Project 2: DNA Computer Design

ER02

January 20, 2017

Abstract

The goal of this project is to design a molecular computer by designing an abstract program to solve some problem, and then designing the DNA strands to implement that design with DNA tiles.

Project. The DNA nanotube circuit model shown in the lectures acts on 6-bit inputs, with each wire carrying two kinds of signals, 0 or 1. Lets generalise this model to allow wires to carry $k > 2$ kinds of signals and lets call this new model the DNA nanotube k-signal circuit model.

1. Design 3 functions to compute using this new DNA nanotube k-signal circuit model
2. Design 3 DNA nanotube k-signal circuits to compute your 3 functions. Convert your gates to tiles. Describe in plain language and using figures how your 3 gate sets, or 3 tilesets, work. Come up with a method to check that they have no bugs and actually work as intended.
3. Translate each of your tilesets into 2×2 proofreading tilesets *(hint: best to use code for this).*
4. Using some or all of the sequence design principles described in Tuesday's lecture, and freely availiable tools such as `NUPACK`[1], design DNA single-stranded tiles that implement your proofreading tilesets (assume growth from a seed structure that encodes the inputs as DNA strands).

   Analyse your resulting sequences in terms of their energetics of binding, and specifically give arguments for the following using carefully chosen plots and other forms of careful analysis:

   (a) Why it is reasonable to abstract your (wriggly, and possibly self-binding strands) as a square tile? Support your argument with data.

   (b) Why there will be few unintended interactions at the growing frontier of the lattice, i.e. wrong tile binds at some location. Support your argument with data.

[1] To directly call NUPACK on your laptop or computer go to `http://www.nupack.org/downloads/register`, **register**, and then download the `NUPACK` source code.
Also, it will be helpful to try some example DNA sequences at `NUPACK`'s online analysis tool `http://www.nupack.org/partition/new`.

(c) Why there will be few unintened interactions in solution away from the growing lattice, i.e. two or more tiles getting together in solution. Support your argument with data.