

ELL796: Major Test (SA)

November 19, 2015

Maximum Marks: 25

- In class we saw how, by including terms of the type $\min(x_1, x_2)$ in the set of features input to the Inferelator, it becomes possible to learn approximations to AND and OR combinatorial logic. In similar fashion, show how the following logic gates can be simulated using \min features:
 - XOR
 - NAND
 - NOR

In each case, show the weights to be assigned to each feature, the overall output function, and how it gives the required truth table. [4.5]

- Suppose you wish to design a genetic algorithm to study the evolution of populations of individuals whose dynamics can be represented as follows:

$$\begin{aligned}\frac{da(t)}{dt} &= w_0 + w_1b(t) + w_2\frac{db(t)}{dt} \\ \frac{db(t)}{dt} &= w_3 + w_4a(t) + w_5\frac{da(t)}{dt}\end{aligned}$$

Here $a(t)$ and $b(t)$ are two real-valued time-varying quantities (say, protein concentrations) possessed by each individual; and w_0, \dots, w_5 are individual-specific real-valued parameters.

Suggest a genetic algorithm for this purpose, in particular addressing the following:

- What would be your 'chromosome' representation for a given individual?
 - How would you implement 'mutation' in your genetic algorithm?
 - How would you implement 'crossover' in your genetic algorithm?
 - Suppose you want to evolve individuals that show oscillatory dynamics; let's say you'd ideally like both $a(t)$ and $b(t)$ to be sinusoidal functions. Given this, how might you define 'fitness' in your genetic algorithm? [6]
- Explain how Guimerà and Amaral used the notions of *within-module degree* and *participation coefficient* to classify network nodes into different roles.
 - What is the connection between these roles and the idea of date and party hubs in protein-protein interaction networks? How were these roles used to undermine the idea of date and party hubs? [6]
 - Consider the following, infrequently observed type of Feed-Forward Loop (FFL):



- Is this coherent or incoherent? Why?
- Assume AND logic at Z, i.e., Z will be produced only if *both* X and Y are at low concentrations. Analyse the dynamics of this circuit in response to ON/OFF steps of X. Are there delays? What is the steady-state logic carried out by this circuit? Compare to the more common type of coherent/incoherent¹ FFL we discussed in class. [8.5]

¹Depending on what your answer to part (a) is.

ELL796 : Signals and Systems in Biology [July 2015]

Time : 45 mins

[Major : Genomics]

Max Marks : 15

Among all the genomic signal processing applications/problems/tools you have come across, which one do you think (a) has the highest accuracy? (b) is the most difficult to solve? Give reason. [7]

Share your thoughts on how one can integrate the signals and systems approach to solve the harder problems in bioinformatics. [4]

How much information about a cell's behaviour is contained in its DNA sequence? Give a rough estimate with reasoning. [4]