Vanilla QAOA:

- Discretized (Trotterized) version of Quantum Adiabatic Approximation
- However, γ_k (counterpart of f) and βp (counterpart of g) are trained variationally (Variational Quantum Eigensolver feature)
- Repeated layers of U=U_c U_m, similar to the following equation for QAA. (r is the number of layers)

$$\hat{U}(t) \approx \prod_{k=0}^{r-1} \exp\left[-i\hat{H}(k\Delta\tau)\Delta\tau\right] = \prod_{k=0}^{r-1} \exp\left[-if(k\Delta\tau)\hat{H}_C\Delta\tau\right] \exp\left[-ig(k\Delta\tau)\hat{H}_M\Delta\tau\right] \qquad (9)$$

Process:

1)

Define Hc according to the problem
Define a Hm that does not commute with Hc

Example Hc and H for MaxCut problem (I and j defining the ith and jth qubit):

$$\hat{H}_C = \frac{1}{2} \sum_{(i,j)\in\mathcal{E}} w_{ij}(I - Z_i Z_j),$$

$$\hat{H}_M = \sum_{j\in\mathcal{V}} X_j,$$

Where each binary variable $x_i = 0.5(I - Z_i)$ i.e., when state= (0 1), x_i= 0.5(1-(-1))=1. And when state=(1 0), x_i= (1-1)=0.

Making Hc the same as the objective function of MaxCut:

$$C(\mathbf{x}) = \sum_{i,j=1}^{|\mathcal{V}|} w_{ij} x_i (1 - x_j),$$

2) Define the initial state as tensor products of |+> states, which corresponds to the highest energy state of the Pauli-X basis ie Hm.

$$|s\rangle = |+\rangle^{\otimes n} = \frac{1}{\sqrt{2^n}} \sum_{\mathbf{x}\in\{0,1\}^n} |\mathbf{x}\rangle ,$$

sqrt(2^n) denominator is used to normalize the state i.e. to make the total probability 1. **x** is the binary string of each combination of the states.

3)

Quantum Alternating Operator Ansatzes:

Also known as QAOAnsatz. In this type of variation, the method can vary whether in terms of:

- number of states, or
- alternating unitaries operators in each circuit layer. The unitaries are from a general set of parameters, instead of fixed Hamiltonian.

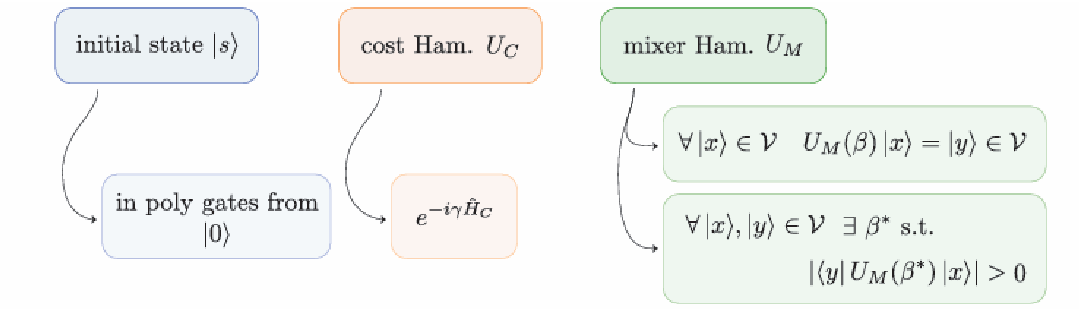

Figure 5: Representation of the QAOAnsatz.

Notable QAOAnsatz Variants:

Grover Mixer QAOA:

Threshold QAOA:

Constraint Preserving Mixers: