array beam processing
- Multi-hypothesis Bayesian tracking and classification
- Adaptive signal processing
- Seismo-acoustic based detection and classification

Statistics

- Probability distribution function (PDF) estimation
- Decision methodologies

Materials and Transducer design

- Highly absorptive Material Design and measurement/analysis of acoustic properties (shear and compressional phase velocities, absorption, etc.)
- Micromachined (MEMS) capacitive acoustic transducer design and analysis
- Advanced 1-3 composite piezoelectric acoustic transducer design, fabrication, and analysis

Unmanned/autonomous vehicles

- Single and Coordinated Small AUV controls
- Small AUV Hydrodynamic simulation and experimental analysis
- Maneuvering and Sensing With Small UUV Vehicles
- Autonomous Surface Craft Systems Engineering

Acoustics and propagation modeling

- Physical models of bottom reverberation: both low and high frequency
- Integral equation methods for solving non-separable problems in acoustics
- Inversion methods applied to acoustics and other areas
- Adiabatic, coupled, and PE modeling techniques
- Elastic (high & low ka) target responses
- Finite Element Acoustic/Elastic Simulation
- HF sonar performance prediction modeling efforts, including propagation model upgrades and specific sonar implementation simulation
- Thermo-acoustics
- Sonolysogenesis
- Acoustic condition based maintenance/non-destructive test & evaluation
- Seismo-acoustic propagation

Electromagnetics

- Precise geolocation and atmospheric/ionospheric physics
- Radio Frequency Computer Communications and Networking
- Radio Frequency Interference Mitigation
- Multi-spectral Imaging Techniques and Image Processing
- Laser-based 3-D Surface Mapping

Specific Project Examples

1. Physical models of bottom reverberation: Construction of underlying scattering theory and inverse problem. Ph.D. level (physics, ME, maybe EE)
2. Integral equation methods for solving non-separable problems in acoustics. Ph.D level (EE, physics, maybe ME, Mathematics)
3. Extensions to Mineray III for predicting performance of HF signal processing algorithms (adaptive null steering, monopulse processing, computer aided detection),. MS level (ME, EE or Physics).
4. Investigating adiabatic, coupled, and PE modeling techniques with the objective of developing a coupled-mode approach that would maintain the efficiency of adiabatic but include a significant portion of the coupling effects, MS and PhD level (ME, EE).
5. Imaging at close range, for assistance with robotic manipulator arms in turbid water, using sonar frequencies rivaling those of medical ultrasound. MS and PhD level (ME or EE).
6. Launch & recovery of a small UUV with a large UUV, including small vehicle vectoring to a target by a larger system, small vehicle maneuvering about a target for close range sensing, and small vehicle rendezvous with large vehicle. MS level (ME, or EE).
7. Develop and refine techniques used in the classification of unknown contacts based on uncertain, undersampled, and/or parametrically sensitive inputs. Current algorithms are based on conditioned likelihood statistics, although there is the potential to explore alternate techniques such as fuzzy logic or genetic algorithms. MS and PhD level, (EE, Mathematics, Physics).
8. Development of methods for real time acoustic geolocations of pulse train events in the presence of ocean surface noise at moderate to high sea states. MS level (Physics, Mathematics, EE).
9. Development of algorithms for synthesis of high density laser profiling data and development of 3-D rendering models (fly-over simulations). MS level (Mathematics, CS, ME, or EE).
10. Extensions of terminal area optical processing for automated image analysis and multi-spectral image fusion. MS level (Physics, EE).
11. Analysis and investigations into hydrodynamics and advanced hull designs for autonomous surface craft to support development of high survivability sensor platforms for extended unattended use. MS level (ME, Physics).

Detailed Project descriptions with identified Campus co-advisors

1. Acoustic scattering by a sandy seabed: surface roughness effects

ARL: Nicholas P. Chotiros, Faculty: Mark Hamilton

The scattering of sound by the seabed is an interesting theoretical challenge and it has numerous applications in acoustical oceanography. There are a number of existing models for the scattering of sound in water by rough surfaces. In all cases, the medium beneath the surface is assumed to be either a fluid or an elastic solid. The seabed, particularly sand, is not an elastic solid, but a porous medium, with rather unique properties. The objective of this project is to formulate and solve the problem of sound scattering from a sandy seabed, using a model of sound propagation that is appropriate for a porous medium, and one or more methods for solving the scattering integral for a rough surface. ARL, in collaboration with UT faculty, have successfully completed a number of projects in related areas.

2. Acoustic scattering by a sandy seabed: granularity effects

ARL: Nicholas P. Chotiros, Faculty: Mark Hamilton

Sandy sediments are very common in coastal areas of the world's oceans, and the interaction of sound with the sediment is an important area of research. Current models attempt to represent the acoustic properties of the sand bed in terms of an equivalent elastic solid medium. Recent research results have shown this to be an invalid approach. It is hypothesized that the granularity of the sand is an important scattering mechanism. The modeling of the scattering process is the objective of this project. ARL, in collaboration with faculty, have developed a 1-D model of the scattering process, which may serve as a useful starting point.

3. Analysis of acoustic penetration by coherent signal processing

ARL: Nicholas P. Chotiros, Faculty: (Elmer Hixson)

Sound penetration into ocean sediments is an important issue for the detection of buried objects by sonar in coastal waters. ARL is currently participating with other university and naval laboratories to study the physics of sound penetration and scattering in ocean sediments, in an ongoing program of analysis and at-sea measurements. A large amount of acoustic data has been accumulated from recent experiments. The data analysis may answer a number of important questions concerning the penetration of sound. The objective of this project is to apply coherent signal analysis methods to the data to determine the acoustic properties of the sediment as it affects sound penetration. ARL has strong track record in sound propagation measurement and analysis.