

Plan of work

Title of the Planned Work: **Evolution of Bio-intelligence in Bacteria**

Details

Definition of Bio-intelligence

I define bio-intelligence as the intelligence displayed by a biological system. This system might comprise of a single organism such as a human or an ant colony.

Bacterial Intelligence

The communication system used by bacteria is quite intricate which lets bacteria co-operatively self-organize in an environment [1]. The mechanisms such as quorum sensing and plasmid exchange lend bacteria an extreme adaptability in diverse environments. The meaningful communication enables the bacterial colony to make group decisions thus displaying a form of social intelligence which is called bio-intelligence or bacterial intelligence in this context.

Evolution of Bio-intelligence

What I plan to do is evolve a bacterial colony which can act as a decision making module. This module will work analogous to a crude form of neural network. We can map a set of inputs to the set of chemicals interpreted by the bacteria. And then, we map the chemicals secreted by the bacteria to the set of outputs of the decision making module. This module can then be applied to problems such as expert systems, pattern recognition, or perhaps even to playing basic games such as tic-tac-toe, etc.

An extremely simple example of decision making can be the problem of identifying whether a given number from range 0-8 is even or odd. Let us imagine there are 4 different chemicals which are used by the bacteria for communication purposes. I, then, can encode numbers as binary numbers and supply the corresponding chemicals to represent those numbers. Later on, we can interpret the change of state of a bacterial colony as an answer, in this case, either yes or no.

The tentative procedure which I have thought to evolve such colonies is:

- Culture a bacterial colony/or many bacterial colonies simultaneously
- Encode inputs as signals/chemicals interpreted by the bacteria in colony
- Encode outputs as signals/chemicals secreted by the bacteria colony
- Provide food to the colony if the output is same as the desired one or in other words, provide food if the decision made is correct
- Provide toxins if output is incorrect or the decision made is incorrect
- If the desired output is not discrete but continuous, provide a combination of both (food and toxins) in correct proportions according to the difference in desired and actual output of the colony
- Mutagens may also be introduced into the culture media to accelerate evolution

According to me, over the time, bacterial colonies which make right decisions on a set of inputs should evolve.

In a nutshell, what I want to do is to create an environment (media) which will serve as input to a bacterial colony and then interpret their secretions as output.

The toxins will serve the purpose of elimination of bacterial colonies which do not perform well and food will promote the proliferation of colonies that perform better.

Once this approach has been demonstrated, I want to apply it to a very specific application which involves intelligence.

Requirements for the Work

To complete this project, I need to study and perform following (in no particular order) during my summer training:

- Which bacterial species is most suitable of this research work?
- How to change nutrient media in real-time according to predefined conditions?
- How do bacteria communicate in a colony?
- How to encode inputs and outputs in form of chemicals which can be processed by bacteria?
- How to rapidly evolve suitable bacterial colonies?
- What practical techniques I need to learn in order to perform this research?

Reference

[1] Eshel Ben Jacob, *et al.*, "Bacterial linguistic communication and social intelligence", TRENDS in Microbiology Vol.12 No.8 August 2004

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