Deep Learning Analysis of Quantum Networks

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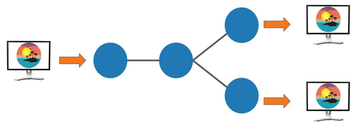
Background

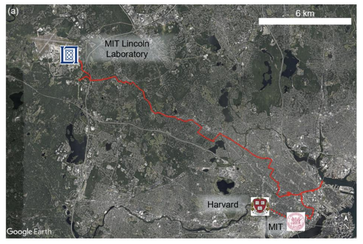
Abstract

This project uses neural networks to analyze quantum networks by predicting channel failure rates. Data from two simulated quantum networks showed that prediction accuracy improves with more measurements. Principal component analysis identified the most effective measurement bases. The neural network's performance coincided with previously determined values, validating its effectiveness. Results indicate that neural networks, combined with principal component analysis, are effective tools for probing quantum networks, with measurement significance varying by network.

Quantum Networks



- Interconnected Quantum Computers have vast implications from simulations, to cryptography, to data processing.
- Quantum Networks send quantum information which is prone to different types of errors



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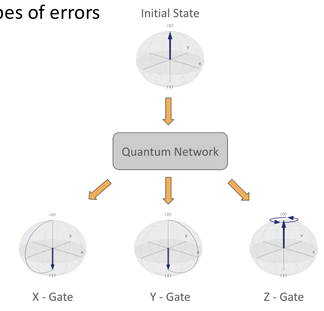
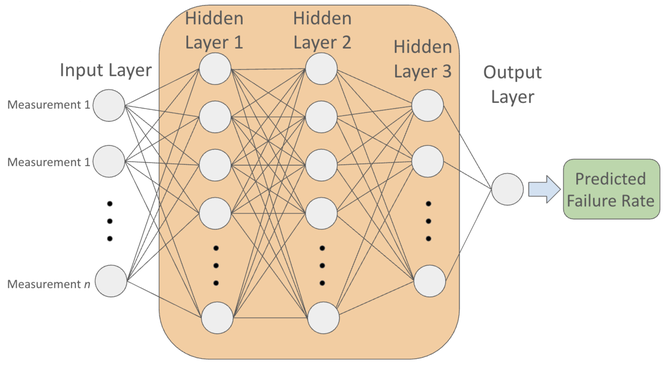
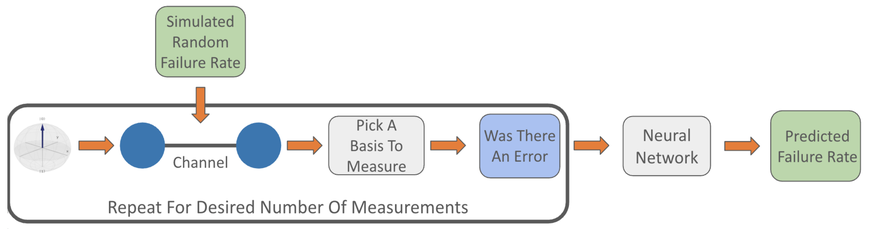


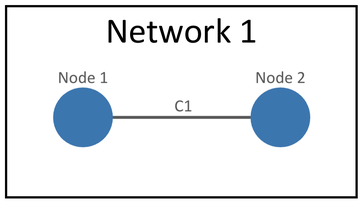
Neural Networks

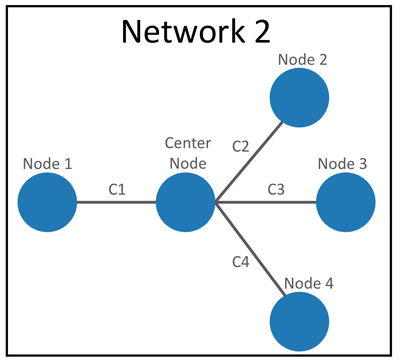
- Neural Networks surpass humans and other machine learning techniques in pattern recognition and data interpretation. (2)
- Neural Networks are high speed, scalable, and more accurate than traditional regression models. (3)
- Neural Networks can solve complex multi-level problems, that can be generalized to broader range of uses. (4)
- Neural Networks reduce image noise, shrink data dimensionality, and identify important input features. (5)



