Bayesian Framework for Quantum Algorithms in Qiskit

Team: Baye's Baes

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Overview

- Problem and use-case
- Project description
- Bayesian Inference with Qiskit
- Results
- Plans for future work

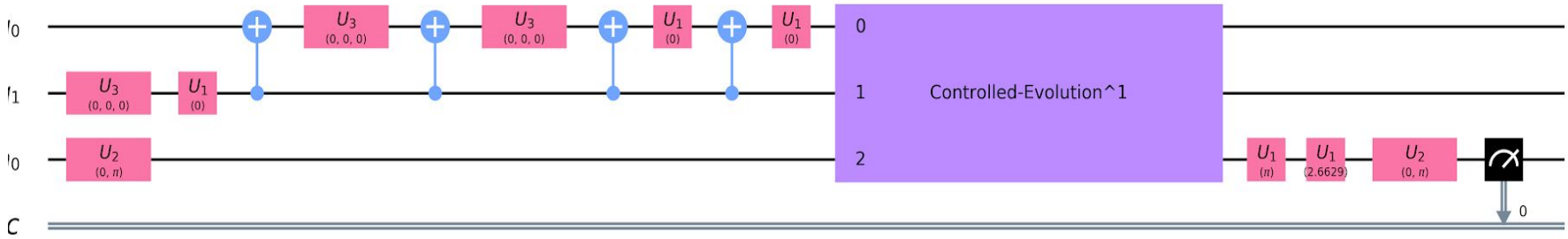
Problem

Bayesian Inference is a principle part of statistical analysis. However, Qiskit does not currently have any framework for conducting such an analysis. It has the potential to improve results over naive methods.

What we did.

1. Learnt and investigated the QInfer library to determine the potential for integration with Qiskit
2. Used Wiebe and Granade as a basis for using IQPE as a PoC
3. Planned an integration procedure for Qiskit Aqua

IQPE



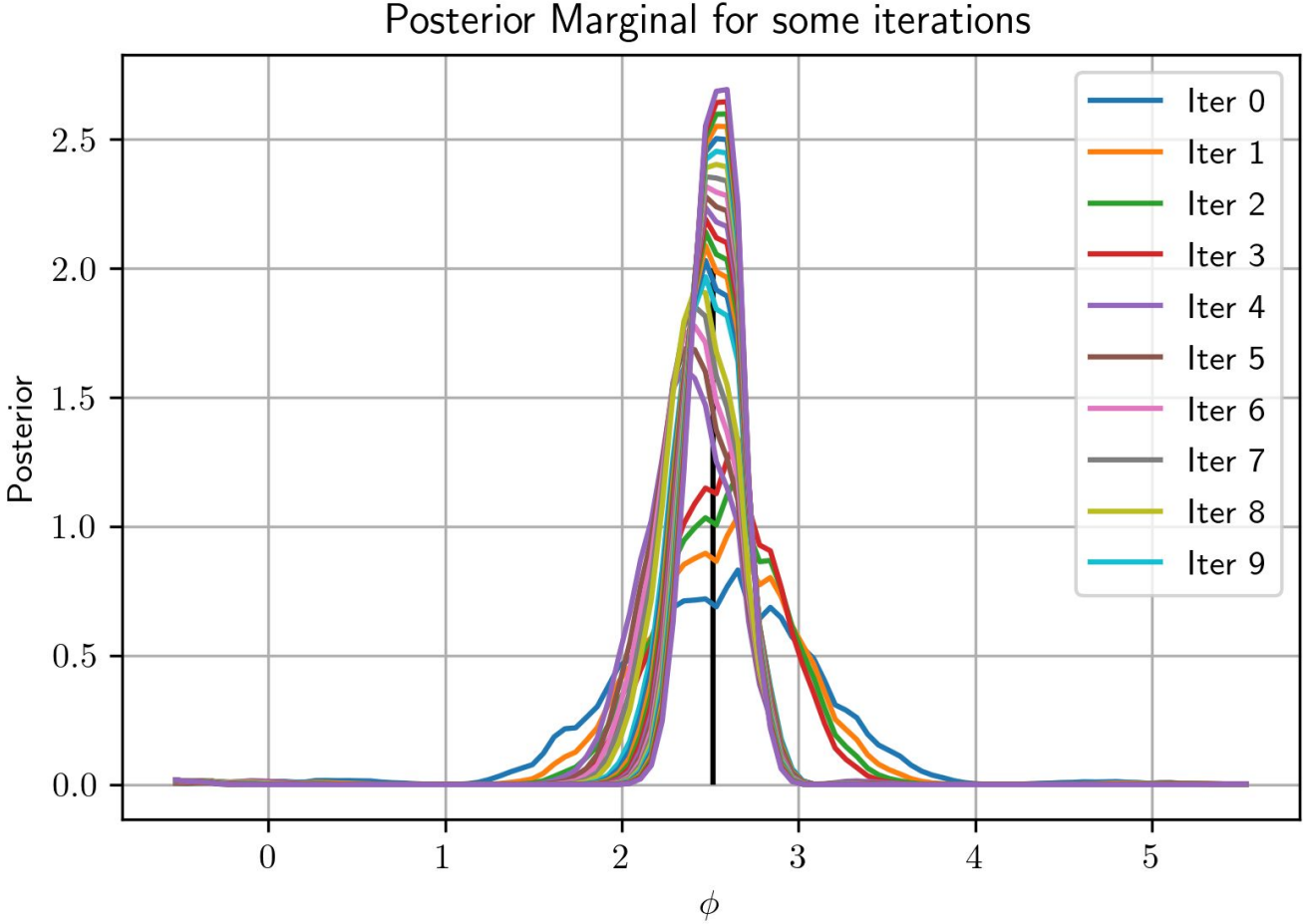
How does it work?

