User Manual
QuantuMoonLight

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1. Introduction

This manual represents a guide for the use of the system, making the comprehension of QuantuMoonLight easier and providing a preview of the functionalities.

2. System description

Quantum Machine Learning was born as a fusion of two ideas: Machine Learning and Quantum Computing. Despite the growing interest in the topic, few tools are useful to simplify the pipeline of quantum machine learning. Moreover, these solutions cannot be used by people without experience in software development. So, our work aims to offer a simple and intuitive product that can be used without deep programming knowledge.

3. System requirements

QuantuMoonLight is supported by any operating system: Windows, Linux, or Mac. The only requirement is a web browser in which the user can use QuantuMoonLight's website.

4. Overview

The platform required a free registration to use all the functionalities. You can find a short description of the system on the website's homepage.

The navbar on the top allows you to reach the services offered by our system:

- **Home:** contains a short description of the platform.

- **Quantum ML:** contains the main functionalities of the system.

- **Get Started:** contains information useful on the first tool usage.

- **Community:** allows you to interact with other users.

- **User Area:** contains your personal information and additional service, i.e., **Statistics and history of operations,** allowing you to see the history and the statistics on your experiments and compare them.

The footer contains information on the university in which the platform was developed, i.e., the University of Salerno. Finally, the page About Us contains information about the development team and the newsletter subscription form.

5. Registration

Regarding the registration on the platform, the user must select the User Area, click on "Register Here" and fill in all the requested fields. Please, consider inserting a valid e-mail and IBM token to use the system correctly. Please note that the password will be encrypted before being saved in the database (Figure 1).
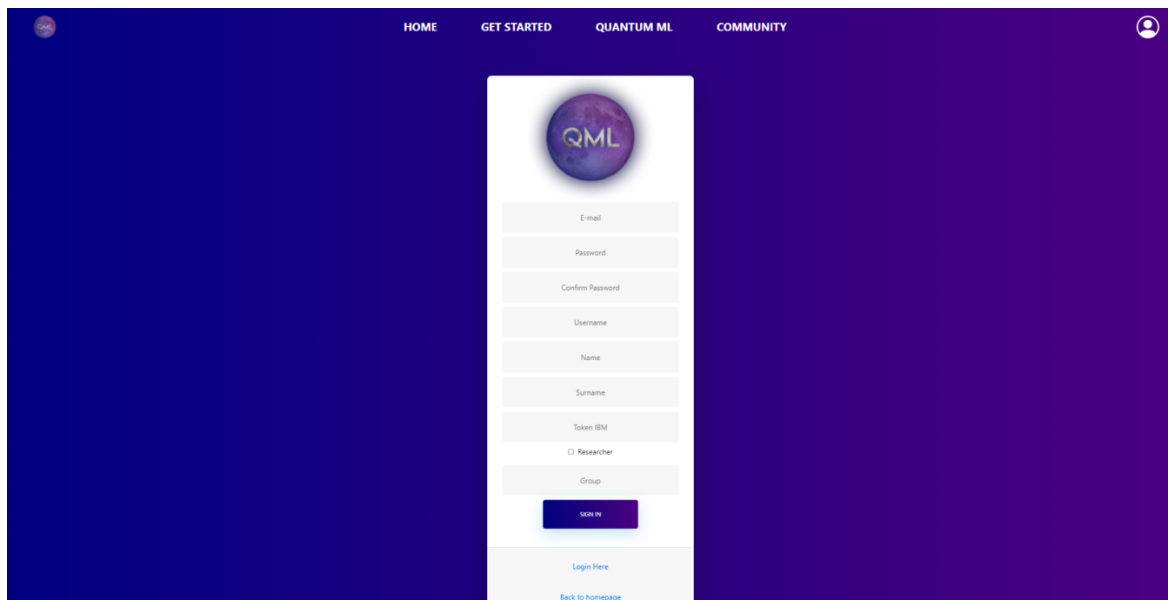

Figure 1: The registration form of the platform.

6. Authentication

The access to the platform is through the User Area by entering username and password (Figure 2).
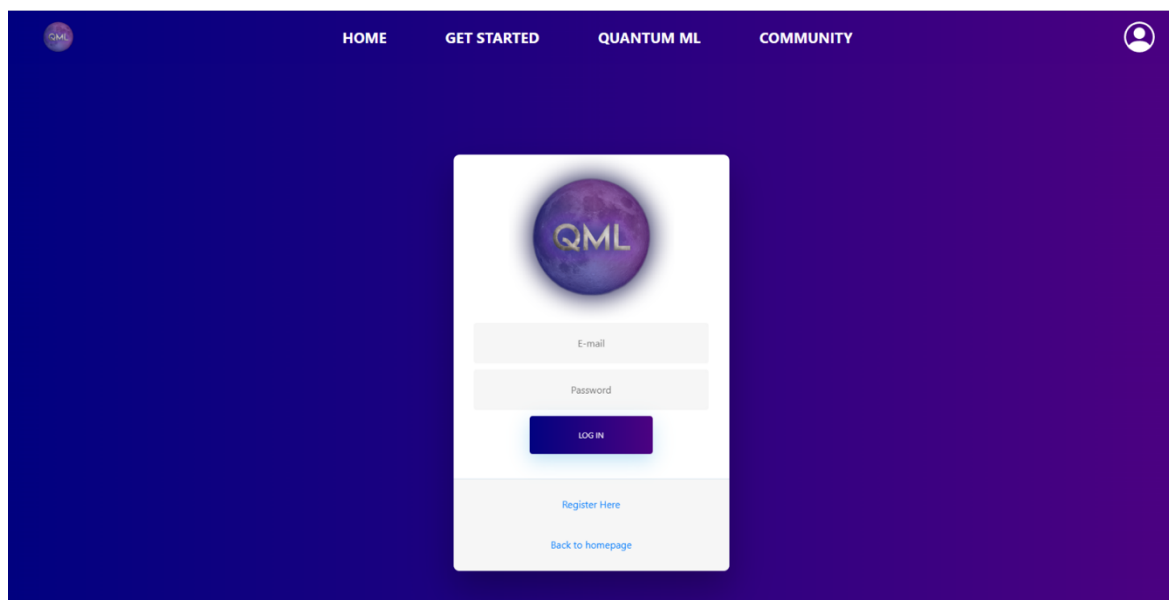
Figure 2: The authentication form of the platform.

To logout the user must go to the User Area and click the appropriate "Log-Out" button.

7. User Profile Management

To change your profile information, you need to go in the user area, as showed in Figure 3. Once the user goes in the user area, Figure 4 shows the user profile in which the user can see and change the personal information.

Figure 3: The homepage on QuantuMoonLight. The red arrow shows where the user area is.
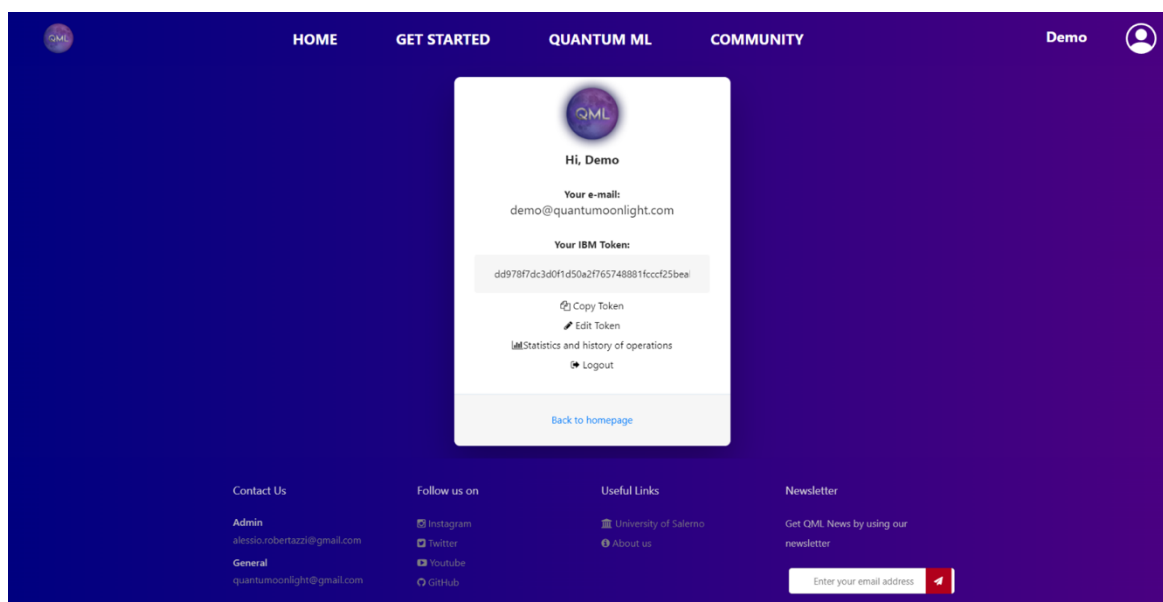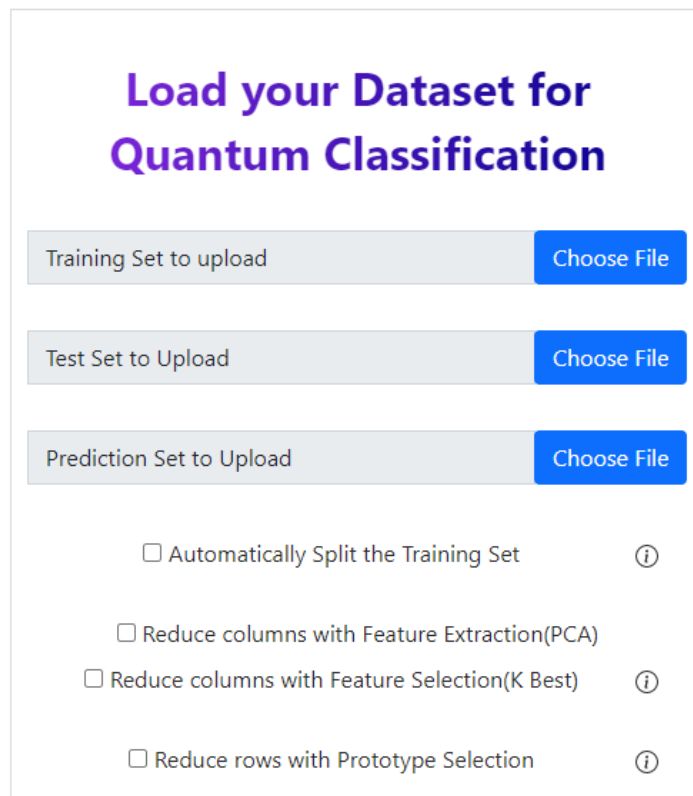
Figure 4: User profile in which the user can change the personal information, i.e., the IBM Token.

