ıother optical technique and hydrophone measurements. This experiment ı robust means of measuring the piezo-optic coefficient directly (assuming he pressure field). The piezo-optic coefficient for water thus obtained com- / with theoretical predictions and other physical measurements.

7.3 **How good is a Gaussian in approximating a point spread function?** Guy Charron, Michel Bertrand and Roch Maurice, *Institut de génie biomédical, École Polytechnique, C.P. 6079, Succ. Centre-ville, Montréal (Québec) H3C 3A7 and Institut de Cardiologie de Montréal, 5000, rue Bélanger, Montréal (Québec) H1T 1C8, Canada.* E-mail: bertrand @igb.polymtl.ca

Gaussian transmit/receive beam profile and space invariant Gaussian impulse response models are often used to develop the theory required to understand the relationships between the dynamics of the backscattered signal and the associated tissue or fluid motion. Such Gaussian 2D or 3D point-spread function (PSF) models are also at the basis of certain motion estimators. This paper discusses the instrumental conditions underlying the Gaussian impulse response approximations, and examines how more realistic impulse responses deviate from the Gaussian model. Impulse responses computed using Field II were fitted to a generalized analytical parametric 'Gaussian' model capable of taking into account various space variant attributes such as PSF curvature, width and height, phase modulation, etc. PSF parameter estimation was done using a Matlab optimization toolbox nonlinear minimization program. Symbolic representation of the PSF was used to derive the Jacobean matrix required by the gradient-based Levenberg-Marquardt algorithm. This study shows that for a narrow-band signal and a Gaussian apodized aperture, the proposed generalized Gaussian model is capable of accurately reproducing the PSF found in a wide variety of situations. Models for accurate representation of PSFs of wide band transducers and non-apodized apertures are discussed.

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8. Tissue Parameters 3

8.1 **Multifrequency ultrasound imaging for carotid plaque characterization: a feasibility study.** Khalil F. Dajani,[1] Robert K. Vincent,[3] Sergio Salles-Cunha,[2] Jian-yu Lu[1] and Hugh G. Beebe[2], [1]*Department of Bioengineering, University of Toledo, 2801 West Bancroft Street, Toledo, OH 43606,* [2]*Jobst Vascular Center, Toledo, OH and* [3]*Department of Geology, Bowling Green University, Bowling Green, OH. E-mail: jilu@eng.utoledo.edu*

Atherosclerotic plaques obstructing the internal carotid artery in the neck are a major cause of cerebral vascular accidents or strokes. Although researchers have used frequency-domain techniques to differentiate and quantify optical absorption and scattering of inhomogeneous tissues, the characterization of plaques with ultrasound is currently limited to the analysis of a single image obtained from one of several available frequency bands. In this report, a multifrequency ultrasonic image processing technique that is used to process multispectral satellite images of the earth was applied to characterize atherosclerotic arterial diseases. In the method, a patient presenting with carotid artery disease was examined with a conventional ultrasound scanner. The patient was supine while the common carotid, the carotid bifurcation, the internal carotid and the external carotid arteries were imaged from low in the neck to the mandible. Four images of an obstrucive internal carotid plaque were obtained at different frequency bands: 3-6 MHz (band I), 4-7 MHz (band II), 5-8 MHz (band

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This work was supported
Health.

8.2 **2-D and 3-D tissue-t**
cer treatment, E.J. Felepp
Kalisz[1], [1]*Riverside Research*
cal Center, New York, NY 1
NY 10021. E-mail: feleppa
Current methods of tr
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III), and 7-10 MHz (band IV). A representative axial, longitudinal image was stored for each frequency band. Several types of multifrequency image processing algorithms were used to process the data. The first principal component image was obtained with the principal component algorithm applied to the histograms of all four bands. A contrast stretched color composite image was obtained after spectral ratioing of bands I and IV. Boundaries of the plaque region were detected with unsupervised classification algorithm along with the first principal component image of three spectral ratio images. These images were obtained from spectral ratioing of bands I and II, bands II and IV, and III and IV. Several classified areas were obtained after the processing. By visual inspection, the largest area was found to associate with a hypoechoic ultrasound region within the plaque. The next largest area was associated with a hyperechoic ultrasound region. The remaining areas were seen as transition regions with intermediary echo intensity. Our approach classifies regions according to their pixel intensity amplitude from a multifrequency prospective. This enables us to visualize the heterogeneous regions and improve the predictive values and sensitivity between distinct regions within the plaque. In conclusion, feasibility of using multispectral algorithms, designed for the analysis of earth data collected via satellite, was studied to process medical ultrasound images. With unsupervised classification, a quantitative, numerical description of intra plaque regions was obtained. This method may have potential in tissue characterization for predicting the risk of cerebrovascular accidents or strokes.

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8.2 **2-D and 3-D tissue-type imaging of the prostate for guiding and monitoring cancer treatment**, E.J. Feleppa,[1] T. Liu,[2] C.S. Wuu,[2] R. Ennis,[2] P. Schiff,[2] W.R. Fair[3] and A. Kalisz[1], *[1]Riverside Research Institute, New York, NY 10036, [2]New York Presbyterian Medical Center, New York, NY 10032 and [3]Memorial Sloan-Kettering Cancer Center, New York, NY 10021. E-mail: feleppa@rrinyc.org*

Current methods of treating prostate cancer include surgery, brachytherapy, external-beam radiation, cryotherapy, and high-intensity focused ultrasound. All methods generally are applied to the entire gland. Targeting treatment and sparing uninvolved portions of the gland and adjacent or internal structures (such as the urethra and rectum) are not practicable because of the inability of current imaging modalities to distinguish cancerous from non-cancerous prostate tissues. Tissue-type imaging based on spectrum analysis of radiofrequency (rf) ultrasonic echo signals shows promise for better differentiation of cancerous from noncancerous prostate tissues than is possible with conventional ultrasound.

Our imaging studies utilize spectral parameters computed using sliding windows to select digitized rf data along each scan line. Linear regression analysis of power spectra computed from the windowed rf data segments provides spectral parameters that are the basis for tissue characterization and typing. Spectral parameters are translated into grey-scale or color pixel values through use of a lookup table. Pixel encoding can be used to indicate the relative likelihood of cancer or other tissue property. For indicating the likelihood of cancer at each pixel location, the lookup table is generated by classifying parameter values over the range of values encountered in cancerous and noncancerous prostate tissue; classification is best performed by neural-network algorithms. To date, we have investigated a variety of neural-network approaches, including learning-vector quantization, radial-basis functions and multi-layer perceptions. We also have utilized a variety of linear and nonlinear preprocessing methods. Neural networks are trained using spectral parameters computed from biopsied regions of the prostate; histology is the gold standard for establishing the actual tissue type in the biopsied regions.

5/22/00

PROGRAM AND ABSTRACTS

25th International
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