The Sound

A Newsletter from the Rochester Center for Biomedical Ultrasound

Spring 2015

Remembering Floyd Dunn

April 14, 1924-January 24, 2015

Courtesy of University of Illinois Archives

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Meet New RCBU Member: Cristian Linte, RIT

Dr. Cristian Linte is the newest member of the RCBU. Dr. Linte is an Assistant Professor of Biomedical Engineering at the Rochester Institute of Technology (RIT).

Dr. Cristian A. Linte completed a BASc in Mechanical and Materials Engineering at the University of Windsor in Windsor, Ontario, Canada in 2004, followed by a MESc and PhD in Biomedical Engineering from the University of Western Ontario in London, Ontario, Canada in 2006 and 2010, respectively. In 2011, Dr. Linte joined the Biomedical Imaging Resource at Mayo Clinic in Rochester MN – a group with a long standing tradition in the development of medical image analysis and image-guided intervention technology – for a post-doctoral fellowship, which transitioned to an academic appointment as Assistant Professor of Biomedical Engineering.

During his undergraduate degree, Dr. Linte was the recipient of a 4-year Faculty of Engineering Dean's Scholarship, as well as two undergraduate research awards from the National Sciences and Engineering Research Council (NSERC) of Canada. During his graduate and post-doctoral career, Dr. Linte secured over $450,000 in federal funding from NSERC, Canadian Institutes of Health Research, Heart & Stroke Foundation of Canada, and the International Society of Optical Engineers, and he served as co-investigator on a National Institutes of Health grant with Mayo Clinic, aimed at the development of image guidance and modeling technologies for minimally invasive catheter-guided ablation therapy for atrial fibrillation treatment.

Dr. Linte's research interests focus on exploring the use of medical imaging to generate new paradigms for image-guided visualization and navigation for minimally invasive therapy. Thanks to the advances in medical image acquisition, visualization and display, surgical tracking and image computing infrastructure, a wide variety of technology has emerged that facilitates diagnosis, procedure planning, intra-operative guidance and treatment monitoring while providing safer and less invasive approaches for therapy delivery. Cardiac interventions have been among the last disciplines to benefit from minimally invasive treatment techniques, mainly due to the challenges associated with access and visualization inside the beating heart. As such, Dr. Linte's research endeavors have employed both technologies (image acquisition, surgical tracking, visualization and display) and techniques (image analysis, modeling, evaluation and validation) toward the development, evaluation and pre-clinical integration of image guidance environments for surgical navigation of minimally invasive cardiac interventions.

In Memoriam: Ultrasound Pioneer Floyd Dunn

The biomedical ultrasound community sadly lost one of its important pioneers. Floyd Dunn passed away on January 24, 2015 at the age of 90. Floyd was a member of the Electrical and Computer Engineering Department at the University of Illinois at Urbana-Champaign for over 50 years. Following the death of Bill Fry in 1968, Floyd became director of the Department's Bioacoustics Research Laboratory and made it a world leader in the field of biomedical ultrasound. Founding RCBU Director Ed Carstensen writes, "It is hard to believe today, but in the mid-1960s, research in this field had dwindled to the point that progress could be reported in biannual sessions at meetings of the Acoustical Society. Floyd and Wesley Nyborg organized those special sessions and we are uniquely indebted to them for keeping the field alive."

Floyd's body of scientific work provides foundation for our understanding of the propagation of ultrasound in tissues and the biological effects of ultrasound. He was a member of both the National Academy of Sciences and the National Academy of Engineering, and served as President of the Acoustical Society America. He was recognized with the highest awards from numerous scientific societies, including the IEEE Edison Award, the ASA Gold and Silver Medal Awards, and the AIUM Joseph P. Holmes Basic Science Pioneer Award. He served on many FDA, NIH, AIUM, and ASA committees, and was a member of Committee 66 of the National Council on Radiation Protection.

Floyd was a Charter Honorary Member of the RCBU and was a long-time friend and colleague for many of us. The RCBU and the wider biomedical ultrasound community will miss Floyd dearly.

Save the date for a gathering in Urbana, IL to celebrate Floyd and Elsa Dunn from August 21-22, 2015. Contact Bill O'Brien to be included on the mailing list for further information: wdo@uiuc.edu.

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Emma Grygotis Wins Outstanding Presentation Award

Emma Grygotis was the recipient of an Outstanding Student Presentation Award at the 2015 Therapeutic Ultrasound Winter School held in Les Houches, France at the École de Physique des Houches. At this forum, held in the French Alps on March 8-13, 2015, a group of twenty professors and fifty students gathered from around the world to discuss a range of topics in the rapidly expanding field of therapeutic ultrasound. Emma presented an overview of her studies focused on developing ultrasound technologies to fabricate bioactive collagen hydrogels for wound repair.

