nano-tera.ch
swiss scientific initiative in health / security / environment systems

UltrasoundToGo RTD 2013

FNSNF

UltrasoundToGo: Portable Ultrasound Imaging Platform

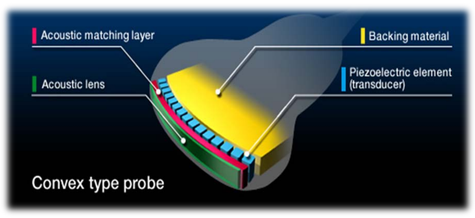
Federico Angiolini[1], Simon Bliudze[3], Jean-Philippe Thiran[2], Joseph Sifakis[3], Giovanni De Micheli[1]

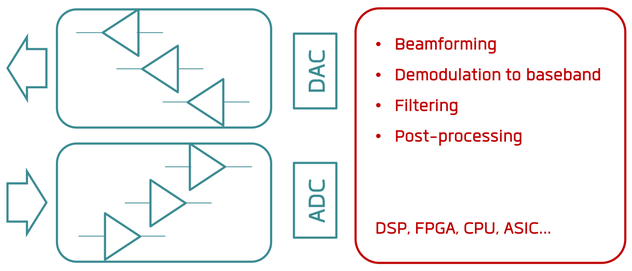
1 - Laboratoire des Systèmes Intégrés (LSI), EPFL, 2 - Laboratoire de Traitement des Signaux 5 (LTS5), EPFL, 3 - Rigorous System Design Laboratory (RiSD), EPFL

Ultrasound Imaging

- Most common medical imaging technique worldwide (as opposed to CT, MRI, etc.)
- Lowest cost, least infrastructure
- Also known as: sonography, Doppler, elastometry, etc.
- Used in: emergency medicine, cardiology, gynecology, neurology, ophthalmology, urology, ...
- Requires trained sonologists and lab-scale equipment

Ultrasound Imaging Basics





Analog amplification

Digital Processing

- Digital logic does "emission beamforming"
- Ultrasound probe (many types) transduces signal into sounds
- Sounds are reflected differently by organic matter
- Echoes are collected and amplified
- Processing logic does "reception beamforming" to reconstruct image line by line
- Many emissions per image, many images per second
- Requires high front-end bandwidth (many GB/s of raw samples) and expensive computation

An Evolving Landscape

- New planar (as opposed to linear) probe geometries allow for 3D imaging
- Miniaturization of imaging devices

The UltrasoundToGo Project

- Joint research project between EPFL and ETHZ, with CHUV hospital involvement
- Encompasses hardware design, software engineering, and algorithmic investigation
- Aims at the development of a forward-looking ultrasound imaging platform
  - Mobility-oriented, recognizing that battery-powered applications in emergency medicine, rural areas and third-world countries represent potentially breakthrough advancements in therapeutic options
  - Targeted to the highest image quality, to provide optimal diagnostic capabilities and expand the application fields
  - Easy to use, ideally allowing for adoption by general practitioners rather than requiring a highly-trained sonologist even for basic procedures
  - Based on a robust software engineering approach, leveraging extensive modeling (including thermal) and parallel system simulation to synthesize formally-verifiable executable code

Project Pillar 1 – An Efficient Parallel Computing Platform

led by LSI laboratory, EPFL

- High-performance , low-power, parallel emerging platforms such as STMicro's STHORM
- Breakthrough computing power in excess of 40 GOPS/W allows for the software implementation of previously hardware-bound logic and makes whole new imaging options available
- Reduces power requirements to levels compatible with battery-powered, mobile targets

Project Pillar 2 – State-of-the-Art Image Processing

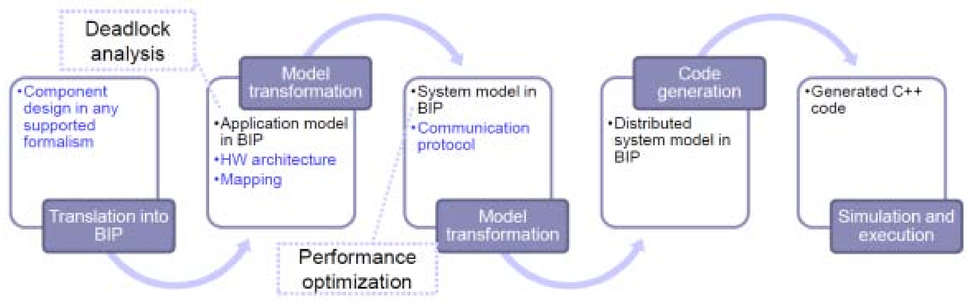
led by LTS5 laboratory, EPFL

- Application of the latest imaging processing breakthroughs to the ultrasound imaging domain
- Compressed sensing and compressive sampling for both 2D and 3D ultrasound images allows for
  - Lower power consumption since the number of samples needed to reconstruct an image is reduced,
  - and/or better image quality since the effective frame rate can be increased

Project Pillar 3 – Formally-Verifiable Software Synthesis

led by RiSD laboratory, EPFL

- A methodology and supporting tools for the design of correct-by-construction applications
- A whole design flow based on a series of semantics-preserving transformations, that lead to executable code from a high-level application model in a Domain Specific Language (DSL) tailored for the project



Project Roadmap