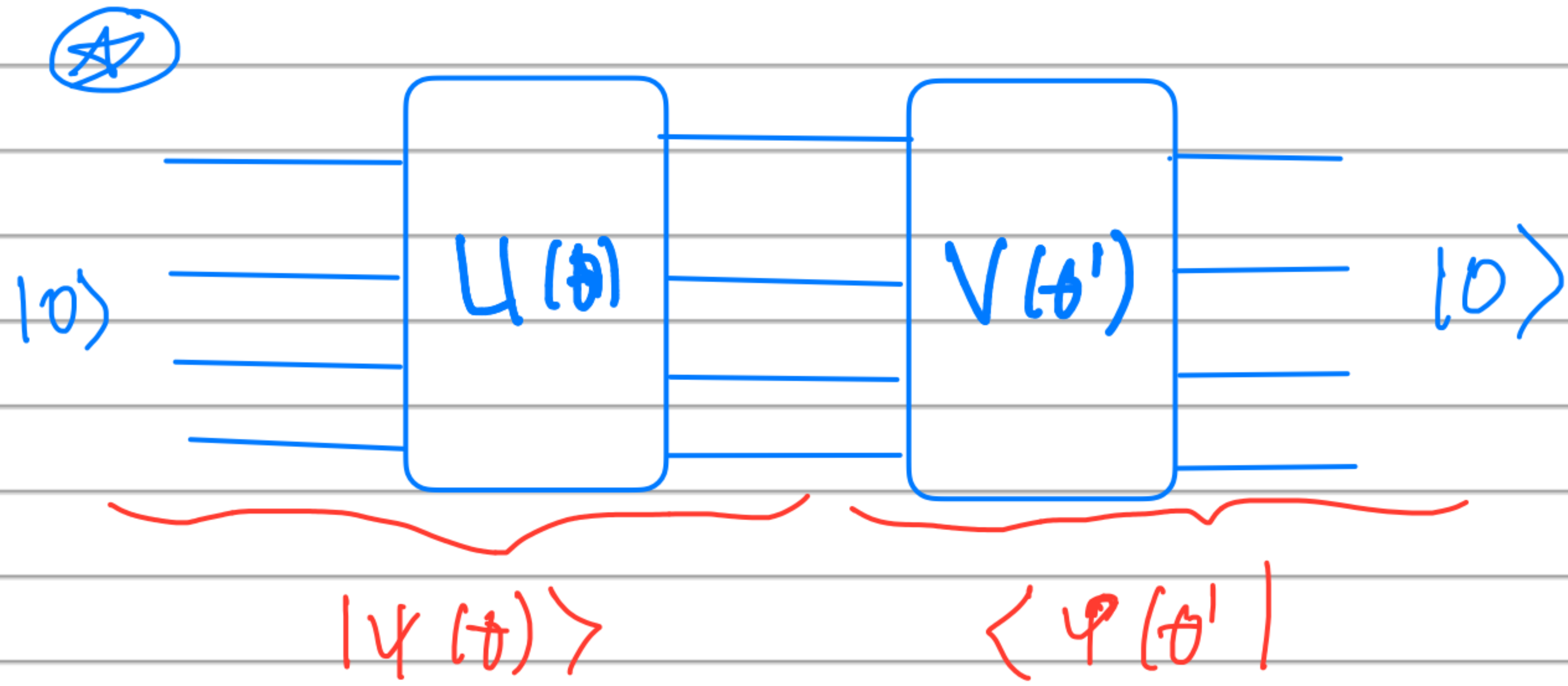
Quantum circuit learing



- We introduce a fidelity landscape:

$$K(\theta,\theta') = \langle \varphi(\theta') | \psi(\theta) \rangle$$

and define a cost function as:

$$C[\theta,\theta'] = 1 - K(\theta,\theta')$$

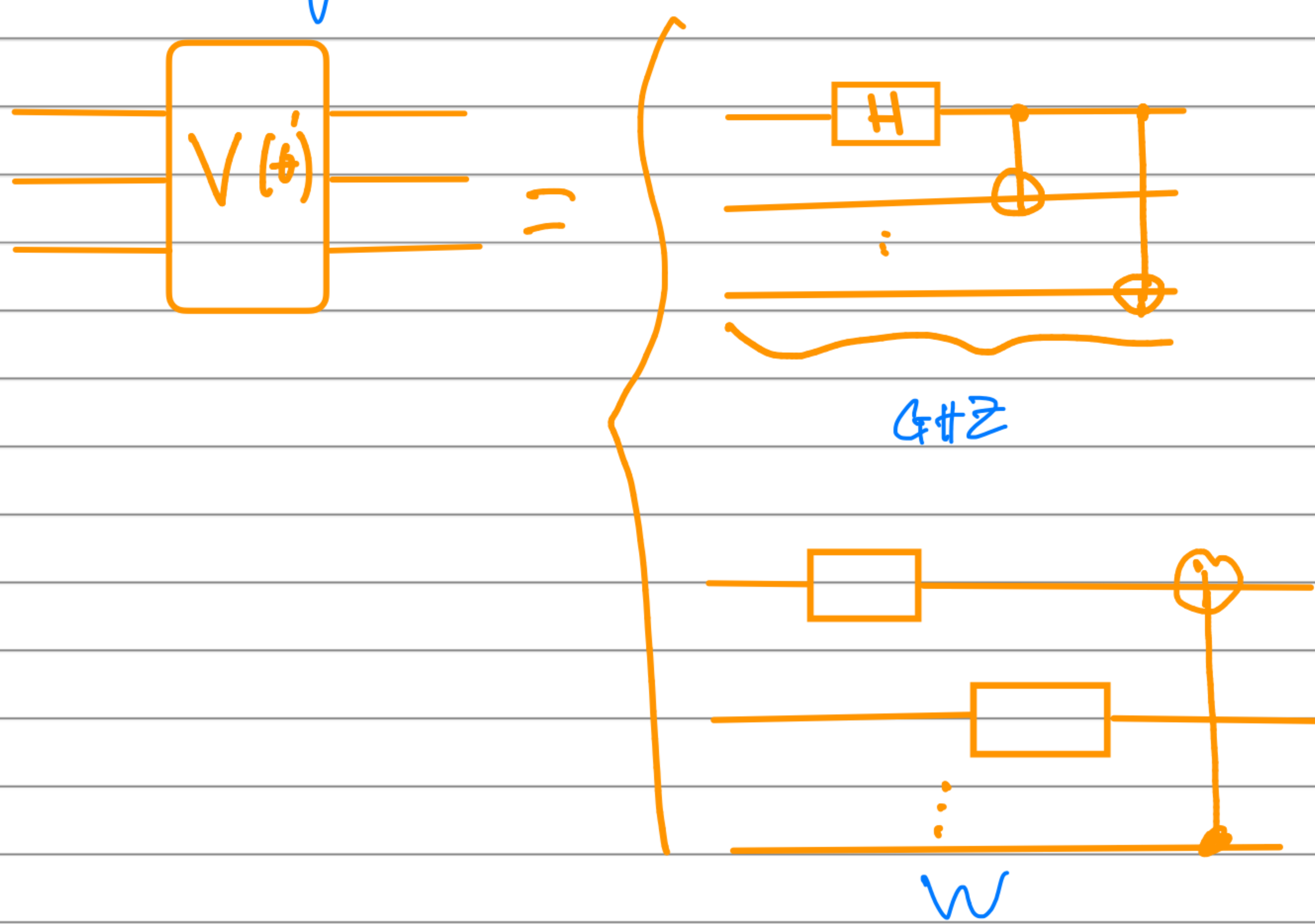
- In quantum learning circuit, we vary θ to lear $|\underset{\text{lear}}{\psi}(\underset{\text{var}}{\theta})\rangle$ to be a target state $|\underset{\text{tar}}{\varphi'}(\underset{\text{fix}}{\theta'})\rangle$

when the learning state becomes the target state we have the minimum cost function

$$\boxed{\min_{\theta_{var}} C(\theta_{var}, \theta'_{fix}) = \min_{\theta_{var}} \left[1 - \langle \varphi_{tar}(\theta'_{fix}) | \psi_{lear}(\theta_{var}) \rangle \right]}$$