Emma is a second year graduate student in Pharmacology and Physiology working with Professor Denise Hocking (Pharmacology and Physiology, BME) and Professor Diane Dalecki (BME) on a joint collaboration to develop ultrasound technologies for tissue engineering and regenerative medicine. Emma is currently a pre-doctoral fellow in the HHMI Med-into-Grad program, and also a student member of the Rochester Center for Biomedical Ultrasound (RCBU). Recent BME alumna Karla Mercado, Ph.D. was also a participant at the 2015 Therapeutic Ultrasound Winter School.

Top: Emma Grygotis receiving her Outstanding Presentation Award at the 2015 Therapeutic Ultrasound Winter School. Shown (Left to right) are conference organizers Gail ter Haar and Vera Khokhlova, and Emma Grygotis. Bottom: Attendees of the 2015 Therapeutic Ultrasound Winter School in the French Alps in Les Houches, France.

John Cormack Visits RCBU

John Cormack returned to Rochester and presented a lecture for the RCBU titled "Propagation of plane non-linear shear waves in soft solids." John is a 2014 UR alumnus and is currently a graduate student at UT Austin working with Professor Mark Hamilton in the Applied Physics Laboratory. John's presentation to RCBU members provided an analytical approach to modeling the nonlinear propagation of shear waves in soft biological materials. While at the UR, John conducted research with Professor Sheryl Gracewski (ME) and Professor Jong-Hoon Nam (ME, BME).

Diane Dalecki Elected Vice Chair AIUM Bioeffects Committee

Diane Dalecki (BME) has been elected Vice Chair of the Bioeffects Committee of the American Institute of Ultrasound in Medicine (AIUM). Professor Dalecki is a Fellow of the AIUM, and Director of the Rochester Center for Biomedical Ultrasound (RCBU). The Bioeffects Committee provides information and guidance to the AIUM on matters relating to the biological effects and safety of ultrasound. In addition to the 14 elected AIUM members, the committee includes select resource members from federal agencies and external organizations. Following completion of a 2-year term as Vice Chair, Professor Dalecki will become Chair of the Bioeffects Committee. Professor Dalecki served previously as Chair of the Bioeffects Committee from 2001-2003. The AIUM is a multidisciplinary association of more than 9000 physicians, scientists, engineers, and clinicians dedicated to advancing the safe and effective use of ultrasound in medicine.

Selected Presentations from the American Institute of Ultrasound in Medicine: March 21-25, 2015

Intravascular ultrasound detection of life-threatening plaques: general principles and preliminary results

Marvin Doyley, University of Rochester, Rochester, New York, United States

In the United States, strokes kill over 137,000 people each year. These deaths occur when life-threatening plaques rupture in carotid arteries. Pathological studies reveal that the life-threatening plaques have distinct features: large necrotic cores, thin fibrous caps measuring 65 mm or less, and are infiltrated by macrophages. Life-threatening plaques can evade detection because atherosclerosis may progress for several years without any symptoms. Conventional imaging techniques, such as magnetic resonance imaging (MRI), diagnostic ultrasound (US), and multislice computed tomography (CT) can evaluate the plaque burden and stenosis in symptomatic patients. Intravascular ultrasound (IVUS) provides real-time cross-sectional images of the arterial wall. In this presentation, we will discuss the general principles of intravascular ultrasound elastography and contrast enhanced IVUS maging: two emerging techniques for visualizing mechanical properties and plaque neovasculature, features which can identify life-threatening plaques. We will include results of phantom and animal studies in this presentation.

Modified Apodization Functions for Superresolution Imaging

Kevin Parker, Shujie Chen
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Objectives: We recently demonstrated an approach to superresolution with stabilized ultrasound pulses (Parker, 2012). We design pulse shapes that when sampled have their Z-transform zeroes lying within the unit circle. This enables the use of inverse filters that are stable. By applying an exact, stable inverse filter, the final result is a higher resolution image.

Methods: Starting with 1D theory for simplicity, we wish to find a stable inverse filter for a pulse p[n]. Unfortunately, the typical ultrasound pulses used for imaging are functions that, when sampled, have Z-transforms with many zeroes on and outside of the unit circle (see Abstracts S27 Michailovich and Adam (2004) for examples), leading to unstable filters. However, a right-sided sequence p[n] with a Z-transform P(Z) is multiplied by an exponential sequence then the location of its zeroes are scaled by a constant. Thus, the multiplication by a geometric series creates an asymmetric pulse in the time domain with its Z-transform zeroes “retracted” into the unit circle. Specific apodization strategies are required to establish stabilized beampatterns.

