Clustering Methods for Excited State Promoted Readout

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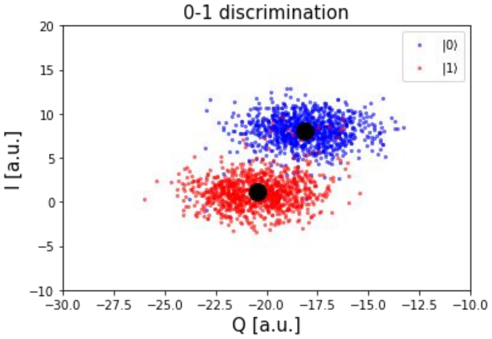
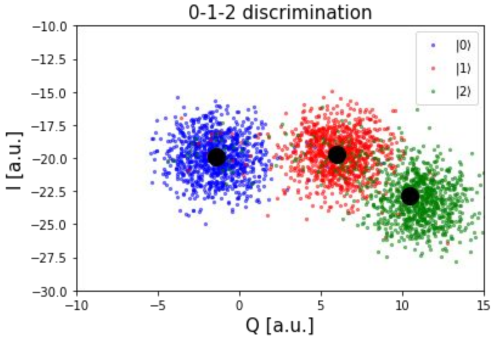
Project Description

1. Excited State Promoted (ESP) readout is a way to improve qubit readout fidelity by exciting the |1⟩ state to the |2⟩ state for readout. This essentially changes the discrimination problem from a two-state to three-state system.

2. In our project, we aim to look at different clustering algorithms on the real data to measure their effectiveness, and implement a method for effective discrimination.

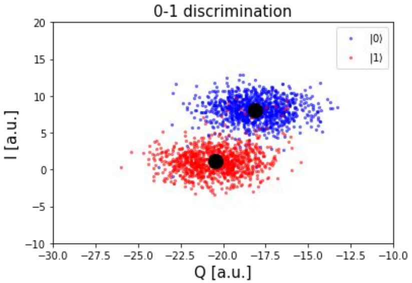
3. The metric for success is the false error rate on the labeled data.

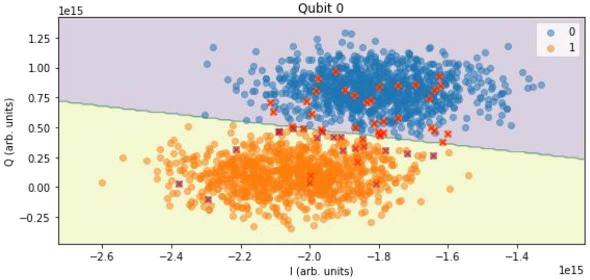


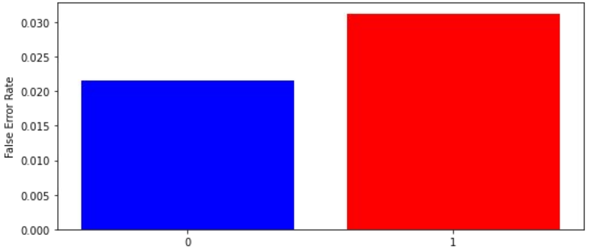


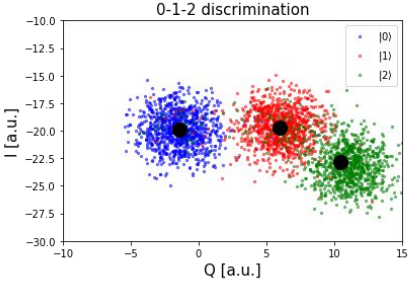
Current Progress - I

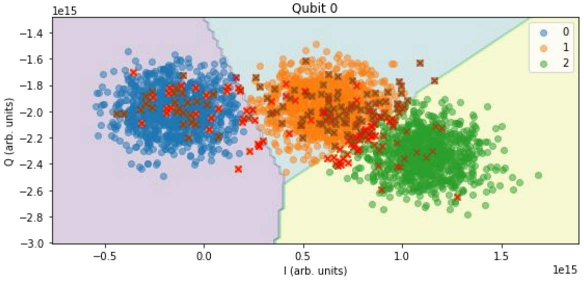
Got the basic Ignis discriminator setup working for the unexcited and excited state readout.

