Do There Exist Non-Sinusoidal, Shape Preserving, Closed Form, Time-Domain Solutions to Lossy, Frequency-Dependent Parameter Wave Equations

Friday, January 27, 2006 4:00 p.m.

Professor Robert Flake
Department of Electrical and Computer Engineering, The University of Texas at Austin
http://www.ece.utexas.edu

To paraphrase Walker Tire Company: If we find them, they exist and we have them. You are invited to come see some found. Experiments conducted during the seminar will demonstrate, with live measurements, the remarkable shape preserving nature of these non-sinusoidal signals while propagating on a 100-meter long RG 58/U coaxial cable. Similar non-sinusoidal shape preserving (or plane wave) solutions exist for lossy acoustical propagation. Examples include: sound traveling in a viscous medium, or sound propagating in a chemical reacting fluid composed of two or more constituents (such as sea water). Several examples of these lossy plane-wave acoustical propagation solutions will be discussed.

Noise of Fan-Cooled Devices

Friday, February 3, 2006 4:00 p.m.

David A. Nelson, INCE Bd. Cert., P.E.
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Fan-cooled devices are ubiquitous in present-day technology and are widely recognized by the general public as a source of objectionable noise. In spite of this, product design approaches have typically treated fans as low-brow commodity items. The sometimes unpleasant acoustic consequences of this approach were usually discovered very late (too late) in the process. But as microprocessor designs run hotter in smaller packages, and as consumers get more finicky about noisy products, these design practices are no longer tenable. Engineering information about fan noise is currently being developed and adapted to allow designers to adequately anticipate noise in early design stages. This presentation will cover the basics of fan aerodynamic performance, fan noise, and their respective relationships to fundamental design parameters.

Numerical Simulation of Multi-Dimensional Acoustic Propagation in Air Including Effects of Molecular Relaxation

Friday, February 10, 2006 4:00 p.m.

Mark Wochner
Applied Research Laboratories, The University of Texas at Austin
http://www.arlut.utexas.edu

A computational acoustic propagation model based upon the Navier-Stokes equations was developed that is able to simulate the effects of absorption and dispersion due to shear viscosity, bulk viscosity, thermal conductivity, and molecular relaxation of diatomic nitrogen and oxygen. To solve this equation set, a weighted essentially non-oscillatory (WENO) scheme is used which allows for highly accurate solutions in smooth regions and stable propagation of multi-dimensional shocks. Verifications are presented showing that the model produces accurate results for known solutions. Simulations of broadband full scale jet noise propagation are presented, and the results are compared to those obtained with a recently developed Burgers equation solution algorithm. The two models were used to propagate recorded scale-model data from one microphone location to another. The predictions by the two models are in excellent agreement with each other but their results do not match the recorded data. Possible causes of this discrepancy are discussed.

Numerical Simulation of Phase-Conjugated Nonlinear Acoustic Waves Propagating through Layered Elastic Media with Rough Surfaces

Friday, February 17, 2006 4:00 p.m.

Michael Stone
Department of Mechanical Engineering, The University of Texas at Austin
http://www.me.utexas.edu
and
Institut d' Electronique, de Microelectronique et de Nanotechnologies
Ecole Centrale de Lille, Villeneuve d' Acsq, France
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The seminar will begin with a brief introduction to the topic of wave phase conjugation, which for a single frequency is equivalent to time reversal. Next we describe a numerical investigation that was performed to explore the possibility of using wave phase conjugation to correct for phase aberrations in a nonlinear sound beam that propagates through an immersed elastic layer with rough surfaces. The numerical method is based on an angular spectrum approach that extends Fourier acoustics to nonlinear wave propagation problems. It accounts for mode conversion of longitudinal and transverse elastic waves at interfaces, and second-harmonic generation in both the fluid and the solid. The method includes the full effects of diffraction, not limited by the narrow beam (paraxial) approximation. Surface roughness at the liquid-solid interfaces is modeled with phase screens. Of interest is the ability of the conjugated beam to compensate for the phase aberrations and refocus to a small spot size for improved resolution in imaging. Effects of nonlinearity, and the size and shape of the phase screens, are examined numerically. Applications of this work are to nondestructive evaluation.

