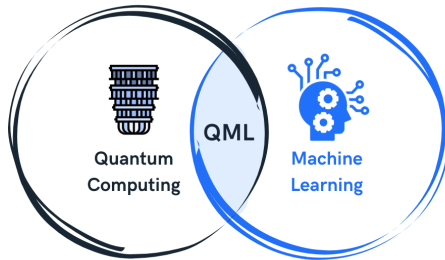


# Genetic algorithm for Quantum Support Vector Machines

Lorenzo Tasca

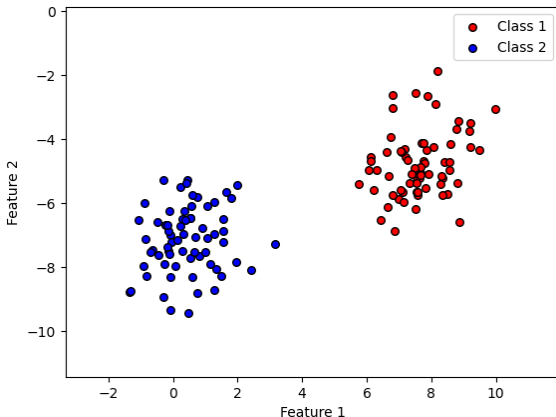
25 Novembre 2024

# Quantum Machine Learning



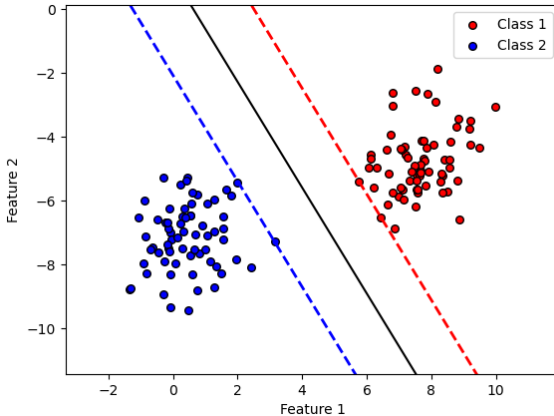
# Support Vector Machine

- La Support Vector Machine è un algoritmo supervisionato di classificazione binaria.



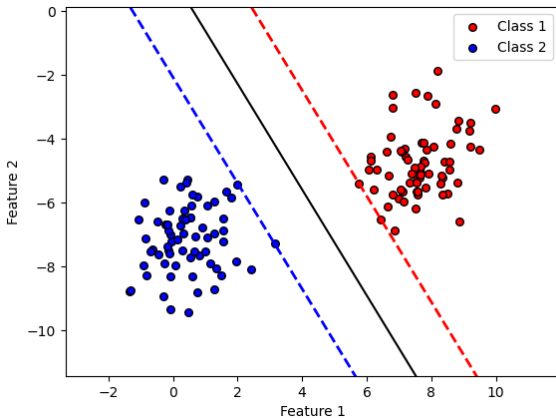
# Support Vector Machine

- L'algoritmo trova il massimo margine separatore tra le classi.



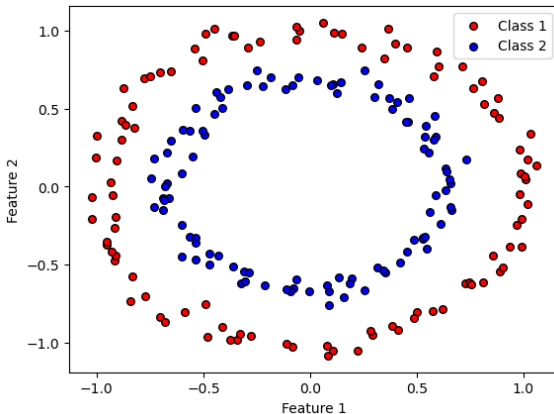
# Support Vector Machine

- Per farlo utilizza solo i prodotti scalari tra i dati  $\langle \mathbf{x}_i, \mathbf{x}_j \rangle$ .



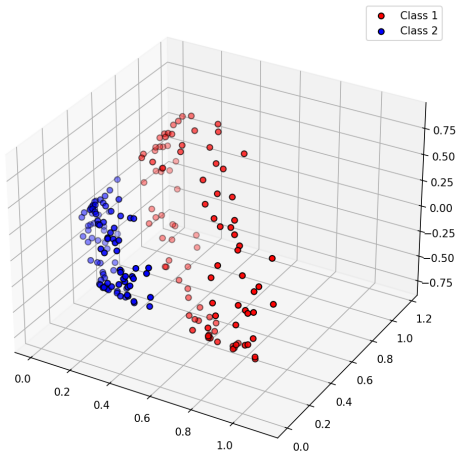
# Kernel Support Vector Machine

- Nel caso in cui i dati non siano linearmente separabili?



