QML|CML

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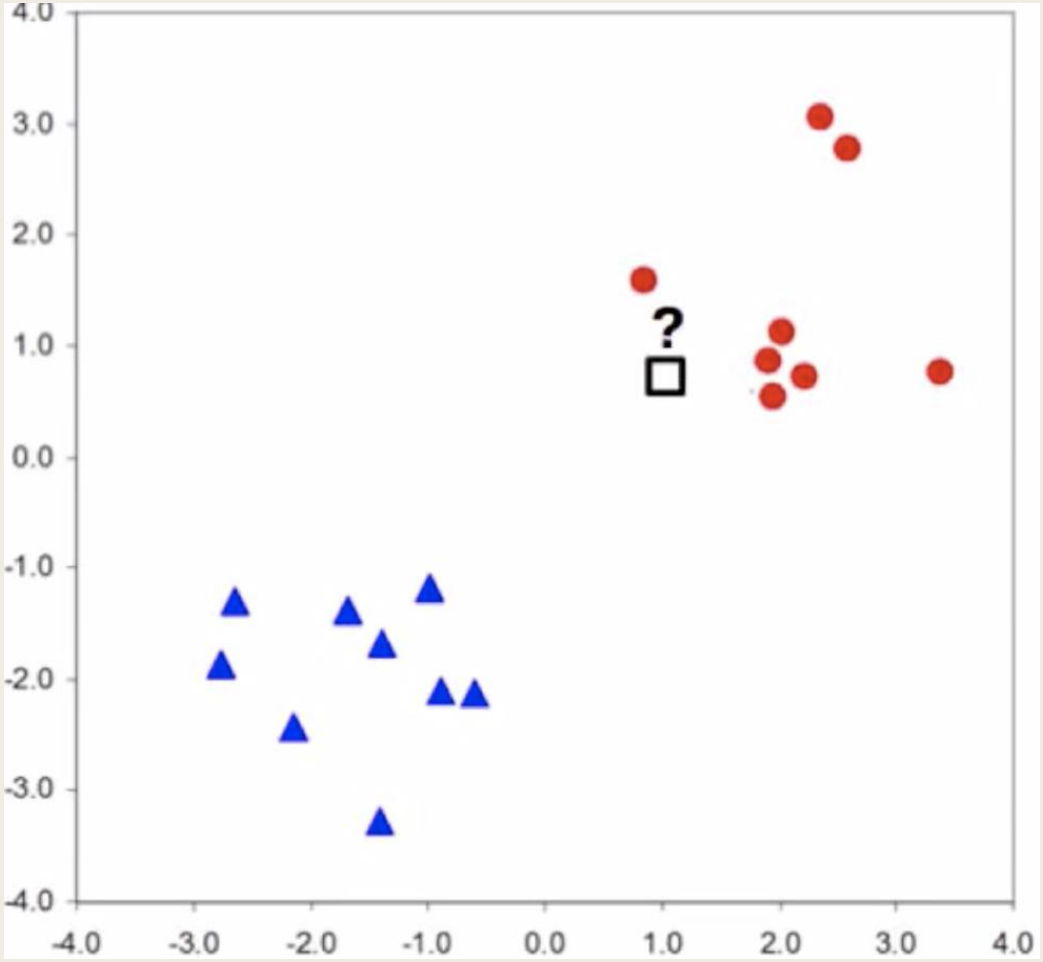
Machine learning

