Using Quantum Machine Learning Classifier to identify alternative food sources

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Abstract

The global population risen from around 2.5 billion in 1950 to almost 8 billion today and will likely continue to rise as predicted by the United Nations (2023). Therefore, sustainable food production is a critical area of study. The United Nations' Sustainable Development Goals (SDG)-2 emphasize the importance of combating hunger and providing food security for all. While core crops like wheat, rice, and potatoes only grow through horizontal farming, there is still an untapped frontier: the cultivation of high-protein crops like mushrooms for vertical farming lies in scarcity.

Our initiative dives into the intriguing world of mushrooms, hoping to harness their potential as a key food source. We intend to categorize mushrooms as "EDIBLE" or "POISONOUS" using both conventional support vector machines (SVM) and forefront quantum computing approaches. Currently, there are over 146,000 classified fungi with experts estimating a total of 2.2-3.8 million total fungi species in existence (Wanasinghe et al., 2022). By realizing the potential significance of vertical farming paired with mushrooms, we decided to explore mushroom classification using a VQC to better understand mushroom classification.

Motivation

We aim to compare classical and quantum computing methods to categorize mushrooms as "EDIBLE" or "POISONOUS," crucial for sustainable agriculture and global food security goals.

Exploratory Data Analysis

- Gilled mushrooms in the Agaricus and Lepiota Family
  - **UC Irvine Machine Learning Repository**
    - 21 total features
    - 1625 total data points

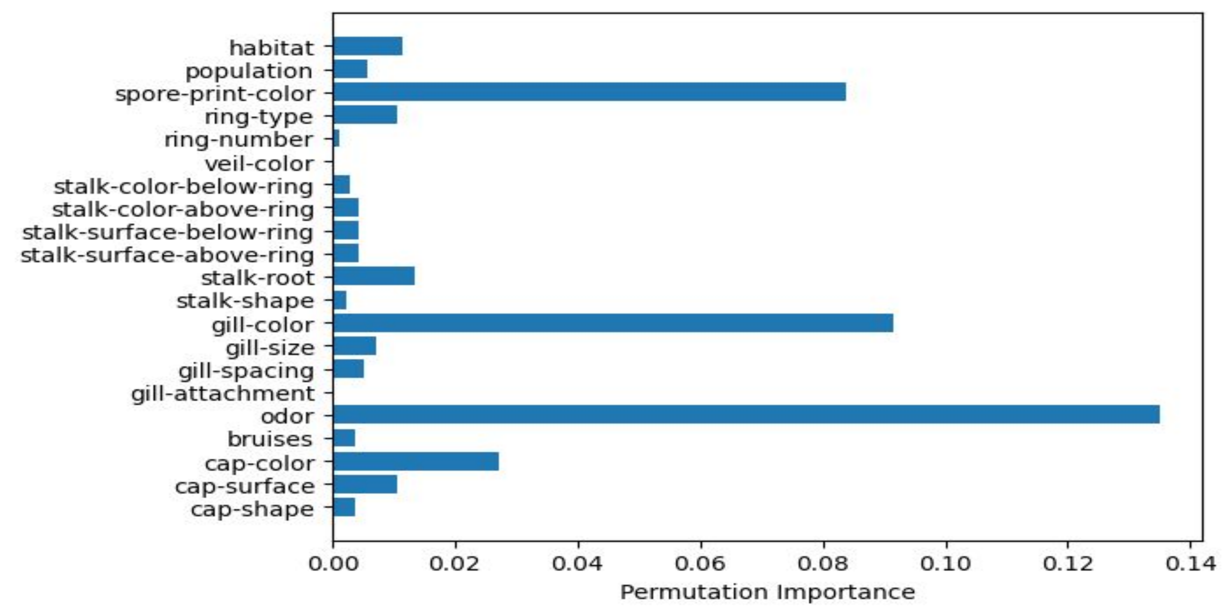

Figure 1 - Permutation importance for mushroom features

After analyzing the permutation importance, Odor, spore-print-color, and gill-color had the highest performing importance values for our dataset.

