How to build an n-input circuit library

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Goal

To build a library of genetic circuits implementing **all three-input one-output Boolean functions**

Plan

- Choose a **basis set** of logic gates
- For each possible Boolean function, generate **optimal** logic circuits
- For each logic circuit, generate abstract genetic circuit
- Assign parts to all abstract genetic circuits from a parts library
- Compute an **optimal** assembly plan
- Compile to **robot** code and execute

Approach

- Basis set: **two-input NOR gate**
- Optimal circuits via **exhaustive search**
- Abstract genetic circuits by **motif mapping**
- Part assignment for **maximal reuse**
- Modular cloning (MoClo) with **primer-minimizing** assembly plan
- MoClo protocols in **Puppeteer** on Tecan

Optimal circuits

A logic circuit is **optimal** if it uses the fewest gates

Define grammar: $S \rightarrow a|b|c|0|(S \star S)$

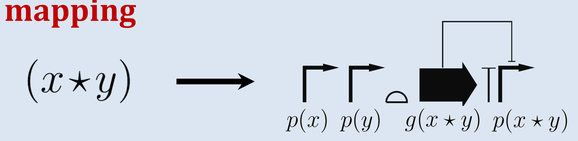
Algorithm

Generate all **distinct expressions *e*** from S

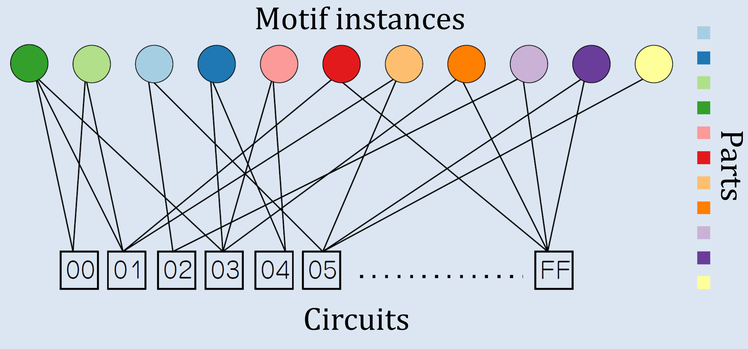
Compute **truth table** of the logic circuit of *e*, *C(e)*

Retain, if size of *C(e)* < size of best expression so far

Motif mapping



Part assignment as bipartite graph coloring



Algorithm

Heuristic constraint solver:

Color all motif instances such that **all colors in a circuit are distinct**

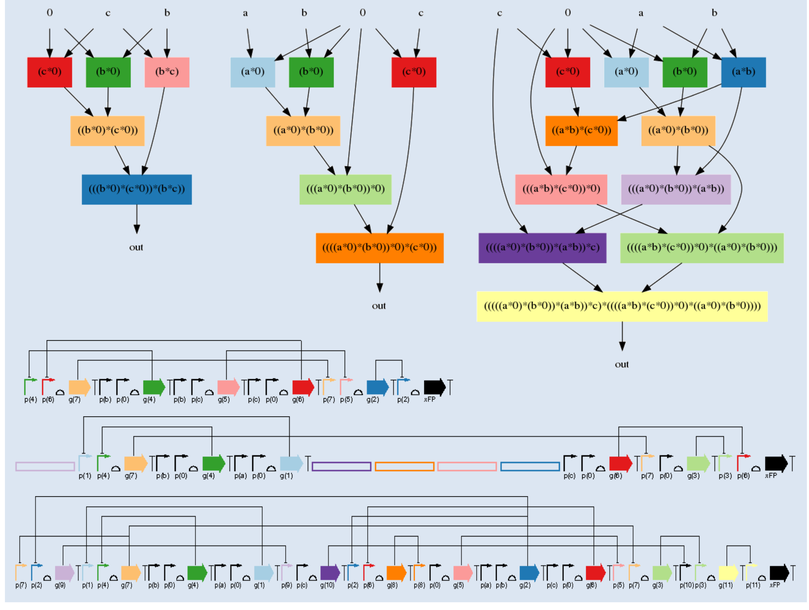
Primer optimal MoClo assembly

Given a collection of sets of transcriptional units (TUs), compute a **linearization** for each set such that the number of **distinct vectors per TU** is minimized.

Heuristic algorithm

Linearize TUs by constituent part usage count

Illustrative results



Development in progress

Puppeteer implementation of MoClo assembly

Robot liquid class optimization

Circuit-level RBS tuning algorithm

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