- Classification
- regression

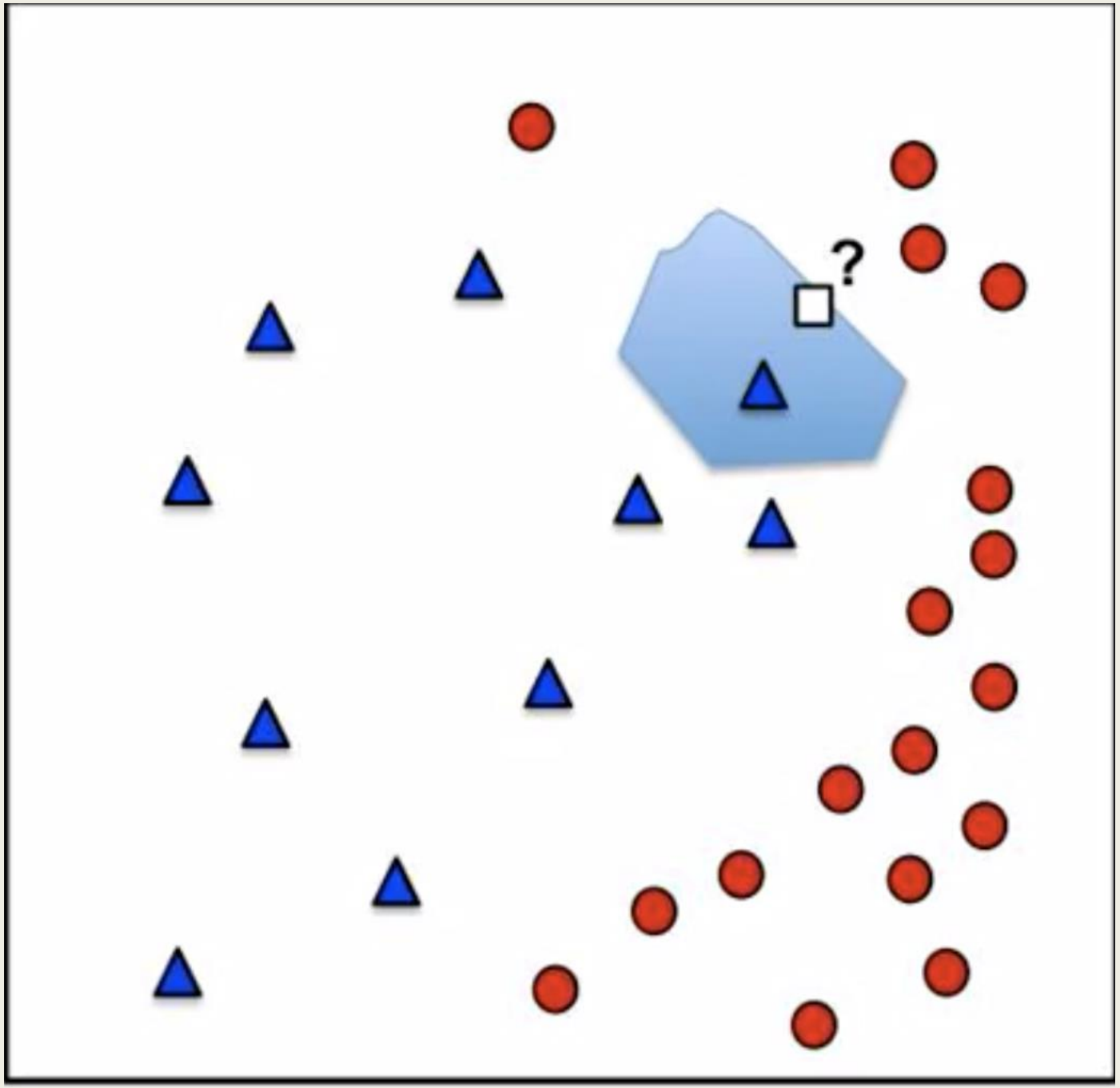
Nearnest neighbor method

