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21M.080 Final Project Background Report

For my final project, I will attempt to find a mapping between quantum algorithms and sound to help recognize patterns in the algorithms, which will hopefully aid in the discovery of new algorithms. Sonification (Walker and Nees 2013) is a very common theme with a wide range of applications.

Some applications are primarily for artistic purposes, but I am more interested in the many applications that involve pattern recognition. For example, a meteorology professor and a music technology professor from Penn State teamed up to sonify the dynamics of tropical storms by turning environmental data into sounds (Ballora and Evans 2017). According to the article, our ears are better than our eyes at detecting change and fluctuations. Another example comes from a music professor at Eastern Washington University and a chemical biology professor at the Francis Crick Institute (Bywater and Middleton 2016). They sonified proteins and protein folding to detect patterns and anomalies, and found that often the ears were able to recognize these anomalies better than the eyes. Astronomer turned astronomical data into music (Communications 2013). Music and engineering professors from Virginia Tech turn big data into sound (Bonasio 2018). And my personal favorite, LIGO (Caltech and MIT collaboration) turned the detection of gravitational waves from the merger of two black holes into sound to discover the well-known “chirp” that occurs during the last moments of the inspiral (LIGO 2016).

There is very little work, however, on turning quantum algorithms into sound. In my researcher report, I detailed the only paper I could find on the subject (Putz and Svozil 2017). There is a quantum advocate at IBM who utilized some of the ideas from this paper in his code to develop a quantum music composer (JavaFXpert 2018). However, his purposes were primarily artistic; he hopes that his work will help with IBM's outreach. I am hoping to create something similar, but use it to see if researchers can decompile quantum algorithms in order to better understand and extend on their function.

Over the summer, I worked at Los Alamos National Laboratory in a theory group working on developing near-term quantum algorithms. They had recently published a paper on a method they used to machine learn a quantum algorithm, and tasked a few of us with a related project they called decompiling. We didn't work on it for very long as we ended up starting a new project, but it is nonetheless something I am very interested in. Essentially, a quantum computer has elementary logic gates just like a classical computer does, and similar to a classical computer, it is very hard to look at a bunch of elementary logic gates and determine an algorithm's function. The machine learning algorithm they developed learned the parameters for a bunch of elementary logic gates to determine the quantum algorithm. The goal of decompiling is to take this algorithm and create abstractions that help us to understand the function and extend on it. For example, very often a particular subroutine called the Quantum Fourier Transform is involved in algorithms, but it would be very hard, if not impossible, to look at a sequence of machine learned elementary gates and see that they represent the QFT. This is the goal of decompiling.

My idea is the following; similar to how researchers in other fields have used a mapping between data and sounds to help find patterns and pattern changes, I want to see if the same can be accomplished with regards to quantum algorithms.

At the moment, I have no idea if I will get any useful results. One of the main challenges is the fact that there are so many possible mappings from data to sound. My starting point will be what

I outlined in my researcher report, put forth by Putz and Svozil (Putz and Svozil 2017). But right now I've found no evidence to show that this can be used to hear patterns, for example subroutines that may exist within a routine.

Nonetheless, sonification is a very powerful tool used by many researchers in many fields, and it is worth a try to see if it can also be used in the classification and development of quantum algorithms.

References

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