Methods



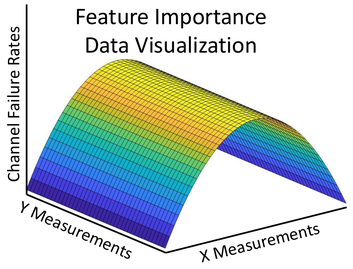




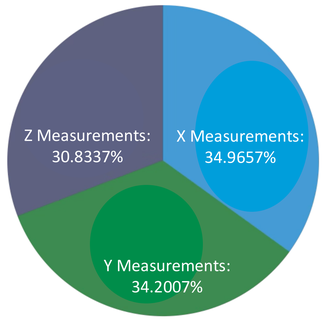
- For each network thousands of random channel failure rates are chosen.
- The neural network trains on this data and is then used to predict the failure rate of channels it has never seen before.

Principle Component Analysis

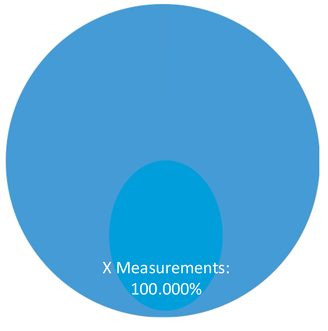
- Principle Component Analysis (PCA) finds which inputs are most important.
- PCA determines input importance by examining how changes in one input affect the output value.
- Inputs that have a high input on the output value are considered the most important.
- Shown to the right is a graph displaying how 2 input variables may affect a third output value.



Measurement Basis Importance: Network 1

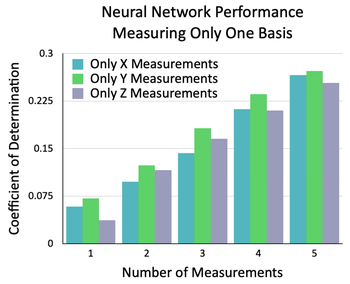


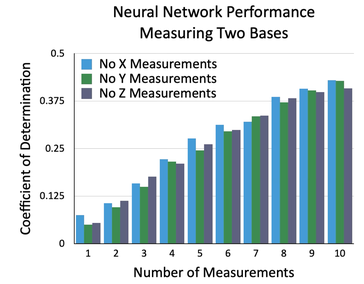
Measurement Basis Importance: Network 2

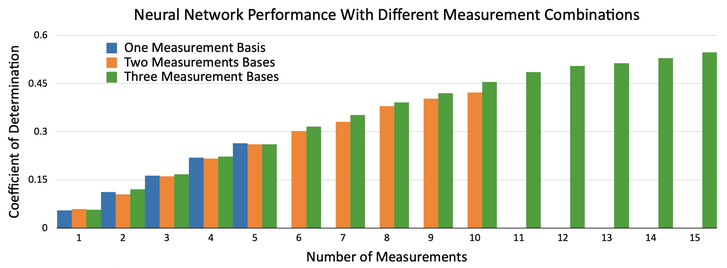


Results

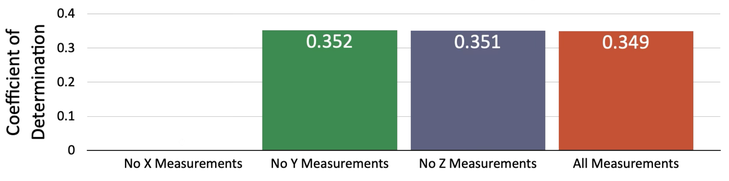
Network 1

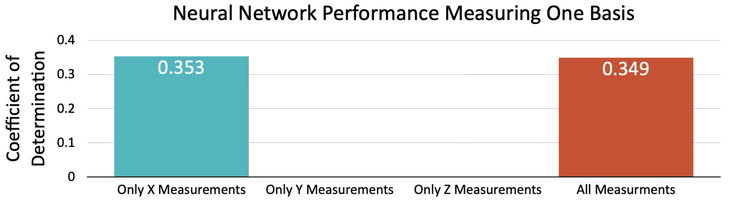






Network 2





Conclusions

- The neural network's performance trends upward with more diverse measurements, indicating the importance of variety in data collection.
- The validation of neural network predictions against known values supports its reliability in characterizing quantum networks.
- Different quantum networks may require distinct measurement bases for optimal error detection, highlighting the need for tailored approaches.

References

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Acknowledgements

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