QML for Conspicuity Detection in Production
Fraunhofer+Womanium Project

The project focuses on conspicuity detection in production, which makes it possible to identify improvement measures for individual work steps or sub-processes at an early stage and thus optimize the production process. To do this, we analyze process data such as image data or time series to uncover deviations and weak points in production. Classical methods for analyzing such data are very time-consuming.
Therefore, our project attempts to explore the potential of hybrid quantum computing in accelerating this process. Our primary focus lies in implementing the necessary hybrid quantum algorithms and rigorously benchmarking them against classical approaches, including machine learning and statistical methods.

Task-1 Problem Statement

Familiarize yourself with Pennylane. The tutorials in the Pennylane codebook are a good way to get started. We recommend the codebooks from the sections “Introduction to Quantum Computing”, “Single-Qubit Gates” and “Circuits with Many Qubits”, which can be found on the following page (registration is required): Pennylane Codebook. Document your progress and share your learnings as you follow these Pennylane tutorials.

Getting started with Pennylane

Pennylane is a python library developed by Xanadu that serves as a bridge between quantum computing and machine learning. My journey with pennylane first started with opening the website for the first time and browsing through the various tabs. Once I figured out what to do, I registered on the website and installed pennylane. Since then the route has been pretty well defined, and the learning experience has been quite smooth as well thanks to how well the codebooks have been made with code exercises as well as theory.

Codebook-1-Introduction to Quantum Computing

The first codebook consists of three modules, namely “All About Qubits”, “Quantum Circuits” and “Unitary Matrices”.
These modules taught the basics of Quantum computing and the basic syntax of Pennylane and gave a good idea on all the components required for coding a complete circuit using Pennylane. Since it was the first codebook, and I had very little prior experience with Pennylane, some of the codercises did give me some trouble. My mistakes mainly consisted of logical errors in my code, or some theoretical misconceptions. To name a few, I didn’t take the conjugate of state1 and was stuck for a while. Learning about depth of the circuit in 1.2.4 was also confusing at first

but I was able to clear my doubts with the relevant theory. In the third module I learned about the qml.Rot function which proved to be a very important function for building complex quantum circuits.

Codebook-2-Single Qubit Gates

This codebook consists of 7 modules, namely “X and H”, “It’s Just a Phase”, “From a Different Angle”, “Universal Gate Sets”, “Prepare Yourself”, “Measurements” and “What Did You Expect?”.

This codebook was considerably longer than the previous and was quite a bit more difficult, but nothing too extreme. Since I already had a basic idea after Codebook-1, the codercises went a bit more smoothly this time around. It started with simple applications of X and H gates and moved to again simple applications and combinations of rotation gates. From Codercise 1.7.x, the difficulty however increased. Figuring out what combination of rotations is equivalent to a Hadamard gate or PauliY gate was quite confusing and time consuming. But all of the exercises were doable once I spent some time thinking and visualizing the problem. From there I learnt about quantum state preparation and thus about pennylane templates. Followed by this I learnt about the applications of the very important qml.probs and qml.expval functions. Codercise 1.10.4 was probably my favorite from this codebook as it utilized all my previous learning all together and was complex enough to feel rewarding once I finished solving it.

Codebook-3-Circuits with Many Qubits

This codebook consisted of 4 modules namely “Multi-Qubit Systems”, “All Tied Up”, “We’ve Got It Under Control” and “Multi-Qubit Gate Challenge”. Though shorter than the previous codebook, this one was by far the most challenging. It had a lot more thought provoking codercises than the previous codebooks, It started off with a simple introduction to creating quantum circuits with multiple qubits and moved to an interesting problem comparing different expectation values for two different kinds of measurements. Followed by that I learnt about different controlled operations and simple applications. Codercise 1.13.x was the most complex and time consuming as it involved multiple problems where I had to figure out what pattern gates formed the desired gate. But with the help of online forums and the pennylane recommended resources I eventually was able to successfully complete the module. After the third module, the fourth module seemed quite simple yet interesting. This codebook thought me the importance of visualizing the different transformations as well the importance of being able to draw quantum circuits.