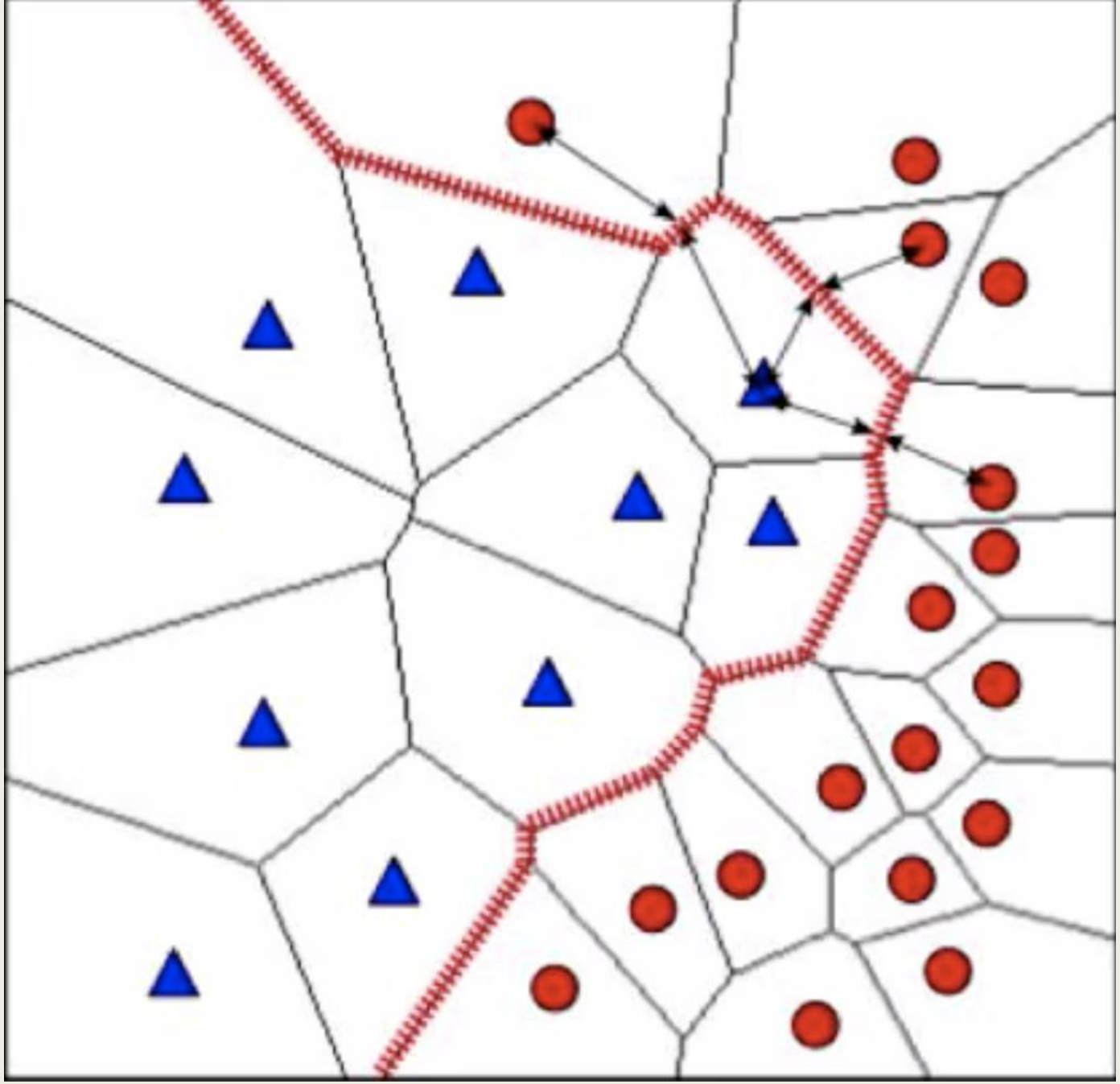


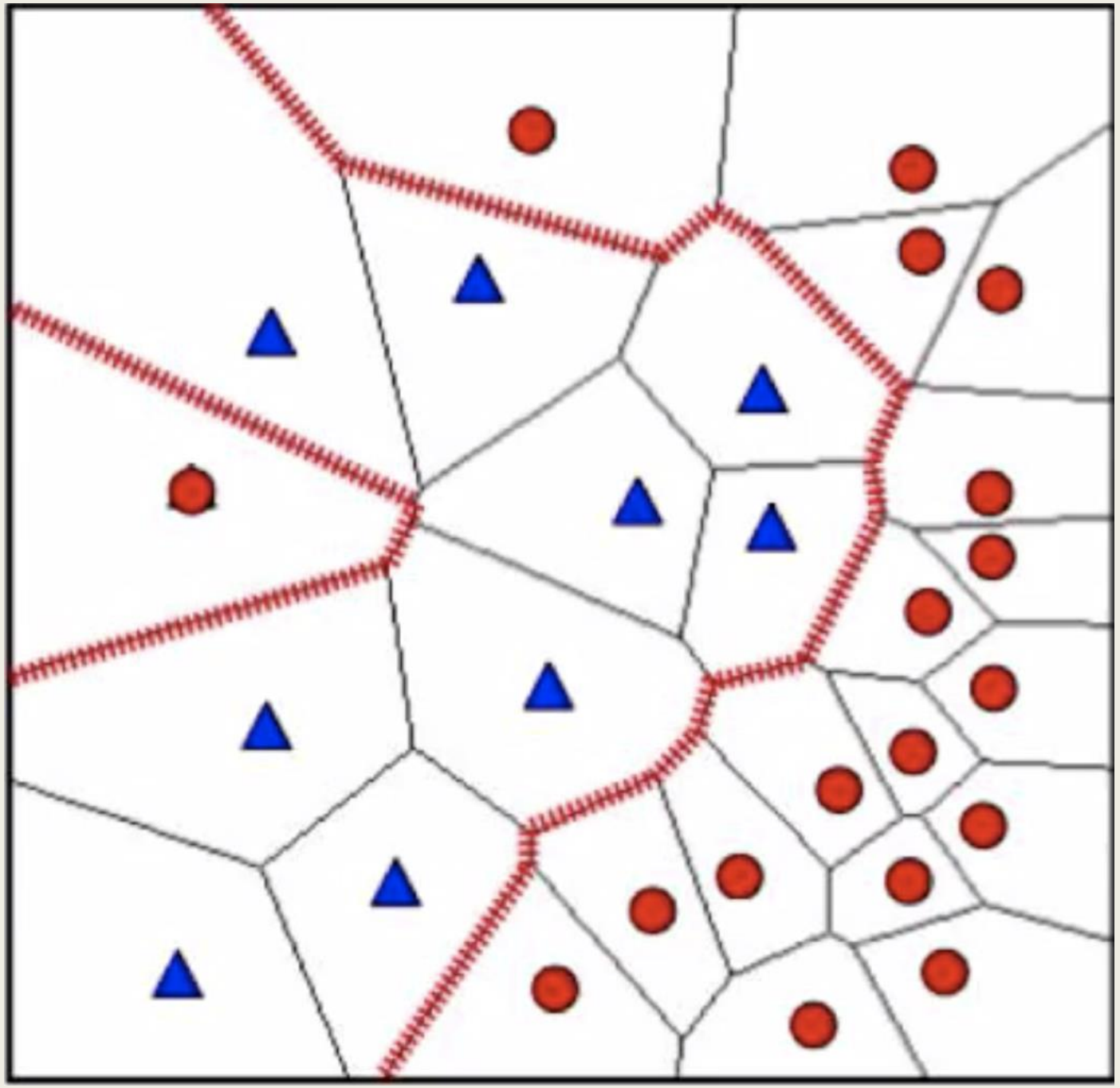
Set of points(x,y)

