7th Mini-Conference of Acoustics (MCA)
11 May 2016
The Catholic University of America
Washington, DC

Washington DC Chapter of the
Acoustical Society of America

Program

6:00-6:40	Upload Presentations / Ice breaker
6:40-6:45	Welcome and introduction to the Washington DC Chapter of the Acoustical Society of America and the 7th Mini-Conference of Acoustics **Hubert Seth Hall (President, Washington DC Chapter of the ASA)**
6:45-7:00	Influence of short-time scale water column variability on high-frequency broadband acoustic beams***** **Justin Eickmeier and Mohsen Badiey**
7:00-7:15	Marine soundscape during a shallow-water seismic survey in the Arctic Ocean **Shane Guan and Joseph F. Vignola**
7:15-7:30	A method to measure in vivo bladder wall biomechanics through the addition of ultrasound to urodynamics***** **Anna S. Nagle, Adam P. Klausner, Jary Varghese, Andrew F. Colhoun, Paul H. Ratz, R. Wayne Barbee, Laura R. Carucci, and John E. Speich**
7:30-7:45	Effects of ultrasound in presence of microbubbles for cartilage tissue regeneration in 3D printed scaffolds***** **Mitra Aliabouzar, Kausik Sarkar, and Lijie Grace Zhang**
7:45-8:00	Analysis of the error sources of the two-microphone transfer function method for measuring absorption coefficient in the free field using numerical modeling **Hubert S. Hall, Joseph F. Vignola, John A. Judge, and Diego Turo**
8:00-8:15	Creating, directing and steering hot spots in wave intensity patterns Tim Poston and Raghu Raghavan
8:15-8:30	Listening for whales using the CTBT sensors***** David Lechner
8:30-8:45	Validation and optimization of 3D strain tracking by volumetric ultrasound image correlation in a pubovisceral muscle model***** Anna S. Nagle, Ashok R. Nageswaran, Jason K. Kleinhenz, Balakrishna Haridas, and T. Douglas Mast
8:45-9:00	Jet formation of contrast microbubbles in the vicinity of a vessel wall***** Nima Mobadersany and Kausik Sarkar

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***** Papers qualified for the Best Student Papers Competition

Abstracts

Influence of short-time scale water column variability on high-frequency broadband acoustic beams*

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Ocean processes with short-time scale variability in the water column influence broadband high-frequency acoustic wavefronts in shallow water. The water column in a recent experiment showed periodic short-time scale isotherm oscillations in depth. This dynamic behavior was significantly pronounced over a 2 hour period (between 70-90 m depth) during a 24 hour deployment. Over a range of 1 km, channel probing waveforms were sent between a stationary source (5 m above the seafloor) and a bottom mounted 8-element vertical hydrophone array. Delay-sum beamforming of measured impulse responses across all array elements and array steering with Gaussian weights revealed strong correlation between isotherm depth fluctuations and angular spread of direct path acoustic beam receptions. Inherently a 3-D problem, we consider a 2-D approach to show beam fluctuations as a function of the environment. 2-D PE modeling uses measured sound speed profiles to calculate the acoustic pressure field between source and receiver which is beamformed across a vertical array with minimal element spacing for data/model comparison. Over time, fluctuations in the intensity of acoustic beams, spatial path and angular spread of the direct path signal can be attributed to the vertical oscillations of isotherms in the water column. [Work Supported by ONR321]

Marine soundscape during a shallow-water seismic survey in the Arctic Ocean

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For noise generating activity that lasts for an extended period of time, an overall increase of noise levels and change of soundscape within a larger area (over tens of km^2) can be expected. This study analyzed the sound field characteristics during a shallow-water marine seismic survey in the Beaufort Sea of the Arctic Ocean. Three bottom mounted acoustic sensors were deployed in the survey area: two outside the barrier islands in water depths about 12m, and one inside the barrier islands in water depth of 2.8m. Averaged 1 min sound pressure levels (SPLs) in broadband, 100-500 Hz, 1-5 kHz, and above 10 kHz bands were computed for periods when airguns were active and inactive. The results showed an 8-dB increase during the period when airguns were active in the 100-500 Hz band for two locations outside the barrier islands. However, there was no noticeable difference in SPLs during periods airguns were active and inactive inside the barrier islands. This is probably due to higher natural ambient noise and low-frequency cut-off of airgun pulses in this extreme shallow location.

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A method to measure in vivo bladder wall biomechanics through the addition of ultrasound to urodynamics*

Anna S. Nagle, Adam P. Klausner, Jary Varghese, Andrew F. Colhoun, Paul H. Ratz, R. Wayne Barbee, Laura R. Carucci, and John E. Speich
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Objective: To develop a measurement method for bladder wall biomechanics by incorporating abdominal ultrasound imaging with urodynamics.
Methods: During a urodynamics procedure, an overactive bladder (OAB) patient underwent ultrasound imaging during filling at a rate of 10%capacity/minute. Ultrasound images were obtained using a 1-5 MHz abdominal probe to capture midsagittal and transverse images every 60s. Using image data and vesical pressure (Pves), detrusor wall tension, stress, and elastic modulus were calculated. Luminal and wall areas and inner perimeters were measured in each image. In the sagittal and transverse directions, wall tension was calculated as Pves*luminal area, wall stress as tension/wall area, and strain as the change in perimeter normalized to the perimeter at 10%capacity. Patient-reported fullness sensation was continuously recorded.
Results: During filling, Pves increased slightly, wall strain increased linearly, and wall tension, stress, elastic modulus, and sensation of bladder filling increased exponentially. This indicates that Pves measurements during urodynamics may not reflect the underlying state of detrusor wall tension, which better correlated with sensation.
Conclusions: This study demonstrates that detrusor wall tension, stress, strain, and elastic modulus can be calculated by adding ultrasound imaging to standard urodynamics. This technique may be useful in assessment of OAB and related disorders.