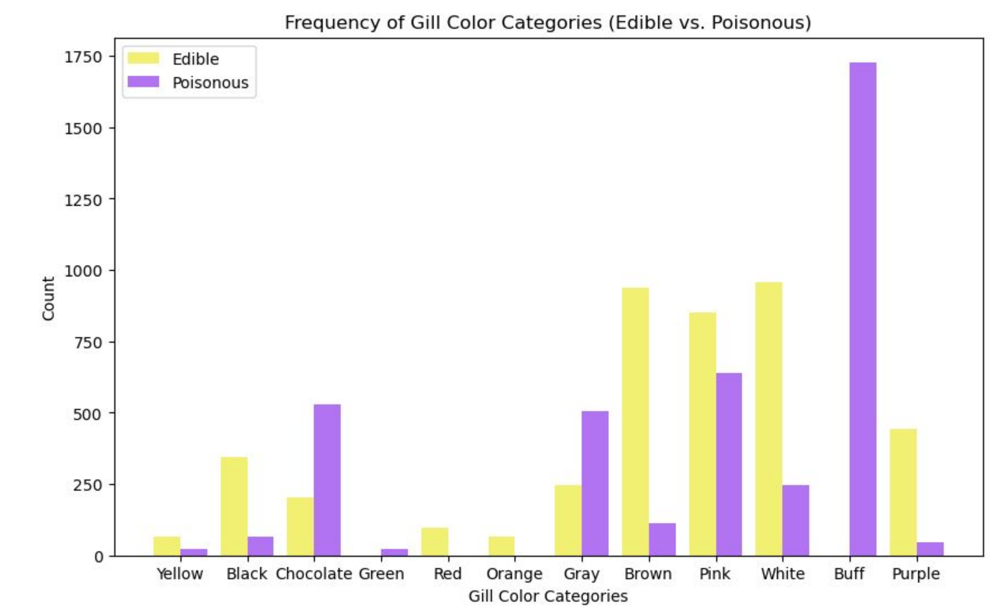

Figure 2 - Frequency by Gill Color

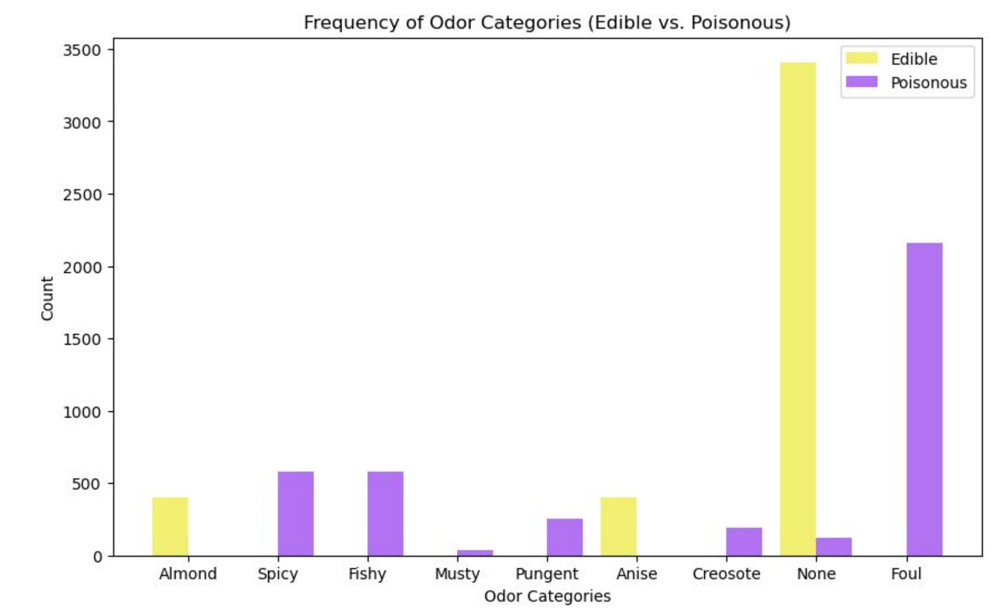

Figure 3 - Frequency by Odor

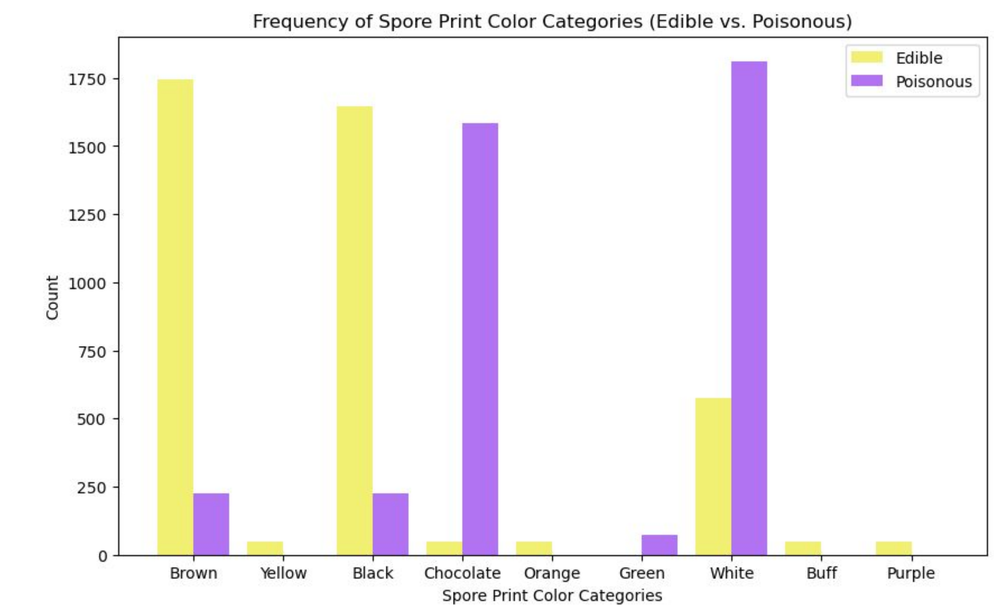

Figure 4 - Frequency by Spore Print Color

Frequency Analysis of Mushroom Characteristics - The frequency bar graphs provide a visual representation of three critical characteristics used to classify mushrooms: gill color, odor, and spore print color.

Results

Classical Model - SVM Classifier

Support Vector Classifier (SVC) - The Support Vector Classifier, renowned for its efficacy, aptly separates edible and poisonous mushrooms by utilizing essential features, resulting in distinct categorizations illustrated in the subsequent table.

	precision	recall	f1-score
edible	0.95	1	0.98
poisonous	1	0.95	0.97
accuracy			0.97
macro avg	0.98	0.97	0.97
weighted avg	0.97	0.97	0.97

Table 1 - Results achieved by Classical SVM

Mean Squared Error: 0.026461538461538464

Quantum Model - VQC

Variational Quantum Classifier (VQC) - The VCQ quantum model, differentiates between edible and poisonous mushrooms by utilizing essential features, resulting in categorizations showcased in the subsequent table. We used quantum simulator inside IBM QISKIT..

	precision	recall	f1-score
edible	0.86	0.77	0.81
poisonous	0.78	0.86	0.82
accuracy			0.81
macro avg	0.82	0.82	0.81
weighted avg	0.82	0.81	0.81

