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Ultrasound ToGo RTD 2013

FNSNF

Prototype Platform for Ultrasonic Imaging

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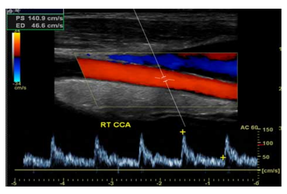
Ultrasound Imaging

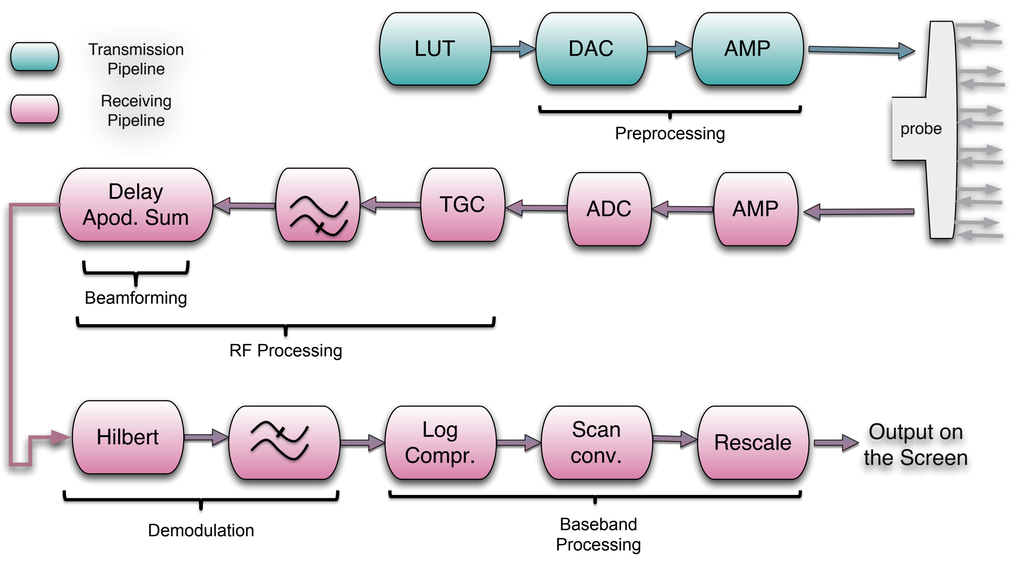
- Ultrasound imaging is a biomedical imaging technique allowing for diagnosis in soft tissues.
- Ultrasound imaging is one of the most popular imaging techniques due to its relatively low cost, safety (e.g. as opposed to high-energy X-Ray radiation), and non-invasiveness.
- Ultrasound acquisition is performed by using a transducer containing an array of vibrating elements, used for both transmit and receive.

- Two common modes of ultrasound imaging are B-mode and Doppler:
  - **B-mode:** for the imaging of stationary objects. The received echoes come with arrival times proportional to the depth of the reflecting scatterers. Used for gastroenterology, obstetrics, etc.

  - **Doppler imaging:** for moving objects and fluids. The received echoes are also Doppler-shifted in frequency by moving scatterers (e.g. blood flowing vessels). Used for cardiology, neurology, etc.



B-mode Processing

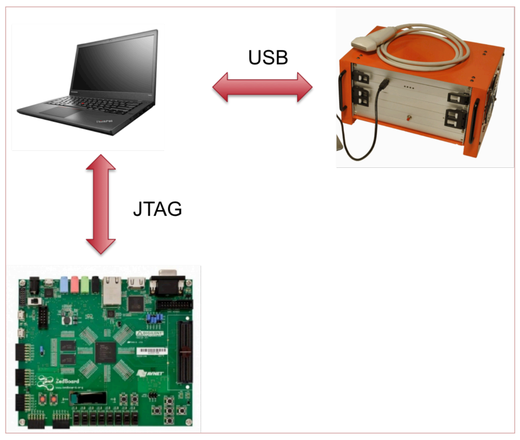


- **Beamforming** is the crucial part of ultrasound imaging, where techniques are used to create an image from the received echoes by calculating the position and reflectivity (tissue type) of scatterers from the arrival time, frequency and intensity of the echoes.

The UltrasoundToGo Project

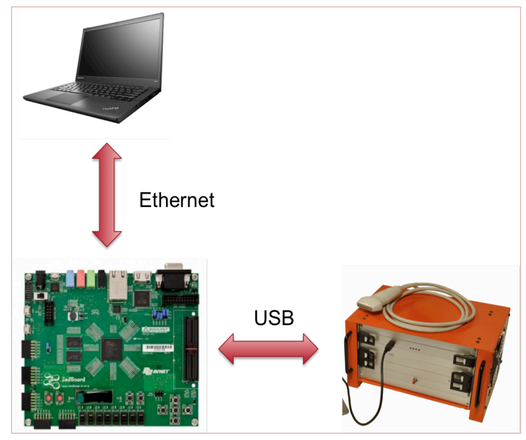
- The **UltrasoundToGo** project aims to develop a high-performance, low-power signal processing platform for ultrasound imaging applications. The ideal goal is portable 3D ultrasound imaging.
- An FPGA embodiment of the project is planned.
- Project development is performed in Matlab as a testing and investigation phase before the implementation and deployment of algorithms on FPGA.

