

Exploring hardware accelerators capabilities in Ultra-High Field MRI systems

Research project/Bachelor/Master Thesis

Research field

In recent decades, hardware accelerators such as GPUs, TPUs, FPGAs, Adaptive SoCs, and NPUs have achieved performance levels of hundreds of TFLOPS. This breakthrough has enabled advances in fields previously limited by computing power, such as real-time medical imaging — essential for image-guided tumor ablation procedures. Ultra-High Field Magnetic Resonance Imaging (UHF-MRI) is one such technology, offering exceptional spatial resolution that allows researchers to capture detailed brain images and monitor functional activity in real time. However, its use in interventional procedures remains limited due to the massive data volumes that must be processed instantly and the strict need to monitor the Specific Absorption Rate (SAR) in real time to ensure patient safety at high magnetic fields. To address these challenges, different hardware accelerators can be employed throughout the imaging pipeline — from sensors to display — while incorporating data reduction strategies to handle high-throughput, low-latency communication. Efficient task mapping, memory management, and optimized pre-processing, reconstruction, and post-processing are essential to overcome non-uniformity, parallel acquisition, and sampling limitations, ensuring high-quality final images.

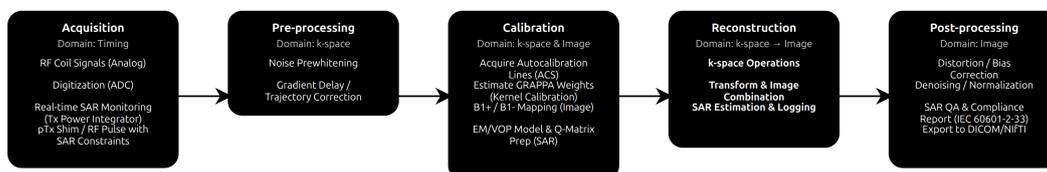


Figure 1: Example of dataflow path in a UH-MRI scanner. Not all steps are required

Research topic and working hypothesis

In this thesis the student will get a MRI reconstruction algorithm to run on GPU, and he will focus on scaling it for a targeted UHF-MRI scanner, considering all the steps showed in the Fig. above. In order to achieve improvement the student has to analyze the computational requirements using analytical models like roofline model and then customize part of the processing on one or more accelerators.

Skills

Required:

- Knowledge in Verilog or VHDL
- Knowledge in C++ and CUDA

Desired:

- Basic knowledge of Vivado
- Knowledge of MRI reconstruction algorithm and parallel computing

Contact



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