technische universität dortmund

Bachelor/Master Thesis

Hardware Acceleration for Real-time Quantum Spin Noise Spectroscopy

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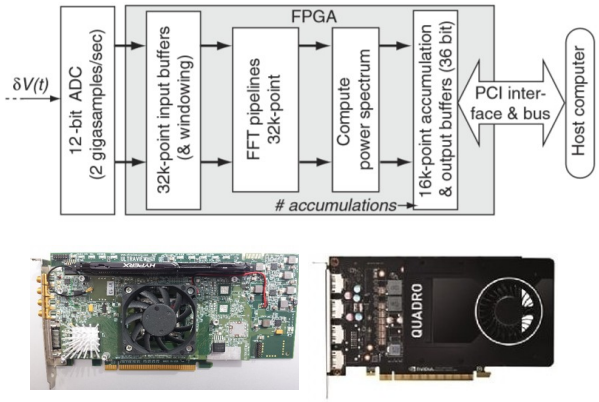
Computers based on quantum mechanical phenomena are expected to provide drastic speedup of particular computations in comparison to classical ones. To realize such quantum computers, a quantum version of classical binary bits is needed, called quantum bits or qubits. Qubits can be realized by different systems, such as: polarization states of photons, electronic states in atoms, super-conducting flux qubits, etc. Each system has its own advantages in comparison to others. Here, we concentrate on one alternative: Spins in semiconductor quantum dots (QDs). These are created by nanometer-sized semiconductor structures localized in the semiconductor host matrix. QDs can be designed to confine a single electron, the spin state of which is used as a qubit. This system can be integrated into the commonly used semiconductor technology, and allows electrical and optical control, has a fixed location in the crystal, and provides a natural connection to the photons, which can be used to transfer a quantum information on a long distance.

One of the main properties for quantum computation is the coherence time, which defines the lifetime of the information. As the qubit state is confined within a semiconductor, its interaction with the surrounding atoms leads to relaxation processes, which needs to be studied. To analyze the interaction, massive amounts of data have to be collected from spectroscopic experiments. Furthermore, the experiments need to be fine-tuned in real-time, for which fast data processing with specialized hardware and software is needed.



Top: Desired pipeline, bottom: FPGA (left) and GPU (right)

***In this thesis**, the objective is to optimize the signal processing pipeline for spectroscopic analysis. The first milestone is to create a CPU-only reference implementation. In the second and third step, the use of GPUs and FPGAs for acceleration should be explored. Finally, the three versions of the pipeline need to be compared.*

Before starting, it would be good have (or develop) basic knowledge of:

- Digital Signal Processing (FFT)
- Hardware-acceleration (GPU, FPGA)

After finishing, you will have acquired:

- Interdisciplinary experience in optimizing signal processing pipelines