Solving Position Measurement Problems for Synthetic Aperture Sonar

Friday, February 24, 2006 4:00 p.m.

Dr. Terry L. Henderson
Applied Research Laboratories, The University of Texas at Austin
http://www.arlut.utexas.edu

The talk will describe problems encountered in conducting Synthetic Aperture Sonar experiments at Lake Travis, and their solutions. Synthetic Aperture Radar (SAR) systems have been in use since the 1960s. However, it has been considerably more difficult to develop Synthetic Aperture Sonar (SAS), even with roughly the same wavelengths and target sizes and reflection characteristics. The reason is that sound travels 200,000 times slower than RF, and by the time the echo returns the sonar sensors will have moved, and that motion is always a bit erratic, degrading the sonar image. Our efforts focused on using precision GPS measurements to resolve this problem as much as possible. After the basic principles of synthetic aperture imaging are described, the specific things we did to resolve the problems will be discussed. Particular attention will be given to using acoustics to survey the positions of the sensors to a degree of precision that would have been awkward to achieve any other way. Images of underwater structures at Lake Travis will be shown.

Bubble-Bubble and Bubble-Particle Interaction Dynamics in Cavitation Clusters Generated During Shock Wave Lithotripsy

Friday, March 24, 2006 4:00 p.m.

Todd Hay and Professor Mark Hamilton
Applied Research Laboratories, The University of Texas at Austin
http://www.arlut.utexas.edu

Bubbles are ubiquitous in liquids. While frequently imperceptible, they are manifest as impurities in all liquids, including blood and other bodily fluids. Bubbles thus provide nucleation sites for cavitation when subjected to the pressure variations in an intense sound wave. Focused shock waveforms used in lithotripsy have negative pressure tails that cause bubble nuclei in urine surrounding kidney stones to grow explosively from microns to millimeters in size. Upon collapse, the bubbles concentrate energy in the form of shock waves and jets that assist disintegration of the kidney stones. While large stones are fractured by internal stresses generated by shock waves that penetrate inside them, erosion by cavitation is required to ultimately disintegrate stones into particles sufficiently small that they can pass through the urinary tract. This seminar begins with an overview of shock wave lithotripsy. The focus of our research is development of theoretical models for the dynamics of bubbles interacting with one another and with solid particles after being subjected to intense acoustic waves and shocks. Animated simulations will be presented that illustrate clearly the growth, interaction, coalescence and collapse of bubbles in clusters, and which compare favorably with published high-speed photographs of these events. Also presented will be animated simulations of the interaction of a bubble with a particle in a sound field.

Variability of High-Frequency Seafloor Acoustic Backscattering Strength

Friday, March 31, 2006 4:00 p.m.

Dr. Nicholas P. Chotiros
Applied Research Laboratories, The University of Texas at Austin
http://www.arlut.utexas.edu

Bottom backscatter is often the dominant component of reverberation for sonars operating in the band from 10 to 500 kHz in littoral waters. In the frequency band chosen, the scatterers are mainly confined to the sediment layer, and many attempts have been made to model the problem. This band was also chosen for its relevance to mine-hunting sonars, and, for this reason, the emphasis will be on backscattering strength at shallow grazing angles. The problem may be analyzed at two levels. At the local level, it may be treated as a stationary random process. At the global level, it is a non-stationary problem in which there are variations in the underlying statistics. Analysis of the published measurements, supported by environmental data, provides an indication of the physical processes involved.

Dynamics of an Acoustically Driven Bubble Confined between Parallel Plates

Friday, April 21, 2006 4:00 p.m.

