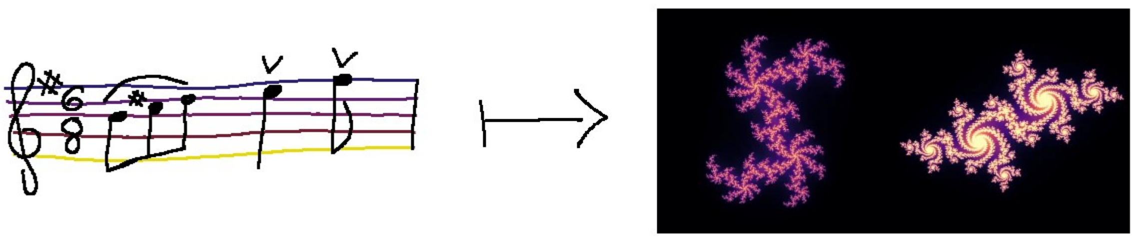
Analyze Music with QFT to Produce a Fractal Film

Hackathon Challenge created by Wiktor Mazin, Qiskit Advocate and Aeriana M. V. Narbonne

Qiskit 2023 January Hackathon



Abstract

In this problem, you will attempt to use QFT to both analyze an example piece of music and create the corresponding fractal image representations.

1 Problem

Take a piece of copywrite free music (for example "Oh Canada") and transform each bar into fractal art. You must scale to 4 or more qubits and run QFT on a real quantum computer.

Hints:

1. Take a look at the work already done by Wiktor Mazin, Thorsten Mühge and Manfred Oevers to familirize yourself with the problem.

2 Motivation

2.1 Fractal

Definition. A **fractal** is a geometric shape containing detailed structure at arbitrarily small scales, usually having a fractal dimension strictly exceeding the topological dimension.

2.2 Quantum Fourier Transformation

You may already be familiar with DFT, the classical Discrete Fourier Transformation. In classical Discrete Fourier Transformation you take an arbitrary time dependent function where the amplitude of the function for a given time interval is defined by a set of numbers. N defines the sampling rate of this wave for a given time interval. For QFT, we implemen the discrete Fourier transform over the amplitudes of a wavefunction.

2.3 Accessing and Running on the IBM Quantum Computer

You may run your solution on IBM's quantum computing by making an account on IBM Quantum lab. See here: https://quantum-computing.ibm.com/lab/docs/iql/first-circuit.

3 Expected Result

1. Greater than 3-qubit QFT quantum circuit is created. The 2^n (where n is the number of qubits) complex amplitudes of the more than 3-qubit statevector are captured with the statevector simulator.
2. Measurement gates are added and the circuit is executed on a noisy quantum simulator (qasm simulator with a noise model). This results in counts and probabilities of each of the 2^n basis states.
3. Two types of more than 3-qubit fractals based on Julia set mating are leveraged utilizing the 2^n complex amplitudes. Four fractal images are created based on these two types of fractals both with (adjusting for the counts) and without noise.
4. Run you solution on a quantum computer.

You must expand on the work provided by Wiktor Mazin, Thorsten Mühge, and Manfred Oevers.

1. Scaling to more qubits
2. Running QFT on a real Quantum Computer.

4 Rules

1. You are allowed to search the web to learn about QFT, fractals, and more, however you must cite these sources.
2. You must explain your code, i.e. you cannot copy and paste.

5 Recomended Resources

The notebooks:

https://github.com/wmazin/Visualizing-Quantum-Computing-using-fractals/tree/main/Quantum-Fourier-Transformation

https://github.com/TMuehge/Quantum-Fourier-Transformation

More information: https://www.linkedin.com/pulse/how-analyze-sound-quantum-fourier-transformation-turn-thorsten-muehge/?trackingId=7sGkad2un%2Bxo04zFlcTUkQ%3D%3D

Other projects: https://iccmr-quantum.github.io/