two classes

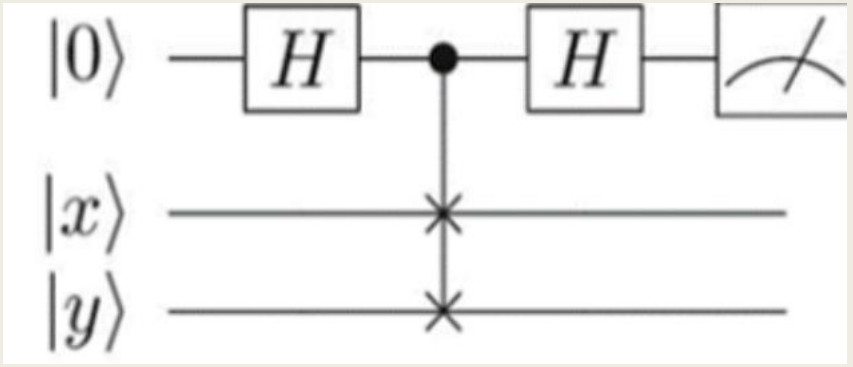
Red and blue







Quantum algorithm
1. SWAP-test



$$|0_{anc}\rangle|x\rangle|y\rangle \rightarrow \frac{1}{2}|0_{anc}\rangle(|xy\rangle + |yx\rangle) + \frac{1}{2}|1_{anc}\rangle(|xy\rangle - |yx\rangle)$$

$$P(|1_{anc}\rangle) = \frac{1}{2} - \frac{1}{2}|\langle x|y\rangle|^2$$

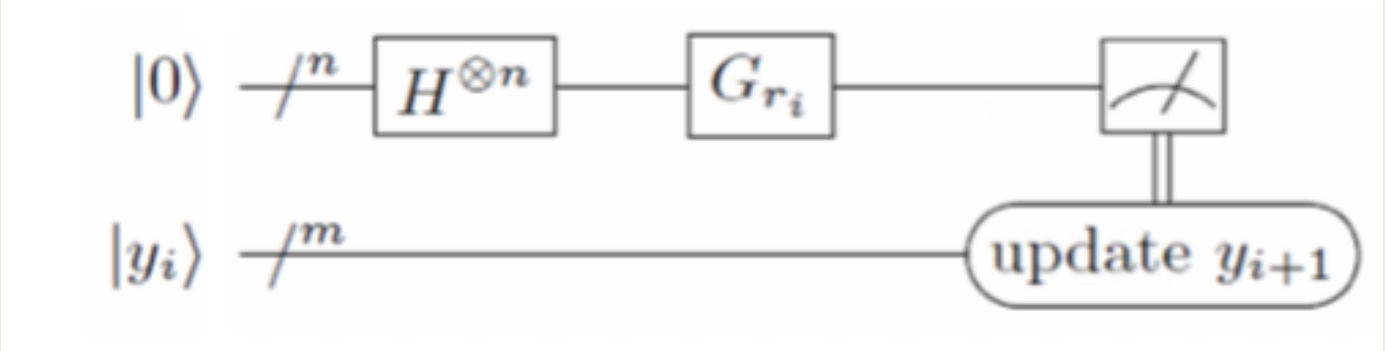
$$EuclideanDistance = \sqrt{(2 - 2|\langle x|y\rangle|)}$$

Quantum algorithm
2.classical data encoding

$$|a\rangle = \frac{1}{|a|}\sum_{i=1}^{d} a_i |i\rangle$$

$$O(\log d)$$

Quantum algorithm
3.Quantum minimization algorithm(QMA)



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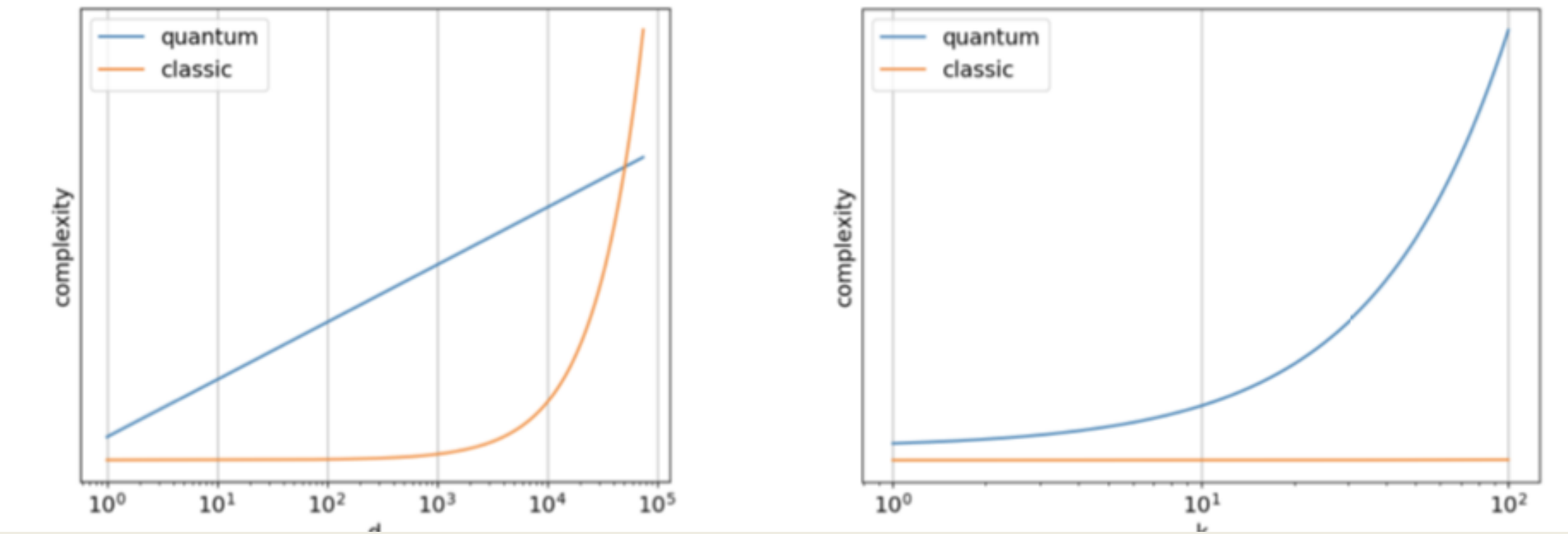