Jianying Cui and Theodore F. Argo IV
Department of Mechanical Engineering and Applied Research Laboratories,
The University of Texas at Austin
http://www.me.utexas.edu

The use of microbubbles as contrast agents in medical ultrasound imaging, their development for drug and gene delivery, and their role in shock wave lithotripsy all involve bubbles subjected to acoustic excitation in confined spaces, such as within blood vessels, and inside the kidney. Motivated by these applications and as a first step toward understanding the behavior of a fully confined bubble, we developed a model of a bubble between two infinite rigid parallel plates. The model yields analytical expressions for the frequency response of the bubble, including its resonance frequency and quality factor, as a function of plate separation distance. The importance of including liquid compressibility in the model will be discussed. For wide channels, approximate results will be presented that account for plates with finite acoustic impedance. Experimental measurements of the resonance frequency and quality factor of air bubbles suspended between two parallel stainless-steel plates will be presented. An acoustic spectral subtraction technique was used to isolate the bubble response from that of the experimental tank. The bubbles were independently sized using diffuse backlighting and video microscopy. These measurements will be compared to the idealized theoretical model and to numerical simulations of the experiment.

Experiments on the Mysteries of Dolphin Sonar

Friday, April 28, 2006 4:00 p.m.

Dr. Tom Muir
National Center for Physical Acoustics, University of Mississippi
http://www.olemiss.edu/depts/ncpa

The rich literature of high-resolution biosonar capability is baffling as to the cetacean species' attainable sonar resolution and beam-scanning dynamics. Simultaneous physical acoustics and psychometric measurements in San Diego Bay on two bottlenose dolphins and one beluga whale are reported. The results indicate that echolocation signals contain frequency components that can extend to the neighborhood of 500kHz, but their hearing capability extends to only 150kHz. Experiments were also conducted to determine if the animals were actually using these high frequency components in echolocation. Measurements with rho-c matched, acoustic, low pass filter panels, placed between the blindfolded subjects (on a bite bar) and their test targets, showed that as the detection tasks became more difficult, the animals increased the intensity of the high frequency content of their transmissions, and their pulse repetition frequencies also increased. Dolphins compensate for environmentally introduced inconvenience, dB for dB (source level and sampling rate versus frequency dependent impairment). Experiments on a free-swimming dolphin, echolocating under a simple "go" paradigm, were also conducted with a linear array of simultaneously and individually processed wideband hydrophones, arranged both vertically and horizontally, with simultaneous video observation. Beam pattern measurements were made on echolocation clicks as a function of time and frequency. The subject emitted echolocation clicks containing high frequency components (above 135kHz), in beams that narrowed with increasing frequency, ranging to only a few degrees, far beyond the subject's hearing range. An amazing observation of the simultaneous acoustic and video data is that the dolphins can steer their high resolution sonar beams without moving their heads.

MEMS-Based Acoustic Arrays: Promise and Challenges

Wednesday, August 23, 2006 4:00 p.m.

Professor M. Sheplak, Professor T. Nishida, and Professor L. N. Cattafesta
Interdisciplinary Microsystems Group, Department of Electrical and Computer Engineering and Department of Mechanical and Aerospace Engineering, University of Florida at Gainesville
http://www.img.ufl.edu

A review of micro-electromechanical system (MEMS)-based directional acoustic array technology is presented. The prospects for reducing cost, improving speed, and increasing mobility over conventional array technologies is critically reviewed. The advantages and limitations of existing devices are discussed. Finally, unresolved technical issues are summarized for future sensor development. A specific example of a system is presented that uses 16 hybrid-packaged silicon-micromachined piezoresistive microphones mounted to a printed-circuit-board and a high-speed signal processing system to generate the array response over 2400 scan locations in under 20 sec. The hybrid microphone packages show an average sensitivity of 0.8 mV/Pa with matched magnitude (+/- 0.6 dB) and phase (+/- 1 degree) responses between devices. The measured array response matches the theoretical response over the frequency range of 3 kHz to 8 kHz with a localization error of +/- 0.3 in. The array has a minimum

detectable signal of 43.5 dB SPL for a 1 Hz bin at 6 kHz and a maximum pressure input of at least 160 dB SPL. These results represent a proof-of-concept demonstration of a high speed, low cost directional acoustic array system.

Sensor Modeling

Friday, September 8, 2006 4:00 p.m.

