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Acoustical Imaging and Holography Seventh International Symposium

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Abstract
I am going to report briefly on the Acoustical Imaging and Holography Conference that was concluded yesterday in Chicago. These conferences were started in 1967, and are concerned primarily with ultrasonics and visualization techniques as applied to medicine, nondestructive evaluation, sonar, seismic analysis and acoustic microscopy.

Disciplines
Materials Science and Engineering

ACOUSTICAL IMAGING AND HOLOGRAPHY
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I am going to report briefly on the Acoustical Imaging and Holography Conference that was concluded yesterday in Chicago. These conferences were started in 1967, and are concerned primarily with ultrasonics and visualization techniques as applied to medicine, nondestructive evaluation, sonar, seismic analysis and acoustic microscopy.

I think what I will do is just present some results, including some slides that various contributors were kind enough to give me. I will not be able to describe the results of all contributors since the conference lasted more than three days. In particular, I have omitted some interesting work from Stanford. Dr. Waugh and Kino's group made some important contributions, but because they are attending this conference they can describe their work much better than myself.

The first slide* is a color-coded image of a normal eye taken from the work of Jones et al. at Case Western[1]. The color-coding of this ultrasonic image shows an interesting way to display frequency domain ultrasonic information. Essentially what they have done is used a broadband pulse with frequency components in the range of 6 to 12 MHz and then color-coded different frequency regions. Components that range from 6 to 8 MHz are red, green represents a 2 MHz bandwidth around 9 MHz, and the blue colors correspond to ultrasonic signals in the range of 10 to 12 MHz.

The next slide* shows a color-coded picture of an eye with a large malignant melanoma. It is obvious from this example that there are some marked differences in the colors (ultrasonic scattering properties) of abnormal as compared with normal eye tissue.

The next slide* is a tomographic image of breast tissue. There are actually two images here which are color-coded and superimposed. The blue image is an ultrasonic index of refraction tomogram where the dark blue regions are areas of lower sound velocity. Superimposed on this image is an attenuation tomogram. The attenuation tomogram is red with the higher attenuation areas the most intense.

These color-coded tomographic images are the work of Greenleaf and colleagues at Mayo[2]. The color-coded images differ from those presented by Dr. Jones in that they are: a) Computer reconstructed ultrasonic images obtained at a single frequency. b) Color-coded according to two distinct physical acoustic properties. In red we have the attenuation properties, in blue the acoustic index of refraction properties. Like the Case Western group, the Mayo group presented some vivid examples contrasting the acoustic properties of normal and abnormal tissues.

In another study Eggleton, at the Indiana Center for Advanced Research, presented some interesting data on changes in the acoustic properties of muscle in the contracted and relaxed state[3]. His investigations were on a much finer scale. Using the scanning laser acoustic microscope he was able to measure slight changes in ultrasonic velocity in muscle tissue undergoing isometric contraction.

The next investigation I want to mention is another application of ultrasonic tomography. This is work done by Percy Hildebrand and D. E. Hufferd at Battelle Northwest[4]. The problem is the following: If you want to do tomographic imaging, normally you have to work in transmission and have access to the object from all sides. If you have a situation where you cannot obtain a 360 degree perspective, is tomography possible? For example, can one image the residual stress resulting from the butt weld of thick metal plates?

Dr. Hildebrand's investigations are involved with determining how well an object can be tomographically imaged by taking ultrasonic data in reflection over only a 90 degree sector. This geometry is illustrated in Fig. 1. Their initial investigations involved imaging test objects. Their particular test object was the finger of a glove filled with a solution which had a 2 percent velocity difference from the surrounding water coupling media. They scanned this object in a 90 degree sector and reconstructed a tomographic index of refraction image. The image they obtained is shown in Fig. 2. The peaks here correspond to the glove where the velocity of sound values are higher. There are actually two images shown. The double image results from the tomographic signal processing algorithms which produce both a real image and a mirror image. The ultimate goal is to look at ultrasonic velocity fields which result from residual stresses in welded thick metal plates They have also imaged a 0.2 percent velocity change with the liquid model and have done work on stress fields in metal samples. The results look encouraging.

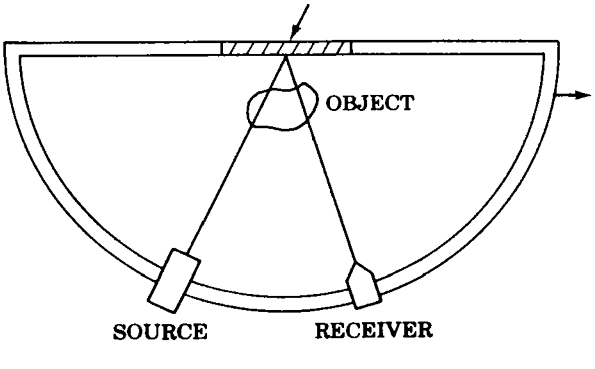

Figure 1. Experimental arrangement for reflection tomogtaphic imaging.