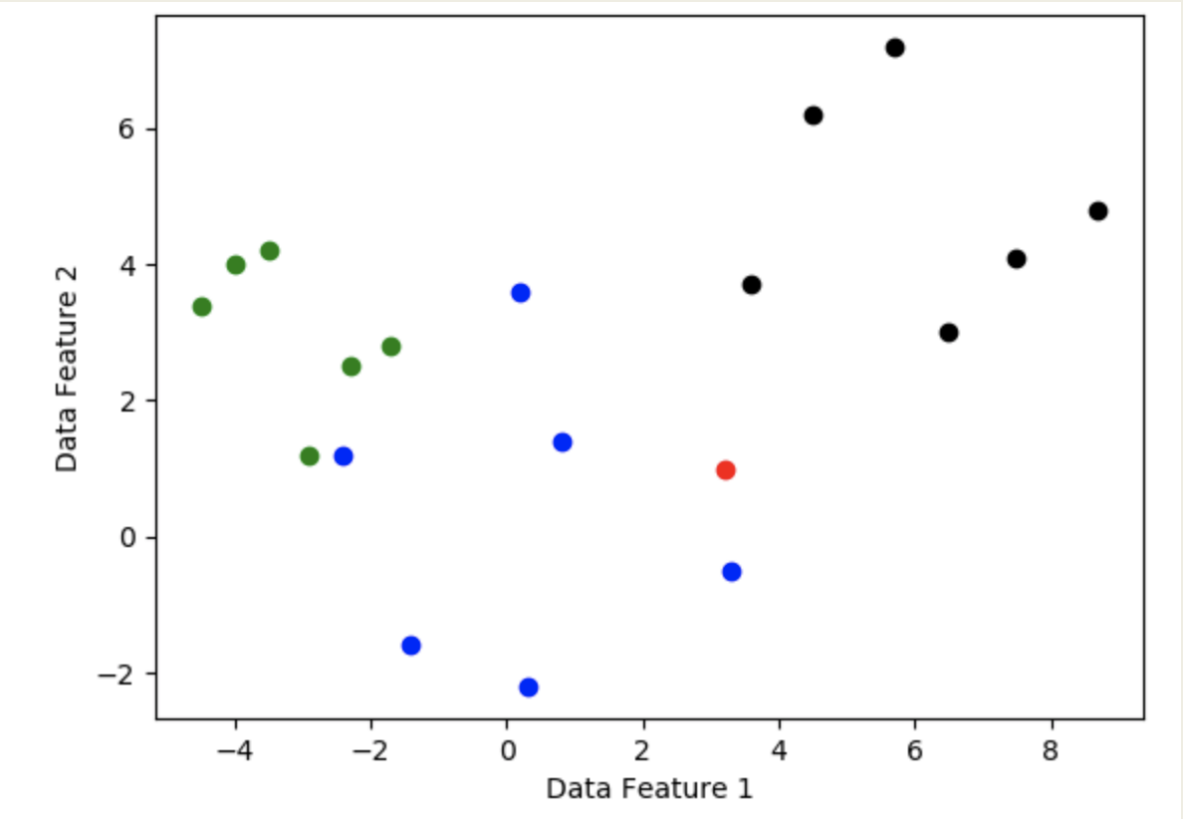
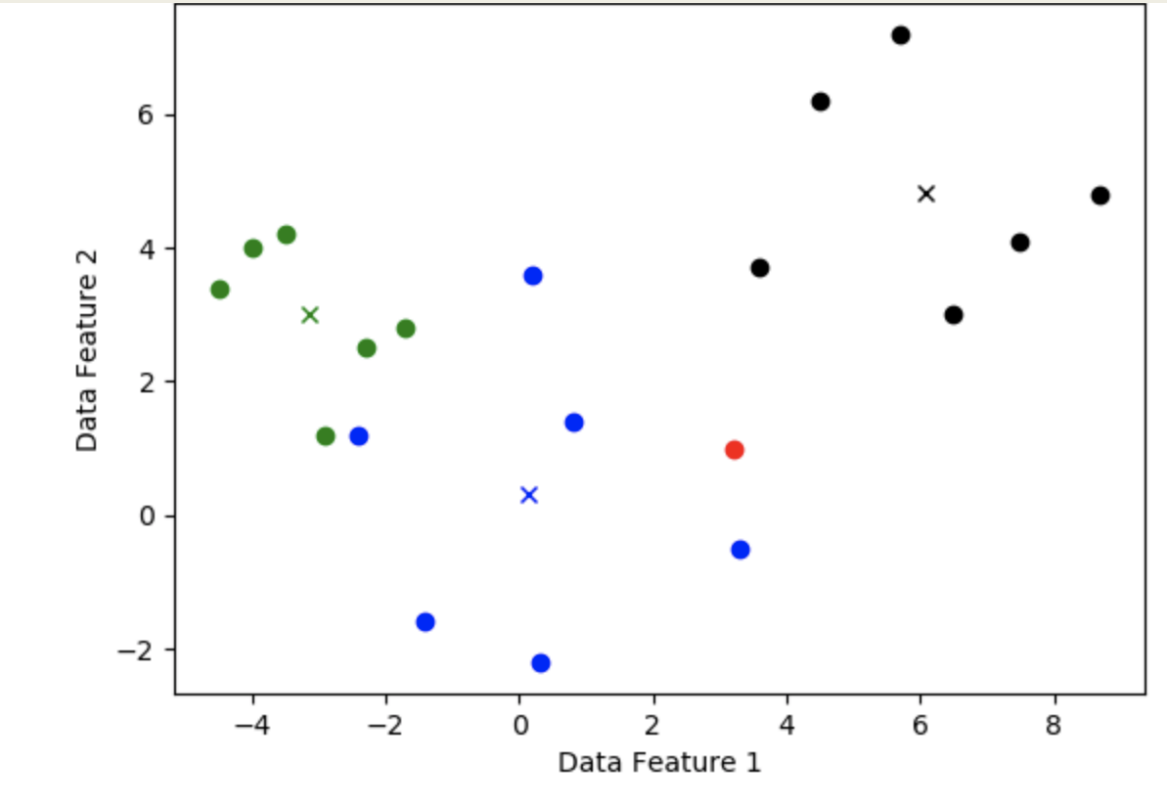