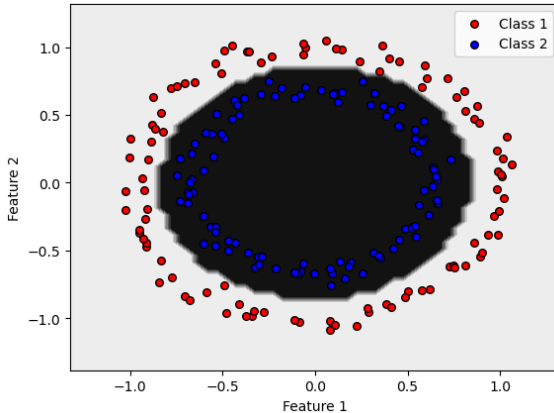
# Kernel Support Vector Machine

- È possibile applicare una feature map  $\phi(\mathbf{x})$ .



# Kernel Support Vector Machine

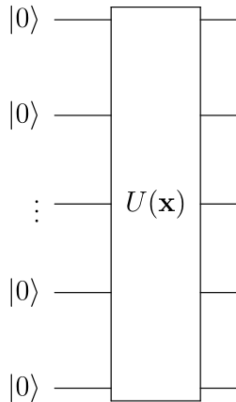
- L'algoritmo è interessato solo a  $K_{ij} = \langle \phi(\mathbf{x}_i), \phi(\mathbf{x}_j) \rangle$ .





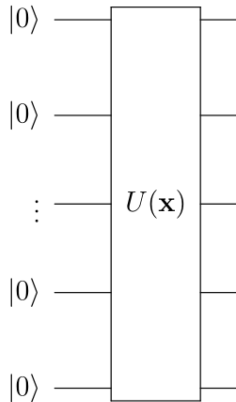
# Quantum Support Vector Machine

- La feature map diventa un circuito quantistico parametrizzato.



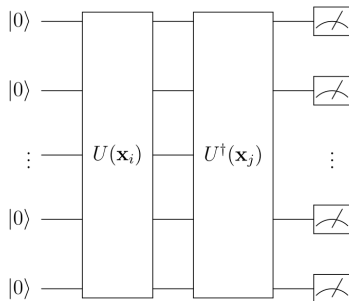
# Quantum Support Vector Machine

- La feature map diventa un circuito quantistico parametrizzato.
- $|\phi(\mathbf{x})\rangle = U(\mathbf{x})|0\rangle^{\otimes n}$ .



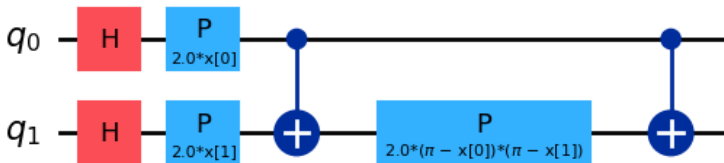
# Quantum Support Vector Machine

- La feature map diventa un circuito quantistico parametrizzato.
- $|\phi(\mathbf{x})\rangle = U(\mathbf{x})|0\rangle^{\otimes n}$ .
- $K_{ij} = \langle \phi(\mathbf{x}_i) | \phi(\mathbf{x}_j) \rangle$ .



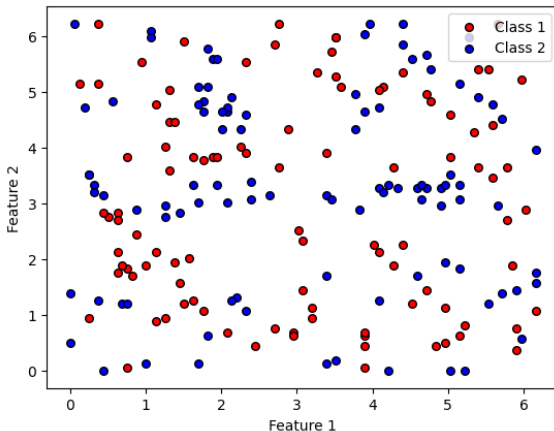
# Quantum Kernels

- Un esempio possibile: la ZZ Feature Map.



