How can a machine automatically discover better feedback strategies for quantum devices?

Florian Marquardt
Max Planck Institute For The Science Of Light, Erlangen, Germany

Many challenging tasks in the areas of quantum computing, communication, sensing and simulation require feedback strategies. Examples include state preparation and stabilization, adaptive quantum-improved sensing, and quantum error correction. In this talk I will explain how reinforcement learning can help to automatically discover elaborate feedback strategies. Reinforcement learning considers the interaction between an agent and environment, and the goal is to discover a strategy for the agent to behave in an optimal fashioning, trying to improve a reward function that encodes the overall goal. In our group, we have applied this general concept to discover better quantum error correction strategies from scratch, to train an agent that can optimize arbitrary quantum circuits, and to find good feedback strategies for quantum devices like qubit-cavity systems. Recently, we have shown how to apply these techniques directly in an experiment involving a superconducting qubit, creating a real-time neural network agent with an unprecedented reaction time. Furthermore, going beyond the so-called model-free reinforcement learning techniques, we have introduced a model-based approach, feedback-GRAPE, where we are able to take gradients through the evolution equations despite the presence of stochastic discrete quantum measurements.