Special Section on Imaging Through Scattering Media

David A. Boas
Massachusetts General Hospital
Harvard Medical School
Charlestown, Massachusetts 02129-2060
dboas@nmr.mgh.harvard.edu

Charles A. Bouman
Purdue University
School of Electrical and Computer Engineering
West Lafayette, Indiana 47907-1285
bouman@ecn.purdue.edu

Kevin J. Webb
Purdue University
School of Electrical and Computer Engineering
West Lafayette, Indiana 47907-1285
webb@purdue.edu

There are many practical situations and imaging modalities where there is significant scatter due to the media being studied. While solutions may involve circumventing the obscuring scatter, there are important new approaches that image based on the scattering properties. This latter category includes optical imaging in tissue, as well as in aerosol and turbid fluid applications, where the scatter may be high but the absorptive losses modest. In many situations, a Boltzmann transport equation or in some cases the simpler diffusion equation may be suitable as forward models in imaging algorithms. In this case, imaging can be treated as an optimization problem, where an image is formed based on the spatial variations of absorption and scatter. This field has become known as optical diffusion tomography (ODT).

Other than cost and performance motivations, the primary reason to use light for imaging is the spectroscopic information available. Media of interest, such as tissue, have important properties, as well as relatively low absorption, in the infrared wavelength range. By making measurements at a number of wavelengths, blood chemistry information can be garnered. By using fluorescence, additional contrast can be achieved. With appropriate targeting, fluorescence data with a suitable imaging approach may provide a means to safely detect tumors at an early stage.

This special section has four papers dealing with imaging in scattering media using light. In “Image reconstruction in optical tomography using local basis functions,” Schweiger and Arridge present a comparison of local basis functions in a finite element representation of the diffusion equation forward model in ODT. The image formed on inversion is dictated by these basis function weights, so the quality of the image will be a function of the character, for example, the order and discretization level, of the local basis functions. In “Three-dimensional optical tomography with the equation of radiative transfer,” Abdoulaev and Hielscher use the Boltzmann transport equation directly for optical imaging in scattering media. This allows imaging in applications where the diffusion equation does not hold, but where there is still significant scatter. In “Application of transform algorithms to high-resolution image reconstruction in optical diffusion tomography of strongly scattering media,” by Konovalov et al., back projection techniques are investigated for ODT applications and compared with a solution achieved by inverting the diffusion equation. Good quality images are shown using this approach, without capturing all the physics, with very little computational effort. In “Near-infrared breast tomography calibration with optoelastic tissue simulating phantoms” by Jiang et al., the imaging performance of a diagnostic tool is evaluated, along with phantom models for tissue that can be used in instrument calibration.

David A. Boas
studied physics and received his BS at Rensselaer Polytechnic Institute and his PhD at the University of Pennsylvania. For his dissertation he received the Burshtein Prize in Condensed Matter Physics. He has been an assistant professor of radiology at Harvard Medical School during the last 5 years where he directs the Photon Migration Imaging Laboratory within the Anthinola A. Martinos Center for Biomedical Imaging at Massachusetts General Hospital. This lab consists of 25 faculty, fellows, students, and staff advancing photon migration technologies for application to brain function and breast cancer.
Charles A. Bouman

received a

BSEE degree from

the University of

Pennsylvania in

1981, and a MS
degree in electrical

engineering from

the University of

California at Berke-

ley in 1982. From

1982 to 1985, he was a staff member in the

Analog Device Technology Group at MIT,

Lincoln Laboratory. In 1987 and 1989, he re-

ceived MA and PhD degrees in electrical en-

gineering from Princeton University under

the support of an IBM graduate fellowship.

In 1989, he joined the faculty of Purdue Uni-

versity where he holds the rank of professor

with a primary appointment in the School of

Electrical and Computer Engineering and a

secondary appointment in the Department

of Biomedical Engineering. Professor Bou-

man’s research focuses on the use of statis-

tical image models, multiscale techniques,

and fast algorithms in applications including

multiscale image segmentation, tomogra-

phic image reconstruction, image printing

and rendering, and document segmentation

and compression. His research has resulted

in new methods for image rendering, half-
toning, and display that have been widely

used in commercial products. He has au-

thored over 39 journal publications, over

100 conference publications, and is an in-

ventor on six issued patents. He has per-

formed research for numerous government

and industrial organizations including the

National Science Foundation, the US Army,

Hewlett-Packard, Xerox, NEC Corporation,

Apple Computer, and Eastman Kodak. Pro-

fessor Bouman is a fellow of the IEEE and a

member of the SPIE and IS&T professional

societies. He has been an associate editor

for the IEEE Transactions on Image Pro-

cessing and the IEEE Transactions on Pat-

tern Analysis and Machine Intelligence. He

has also been the awards chair for the ICIP

1998 organizing committee, co-chair of the

SPIE/IS&T conference on Visual Communi-

cations and Image Processing 2000 (VCIP),

and a member of the IEEE Image and Mul-
tidimensional Signal Processing Technical

Committee. Currently, he is the vice presi-
dent of publications and a member of the

board of directors for IS&T, and he is the

founder and co-chair of the SPIE/IS&T con-

ference on computational imaging.

Kevin J. Webb

is

a professor in the

School of Electrical

and Computer En-

gineering at Pur-

due University. He

received BEng and

MEng degrees

from the Royal

Melbourne Institute

of Technology in

1978 and 1983, re-

spectively, the MSEE

from the University of California, Santa Bar-

bara, in 1981, and a PhD from the University

of Illinois, Urbana, in 1984. During calendar

year 2003 he is a visiting professor at the

Massachusetts Institute of Technology.