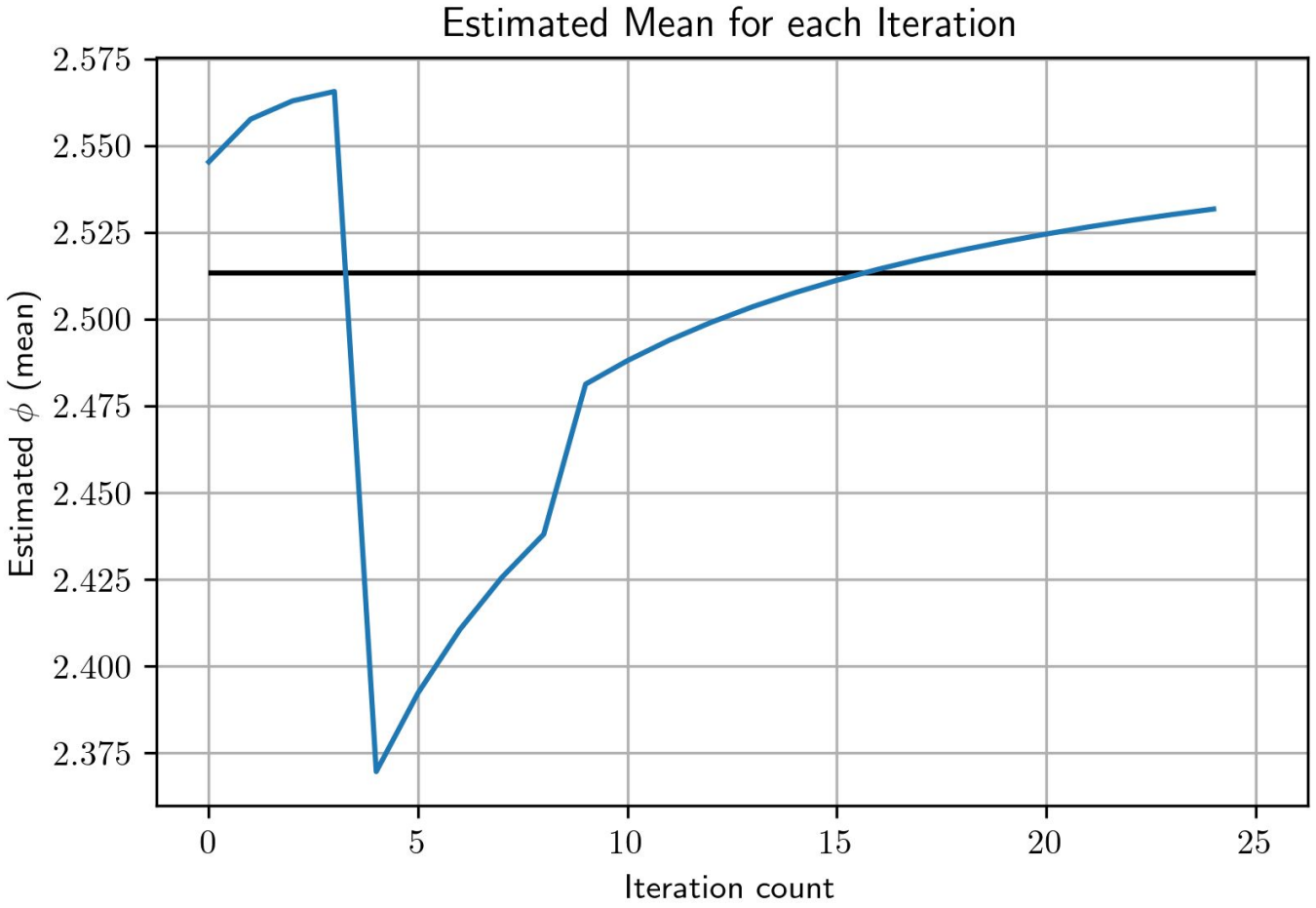
QInfer

- Python Library
- Conducts B.I. on analytical models
- Determines the model parameters