CMPT 440 – Spring 2019: Quantum Finite Automata

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Theoretical Background

A Quantum Finite Automata (QFA) is a special type of finite machine. They have something to do with Hilbert Space. Hilbert space takes Euclidean space and expands it to any finite or infinite number of dimensions. There are also Pure quantum states. A quantum state provides a probability distribution for the value of each observable in the quantum system. A pure quantum state however will correspond to the vectors in Hilbert space. To understand QFAs we need to understand Probabilistic Automata. That is to say we allow fractional values in our Matrix, such that those fractional values add up to 1 (therefore shows probability of something). Quantum finite automata then are when we allow the matrix to have complex entries, with the added requirement that they be unitary. (sum of the norms in each column add up to 1 and the dot product of any two columns is 0. There are two main types of QFAs, the measure-once and measure-many automata. "The class of languages accepted by Measure Many QFA with bounded-error probability is a proper subset of regular language" Frian (2018) "Bertoni and Cerpentieri proved, that the class RMO is exactly the class of languages accepted by AF-reversible automata, i.e the class of reversible regular languages." Frian (2018)

An Example

The Double-Zero Golden Mean: a generation of sequences of the form: $(...1^{n1}001^{n2}001^{n3}00)$ which means sequences where zeros must come in pairs, and a pair of zeros must be followed by a one. "we aim to produce a four-state stochastic deterministic finite-state machine which generates the same word distributions as the Double-Zero Golden Mean Process and such that the transition matrix is unistochastic. Once we find such a stochastic finite-state machine, we will then produce a quantized version" Young (2014)

References

M. Frian. Simple models of quantum finite automata. 2018.

A. Young. Quantum finite state machines. *University of California, Davis*, 2014.