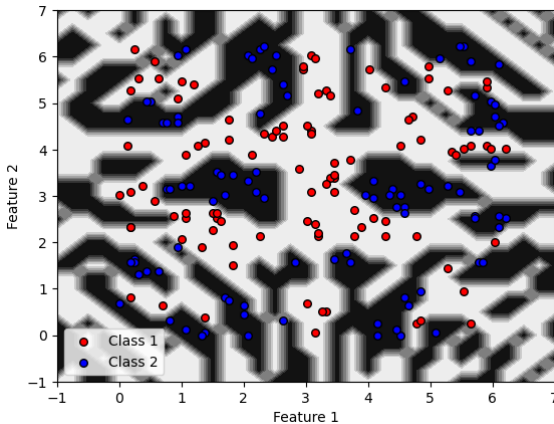
# Quantum Kernels

- Ottime performance su dataset complessi.



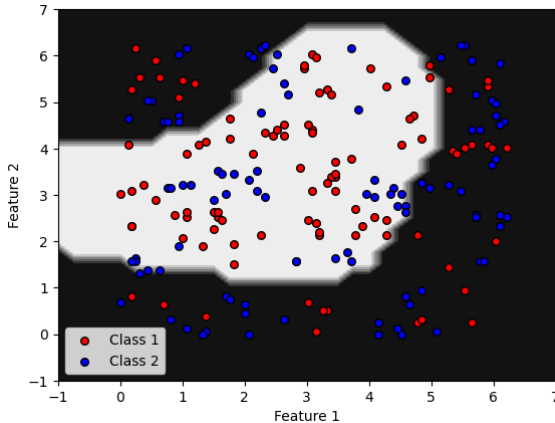
# Quantum Kernels

- Ottime performance su dataset complessi.



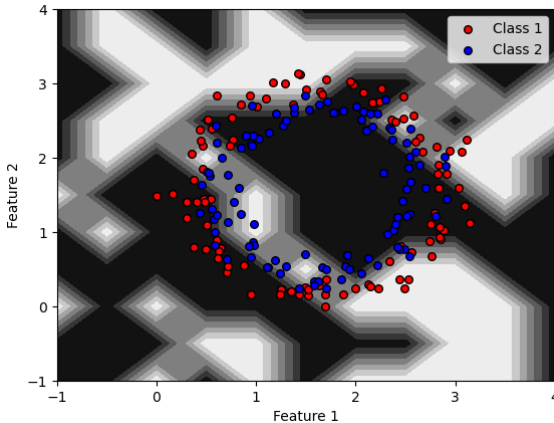
# Quantum Kernels

- I metodi classici falliscono.



# Scelta del Quantum Kernel

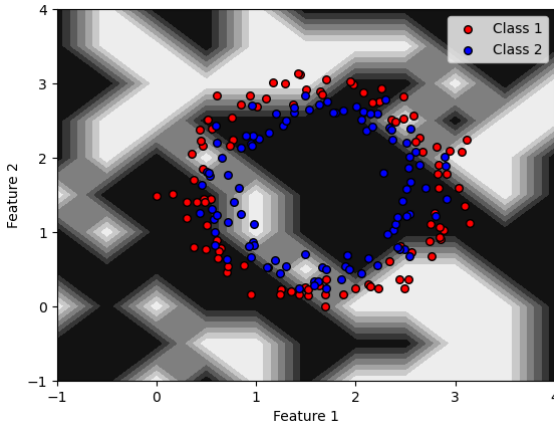
- La scelta del kernel risulta spesso problematica.





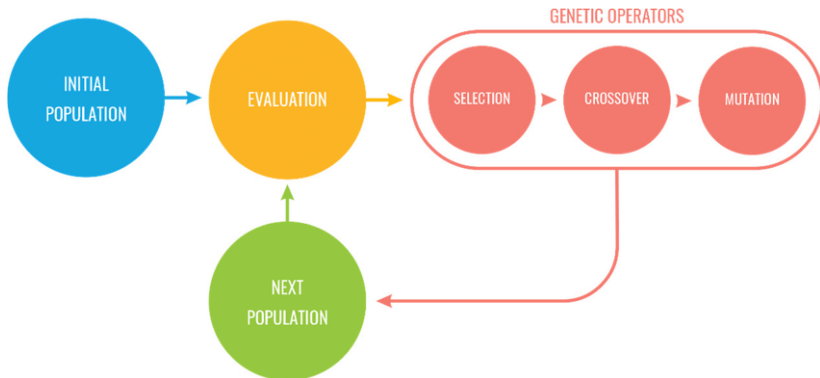
# Scelta del Quantum Kernel

- Manca una guida per effettuare la scelta.