- We consider a learning ansatz as before
- We consider several entangled target sates, such as GHZ, W, and also a random state.

The circuits for these target states as in Fig. 1 :



- Quantum state tomography.

- We generate an unknow state (θ_{unk} : random and unknow)

$$|\psi(\theta_{unk})\rangle$$

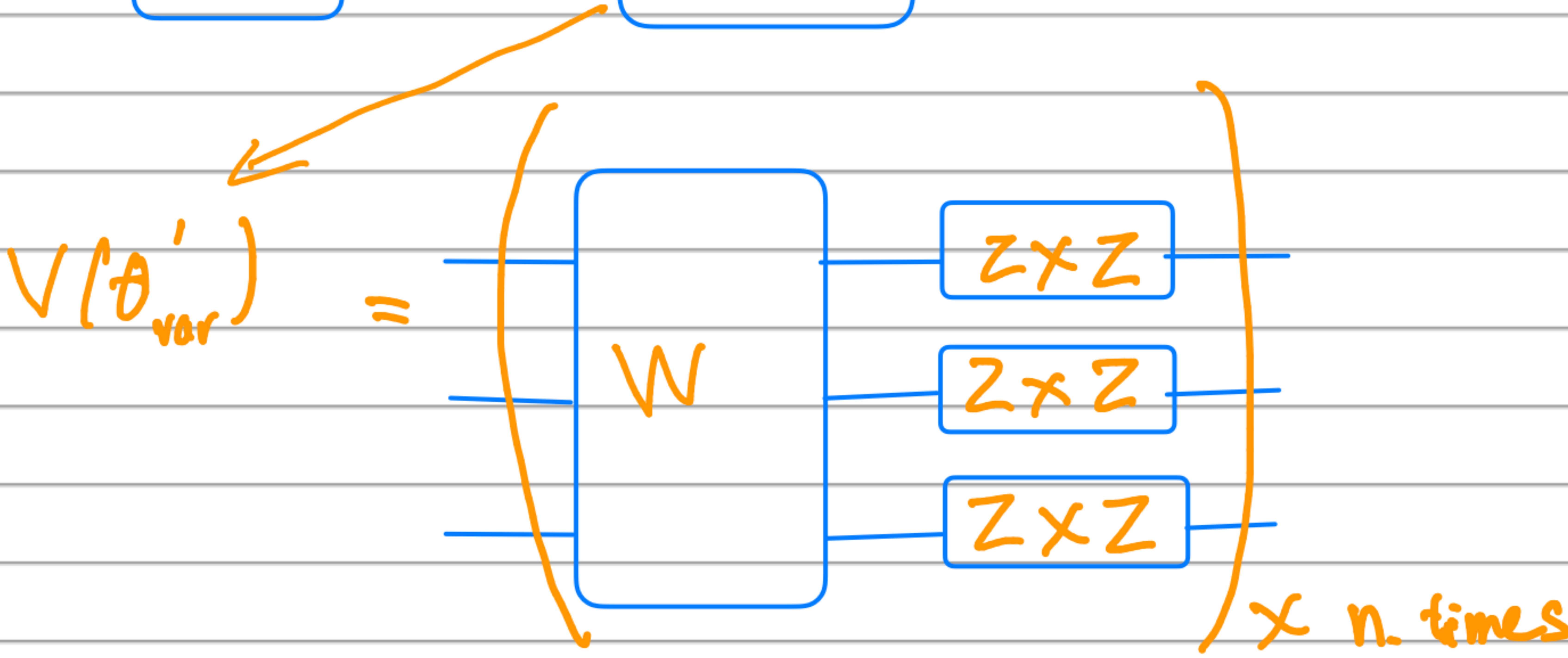
and using the varianal ansatz θ'_{var}, such that $|\psi(\theta'_{var})\rangle$ to minimize the cost function:

$$\min_{\theta'_{var}} C(\theta_{unk}, \theta'_{var}) = \min_{\theta'_{var}} \left[1 - \langle \psi(\theta'_{var}) | \psi(\theta_{unk}) \rangle\right]$$

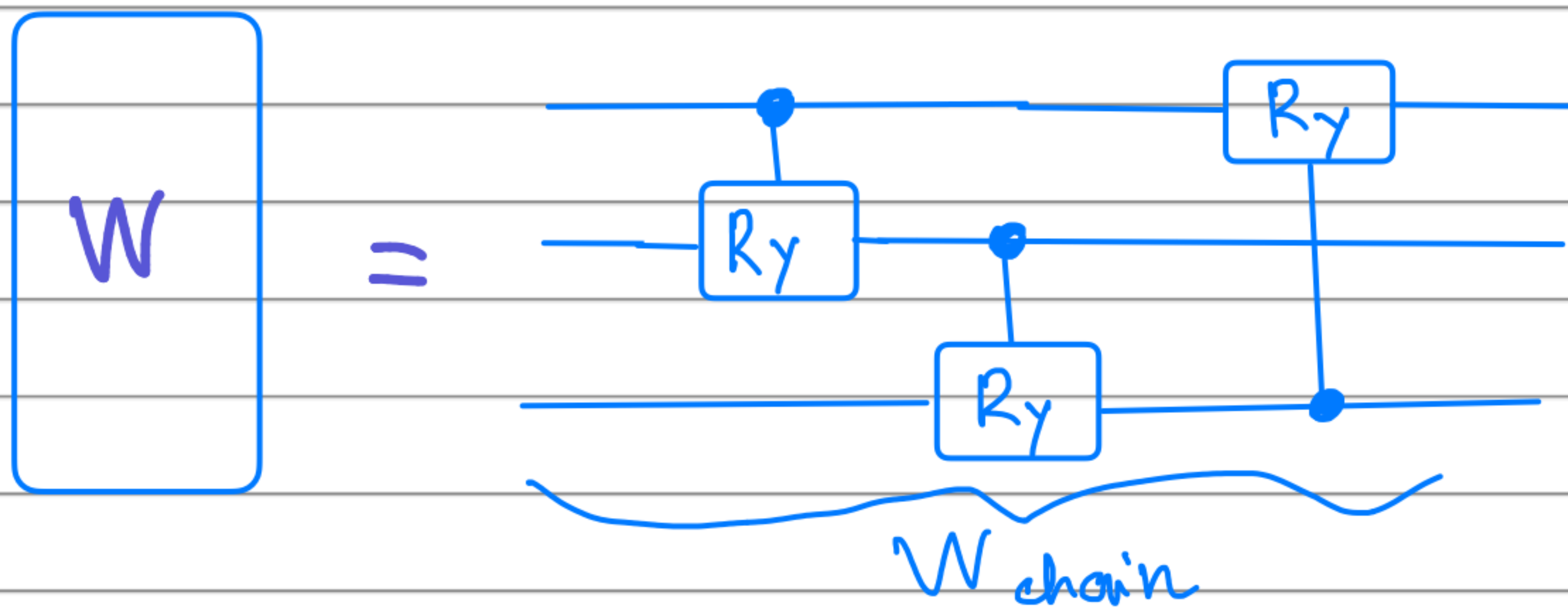
- We use the Haar random ansatz to generate an unknow state $|\psi_{Haar}(\theta_{unk})\rangle$

- The structure of learning ansatz is as folow.

