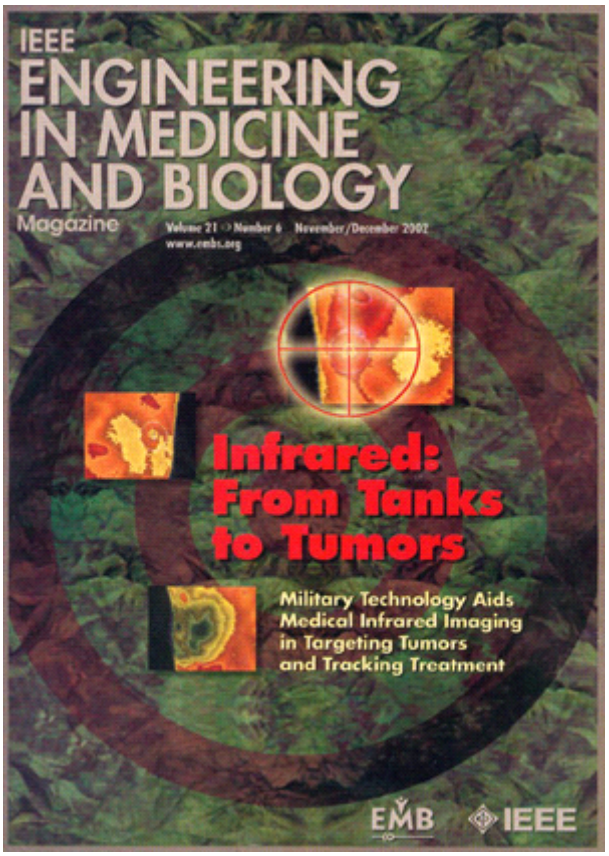
Advances in Medical Infrared Imaging

This is the third special issue on the use of infrared imaging in medicine, and it is with great pleasure that we are reporting the significant innovations in this field. The previous issues were well received by the medical and biomedical engineering community (IEEE EMB Magazine, July/August 1998 and May/June 2000). These two events coupled with the annual IEEE/EMBS conferences have helped create a unifying forum for forward-looking research world-wide.



A significant number of government-sponsored programs have been initiated in Europe, Japan, and the United States. The evolution of technological advances in infrared sensor technology, image processing, and smart algorithms and their integration led to new methods of research in medical infrared imaging. These were highlighted at the special event “From Tanks to Tumors: A Workshop on the Application of IR Imaging and Automatic Target Recognition(ATA) Image Processing for Early Detection of Breast Canner,” held in Arlington, Virginia, 4-6 December 2001. This workshop was sponsored by the Office of the Deputy Undersecretary of Defense (S&T-Sensor Systems), Office of the Deputy Assistant Secretary of the Army for Installations and Environment (Environmental Safety and Occupational Health), The Army Research Office (ARO), and the Defense Advanced Research Projects Agency (DARPA). Leaders in multidisciplinary fields presented plenary papers and participated in three working groups:Image Processing, Web-based Database, and Sensor Technology.The working group results were then presented to the attendees in a plenary session. These recommendations are being implemented in a highly leveraged, government-sponsored program to develop a “Web-based database” for the quantification of

thermal signatures of the breast. This issue contains two articles highlighting the workshop and its findings.

Currently, there are several methods being used in medical infrared imaging. They are the following:

static
dynamic (DAT, subtraction, etc.)
multispectral and hyperspectral
thermal texture mapping
multimodality
sensor fusion
infrared regulation imaging (IRI).

They are being used in a variety of applications including: oncology (breast, skin, etc.), pain, vascular disorders (diabetes, deep venous thrombosis), arthritis, rheumatism, surgery, tissue viability (burns, etc.). dermatological disorders, monitoring the efficacy of therapeutic drugs, etc., and sports medicine.

Articles have been contributed by experts with many years of experience in the use of this modality in universities, industry, government research, and clinical settings. There are two introductory articles: one by Jeff Paul and Jasper Lupo (United States) on the “Tanks to Tumors Workshop structure, its scope and intent, and its potential outcome with reference to the Web-based database initiative. The second is by John Irvine (USA), who explores the possibility of leveraging the experience and knowledge of the military automatic target recognition (ATR) community toward addressing the medical imaging problem. He makes a compelling case for this.

Bryan Jones (United Kingdom) and P.Plassmann present digital imaging of thermal radiation emanated from the human body and measured on the surface of the skin. His article also discusses its analysis and interpretation by image processing. Several medical applications are presented. Kimio Otsuka et al. (Japan) present a novel method and system for measuring emissivity, emissivity-corrected temperature, and thermal inertia simultaneously and highlight some interesting phenomena found by this technique. It not only provides precise temperature distribution of the skin but also allows speedy measurement of emissivity and inertia distribution. Ioannis Pavlidis et al. (United States) discuss a new method for scoring polygraph tests using thermal image analysis. It features three stages: image acquisition, physiological correlation, and pattern recognition. This approach achieved a correct classification rate of 84% on the population tested, and it demonstrates an enhancement in reliability and accuracy of traditional polygraph examinations.

Naoto Kakuta et al. (Japan) use a human thermal model with which IR images obtained under certain environmental conditions can be converted into images taken under other conditions. The modeling is based on numerical calculations of the bio-heat transfer equations that express heart transfer phenomena with the human body. Their research shows that this method is effective in eliminating the influence of the thermal environmental conditions. Arcangelo Merla et al. (Italy) present a novel approach for the evaluation of Raynaud's phenomenon based on infrared functional imaging. The results of this pilot study are encouraging. A larger study is underway. Jonathan Head and Robert Elliott (United States) review the past, present, and future applications of infrared

imaging in medicine. They discuss predominant areas of interest, such as breast cancer, and other promising applications. Arcangelo Merla et al. (Italy) in their second article introduce the "Tau Image"-a new complementary inaging technique based on infrared functional imaging. The basic idea of this work was to identify the altered thermoregulatory properties associated with a specific disease in order to detect and classify the kind and the stage of the disease itself.

I would like to acknowledge the U.S. Department of Defense for developing the infrared technology and the Office of the Undersecretary of Defense for Science and Technology (ODUSD-S&T), the ARO, and DARPA for the continued support toward the transfer of this technology to medicine. Also, I would like to acknowledge the Office of the Deputy Assistant Secretary of the Army for Installations and Environment (Environmental Safety and Occupational Health) and the Office of Naval Research (ONR) for their support in the Web-based database initiative. I am indebted to John Enderle, editor-in-chief of this magazine, for his guidance, assistance, and advice in making this special issue possible. My appreciation and thanks also go to all the authors for their excellent contributions and the reviewers for their time and valuable comments.

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From 1962-1983 he was program manager for various areas of IR technology and electro-optics at the Army Night Vision and Electro-Optics Laboratory. He has published more than 50 papers and one book chapter (invited) in the Electronics Engineers Handbook. Professional Activities: IEEE/EMBS, publicity chair and member of the conference and technical program committees in Baltimore (1994); organizer and chair of all infrared imaging activities (tracks, sessions, workshops and mini-symposia) for IEEE/EMBS International Conferences (1994-2002); member IEEE/USA member for the following committees: R&D Policy (1994-present) and Healthcare Engineering Policy (1989-1994); guest editor, IEEE EMB Magazine special issues on medical infrared imaging (July/August 1999 and May/June 2000). He is a Fellow of the American Institute of Medical and Biological Engineering and a member of the Executive Committee of the American Academy of Thermology (1998-present).

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