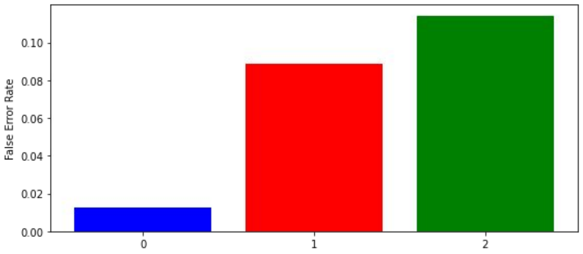








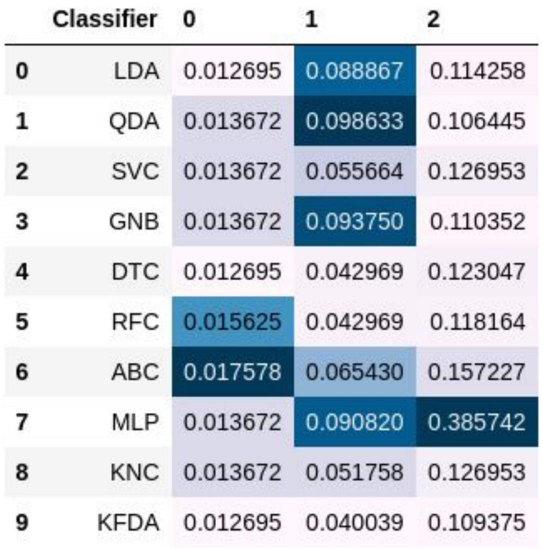




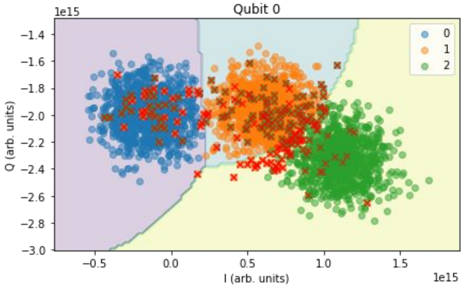
Current Progress - II

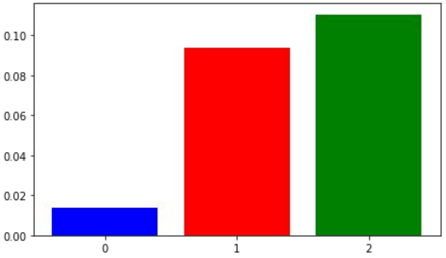
Comparison between the different *multiclass* classifiers.

1. Linear and Quadratic Discriminant Analysis
2. Support Vector Machines
3. Gaussian Naive Bayes
4. Decision Tree Classifiers and Random Forests
5. K-Nearest Neighbors
6. Multi-Layer Perceptrons and Ada Boost
7. Kernel Fisher Discriminant Analysis



	Classifier	0	1	2
0	LDA	0.012695	0.088867	0.114258
1	QDA	0.013672	0.098633	0.106445
2	SVC	0.013672	0.055664	0.126953
3	GNB	0.013672	0.093750	0.110352
4	DTC	0.012695	0.042969	0.123047
5	RFC	0.015625	0.042969	0.118164
6	ABC	0.017578	0.065430	0.157227
7	MLP	0.013672	0.090820	0.385742
8	KNC	0.013672	0.051758	0.126953
9	KFDA	0.012695	0.040039	0.109375



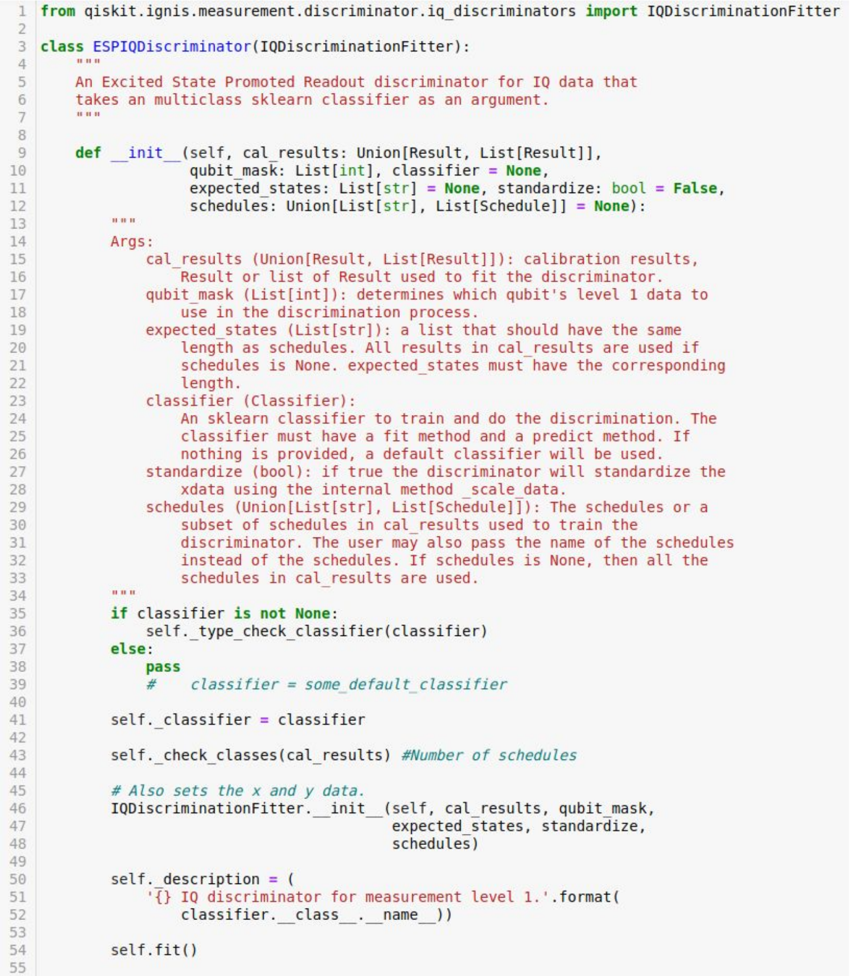


Current Progress - III

Attempting at an effective implementation of ESP discrimination.