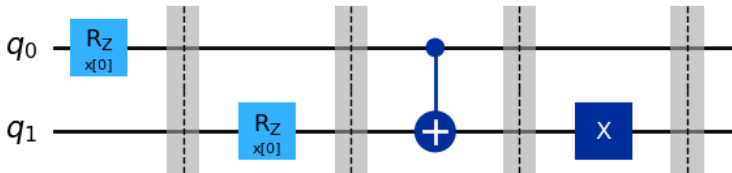
# Algoritmo genetico

- Un algoritmo genetico può scegliere la miglior feature map.



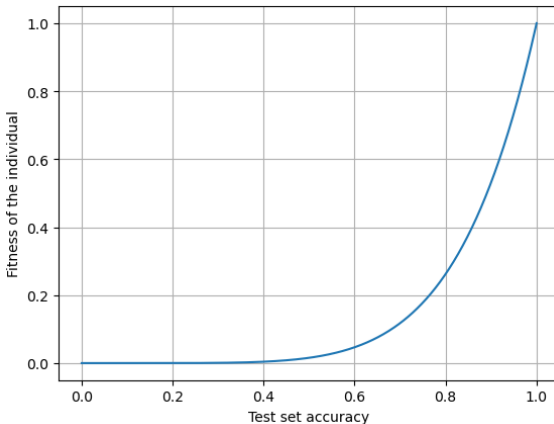
# Algoritmo genetico

- Gli individui sono formati da gate scelti da un set completo.



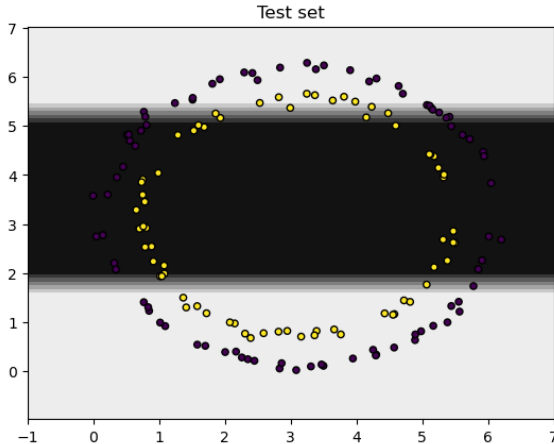
# Algoritmo genetico

- La fitness di un individuo si calcola a partire dalla sua accuratezza.



# Algoritmo genetico

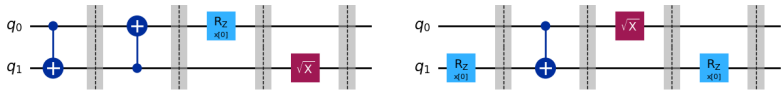
- La prima generazione è generata randomicamente.



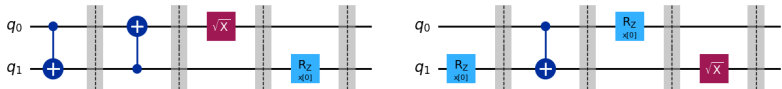
# Algoritmo genetico

- Gli individui sono passati alla seguente generazione con il crossover.

*Parent individuals*

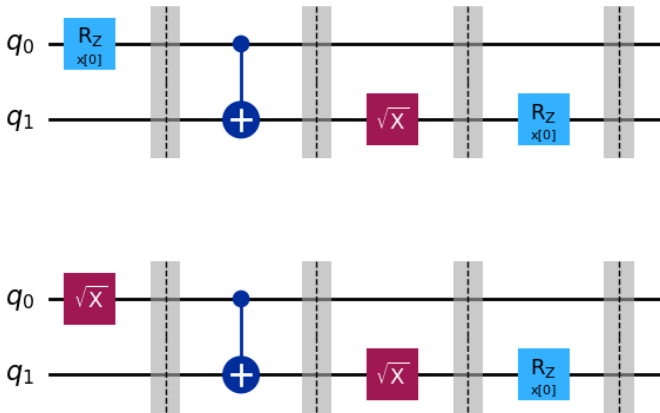


*Child individuals*



# Algoritmo genetico

- Inoltre subiscono una mutazione casuale.



# Algoritmo genetico

- Con l'andare delle generazioni aumenta l'accuratezza media.

