CMPT 440 – Spring 2019: Quantum Finite Automata

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Theoretical Background

The quantum finite automata is define by the 15-tuple that is: $T = (\Sigma, Q, q_0, P, \alpha)$.

$$P = \frac{1}{R} \sum_{i-0}^{N} x - \delta(1, 0) \tag{1}$$

This formula was first introduced by Lu et al. (2013) and by Ambainis and Freivalds (1998). Ambainis and Freivalds (1998) States that there are two different types of QFAs, 2-way and 1-way. 2-way QFAs are considered more powerful, but based on the assumption that a quantum computer will have a quantum and a mechanical part, they would not be as effective as 1-way. This is because 2-way QFAs require more quantum states, as the size of input grows. If a quantum computer is supposed to have as small of a quantum component as possible, and a larger classical component, then this would not allow someone to handle large data inputs, which is even more relevant now then when that source was written.

There are 2 types of 1-way QFAs, reversible and non-reversible. Non-reversible QFAs take in a word, and add markers to the left and right side of the word. Then each letter is checked one after the other. If any letter is found to not exist in the language that is specified, then the word is rejected, otherwise the QFA continues.

Reversible QFAs are similar to non-reversible, there are accepting, rejecting, and non halting states. Non-halting states are simply where the word continues to another state and is neither accepted or rejected. There can be multiple accepting states in an RFA.

An Example

Lu et al. (2013) talks about a study on language, and trying to find the emotions behind "emotion-inducing" words. This means using emotion describing words, like happy or sad, to describe the emotions behind another word, like school or work. For their study they pulled a large sample of posts from a Taiwanese social network, and examined the posts for words that were one of their "emotion describing words". This means that the post was most likely one of those emotions. If the post didn't contain that, then they examined it for other signs of what the emotion of the post was.

This would be a good problem that an RFA could be used to examine. By taking a sample post from the input data, word could each be checked separately to see what emotions they carry. The entire post could then be looked at, and whichever emotion was most strongly found in the post would be the overall emotion for it. This would be done by creating a dictionary of words for each emotion. The RFA would then compare words to

that dictionary, and decide the overall emotion based on what words are found. Any words not in the dictionary could then be added to the correct dictionaries as they appear.

Conclusion

Quantum DFAs have a wide variety of applications, and and are something that will be even more relevant today thanks to the massive data sets that the internet provides us. By using QFAs and their different types effectively we will be able to work with increasingly large data sets even more quickly.

References

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P.-Y. Lu, Y.-Y. Chang, and S.-K. Hsieh. Causing emotion in collocation: An exploratory data analysis. In *Proceedings of the 25th Conference on Computational Linguistics and Speech Processing (ROCLING 2013)*, pages 236–249, 2013.