Effects of ultrasound in presence of microbubbles for cartilage tissue regeneration in 3D printed scaffolds*

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Gas-filled microbubbles encapsulated with lipids and other surfactants are highly responsive to ultrasound, which has led to their effective role as ultrasound contrast agents (UCA). In this study, for the first time, we used lipid-coated microbubbles (MB) prepared in-house in order to better harness the beneficial effects of ultrasound stimulation on proliferation and chondrogenic differentiation of human mesenchymal stem cells (MSCs) within a novel 3D printed poly (ethylene glycol) diacrylate (PEG-DA) hydrogel scaffolds. A significant increase in cell number ($p<0.001$) was observed with low intensity pulsed ultrasound (LIPUS) treatment in the presence of 0.5 % (v/v) MB after 1, 3 and 5 days of culture. MSC proliferation enhanced up to 40% after 5 days of culture in presence of MB and LIPUS while this value was only 18% when excited with LIPUS alone. We investigated the effects of acoustic parameters such as excitation intensity, frequency and pulse repetition period on MSC proliferation rate. Our 3-week chondrogenic differentiation results demonstrated that combining LIPUS with MB significantly enhanced both Glycosaminoglycan (GAG) and type II collagen production. Therefore, integrating LIPUS and MB appears to be a promising strategy for enhanced MSC growth and chondrogenic differentiation.

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Analysis of the error sources of the two-microphone transfer function method for measuring absorption coefficient in the free field using numerical modeling

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Extension of the two-microphone transfer function absorption coefficient measurement technique from impedance tubes to the free field introduces several error sources. The three-dimensional nature of the sound field necessitates consideration of factors that are not relevant in an enclosed tube below the cutoff frequency. The impedance tube technique has been modified to account for non-planar wave propagation due to an acoustic point source. The sound field contamination from sample edge diffraction has generally restricted use of the technique to frequencies such that wavelengths are small relative to sample dimensions. This requires the use of very large test panels for low frequencies. Numerical models of the two-microphone free field technique have been created to quantify these effects. Each effect was isolated to better understand its independent impact on the accuracy of the technique. Finally, a series of experimental tests were conducted to validate the numerical modeling results.

Creating, directing and steering hot spots in wave intensity patterns

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Focused acoustic waves are needed for usefully large amplitudes in a number of applications. In inhomogeneous media, a known time reversal method for such focusing is briefly: emitting a pulse from a target point P; record the signals received at a “mirror” set of points R; time-reverse those signals; and emit these from R. This gives a transient high concentration in space at P. Given two or more points like P, it does not give a way to achieve high concentration at a point Q between them that was not a source point. In contrast, we record pulse arrival times, and Taylor expand them with respect to position for phases that give a high concentration ‘hot spot’ as a steady caustic C (not a focus) at P. Structural stability of C allows steering and interpolation, ensuring robustness of the waveform and the predominant direction of its flux of energy, and improves controllability of the location of the regions of high energy flux, despite limited knowledge of the exact properties of the medium. Applications to enhancing drug delivery in brain, or of flow of underground fluids, such as oil, towards a borehole collection point, are envisaged.

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Listening for whales using the CTBT sensors*

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Under the Comprehensive Test Ban Treaty (CTBT), seven acoustic monitoring stations have been installed in oceans across the world for use in detecting nuclear test events. The data from these stations is being made available for academic work for free, and the stations are also detecting bioacoustics sounds as well as seismic activity. We present the approach used to use several of the hydro-acoustic stations of the CTBT network to search for biologic activity. After providing an overview of the CTBT stations and how to obtain and process their data, we will review the results of searching for whales using this data, an analysis of one suspected biologic signal that was detected, and comparisons to known whale sounds.

Validation and optimization of 3D strain tracking by volumetric ultrasound image correlation in a pubovisceral muscle model*

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Objective: To validate and optimize a texture tracking algorithm to measure displacement and strain on 3D B-mode ultrasound images of the pubovisceral muscle (PVM).
Methods: This algorithm was validated on an ex vivo model of the PVM using sonomicrometry to provide an independent strain measurement. Two likelihood functions were compared: an exponential sum function and the more common Pearson correlation coefficient. Strains were computed using both likelihood functions over a range of sizes for the tracked tissue sub-volume to determine an optimum sub-volume size. Echo decorrelation of the ultrasound signal was compared to accuracy of the texture tracking algorithm by analyzing images separated by increasing indentation sizes.
Results: Sub-volumes 3-4 times the image correlation length yielded the smallest strain errors. The two likelihood functions provided comparable results overall, with the Pearson likelihood yielding slightly higher root-mean-square errors than the Clocksin likelihood at most of the sub-volume sizes investigated. A series of small, incremental strains yielded lower levels of decorrelation of the ultrasound signal and resulted in more accurate strain tracking than larger increments of strain.
Conclusions: At the optimal sub-volume sizes, strains were measured in the PVM model with accuracy sufficient for useful characterization of the levator ani in vivo.

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Jet formation of contrast microbubbles in the vicinity of a vessel wall*****

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Behaviors of microbubble contrast agent near a vessel wall under ultrasound excitation are investigated using a boundary integral method. Ultrasound in the presence of microbubbles facilitates drug delivery by streaming and jetting phenomena. The microbubbles are encapsulated by a layer of proteins or lipids to stabilize them against dissolution. The encapsulating shell of the contrast microbubble is viscoelastic modelled here by interfacial rheological model. While at low excitations microbubbles undergo regular oscillations, at high amplitudes excitation, they form jets towards the wall. The dynamics and the resulting shear stress on the wall are studied varying the shell rheology and other relevant parameters of the problem.

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