Results: In general, stabilized pulses have envelopes that have a sharp initial rise and a more gradual fall-off from the peak. As an example, an asymmetric p[x] for x≥0 is selected as a stable function for the transverse beampattern. The program Field II (Jensen, 2004) was used to simulate a focused beampattern. The approximate Fourier transform of p[x] is used to set the apodization function. A 5 MHz transducer with 129 active elements is simulated with half-wavelength spacing. The transverse beampattern at the focus (60 mm depth) is found to closely match the design function p[x].

Conclusions: An inverse filter approach has been derived using the Z-transform on stabilized but realizable pulses. A major issue in the use of the inverse filter is the realization of stabilized waveforms in conventional focused systems. Examples are shown comparing Field II simulations and images obtained from the Verasonics scanner in conventional and superresolution modes. System limitations include the diffraction limits and aperture limits which restrict the sharpness of the asymmetric beams. Resolution improvements from 3-10X are possible after inverse filtering.

The Clinical Significance of Deep Vein Thrombosis Within The Calf Veins

Refky Nicola, Shirley Chan, Anthony Almudevar, Vikram Dogra
Imaging Sciences, University of Rochester, Rochester, NY, United States

Objectives: Deep vein thrombi (DVT) are great medical burden, with regards to morbidity and mortality when associated with pulmonary emboli (PE). While the significance of DVT in the lower extremities has been well established, the clinical value of DVT in the calf veins is still indeterminate, especially in patients without a history of malignancy. This study aims to clarify the significance of calf vein thrombosis in an IRB approved retrospective analysis which compares calf vein DVT with upper leg DVT in determining the presence of PE on computed tomography angiograms of the pulmonary arterial circulation (CTA).

Methods: 700 patients with ultrasound studies of the bilateral lower extremity for DVT screening were obtained from 1/2009-9/2011 at University Hospital with a Level 1 Trauma Center CTA of the chest were used as gold standards. The same patient population was screened for receiving CTA (PE protocol) within 14 days; 198 out of 700 fit the criteria. History of malignancy or prior DVT or PE excluded 54 subjects from the study. Of the 700 patients, a total of 144 patients were included. The presence or absence of DVT in the calf veins were compared to presence or absence of DVT in the femoral to popliteal veins. DVT data was then compared to the results of the CT PE.

Results: There is very strong association between a positive calf DVT and PE (odds ratio 5 14.1, P , 0.0001) with a positive predictive value of 85.7%, and specificity of 96.6%. In comparison, the association between a thigh DVT (femoral to popliteal vein) and PE is not as robust (odds ratio 5 7.4, P , 0.0001) with a positive predictive value of 76.0%, and specificity of 93.3%. However, the sensitivity of ultrasound examinations of lower and upper veins of the lower extremity for predicting PE is relatively limited, measuring 33.3% and 35.2% respectively. Sensitivity for the calf vein examination in predicting PE is highly dependent on visualization of the calf veins. There is an increase in sensitivity with concurrent increase towards complete visualization.

Conclusions: The diagnostic value of a positive calf vein DVT on ultrasound is as significant or even more significant than the diagnostic value of a positive upper leg DVT for predicting PE.

The Microchannel Flow Model for Soft Tissues

Kevin Parker
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Objectives: A number of advances in elastography have increased our ability to make measurements of viscoelastic properties of tissues. Accordingly, the question of an appropriate viscoelastic model becomes paramount. This study examines normal soft tissues and develops a model of behavior based on the flow of viscous fluids through the extensive network of tissue microchannels in response to applied stress. This behavior can be captured in a 2-parameter model, and the model appears to predict the stress-relaxation behavior and the dispersive shear wave behavior of bovine liver specimens and other soft tissues and phantoms over a frequency range of 60 – 400 Hz. The relationship of the microchannel flow model (MFM) to more traditional models is also examined.

Methods: We consider a block of liver tissue, comprised of a fine-scale interlocking of hepatic cells, connective tissue, and a variety of fluid channels including billary, capillary, and lymphatic. We then consider a small fluid microchannel as a fluid-filled inclusion and derive a characteristic time constant for stress relaxation. Assuming there are multiple microchannels of unequal radius r_n and therefore unequal flow rates Q_n, and that each contributes to the stress relaxation at their respective time constant t_n, then the simplest model for this looks like a generalized Maxwell-Weichert model. Next, a relaxation spectrum is defined by a power law, linked to the fractal branching behavior of vessels. Combining these yields the constitutive equations for soft tissue.