8. System functionalities

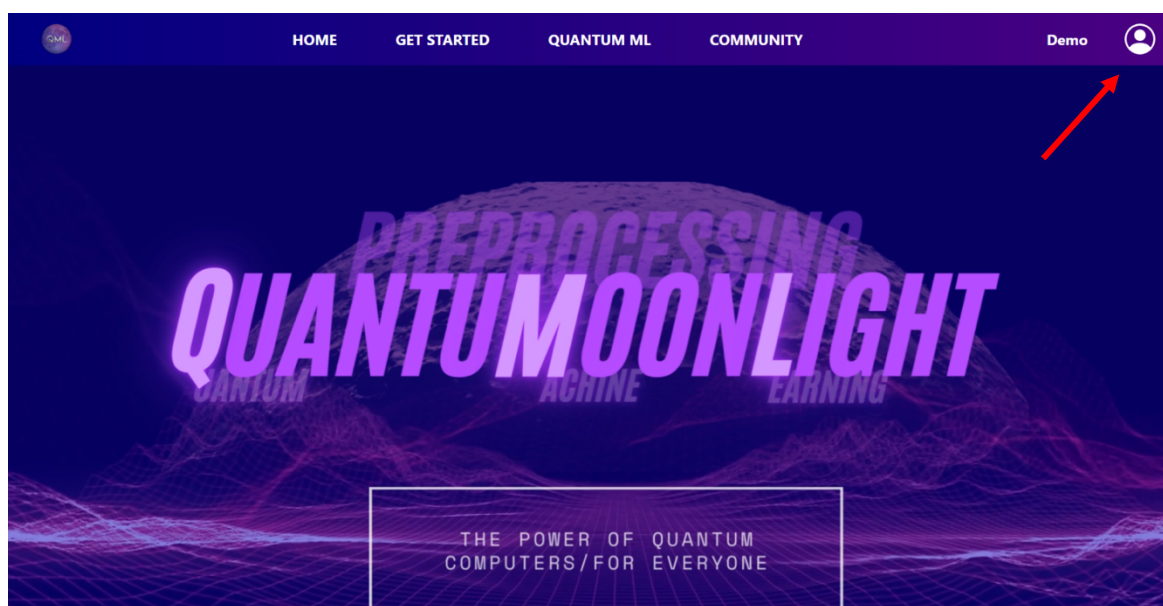The Quantum ML page contains information through which the user can decide on validation, preprocessing and classification steps. As the reader may notice in Figure 5, there is a box where the user can load Training (with the possibility of also selecting an automatic split), Test, and Prediction sets. It is also possible to preprocess data to reduce columns through the Feature Extraction by PCA or the Feature Selection by K-best. Finally, it is also possible to minimize rows with the Prototype Selection.

Figure 5: Setup of the dataset for Quantum Computing.

Figure 6 shows a list of different algorithms implemented in our tool. In particular, there are QSVM, QSVC, PegasosQSVC, and QNN for quantum classification. Then, QSVR, and VQR for quantum regression; As the reader may see SVC, KNN, Decision Tree, Naive Bayes, and Random Forest for canonical classification. Finally, SVR and Linear Regression for canonical regression.

Figure 6: List of classification and regression algorithms available in QuantuMoonLight.

Users can set advanced options such as K-Fold Cross Validation by choosing the "K" parameter (default is 10) and entering the number of columns and rows to be reduced, as shown in Figure 7.

Figure 7: Advanced setting options.

Figure 8 shows the preprocessing process; the reader may notice that the users can select Data Balancing with SMOTE and/or Data Imputation and choose between Min-Max Scaling and Standard Scaling.

Figure 8: The preprocessing steps.

Moreover, it is possible to choose also the number of columns for Feature Extraction and Feature Selection and the number of rows for Prototype Selection to reduce (Figure 9).

Feature Extraction

Insert nr of columns to reduce Feature Extraction:

2   ⓘ

Feature Selection

Insert nr of columns to reduce Feature Selection:

2   ⓘ

Prototype Selection

Insert nr of rows to reduce: 100   ⓘ

Figure 9: Feature extraction, Feature Selection and Prototype Selection.

Finally, for Classification and Regression algorithms, the users may change the hyperparameters and choose the Backend of IBMQ family (Figure 10). For this option, you will need to see the backend associated with the token. These backends are divided into Simulator and Quantum System. After uploading the dataset, the system will redirect the user to a page where they can download validation and preprocessing results. If you have selected an algorithm for classification/regression, you will receive the results via mail.

