P256B Project Proposal

Christian Pratt

April 28, 2022

Goal

The goal of the project is consider an unconventional candidate to be an example of a computational system, and to observe what information, dynamical and computational properties does this system exhibit or satisfy. The ultimate motivation for the project is to generalize the definition of what it means to be a computer, such that an axiomatic framework can be implemented which remains independent of medium, substrate, or combination of materials. A proposed candidate for this project is a biological organism, namely a *Caenorhabditis elegans (C. elegans)*, due to having it's entire connectome mapped out, with the hope that various measures could be studied. Because classical, quantum and chemical computers are extensively studied and are considered to be well-defined computers (taking note that multiple forms of quantum computers are currently being investigated by various academic and corporate entities) under the modern, technical definition of a computer, the choice for finding a suitable candidate for a biological computer is an alternative route to satisfy the goal of this project.

System

The state space would include

- The space which represents information, whether its processed or stored. For example, in the classical case, this would be the set of bits in memory and storage.

The dynamic is described by

- How information is designated to be processed and stored.
- How does the system adapt to its environment in order to survive, i.e. what is the extent of its programmability.

The interesting system behavior that could be observed is that a candidate for a biological computer can exhibit the same general properties as classical and quantum computers, but whose outputs, efficiency, and range of programmability differs.

Dynamical properties

The dynamical properties that will be investigated are the following:

- How the system responds to external changes in the environment.
- The efficiency of processing and storing information, and how a media can be dynamically modified to satisfy criteria.

Intrinsic computation properties

The information processing properties that will be investigated are the following:

- How outputs, computational complexity, and heat production compare between different media.

Methods

The methods that will be used will be the following:

- Investigate literature to understand how *C. elegans* interacts with other members of its species, the environment and its adaptability to changes in the environment.
- Define specific properties which *C. elegans* exhibits, and compare these properties to known computers defined by the modern, technical definition.
- Attempt to compute different measures for the *C. elegans.*
- Analyze results, and potentially show how this form of media will exhibit the same general computational properties that a classical or quantum computer does.

These methods are appropriate because in order to understand what is currently being done on the frontier of research, observing patterns in the literature is helpful. To further investigate what *C. elegans* can do is important for then observing potential computational properties, and how it processes information.

Hypothesis

In this project, the hypothesis is that this form of a biological computer will exhibit the same general properties as a classical or quantum computer, but whose qualitative characteristics differ drastically. The far reaching scientifically plausible guess is all forms of computation can perform a non-empty intersection of computations under a certain axiomatic framework, while some computations are intrinsically optimized for certain classes of problems.

Steps + Time

A reasonable set of steps are:

- (2 weeks) Investigate literture and potential simulations of *C. elegans*
- (1 week) Find and determine potential measures which can be feasibly computed for *C. elegans*
- (3 days) Pick certain processes from classical or quantum computers and calculate the same measures.
- (4 days) Compare, contrast and extrapolate similarities and differences between these systems.
- (rest of time remaining) Summarize and write up results.

I believe it is reasonable to complete, or at least advance the project to the point where the results are interesting, within a month.