A Wireless Software Defined NDT Phased-Array System for Remote Applications

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Background, Motivation and Objective

Classical ultrasound Phased-Array (PA) technology are now widely adopted by the industry for non-destructive testing (NDT). A novel Full-Matrix Capture (FMC) technique supplemented by the Total Focusing Method (TFM) features a depth-independent lateral resolution and opens up opportunities for advanced post-processing algorithms.

However, a massive amount of raw FMC data and the required high processing capabilities somewhat limit its real-world applications, in particular for remote and motorized inspection.

We have already created a demonstrator of a portable Phased-Array device with an embedded Nvidia® Tegra X2 GPU enabling real-time TFM implementation. Now, our objective was to present the benefits of close-to-the-probe, software-defined ultrasound processing in limiting the required external data transfer, and thus enabling wireless remote inspection applications.

Statement of Contribution/Methods

Our demonstrator is built around a compact low-power ultrasound front-end module (us4us® Ltd., Poland). The module supports 32:128 configuration and interfaces directly to a mobile GPU module, creating a complete Phased-Array scanner system. Both the front-end and the processing is software programmable, enabling the implementation of classical and novel processing image reconstruction algorithms. External interfaces include USB, Ethernet, and Wi-Fi.

For real-time scanning applications, the transfer of raw FMC through wireless (200-300Mbps) is not feasible. Yet, by applying local GPU processing for the TFM image reconstruction, one can greatly reduce the amount of data to transfer. Instead of transferring raw FMC data, we can transfer the resulting reconstructed image only.

We have evaluated the TFM algorithm and effective real-time data transfer from the scanner to a notebook PC. A 5MHz, 128-element Olympus® NDT PA probe and a standard steel PA test block were used. The raw RF signal was sampled at 40MSPS.

Results/Discussion

Applying standard FMC acquisition results in a dataset of 128x128 RF lines. Sampling 40MSPS/12-bit and imaging of just 10cm in stainless steel give ~1400 samples per RF line, and thus ~46MB for a single FMC set. With local TFM processing, we create a single uncompressed B-mode image consisting of 128 scanlines, thus reducing the amount of data by 128 to ~0,36MB. Assuming a sustained Wi-Fi transfer rate of 300Mbps, this will provide an image refresh rate of 0.8fps in the case of raw FMC data transfer, and over 100fps for the reconstructed data. A simple image streaming application can be implemented for real-time imaging on a remote PC computer.

We have shown the feasibility of applying FMC/TFM methods in portable NDT scanners for real-time remote inspection and wireless data transfer. Remote and robotized inspection systems can benefit from advanced signal processing by integrating low-power GPU processing.

In the next step, we are planning to evaluate the system performance in a real-world industrial setup.