* Images of these slides did not reproduce due to color-coding.

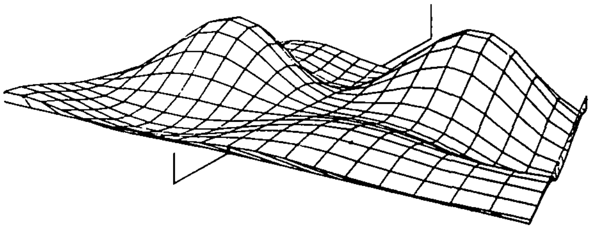

Figure 2. Reconstruction of the 2 percent liquid model profiled by reflection

Figure 3 is an interesting image. This is the work of a French group from the University of Paris, Alais and Fink[5]. It is an image of a 7 month old fetus. Their transducer configuration is a linear Fresnel zone focusing array of 160 elements. As you can see, the detail is quite good. One can visualize a number of the features, such as the lungs and the vertebrae of the fetus. The dimensions here are about 120mm across the figure.

Figure 3. Ultrasonic C-Scan image of a 7 month fetus made using a 160 element linear Fresnel zone focusing array.

I would also like to mention some work done by R. Mezrich at RCA Laboratories[6]. He employs two sets of Risley prisms to form a rapid X-Y raster scan of an ultrasonic beam. Using this technique in a C-scan, impressive, high resolution images are obtained at a frequency of 1.6 MHz. Shown in Fig. 4a is the acoustic image of a nickel resting on a metal canning. Using this system depth resolution can be obtained by time gating the echoes.

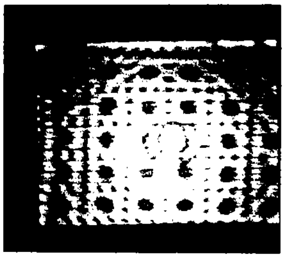

Figure 4a. Ultrasonic image (1.6 MHz) of a coin placed on a metal canning.

Figure 4b and 4c show the nickel and canning, respectively. These images were obtained by changing the detection gate delay. The time required to form each image is approximately 4 seconds.

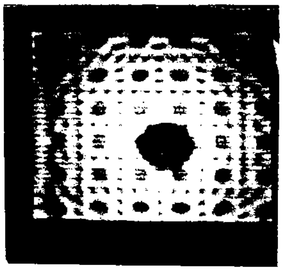

Figure 4b. Image of canning

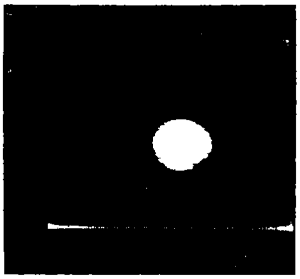

Figure 4c. Image of coin.
Latter two images are produced by changing the detection gate delay time

The next slides are images produced by Havlice and colleagues at the Stanford Research Institute[7]. They were trying to eliminate spurious detail in transmission acoustic images which result from the spatially and temporally coherent insonification. Figure 5a shows a transmission image of a human elbow made with coherent ultrasound. As you can see there is considerable image clutter in the fleshy part of the arm which makes these images difficult to interpret. A second image of the elbow is shown in Fig. 5b. This image was produced by placing an acoustic "shower window" (diffuse scatter) between the transmitter and receiver and vibrating it very rapidly, thus introducing spatial and temporal incoherency. This reduces extraneous features produced by out-of-focus structures which might otherwise mask important features.

Figure 5. Comparison of ultrasonic transmission images of the elbow. Image on the left (a) was obtained with coherent insonification while that on right (b) used incoherent insonification.

References

1. J. P. Jones, E. Holasek, E. W. Purnell and A. Sokollu, A Technique for Incorporating Spectral Information into a B-scan Ultrasonic Display. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.

2. J. F. Greenleaf, S. A. Johnson, W. F. Samayou and C. R. Hansen, Refractive Index by Reconstruction: Use to Improve Compound B-Scan Resolution. Proceedings of Seventh International Symposium on Acoustical Imaging and Holography.

3. R. C. Eggleton and F. S. Vinson, Heart Model Supported in Organ Culture and Analyzed by Acoustic Microscope. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.

4. B. P. Hildebrand and D.E. Hufferd, Computerized Reconstruction of Ultrasonic Velocity Fields for Mapping of Residual Stress. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.

5. P. Alais and M. Fink, Fresnel Zone Focusing of Linear Arrays Applied to B and C Echography. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.

6. R. Mezrich, High Resolution, High Sensitivity Ultrasonic C-Scan Imaging System. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.

7. J. F. Havlice, P. S. Green, J. C. Taenzer and W. Muller, Spatially and Temporally Varying Insonification for the Elimination of Extraneous Detail in Acoustic Transmission Imaging. In Acoustical Holography Vol. VII (ed. L. W. Kessler) in press.