Basic Idea -

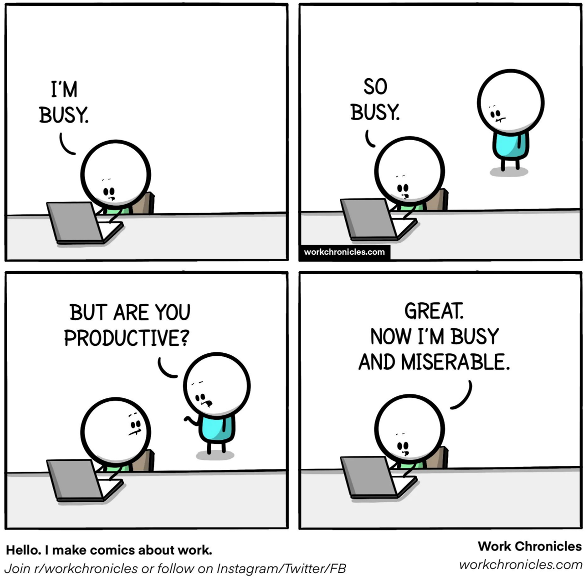
1. An **optional** multiclass classifier. If not provided by the user, choose an ideally best performing by **default**.
2. A check on **number of schedules** provided. Should be least *3*?
3. Should not break any of the existing functionalities in the discriminator code.



```python
from qiskit.ignis.measurement.discriminator.iq_discriminators import IQDiscriminationFitter

class ESPIQDiscriminator(IQDiscriminationFitter):
    """
    An Excited State Promoted Readout discriminator for IQ data that
    takes an multiclass sklearn classifier as an argument.
    """

    def __init__(self, cal_results: Union[Result, List[Result]],
                 qubit_mask: List[int], classifier = None,
                 expected_states: List[str] = None, standardize: bool = False,
                 schedules: Union[List[str], List[Schedule]] = None):
        """
        Args:
            cal_results (Union[Result, List[Result]]): calibration results,
                Result or list of Result used to fit the discriminator.
            qubit_mask (List[int]): determines which qubit's level 1 data to
                use in the discrimination process.
            expected_states (List[str]): a list that should have the same
                length as schedules. All results in cal_results are used if
                schedules is None. expected_states must have the corresponding
                length.
            classifier (Classifier):
                An sklearn classifier to train and do the discrimination. The
                classifier must have a fit method and a predict method. If
                nothing is provided, a default classifier will be used.
            standardize (bool): if true the discriminator will standardize the
                xdata using the internal method _scale_data.
            schedules (Union[List[str], List[Schedule]]): The schedules or a
                subset of schedules in cal_results used to train the
                discriminator. The user may also pass the name of the schedules
                instead of the schedules. If schedules is None, then all the
                schedules in cal_results are used.
        """
        if classifier is not None:
            self._type_check_classifier(classifier)
        else:
            pass
        #    classifier = some_default_classifier

        self._classifier = classifier

        self._check_classes(cal_results) #Number of schedules

        # Also sets the x and y data.
        IQDiscriminationFitter.__init__(self, cal_results, qubit_mask,
                                        expected_states, standardize,
                                        schedules)

        self._description = (
            '{} IQ discriminator for measurement level 1.'.format(
                classifier.__class__.__name__))

        self.fit()

```

Deliverables

1. A pull request for code that implements ESP discrimination.
2. Unit Test cases for the above implemented code.
3. Lots of hope for not breaking existing codebase.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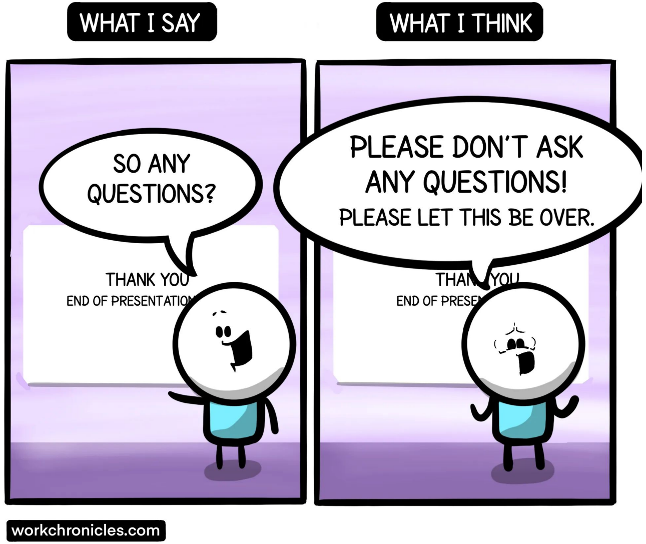

Thank You.

Questions?