Hyperparameter

Pegasos QSVC

Insert PegasosQSVC C: 1000   ⓘ

Insert PegasosQSVC tau: 100   ⓘ

Hyperparameter

Quantum Neural Network

Insert NN optimizer: SLSQP ▾   ⓘ

Insert NN loss function: Squared Error ▾   ⓘ

Insert max iterations optimizer: 100   ⓘ

Figure 10: Example of PegasosQSVC, Quantum Neural Network, SVC, and SVR Hyperparameters.

Once the user has run the experiments, from the user area the tool allows access to the history and statistics of the models. The first step is to select "Statistics and history of operations". Then, QuantuMoonLight will show the list of all experiments done by the user and some statistics about the various features used to run a model, e.g., type of validation, as shown in Figure 11.
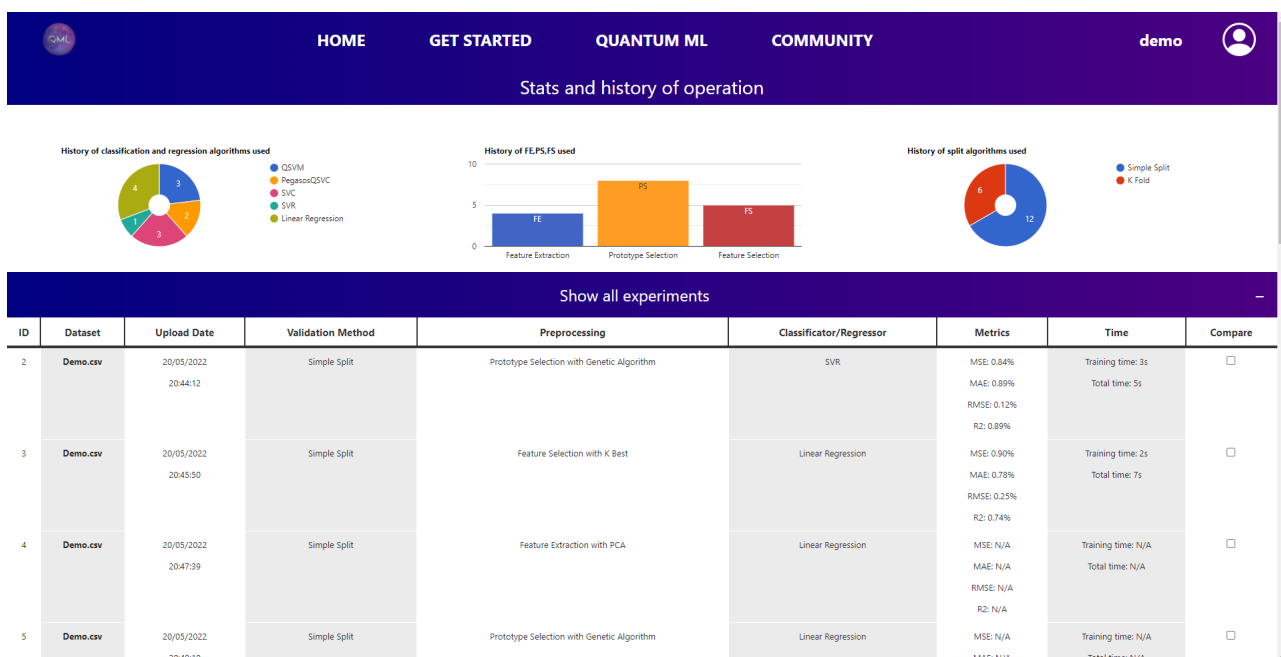

Figure 11: List of all experiments done by the user.

By selecting two experiments, the user can see a comparison in terms of time, accuracy, precision, recall, and F-Measure (Figure 12).

