Continuous emission echography: a new paradigm to break the temporal resolution in ultrasound imaging

The development of real-time **3D ultrasound** imaging is constrained by two fundamental challenges: **probe design and acquisition speed**. Achieving wide-aperture insonification with high sensitivity typically requires a channel count incompatible with practical systems; **sparse array** configurations provide an effective tradeoff by enabling spatial aperture decimation while preserving transmit–receive performance.

A second limitation arises from time of flight with pulse-echo (PE) acquisition modes. Because acoustic propagation speed is fixed, PE inherently restricts frame rate and exhibits extremely low sensing duty cycles, limiting its ability to capture short-lived or high-velocity events. On the other hand, long coded excitations can increase energy deposition. They also generate transmit–receive overlap and blind zones in single-aperture implementations.

We recently introduced **Continuous Emission Ultrasound Imaging** (CEUI) that addresses these constraints by replacing temporally discrete pulses with continuous, spatially and temporally encoded waveforms. Leveraging sparse arrays to physically decouple transmit and receive apertures, CEUI enables uninterrupted insonification and continuous data acquisition. This architecture removes the round-trip waiting time, theoretically allowing **unbounded frame rates**.

This talk introduces CEUI as the convergence of sparse array design, compressed acquisitions and computational methods for image reconstruction. We will outline its core principles and theoretical foundations, the methods designed to decode the received raw signals and beamform M- and B-mode images, and demonstrate its ability to reach unprecedented imaging speeds—exceeding 100,000 frames per second—through simulations and early experimental results.

Hervé Liebgott is full professor at the Department of Electrical Engineering of the University Institute of Technology Lyon 1 (Lyon University, France) since 2016 (associate professor 2006-2016). He has been a junior member of the French ("Institut Universitaire de France") (2014-2019). His research focuses on image and signal processing applied to medical ultrasound imaging. He is particularly interested in image reconstruction techniques and motion estimation. He has published 76 journal articles and more than 120 conference proceedings.

He received the Masters degree in Electrical Engineering and the Masters degree in Acoustics from the Lyon National Institute of Applied Sciences (INSA Lyon) in 2002, and the PhD degree in 2006 for his research on Transverse Oscillations techniques adapted to elastography. His PhD has been the opportunity to visit the Technical University of Denmark (Lyngby, Denmark) for a 6 months period. In 2011 he received the French Habilitation to Lead Research (HDR) from University Lyon 1. In 2014 Hervé Liebgott has been for 6 months invited researcher at the Université de Montréal (Montreal, Canada) in the research group lead by Dr. Damien Garcia.

He has been the head of the Ultrasound imaging team at CREATIS between 2017 and 2022. The team is composed of 12 permanent researchers and professors and as many students. He has supervised or co-supervised 28 PhD students, 7 post-docs and 26 maters students.

Between 2014 and 2016 Hervé Liebgott has served as an elected associate member of the IEEE Bio Imaging and Signal Processing (BISP) technical committee. In 2014 he became an elected member of the IEEE International Ultrasonics Symposium Technical committee and has been chair of Medical Ultrasonics group within the TPC between 2021 and 2023. He has been an associate editor of the IEEE UFFC Transactions between 2015 and 2022.