Problem Set 4 - Quantum Projects

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The goal of the problem set 4 show the some projects currently being developed by the quantum computing community.

1.

Quirk is a quantum computer simulator that runs on the browser. It is a drag-and drop, that reacts, simulates, and animates in real time. More information in
`https://algassert.com/2016/05/22/quirk.html`

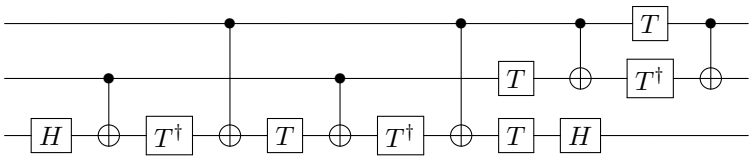
Go to Quirk `https://algassert.com/quirk`

(a) The quantum Half Adder has the following truth table:

Input			Output		
q_{c_0}	q_{c_1}	q_t	q_{c_0}	$q_{c_1} = sum$	$q_t = carry$
0	0	0	0	0	0
0	1	0	0	1	0
1	0	0	1	1	0
1	1	0	1	0	1

Implement the half adder in quirk.
Hint: Start with carry.

(b) Implement the following circuit.



This circuit is a decomposition of a gate. Which gate is it?

2.

Quipper is a scalable functional quantum programming language for quantum computing simulations.
More information in
`https://www.mathstat.dal.ca/~selinger/quipper/`

(a) Install quipper

(b) Test your installation by running the the functions plus_minus and print_plus-minus of `https://arxiv.org/pdf/1304.5485.pdf`

(c) Use quipper to generate a circuit with the matrix $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$

(d) Print the circuit or its ASCII description.

3.

Pyzx is a tool to create, visualise, and rewrite quantum circuits.
More information in:
`https://github.com/Quantomatic/pyzx`
`https://www.youtube.com/watch?v=iC-KVdB8pf0`

(a) Install pyzx.

(b) Load the quipper circuit `https://github.com/Quantomatic/pyzx/blob/master/circuits/Fast/mod5_4_before`

(c) Optimise your circuit.

- Convert the initial circuit to the Clifford+T gate set with to_basic_gates() function
- PyZX is based on the ZX-diagrams, in other words, you need to convert your circuit to a graph, use the function circuit_to_graph()
- Use simplify.full_reduce to simplify the graph
- Convert your graph into a circuit: zx.extract_circuit(g).to_basic_gates()
- Make a final optimisation with optimize.full_optimize(your_circuit)

(d) Analyse the difference between circuits.
Hint: Try it with **qiskit**.

4.

Fun with quantum

- Hello Quantum App `https://helloquantum.mybluemix.net/`
- Entanglion `https://github.com/Entanglion/entanglion`

Find more projects in `https://qosf.org/project_list/`.