COMPARISON OF TOTAL/TRAINING TIME

Comparison of total processing times

Total processing time in seconds

Comparison of training processing times

Training processing time in seconds

METRICS COMPARISON

Comparison of accuracy metric

Accuracy metric %

Comparison of Precision metric

Precision metric %

Comparison of Recall metric

Comparison of F1 metric

SELECTED DATASET

Code	Dataset	Preprocessing & Classification/Regression algorithm used	Metrics	Time
9	training_fold_7.csv	Prototype Selection with Genetic Algorithm **QSVC**	**Accuracy:** 96.94% **Precision:** 12.77% **Recall:** 7.50%	Training time: 172 s Total time: 5672 s
10	training_fold_7.csv	Prototype Selection with Genetic Algorithm **QSVC**	**Accuracy:** 90.47% **Precision:** 31.07% **Recall:** 49.11%	Training time: 191 s Total time: 5924 s

Figure 12: Comparison between two models in terms of time and performance.

9. Dataset requirements

The system does not check the quality of your dataset and does not provide any data cleaning operations. Therefore, the user who will upload the datasets, should take a look at the following requirements:

- The dataset should be a CSV file.
- The dataset should contain <u>only</u> numbers and, at most, the "NaN" value, separated by commas.
- The dataset does not include the column id and the name of the features.
- Each row must have the same number of values.
- The dataset should not have strings or empty strings.
- The dataset useful to predict must be coherent at the training set, i.e., the same number of the features.
- The dataset useful to predict must contain just one column less than the training and test datasets.

10. Community

In the last section of our system, i.e., the community, the registered users can interact with each other by joining a discussion and/or sharing their results. To create a new thread, you must login to the system. Then, as shown in Figure 1, the user can choose to share an article or an experiment and /or comment the other posts.
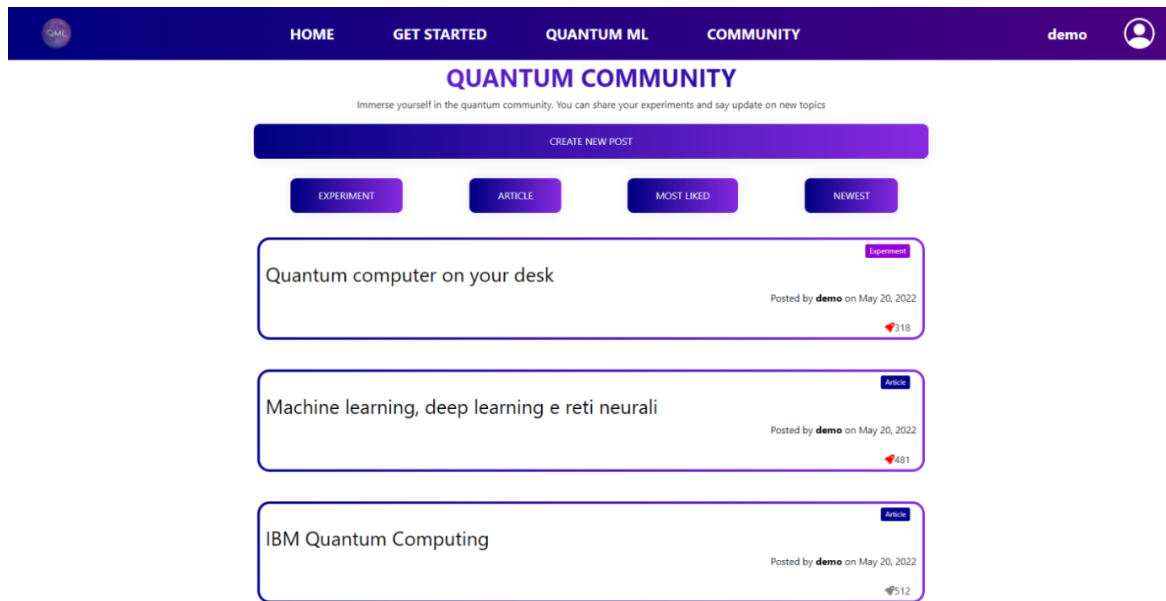

Figure 13: The QuantuMoonLight community page.