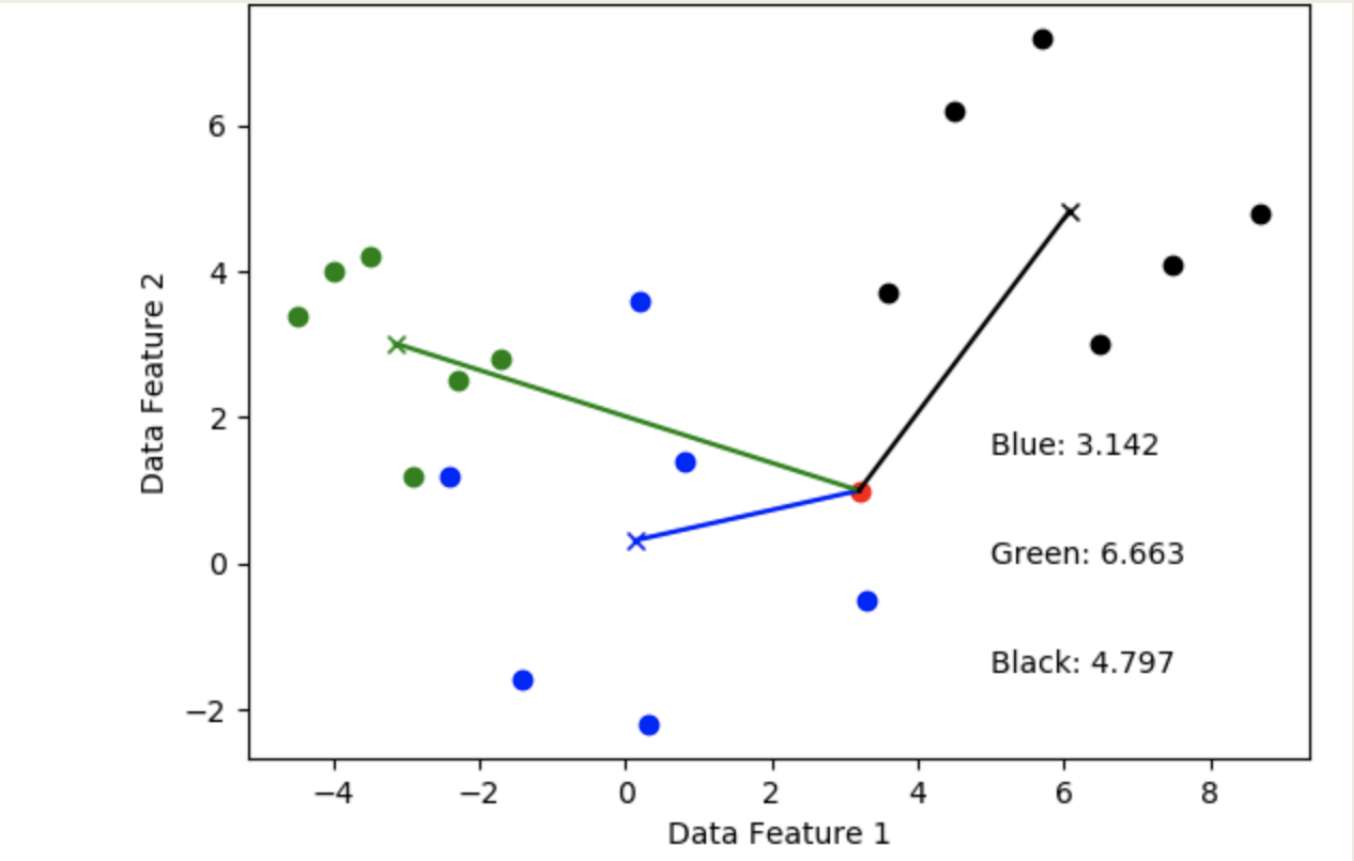
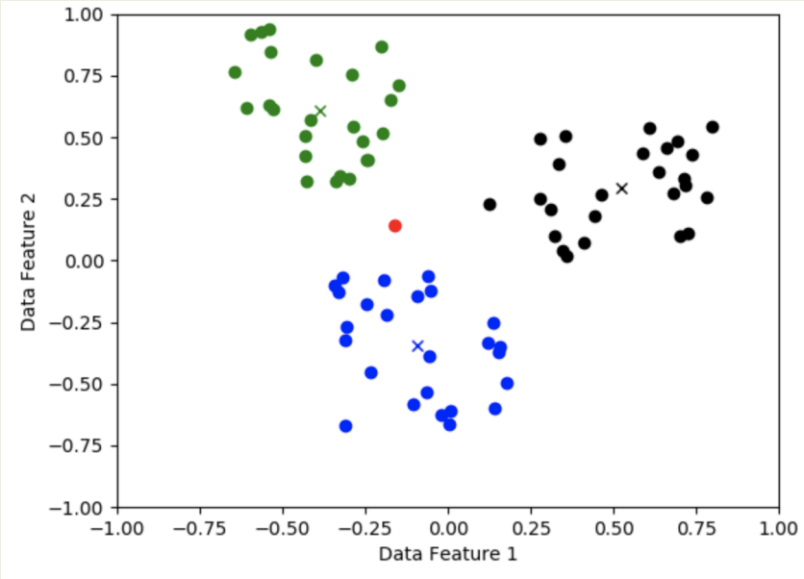