from simulation results

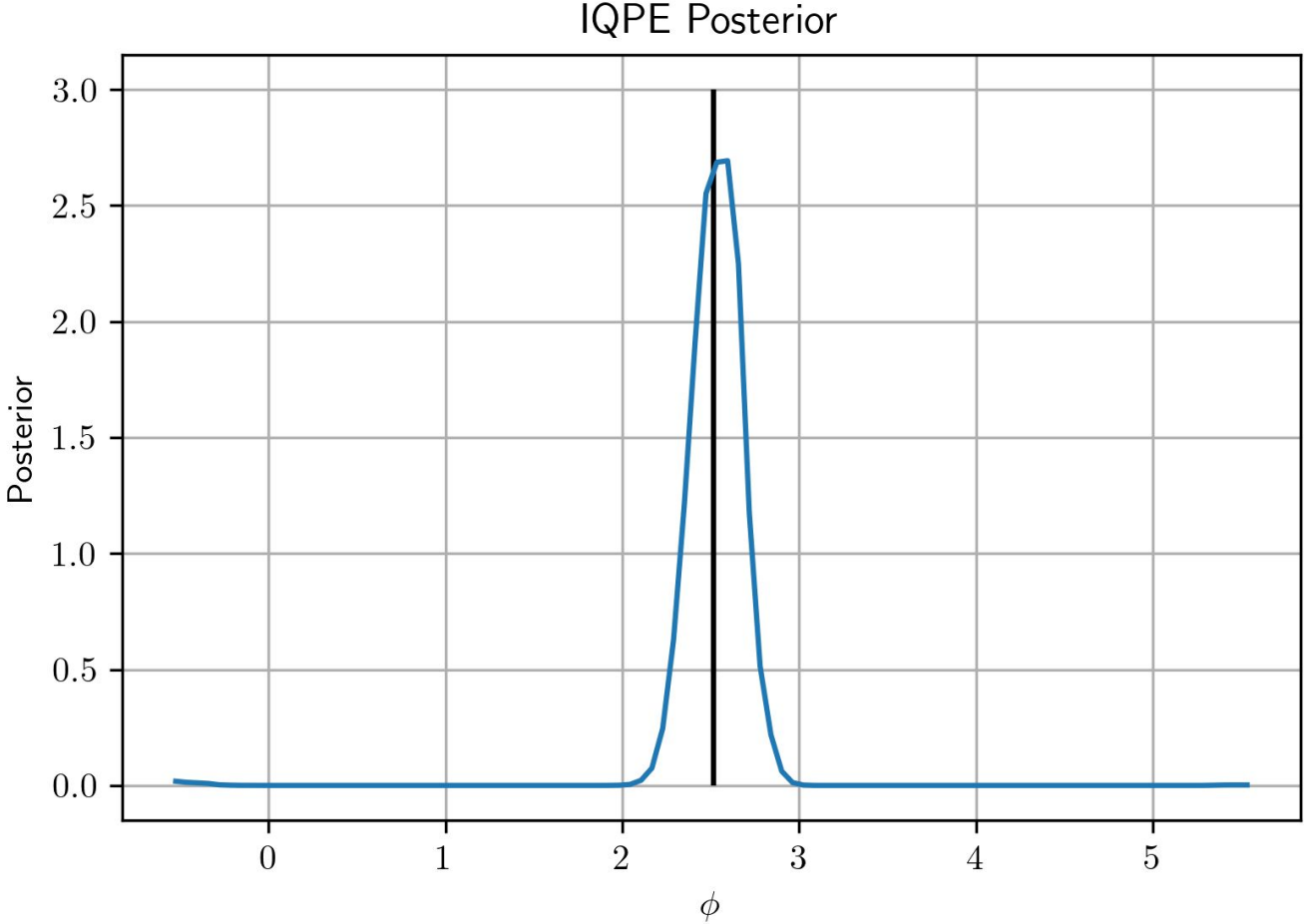
$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Results