Professor Elmer Hixson
Department of Electrical and Computer Engineering, The University of Texas at Austin
http://www.ece.utexas.edu

The seminar will start with a motivation for modeling sensors, and then some fundamentals of the kinds of sensors to be discussed will be presented. The analytical tools and the topology necessary to predict the sensor's properties are discussed. Stored energy (nonlinear) and linear types of energy conversion will be used in examples of motion sensors. Models will be presented and their responses calculated. It will be shown that mechanical impedance of the source is needed to make accurate “free” motion measurements. Conclusions will follow.

Integrated System for Ultrasonic, Elasticity and Photoacoustic Imaging

Friday, September 15, 2006 4:00 p.m.

Suhyun Park
Biomedical Engineering Department, Panscopic Imaging Laboratory, The University of Texas at Austin
http://www.bme.utexas.edu/research/pil

By integrating three complementary imaging techniques – ultrasound, elasticity and photoacoustic imaging, a hybrid imaging system is proposed for cancer detection, diagnosis and therapy monitoring. Indeed, simultaneous imaging of the anatomy (ultrasound imaging), changes in biomechanical properties (elasticity imaging) and cancer-induced angiogenesis (photoacoustic imaging) of tissue is based on many synergistic features of these modalities and may result in a unique and important imaging tool. In this paper, numerical simulations and experimental studies will be presented both to demonstrate the feasibility and to evaluate the performance of the combined array-based ultrasound, elasticity and photoacoustic imaging system. To estimate spatial resolution, a point source was imaged using ultrasound and photoacoustic imaging. Then, several tissue mimicking phantoms were examined using ultrasound, photoacoustic and elasticity imaging. In elasticity imaging, ultrasound frames were acquired during deformation of the tissue. To reduce the data acquisition time of the system, high frame rate imaging was used. High frame rate imaging is possible by transmitting the broader and less focused ultrasound beam but the image quality is sacrificed. Thus, we compared the quality of the high frame rate and conventional ultrasound images. In photoacoustic imaging, acoustic transients are generated simultaneously in the entire volume of the laser irradiated tissue. Hence, image formation (beamforming) algorithms were developed based on the characteristics of the photoacoustic signals. The results of the numerical analyses and experimental studies clearly indicate that combination of ultrasound, elasticity and photoacoustic imaging techniques complements each other and provides critical information needed for the reliable detection and diagnosis of the cancer.

Displacement of a Solid Sphere in a Viscoelastic Medium in Response to Acoustic Radiation Force: Theoretical Analysis and Experimental Verification

Friday, September 22, 2006 4:00 p.m.

Dr. Salavat Aglyamov
Biomedical Engineering Department, Panscopic Imaging Laboratory, The University of Texas at Austin
http://www.bme.utexas.edu/research/pil

The goal of this study was to investigate the dynamic behavior of a rigid sphere in viscoelastic medium when acoustic radiation force is applied. In theoretical model, equations describing the displacements of the object (Voigt model) were derived and solved using frequency domain formalism. To verify our theoretical model, the experiments were performed using the rigid spheres of various diameters and densities embedded into tissue-like gel-based phantoms of varying mechanical properties. A 1.5 MHz single-element focused transducer was used to apply the desired radiation force. Another single-element focused transducer operating at 25 MHz was used to track the displacements of the sphere. The results of this study demonstrate good agreement between theoretical predictions and experimental measurements. The developed theoretical model a can be used to evaluate mechanical properties of viscoelastic medium.

Pneumatically Isolated Inertia Base with Active Damping for a Transmission Electron Microscope

Friday, September 29, 2006 4:00 p.m.

