Bachelor's Project

Machine Learning techniques for automated tuning of quantum dots

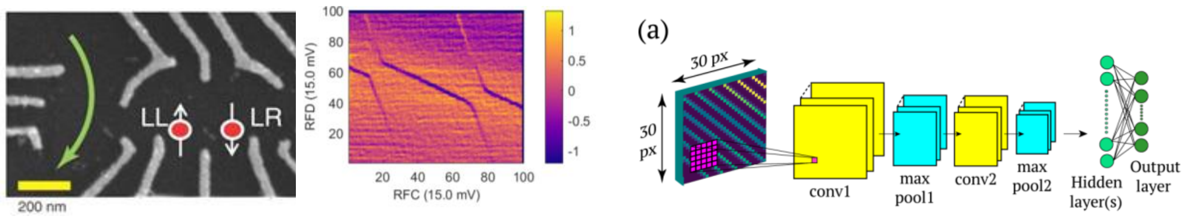

Fig. 1: (left) *Four electrons confined in two double quantum dots, similar to the current experimental setup at our group. The metal gates confine the electrons and control the energy level spacing in the dots, the coupling between the dots as well as the coupling to the leads for electron loading. (Figure from Shulman et al., Science 2012).* ***(middle)*** *Changes in charge occupation of a double quantum dots can be seen as jumps in the sensor signal.* ***(right)*** *Sketch of a convolutional neural network to detect these features. (Figure from Kalantre et al., 2018).*

Background

A quantum system consisting of 2 electrons can be used to realize a quantum bit (qubit), the smallest unit of a revolutionary new computer concept. The two electrons are confined in a double quantum dot where metal gates allow the manipulation of the qubit's quantum state by applying high-frequency electrical pulses. Fig. 1 shows the experimental realization of two qubits, similar to the device used in our group.

In order to be usable for quantum computation the double quantum dot has to be tuned electrostatically by metal gates on top of the semiconductor heterostructure. The exact voltages applied to these gates determine the position, size and coupling of the individual quantum dots. The system can be measured using the resistance of a nearby sensing (quantum) dot. Using the response of this sensing dot, the gate voltages have to be tuned such that the double quantum dot can be used for quantum computation. At the moment this task is performed manually every time an experiment is conducted.

Your Task

We have recently compiled a set of a couple of thousand sets of measurement data. Your task will be to research and implement machine-learning techniques to identify certain features and classify the data by the number of visible quantum dots. These algorithms will then be used to automate tuning procedures in the future. The goal of this project is not only to successfully implement first machine learning approaches and use them for automated tuning, but also to establish this knowledge in our group.

This project will allow you to extend your knowledge of these topics, among other things:

- Theory of electron spin qubits and quantum computation
- Quantum mechanics and quantum information experiments
- Machine learning techniques and programming in MATLAB or Python

Furthermore, you will participate in group seminars and Journal Clubs to discuss cutting edge developments in this area of research.

References

https://arxiv.org/abs/1712.04914

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