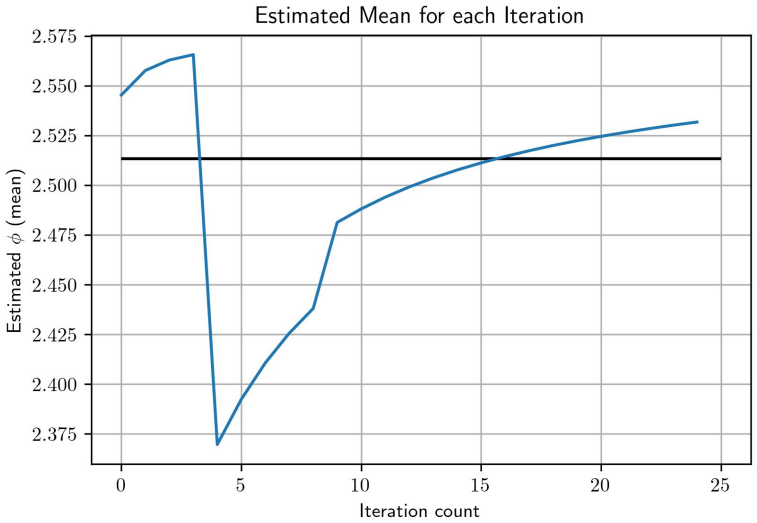

Posterior Marginal for some iterations
Posterior
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
ϕ
Iter 0
Iter 1
Iter 2
Iter 3
Iter 4
Iter 5
Iter 6
Iter 7
Iter 8
Iter 9

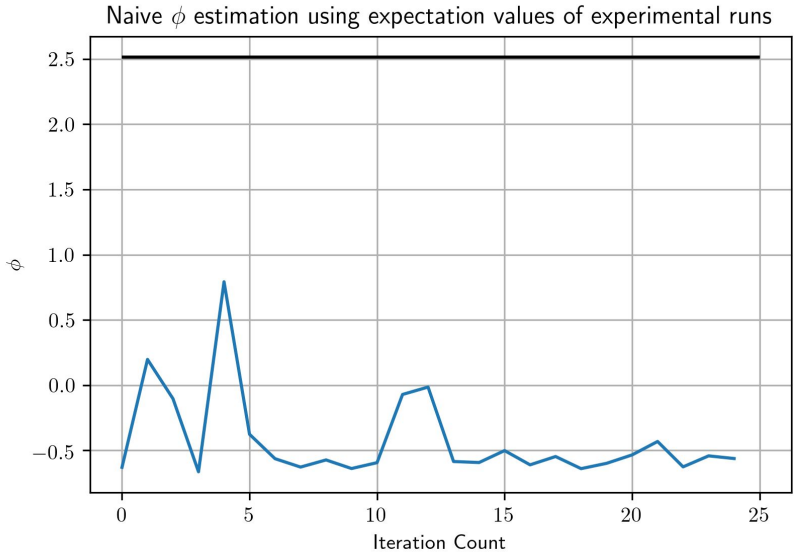

Estimated Mean for each Iteration
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
Estimated ϕ (mean)
0
5
10
15
20
25
Iteration count

True Error over each Iteration
True Error
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
5
10
15
20
25
Iteration count


IQPE Posterior
Posterior
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
ϕ

Compared to naive method


Estimated Mean for each Iteration
Estimated ϕ (mean)
Iteration count
2.575
2.550
2.525
2.500
2.475
2.450
2.425
2.400
2.375
0
5
10
15
20
25


Naive ϕ estimation using expectation values of experimental runs
ϕ
Iteration Count
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
0
5
10
15
20
25

Requirements

- Analytical representation of output probabilities
- Classical component in the computation
- Algorithm must expose the analytical representation to QInfer

Future Work

Qiskit Contribution

- Add likelihood parameters to Aqua BaseAlgorithm class
- Create a parent Aqua Algorithm to run each algorithm
- Write the output probabilities for some Aqua implementations
- Use ProbTorch to compliment Qiskit and QInfer

Conclusion

- Demonstrated a new method for analysing algorithm results
- Planned an integration method for future work
- Shown the applicability of recent research to Qiskit

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