

ADVANCED BIOMEDICAL ULTRASOUND IMAGING AND THERAPY LABORATORY

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Résumé

Laboratoire avancée de l'imagerie et de thérapie biomédicale à ultrasons (ABUITL) est un laboratoire de recherche 1600 pieds carrés affilié conjointement à l'Université Ryerson et l'Hôpital St. Michael. Il est l'un des principaux laboratoires de recherche dans le domaine d'ultrasons biomédicale au Canada. Le laboratoire a été créé en 2007 dans le Département de physique de l'Université Ryerson et a été transféré à iBEST (institut de génie biomédical, sciences et technologie) dans l'Hôpital St. Michael en Septembre 2015. Le laboratoire accueille un éventail d'équipements de recherche d'ultrasons biomédicale dans les domaines diagnostic et thérapeutique, et a été actif dans la conduite de projets et la formation de personnel hautement qualifié (PHQ). Champ d'application des projets de recherche dans le laboratoire étend de la compréhension de la science fondamentale et l'investigation des mécanismes biophysiques à de nouvelles applications cliniques dans tous les principaux domaines d'ultrasons biomédicale.

Mots clefs: ultrasons biomédicale; l'imagerie, la thérapie et la simulation par ultrasons; imagerie photoacoustique; l'administration de médicaments par ultrasons.

Abstract

The Advanced Biomedical Ultrasound Imaging and Therapy Laboratory (ABUITL), a 1600 square-foot research laboratory jointly affiliated to Ryerson University and St. Michael's Hospital, is one of the leading research laboratories in the field of biomedical ultrasound in Canada. The laboratory was established in 2007 in the Dept. of Physics, Ryerson University and was relocated to iBEST (Institute for Biomedical Engineering, Science and Technology) in St. Michael's Hospital in September 2015. The laboratory hosts an array of research equipment in diagnostic and therapeutic biomedical ultrasound and has been active in conducting research and development and the training of highly qualified personnel (HQP) in the field. The scope of the research projects in the laboratory spans from ultrasound basic science and the investigation of biophysical mechanisms of the interactions of ultrasound with cells and tissues to novel clinical applications in all main areas of biomedical ultrasound.

Keywords: biomedical ultrasound; ultrasound imaging, therapy, and simulation; photoacoustic imaging; ultrasound drug delivery.

1 Introduction

The Advanced Biomedical Ultrasound Imaging and Therapy Laboratory (ABUITL) was established in 2007 through multiple investments from the Canada Foundation for Innovation (CFI), and a strategic investment by Ryerson University that was leveraged by an Ontario Research Fund-Research Excellence (ORF-RE) grant from the Ontario Ministry of Research and Innovation. Since its establishment, the laboratory has been receiving equipment funding support from several external funding agencies and Ryerson internal funding sources (see Acknowledgments section for details). The laboratory hosts an array of state-of-the-art biomedical ultrasound research and development resources to be used for various research projects, spanning a wide range of topics in both therapeutic and diagnostic ultrasound. The laboratory is currently co-directed by the authors of this paper.

2 iBEST in St. Michael's Hospital

In 2013, Ryerson University and St. Michael's Hospital agreed on a long-term partnership to launch iBEST (Institute for Biomedical Engineering, Science and Technology). The leadership from both institutions, who believe that innovation in healthcare is borne from multidisciplinary collaboration, supported this partnership. Both institutions have a history of strong research collaborations, joint commercialization projects, and education and training opportunities dating back nearly two decades. Connected to St. Michael's Keenan Research Centre for Biomedical Science, iBEST's access to biomedical, technological and clinical expertise allows its members and partners to identify challenges and rapidly pilot, modify and introduce biomedical discoveries and inventions to improve health. In September 2015, the laboratory was relocated to iBEST in St. Michael's Hospital's Keenan Research Centre leading to further expansion based upon the institute's foundation of excellence that combines researchers' expertise with state-of-the-art research labs and infrastructure.

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3 Mission and Areas of Research Focus

Ultrasound is a non-ionizing wave-based energy modality with a wide range of applications in medicine and biology. The mission of ABUITL is to advance the scientific understanding and applications of biomedical ultrasound in Canada and worldwide. To this end, the laboratory has been active in securing research funding, in conducting a wide range of R&D projects in biomedical ultrasound, and in the training of highly qualified personnel (HQP) in various levels from undergraduate and graduate students to post-doctoral fellows and visiting researchers. The laboratory collaborates actively with a number of higher education, clinical research, and private-sector industrial institutions within Canada and abroad. Research and development projects in all areas of biomedical ultrasound diagnostics and therapeutics and the interaction of ultrasound with other energy modalities are being undertaken in the lab. The scope of the research projects spans from basic science and the investigation of biophysical mechanisms to novel clinical applications.

4 Main Research Themes in the Laboratory

- Ultrasound imaging (high-frequency ultrasound imaging, ultrasound tissue characterization and cancer detection, and acoustic microscopy and cell imaging)
- Photoacoustic imaging and optical coherence tomography for diagnostic and therapeutic monitoring applications
- Ultrasound in combination with microbubbles in medical imaging and therapeutics
- Ultrasound-mediated targeted drug delivery
- Ultrasound-enhanced radiotherapy and chemotherapy in oncology
- Modeling and simulations of ultrasound propagation and interactions in tissues in linear and nonlinear regimes
- Image-guided ultrasound therapy including high intensity focused ultrasound (HIFU), histotripsy, and low intensity pulsed ultrasound (LIPUS)
- Ultrasound therapy in neurology and neurosurgery
- Biomedical ultrasound signal and image processing

5 Main Research Equipment in the Laboratory

- High-frequency ultrasound scanners (up to 100 MHz) and an acoustic microscope (up to 2 GHz)
- Several ultrasound scanners and imaging probes
- A high frame rate optical camera (2 million frames/sec) integrated with a high magnification microscope
- Ultrasound transducers for diagnostic and therapeutic applications and associated electronics
- HIFU, histotripsy and LIPUS systems and electronics
- RF power amplifiers, digital oscilloscopes, impedance meters, pulser/receivers, acoustic power meters, and calibrated hydrophones
- 3D micro-positioning systems and water tanks for acoustic field measurements
- A water conditioner system (degasser and deionizer)
- Various ultrasound simulation software tools

- Thermometry systems with calibrated thermocouples
- A high-resolution thermal camera
- Several optoacoustic imaging systems
- An optical parametric oscillator with double integrating spheres for measuring materials' optical properties
- Compact spectrometers operating over the visible and near infrared (NIR) range of the spectrum
- Solid state laser interferometry setups
- A 4-channel laser delivery system for therapy
- A nerve electrophysiology system



Figure 1: Advanced Biomedical Ultrasound Imaging and Therapy Laboratory (ABUITL) at iBEST in St. Michael's Hospital's Keenan Research Center.

6 Conclusion

ABUITL, a research laboratory jointly affiliated to Dept. of Physics, Ryerson University, and iBEST, St. Michael's Hospital, is one of the leading research laboratories in the field of biomedical ultrasound in Canada. The laboratory will continue pushing the boundaries of knowledge and filling the gap between basic science research and clinical applications in the field of biomedical ultrasound and related areas.

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