Development Setup



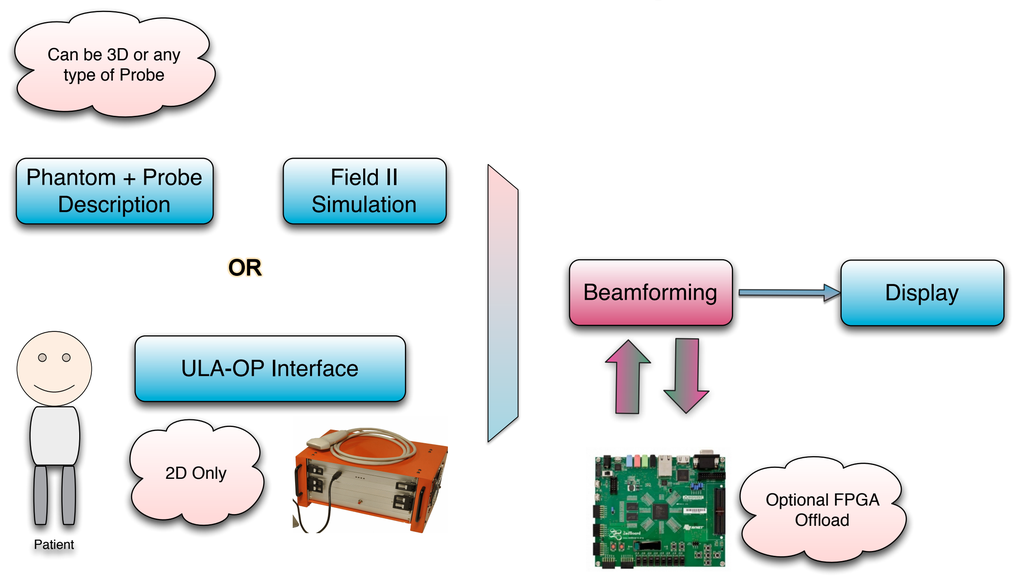
- Matlab, running on the computer, used to implement the imaging flow.
- USB-connected equipment can provide real-world digitized echoes.
- Computer runs the echo processing flow, with FPGA offload of some blocks.

Longer-Term Objective



- Computer is just used to supervise operation and display images.
- Hardware board in charge of all processing.
- USB-connected equipment provides real-world digitized echoes.

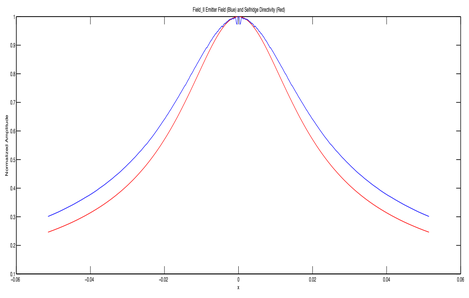
Matlab Flow In Development



- ULA-OP [1] is a complete and powerful hardware platform for ultrasound research purposes. In this project, it is used only for the acquisition and storage of echo data from test subjects, while image processing is re-implemented. Only standard probes for 2D imaging can be connected to ULA-OP.

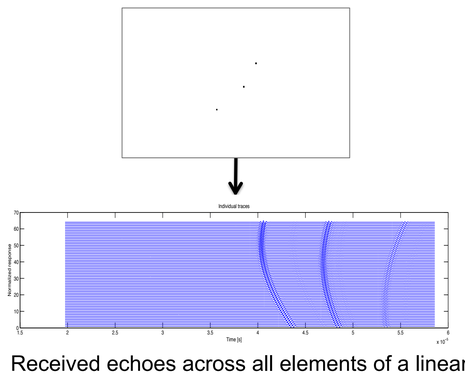
Simulation of Synthetic Ultrasonic Signals

- Based on the Field II simulator [2], running in Matlab.
- Field II is a simulator for ultrasound transducer fields (i.e. emitted field and pulse-echo fields).
- Multiple types of transducers can be defined, including research-oriented models of probes for 3D imaging that are otherwise too expensive to acquire or unavailable for research.
- The simulation output is a set of sound pressure intensities sampled in time:
  - Typically at the surface of the transducer (measurement of received echoes)
  - Can also be sampled anywhere in the volume and in time (study of sound and echo propagation)
- Arbitrary synthetic phantoms can be defined for testing:
  - Not necessarily realistic
  - Main advantage is that this allows for objective comparisons between the reconstructed image and the ideal one, yielding beamforming quality metrics.



Measurement of single-element emission using Field II (blue) against Selfridge's theoretical directivity prediction (red) [3]

Three scatterers to be imaged



Received echoes across all elements of a linear probe when the phantom is imaged

References:

[1] ULA-OP website, http://www.msdlab.dinfo.unifi.it/CMpro-v-p-19.html .
[2] Field II website, http://field-ii.dk/ .
[3] A. R. Selfridge, G. S. Kino, and B. T. Khuri-Yakub, "A Theory for the Radiation Pattern of a Narrow-strip Acoustic Transducer", in Applied Physics Letters, vol. 37, Jul 1980, pp. 35-36.

Studying Beamforming Algorithms with Field II Simulator