Results: Time domain measurements of stress relaxation in liver tissue speciments, and shear wave measurements between 60 – 400 Hz, demonstrate the accuracy of the MFM and the relevance of its parameters. The key power law parameter "a" is in the range of 0.15 – 0.25 for normal liver and can indicate the branching microvasculature and microvessel distribution.

Conclusions: The MFM is capable of describing the viscoelastic properties of soft tissues such as the liver, and predicts a power law form of dispersion of shear waves.

Recent Publications by RCBU Members

Barbaux S, Erwich JJ, Favaron PO, Gil S, Gallot D, Golos TG, Gonzalez-Bulnes A, Guibourdenche J, Heazell AE, Jansson T, Laprévote O, Lewis RM, Miller RK, Monk D, Novakovic B, Oudejans C, Parast M, Peugnet P, Pfarrer C, Pinar H, Roberts CT, Robinson W, Saffery R, Salomon C, Sexton A, Staff AC, Suter M, Tarrade A, Wallace J, Vaillancourt C, Vaiman D, Worton SA, Lash GE (2015 Apr 01). IFPA meeting 2014 workshop report: Animal models to study pregnancy pathologies; new approaches to study human placental exposure to xenobiotics; biomarkers of pregnancy pathologies; placental genetics and epigenetics; the placenta and stillbirth and fetal growth restriction. Placenta. 36 Suppl 1, S5-S10.

Parker KJ (2015 Apr 01). Could linear hysteresis contribute to shear wave losses in tissues? Ultrasound Med Biol. 41, 1100-4.

Liu B, Zhu T, Zhong J (2015 Apr 01). Comparison of quality control software tools for diffusion tensor imaging. Magn Reson Imaging. 33, 276-85.

Mercado KP, Helguera M, Hocking DC, Dalecki D (2015 Mar 12). Noninvasive Quantitative Imaging of Collagen Microstructure in Three-Dimensional Hydrogels Using High-Frequency Ultrasound. Tissue Eng Part C Methods. In press.

Guo H, Santner TJ, Chen T, Wang H, Brial C, Gilbert SL, Koff MF, Lerner AL, Maher SA (2015 Feb 26). A statistically-augmented computational platform for evaluating meniscal function. J Biomech. In press.

Cheng Y, Huang L, Zhang X, Zhong J, Ji Q, Xie S, Chen L, Zuo P, Zhang LJ, Shen W (2015 Feb 24). Liver transplantation nearly normalizes brain spontaneous activity and cognitive function at 1 month: a resting-state functional MRI study. Metab Brain Dis. In press.

Parker KJ, Partin A, Rubens DJ (2015 Feb 23). What do we know about shear wave dispersion in normal and steatotic livers? Ultrasound Med Biol. In press.

Chen Y, Chen S, Zhong J, Chen Z (2015 Feb 20). Reference-free unwarping of single-shot spatiotemporally encoded MRI using asymmetric self-refocused echoes acquisition. J Magn Reson. 254, 1-9.

Prodanovic S, Gracewski S, Nam JH (2015 Feb 03). Power dissipation in the subtectorial space of the mammalian cochlea is modulated by inner hair cell stereocilia. Biophys J. 108, 479-88.

Wei Z, Lin L, Wang C, Yang J, Liu G, Zhong J, Lin Y, Chen Z (2015 Feb 01). High-resolution localized spatiotemporal encoding correlated spectra under inhomogeneous magnetic fields via asymmetrical gradient encoding/decoding. NMR Biomed. 28, 210-6.

Rojas R, Ormachea J, Salo A, Rodríguez P, Parker KJ, Castaneda B (2015 Jan 26). Crawling waves speed estimation based on the dominant component analysis paradigm. Ultrason Imaging. In press.

Sherazi S, McNitt S, Choudhary N, Shah AH, Aktas MK, Asgher A, Schwarz KQ, Zareba W (2015 Jan 15). Predictors of mortality in patients hospitalized for congestive heart failure with left ventricular ejection fraction ≥ 40% Cardiol J. In press.

Upcoming Conferences

Acoustical Society of America

May 18th - 22nd 2015

Pittsburgh, Pennsylvania, US
http://acousticalsociety.org

IEEE International Ultrasonics Symposium

October 21st - 24th 2015

Taipei International Convention Center

Taipei,Taiwan

http://ewh.ieee.org/conf/ius/ius_2015/