RNA logic gates

Daniel Svane

April 17, 2017

1 Introduction

Logic circuits using DNA and RNA has many interesting applications in diagnostics and treatment. An example is cancer detection, where miRNA's can be used as biomarkers [2]. These biomarkers can be used as inputs for logic circuits, which can be designed to activate FRET signals [3] or enzymes [1] when combinations of biomarkers are present or absent. For example, a circuit could be designed to activate when 2 unique miRNA's are present at the same time, or when a certain protein is present. This is represented schematically in figure 1.

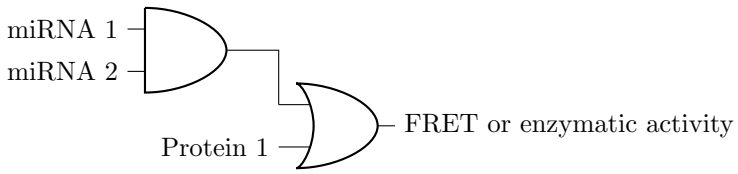


Figure 1: Example of logic circuit

The logic gates can be made using strand displacement [4], where the outputs of one gate can be linked to the input of another by unique DNA or RNA sequences. The strand displacement technique can for example be used to create an AND gate, as seen in figure 1.

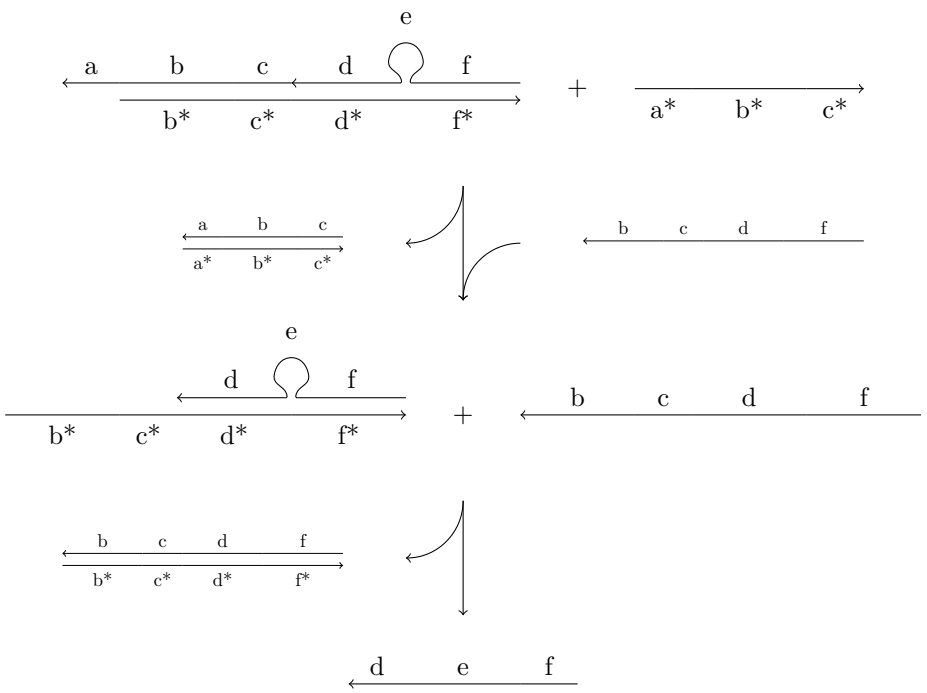
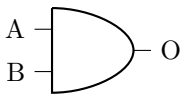


Figure 2: An AND gate made with strand displacement. After two strand displacements by the input strands $a^*b^*c^*$ and $bcdf$, the ouput strand def is released and can react in further strand displacements with other logic gates, or activate enzymes and FRET signals.

2 Logic gates

Logic gates in electric circuits are usually made using transistors. They can take boolean inputs (0 or 1) and output another boolean signal depending on the inputs and type of logic gate. An example of an AND logic gate can be seen in figure 2.



A	B	O
0	0	0
0	1	0
1	0	0
1	1	1

Figure 3: To the left, an AND gate with inputs A and B, and output O. To the right, the truth table for the AND gate.

Different gates exist, with different truth tables. These gates can be combined into more complex circuits, like calculators and integrated circuits, which

exist in all modern computers.

References

[1] W Engelen, B M G Janssen, and M Merkx. DNA-based control of protein activity. *Chemical communications (Cambridge, England)*, 52(18):3598–3610, 2016.

[2] Yong Peng and Carlo M Croce. The role of MicroRNAs in human cancer. *Signal Transduction and Targeted Therapy*, 1:15004, jan 2016.

[3] Georg Seelig, David Soloveichik, David Yu Zhang, and Erik Winfree. Enzyme-Free Nucleic Acid Logic Circuits. *Science*, 314(5805):1585–1588, 2006.

[4] David Yu Zhang and Georg Seelig. Dynamic DNA nanotechnology using strand-displacement reactions. *Nature chemistry*, 3(2):103–113, 2011.