Live Demonstration: Inexpensive 1024-Channel 3D Telesonography System on FPGA

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Abstract

Volumetric ultrasound (US) is a very promising development of medical US imaging. An under-exploited advantage of volumetric US is the mitigation of the strict probe positioning constrains necessary to acquire 2D scans, potentially allowing the decoupling of US image acquisition and diagnosis. However, today's 3D US systems are large and beset by high power and cost requirements, making them only available in well-equipped hospitals. In this work [1], [2], we propose the first telesonography-capable medical imaging system that supports up to 1024 channels, on par with the state of the art. As a first embodiment, we have implemented our design in a single development FPGA board of 26.7cm×14cm×0.16cm, with an estimated power consumption of 6.1 W. The imager exploits a highly scalable architecture which can be either downscaled for 2D imaging, or further upscaled on a larger FPGA. Moreover, our design supports two types of data inputs: real-time via an optical connection and offline over Ethernet. The reconstructed images can be visualized on an HDMI screen. The estimated cost of the proposed prototype materials is less than 4000€. TABLE I shows the resources utilization of the current design and the extrapolated utilization in case of further upscaling on a larger FPGA.

Demonstration Setup

Figure 1 shows the setup of the proposed telesonographic platform. The US reconstruction of the input data, which can be supplied in realtime by a probe or come from an offline pre-acquired dataset, is performed based on efficient proposed algorithms and architecture implemented on a single Kintex UltraScale KCU105 FPGA board. The imager output is then sent over an HDMI transmitter to a screen. The platform is also able to communicate with a laptop using Ethernet, for simulated data processing. Moreover, a graphical user interface (GUI) has been developed in C# (Figure 2) to allow controlling the imaging modes and settings. The demonstration material requirements are:

- Provided by demonstrators: (i) the Kintex UltraScale KCU105 FPGA board, (ii) a laptop, (iii) DVI to HDMI converter, (iv) an HDMI cable, and (v) a poster.
- Provided by BioCAS organizers: (i) a table for the demo setup, (ii) a power plug, and (iii) a pin wall for a poster.
- Additional requirements from the organizers: (i) a screen with HDMI or DVI input, (ii) a DVI cable, and (iii) a power strip of at least 5 ports.

Visitor Experience

The visitor should experience a live 3D US reconstruction of 3D data performed on a single, inexpensive, and low-power FPGA, which is unprecedented. The demonstration will be performed using pre-acquired simulated data since the 3rd-party probe is currently unavailable. The developed GUI gives the user the control for choosing the imaging modes, the reconstruction settings - like 3D/2D, reconstruction resolution, the field-of-view (FOV) size, etc. -, the brightness of the output image, and the type of the dataset to be reconstructed.

TABLE I
IMAGER RESOURCE UTILIZATION.
*Kintex UltraScale KU040 implementation results.
**Virtex UltraScale XCVU190 extrapolated results.

Supported Channels	Logic LUTs	Regs	BRAM	DSP	Clock	Theo. Rate
32×32*	85%	34.5%	97.1%	7.2%	133 MHz	66 vps
90×90**	84.3%	31.5%	89.4%	7.7%	133 MHz	66 vps

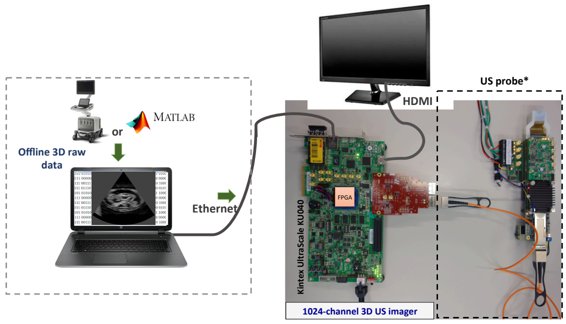

Fig. 1. Setup of the telesonographic-capable 3D US imager. *The probe on the right is a 1D probe for proof-of-concept and to be replaced with a matrix probe whenever available.

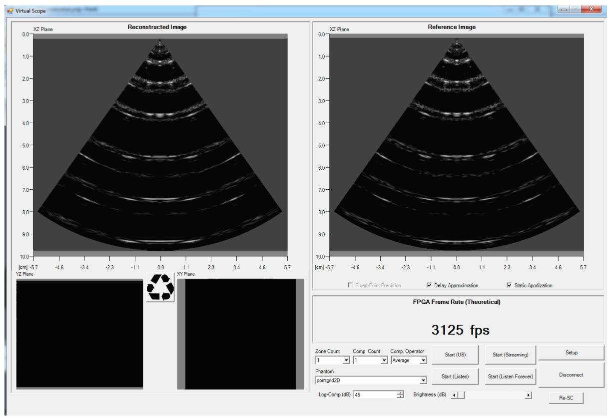

Fig. 2. GUI to allow controlling imaging modes and reconstruction settings.

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Earlier Publications

[1] A. Ibrahim, W. Simon, D. Doy, E. Pignat, F. Angiolini, M. Arditi, J.-P. Thiran, and G. De Micheli, "Single-FPGA complete 3D and 2D medical ultrasound imager," in *Proceedings of the Design and Architectures for Signal and Image Processing 2017 Conference (DASIP 2017)*, 2017.

[2] A. Ibrahim, D. Doy, C. Loureiro, E. Pignat, F. Angiolini, M. Arditi, J.-P. Thiran, and G. De Micheli, "Inexpensive 1024-channel 3D telesonography system on FPGA," in *Proceedings of the 13th IEEE Biomedical Circuits And Systems Conference (BioCAS 2017)*, 2017.