quantum
classic
complexity
10^0
10^1
10^2
10^3
10^4
10^5
quantum
classic
complexity
10^0
10^1
10^2

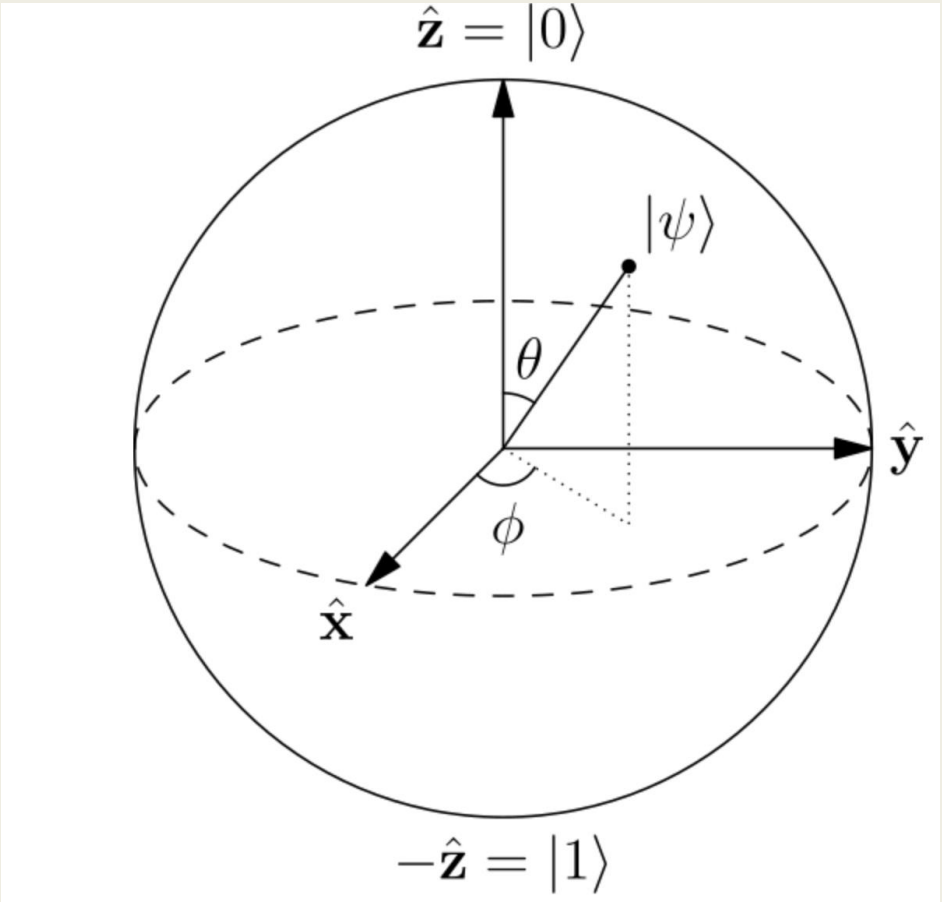
K-mean




Data Feature 2
6
4
2
0
−2
−4
−2
0
2
4
6
8
Data Feature 1


Data Feature 2
Data Feature 1
6
4
2
0
−2
−4
−2
0
2
4
6
8
Blue: 3.142
Green: 6.663
Black: 4.797


Data Feature 2
Data Feature 1
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00


$\hat{\mathbf{z}} = |0\rangle$
$|\psi\rangle$
θ
$\hat{\mathbf{y}}$
ϕ
$\hat{\mathbf{x}}$
$-\hat{\mathbf{z}} = |1\rangle$

convert a data point

- Take a zero-initialized qubit, and apply a Hadamard gate to it, which moves the vector representing the qubit so that it lies along the x-axis.
- Set Φ depending on the value of the data point corresponding to feature 1.
- Set θ depending on the value of the data point corresponding to feature 2.

$$\phi = (d_0 + 1)\frac{\pi}{2}$$

$$\theta = (d_1 + 1)\frac{\pi}{2}$$

reference

- Quantum machine learning: distance estimation for k-means clustering
(https://towardsdatascience.com/quantum-machine-learning-distance-estimation-for-k-means-clustering-26bccfbfcc76)

- K-means clusterization algorithm with Quantum Circuit
(https://developer.ibm.com/recipes/tutorials/kmeans-clusterization-algorithm-with-quantum-circuit-part-2/#r_step1)

- KNN Algorithm Simulation Based on Quantum Information
(http://csis.pace.edu/~ctappert/srd/a11.pdf)
- **Image Classification Based on Quantum KNN Algorithm**
(https://arxiv.org/abs/1805.06260)