Notes for Quantum Approximate Optimization Algorithm

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# How to run QAOA:

Input:

An instance of the CSP constraint problem: m constraints, n binary variables

Objective function

Where z is an n-bit string, and if z satisfies the l-th constraint, otherwise 0.

QAOA:

1. Generate the initial state to be uniform superposition
2. Define C = C(Z) is the objective operator as defined by the objective function, with the variable z replaced by Pauli matrix Z.
3. Define is the sum of all Pauli matrices X on each single qubit.
4. Define the state
5. Choose best for optimizing
6. Once find , measure in the computational basis, we can obtain
   1. find the proper assignment which has greatest probability
   2. C(z) --- the value of objective function
7. How to choose **?**

Run a quantum computer with angles () that are chosen from a grid on the compact set: [0, 2Pi]\*[0, Pi]. Moving along the grid to find the maximum of

Example 1:

* Max2Xor problem for 2-qubit

Constraint: , where and with probability ½ for each sign.

Objective function:

We assume that , and then

Therefore,

We can scan in a grid for finding proper () as mentioned above.

* What result we expect?

Should get proper () that makes is close to .

Simulation result: set scan step size to be 2Pi/100 and Pi/100, =1.5708, , the obtained is . When measuring such state in computational basis, we have the highest probability to obtain , corresponding to Z1 = 1, Z2 =1 ----- maximize objective function.

Example 2:

* From arXiv 1602.07674

The Constraints:

Objective function:

Therefore,

Where

, i.e. , and

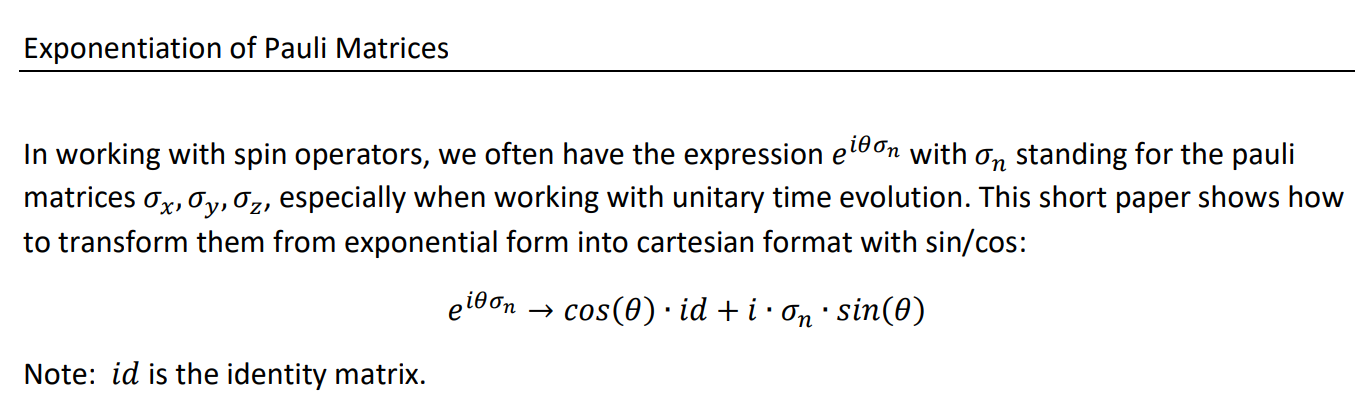
* What result we expect?

Similarly, should obtain proper () that makes is close to .

Simulation results:

We set step size to be 2Pi/100 and Pi/100, can get , =0.9961, , the obtained is . When measuring such state in computational basis, we have the highest probability to obtain , corresponding to Z1 = 1, Z2 =1 ----- maximize objective function.

Update Note: 2023/07/19



**The following are two examples for being demonstrated using qudits.**

第一个例子是p=1 QAOA

第二个例子是p=2 QAOA