Table 2 - Results achieved by VQC

Mean Squared Error: 0.21723076923076923

Objective function and Quantum Circuit

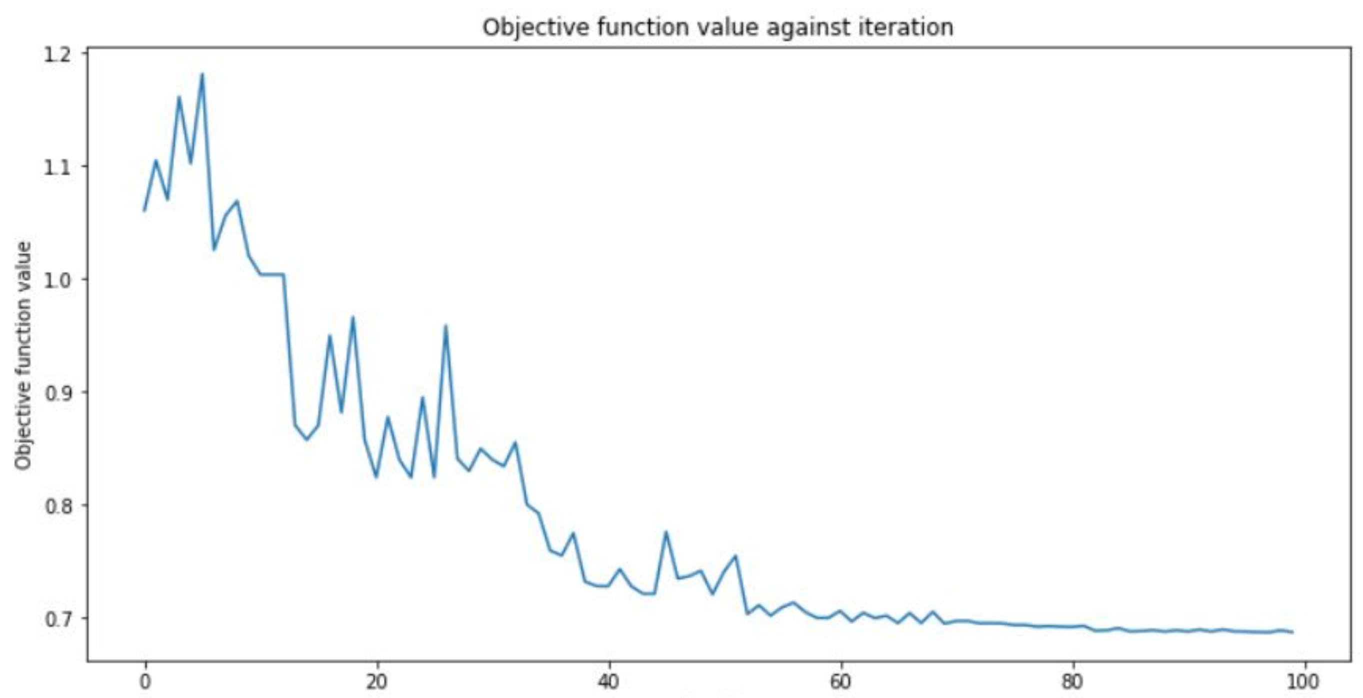

Figure 6 - Objective Function variation across epochs when using VQC

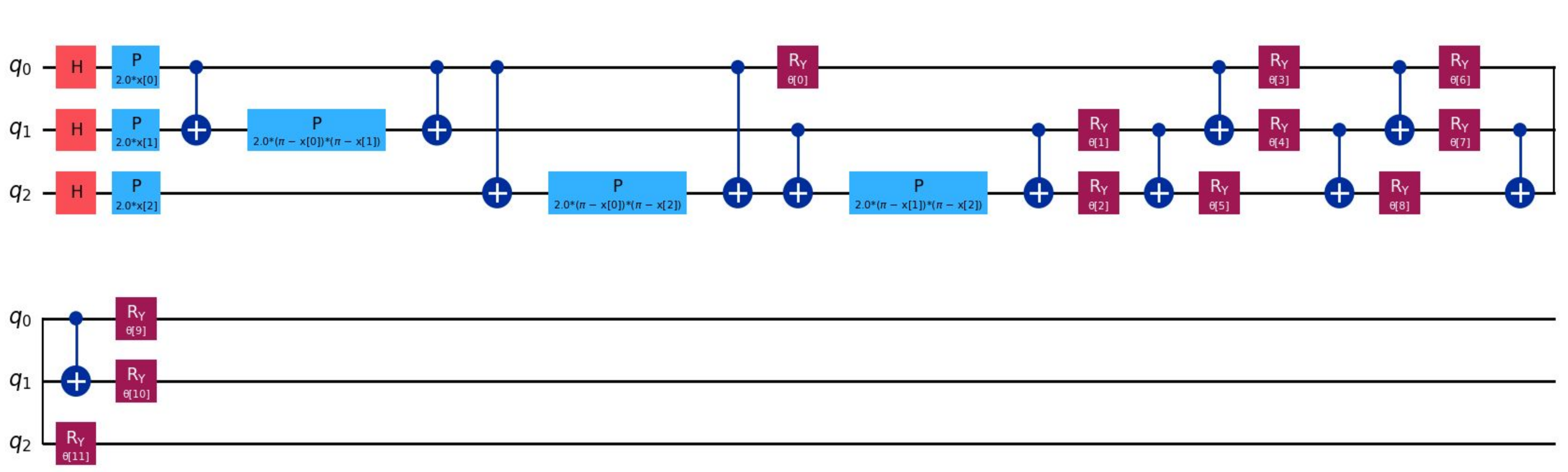

Figure 5 - VQC Circuit Utilized

VQC involves three steps: data encoding using the ZZFeatureMap, application of the RealAmplitudes ansatz, and integration into a QNN model circuit for classification tasks. In our case, the three chosen features are being inputted into the VQC as q0, q1, and q2.

Conclusion and Future Work

While classical techniques currently outperform quantum methods, it is only a matter of time before quantum techniques evolve and become even more potent. Furthermore, with the support of the new technology: IBM Quantum System One, our project can extend to a non-simulated quantum backend. Moreover, understanding varied food supplies is a crucial step toward providing reliable and abundant food sources for our growing population. The fusion of tradition with innovation holds limitless promise. By harnessing quantum techniques, such as Variational Quantum Classifiers, we transcend the boundaries of classical computing and allow us to delve deeper into critical topics, including the safe consumption and precise classification of food sources like mushrooms.

Citations

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