Variants of QAOA

Why variants of ansatz are needed?

The Ansatz Circuit can be transformed in various ways by making guesses about the varionational parameters' characteristics. The guesses depend on the problem type, such as a combinatorial problem or problems strongly influenced by their hardware type would need different requirements met.

However, overfitting a problem may make the circuit unfit for other problems of the similar type.

Multi-Angle QAOA:

- Also known as ma-QAOA

Components:

- Vanilla QAOA
- Each element of the variational parameters has their designated angles. (if all angles are same then it becomes vanilla QAOA), making the cost and mixer unitaries:

$$\hat{U}_C(\gamma_l) = e^{-i\sum_{a=1}^{m} \gamma_{l,a}\hat{H}_{C,a}} = \prod_{a=1}^{m} e^{-i\gamma_{l,a}\hat{H}_{C,a}}$$

$$\hat{U}_M(\beta_l) = e^{-i\sum_{v=1}^{n} \beta_{l,v}\hat{H}_{M,v}} = \prod_{v=1}^{n} e^{-i\beta_{l,v}\hat{H}_{M,v}},$$

> Why does cost layer have m number of elements and the mixer layer have n number of elements?

Where m is the number of edges and n is the number of nodes. l is the layer number. From here we can see that the cost ansatz in each layer has m number of elements and the mixer layer has n number of elements. Considering each element to be each parameter makes the *total parameters = (n+m) * total number of layers*

Performance:

- Better approximation ratio than vanilla QAOA
- Lower circuit depth despite more parameters
- Using the natural symmetries of the problem graphs, the number of parameters can be reduced by 33% without affecting the objective function. [Ref. Shi et al.]