Jack B. Evans, P.E.
JEAcoustics, Austin, Texas
http://www.jeacoustics.com

An expansion was planned to an existing scanning electron microscope (SEM) research suite that included installation of a transmission electron microscope (TEM). The TEM, which is rather tall and has a high center of gravity, is very sensitive to floor vibrations. A massive inertia base was designed to be supported on vibration isolators. Ground borne vibration measurements were conducted outside the building near the proposed site to characterize external vibration sources. Structure borne vibration was measured on the floor of the proposed TEM installation site to characterize building vibration sources. After comparisons with the TEM manufacturer's allowable vibration criteria, attenuation requirements were determined. Very low frequency transient disturbances due to truck and bus traffic on a nearby street presented significant challenges. It would be necessary to specify isolators capable of effective vibration isolation below 5 Hz, or with resonant frequency at 1 Hz or lower. Even in that low frequency range, a damping system was required that controlled potential resonance disturbances of the isolators. An active vibration cancellation system was selected to supplement the isolators. This case study presents the disturbing vibration sources, design of the actively-damped, pneumatic isolation system and post-installation vibration measurement results to validate performance. Vibration data will be presented in spectral analysis charts versus criteria. Drawings and photographs will illustrate the installation.

Advances on Borehole Acoustic Measurement

Friday, October 6, 2006 4:00 p.m.

Fernando Garcia-Osuna and Vivian Pistre
Schlumberger Corporation, Sugarland, Texas and Fuchinobe, Japan
http://www.slb.com

This talk describes the development and answer products of Schlumberger's latest wireline acoustic logging technology (Sonic Scanner TM). For decades, the oil and gas industry has used borehole acoustic measurements throughout the lifecycle of wells to evaluate rock properties in the near-wellbore region. However, unconsolidated formations, cemented casing, and large boreholes are, among other things, acoustic measurement barriers. In order to overcome such acoustic measurement barriers, Schlumberger has designed an innovative sonic logging tool using the latest acoustic technology for advanced acoustic acquisition, including borehole-compensated monopole with long and short spacings, cross-dipole, and cement bond quality measurements. The new Sonic Scanner tool has been developed with more transmitters (5) and receivers (104) than current generation tools. It provides the benefits of axial, azimuthal and radial information from both the monopole and the dipole measurements for near-wellbore and far-field slowness information. Its high quality waveforms and advanced processing techniques lead to robust estimates of compressional and shear slowness whilst their radial profiles offer enhanced anisotropy detection and mechanism identification, as well as reliable through-casing slowness measurements. When sonic measurements are used with other formation measurements, the knowledge gained may help to reduce overall drilling and completion costs while improving well productivity and ultimate recovery.

Development of Ultrasound Technique to Detect and Characterize Laser-Induced Microbubbles

Friday, October 20, 2006 4:00 p.m.

Dr. Andrei Karpiouk
Biomedical Engineering Department, Panscopic Imaging Laboratory, The University of Texas at Austin
http://www.bme.utexas.edu/research/pil

An ultrasound technique to assess the temporal and spatial behavior of a laser-induced cavitation bubble in liquid and tissue will be presented and discussed. The developed technique is based on passive detection of shock waves produced by the expanding and collapsing cavity, and active pulse-echo ultrasound sensing of the cavity or the gas bubble. This ultrasound technique is well suited to detect and characterize laser-induced cavitation bubbles formed, for example,during laser ablation of biological tissues. In addition, the technique can be used in clinical and biomedical applications of laser including ophthalmology, microsurgery, etc. The cavitation bubbles were created in water or tissue-mimicking gels using either nanosecond or femtosecond pulsed lasers. The laser-tissue interaction was monitored using an ultrasound system with a single element high-frequency focused transducer. The recorded ultrasound radio frequency signal from each laser pulse contained acoustic signatures corresponding to initial cavity formation, bubble collapse, and ultrasound pulse-echo signals from the cavity over time. Amplitude and temporal parameters of the signal were analyzed to measure bubble dynamics such as position, size, lifespan, etc. Furthermore, the experimental system and ultrasound measurements of the bubble size and

dynamics were verified against the Rayleigh model of cavity collapse. The results of our study strongly suggest that the ultrasound technique utilizing the passive and active acoustic signals from the cavitation bubble can be used to study physical mechanisms of interaction of focused laser pulses and tissue.

Nonlinear Acoustics, Jet Noise, and Nonlinearity Indicators

Friday, October 27, 2006 4:00 p.m.