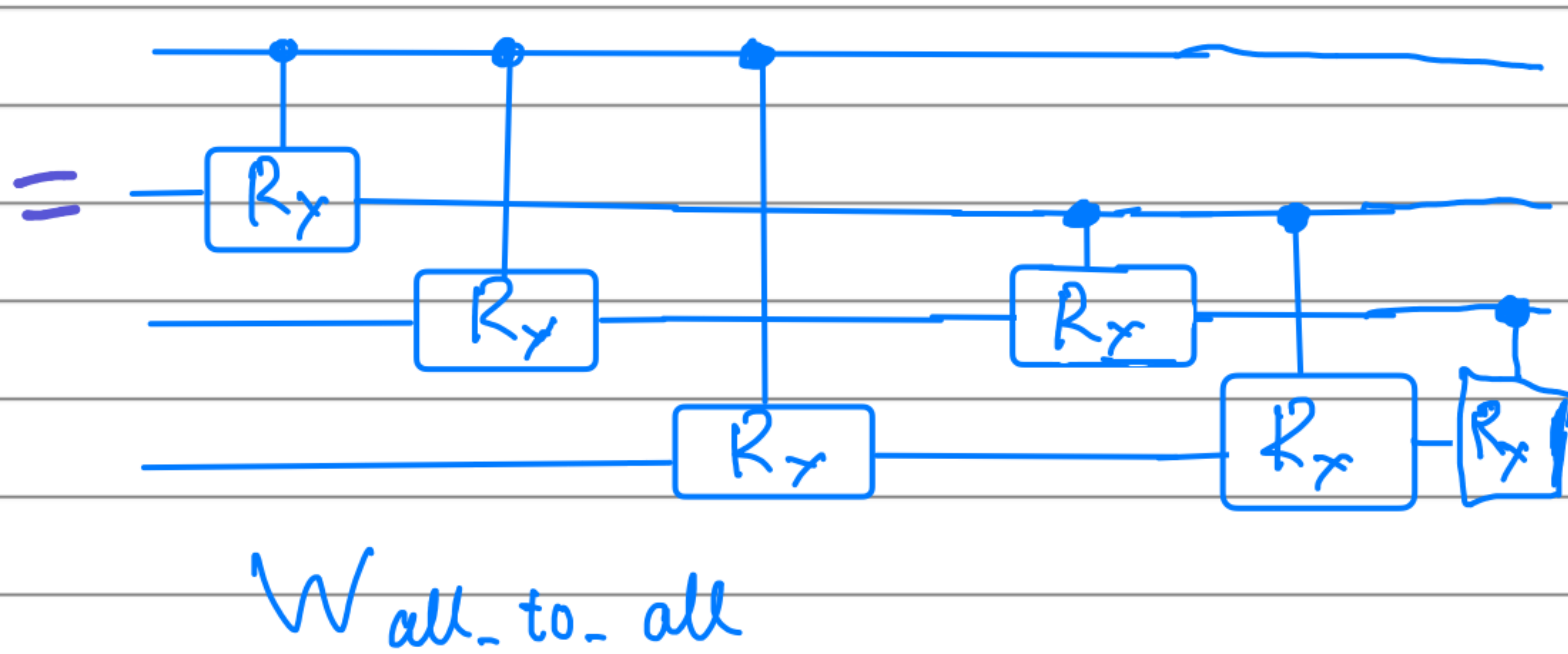
|ψ⟩
|φ⟩
U Haar
V(θ'var)



V(θ'var) =
W
ZxZ
ZxZ
ZxZ
x n times

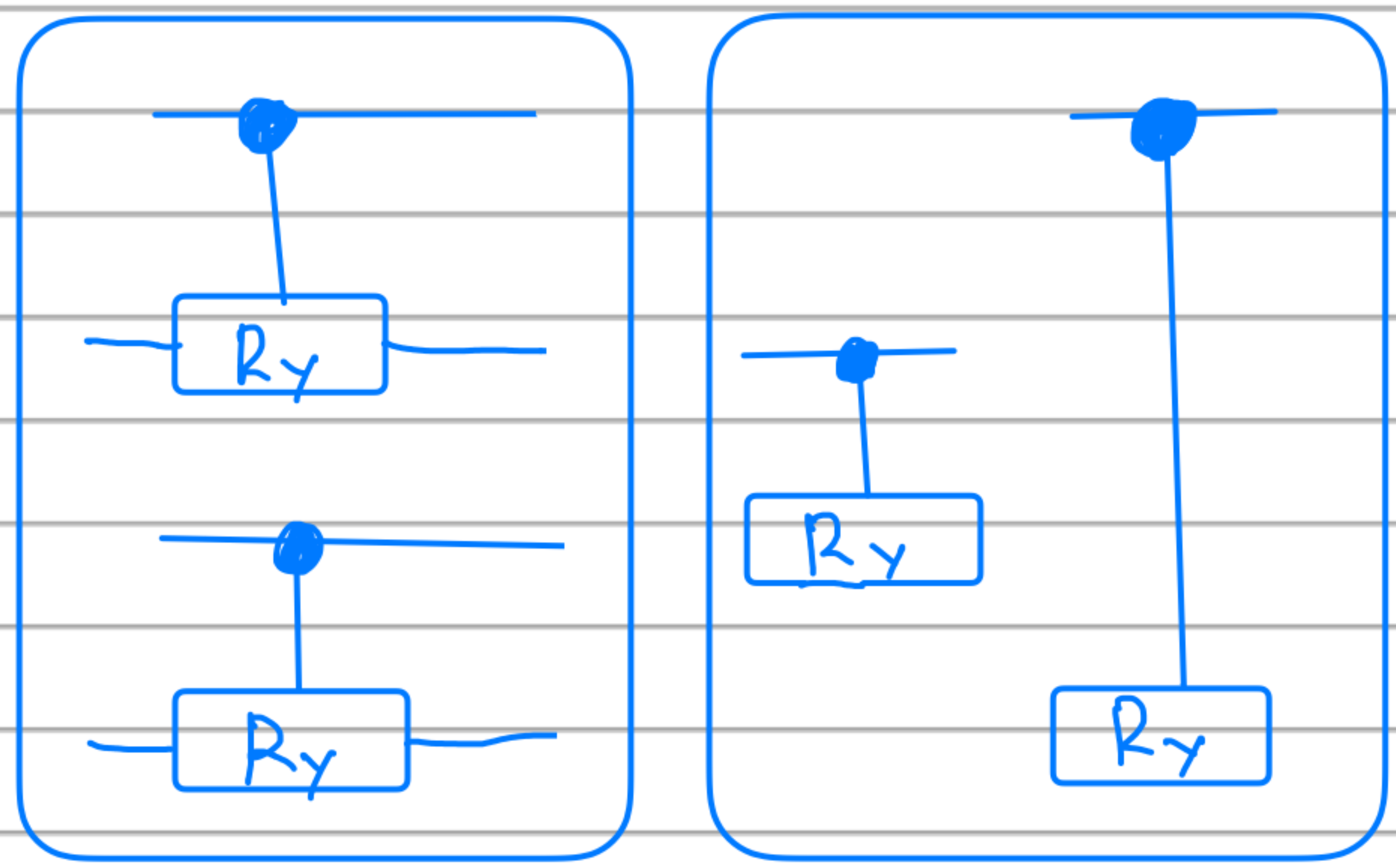


W =
Ry
Ry
Ry
W chain



=
Ry
Ry
Rx
Rx
Rx
Ry
W all_to_all

=



l- odd $\qquad$ l- even

W alternating

-) Later, we can try CR_y by $\sqrt{iSWAP}$