Lauren Falco
Graduate Program in Acoustics, The Pennsylvania State University
http://www.acs.psu.edu

The approximations used in linear acoustics are appropriate for most acoustics applications, but when they no longer hold and nonlinear effects become significant, it is very important to account for nonlinearity in models, predictions, and analysis. In some applications, such as jet noise, it can be difficult to detect the presence of nonlinearity using traditional measurement and analysis techniques. Therefore, work has been done to develop a new indicator of nonlinearity for use in jet noise and other finite-amplitude applications. This talk provides an overview of the sources of nonlinearity and its primary effects for periodic waves and for noise, including wave steepening, shock formation, harmonic generation and nonlinear energy transfer.

A brief summary of the sources and characteristics of jet noise is followed by a discussion of the drawbacks of traditional methods of jet noise analysis. Finally, a quantity that serves as a single-point nonlinearity indicator is introduced. The physical significance and potential uses of the indicator are discussed, and some results of its application to laboratory measurements are presented.

Technology, Techniques, and Tips to Instrumenting Large Acoustic Arrays

Friday, November 3, 2006 4:00 p.m.

Chris DeFilippo
National Instruments, Austin, TX
http://www.ni.com

National Instruments has been involved in acoustic data acquisition for over 10 years. Over this span, NI has helped countless customers put together instrumentation systems for microphone arrays and we've picked up a few pointers along the way. Microphone arrays for noise mapping have been around for years but technical limitations and high cost have limited their applications. By selecting the right technologies, implementing the best techniques, and taking advantage of a few key tips, it is possible to architect a low-cost system with 100s of sensors to get the best spatial resolution out of an array. Some of the topics included are: XML data storage schemes, redundant arrays of inexpensive disks (RAID), gigabit Ethernet communication, PCI Express data transfer, and 24-bit sigma-delta ADCs. NI will also present a case study on the 600+ channel acoustic array that Boeing developed to identify noise sources on the 777 and the new 787 Dreamliner aircraft.

Foraging Flexibility in the Frog-Eating Bat, Trachops Cirrhosus

Friday, November 10, 2006 4:00 p.m.

Rachel A. Page and Professor Michael J. Ryan
Section of Integrative Biology, The University of Texas at Austin
http://www.biosci.utexas.edu/IB/Default.htm

The fringe-lipped bat, Trachops cirrhosus, feeds on frogs and uses frog advertisement calls to detect, identify, and localize its prey. Given acoustic cues alone, T. cirrhosus is able to discriminate between poisonous and palatable prey species. The auditory system of T. cirrhosus is highly modified for low-frequency hearing and may be specially adapted for frog call detection; however, T. cirrhosus is opportunistic in its acquisition of prey, and feeds on a wide variety of prey items. Given the foraging plasticity of this species, we hypothesized that the strong associations between acoustic stimulus and prey quality are largely learned and are flexible. We tested the ability of T. cirrhosus to reverse its response to the calls of a preferred prey species and a poisonous one. We found rapid reversal learning, supporting the hypothesis that rather than being fixed, this bats associations between prey cue and prey quality are highly flexible. We tested for the social transfer of a learned foraging preference, and found that novel foraging responses be rapidly transferred via social learning. These studies demonstrate a high degree of flexibility in bat foraging ability, and point to the role of learning in foraging success.

Tour of Acoustic Systems

Friday, November 20, 2006 4:00 p.m.

Mike Black
Acoustic Systems, Austin, Texas
http://www.ets-lindgren.com/page/?i=Acoustics

Acoustic Systems, located in Austin, Texas, has been designing, manufacturing, and installing acoustical products since 1971. While Acoustic Systems does offer standard products, our focus is on custom designs, manufactured per customer specifications. Acoustic Systems is staffed by highly qualified sales professionals who work in tandem with a team of talented designers to provide responsive customer support throughout the design, manufacture and installation phases of every project. The company operates a state-of-the-art manufacturing facility and a NVLAP (National Voluntary Laboratory Accreditation Program) certified laboratory for the measurement of acoustic transmission loss, absorption and noise reduction. The test facility is used for ongoing analysis and improvements to Acoustic Systems' products as well as independent testing for companies throughout the United States.