



Generative Models using Continuous Variable Quantum Computing

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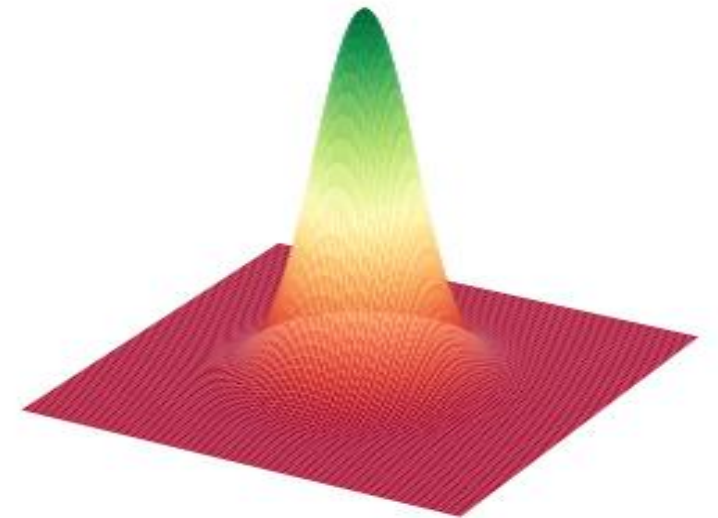
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PROJECT INTRODUCTION

Aim: Define and implement generative models in continuous variable architecture to take advantage of its inherent continuous nature to simulate the outputs of the Calorimeter.

Continuous Variable Model

- A paradigm of Quantum Computation which uses continuous systems.
- Such systems reside in an infinite dimensional Hilbert Space.
- Basic element of computation is Qumode.
- Suitable for simulating bosonic systems, electromagnetic fields, harmonic oscillator, phonons, Bose-Einstein condensates etc.
- Deals with continuous observables like position and momentum.



CV GATES

Gaussian Gates

Squeezing Gate

Displacement Gate

Rotation Gate

Non-Gaussian Gates

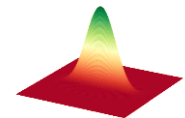
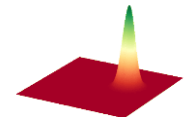
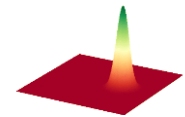
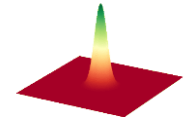
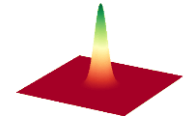
Kerr Gate

Cubic Phase Gate

Symbol



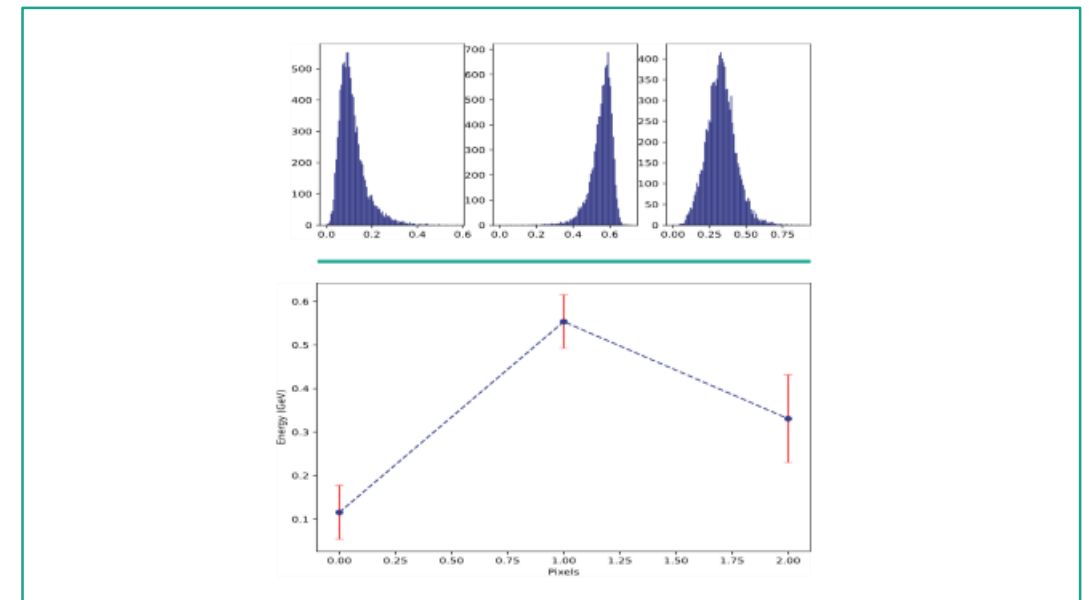
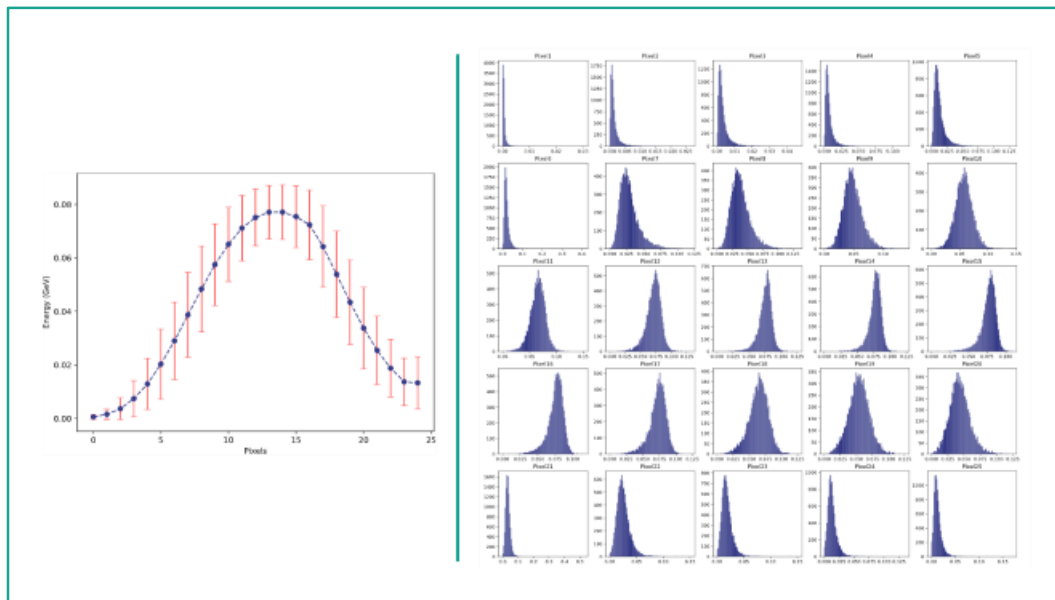
Transformation

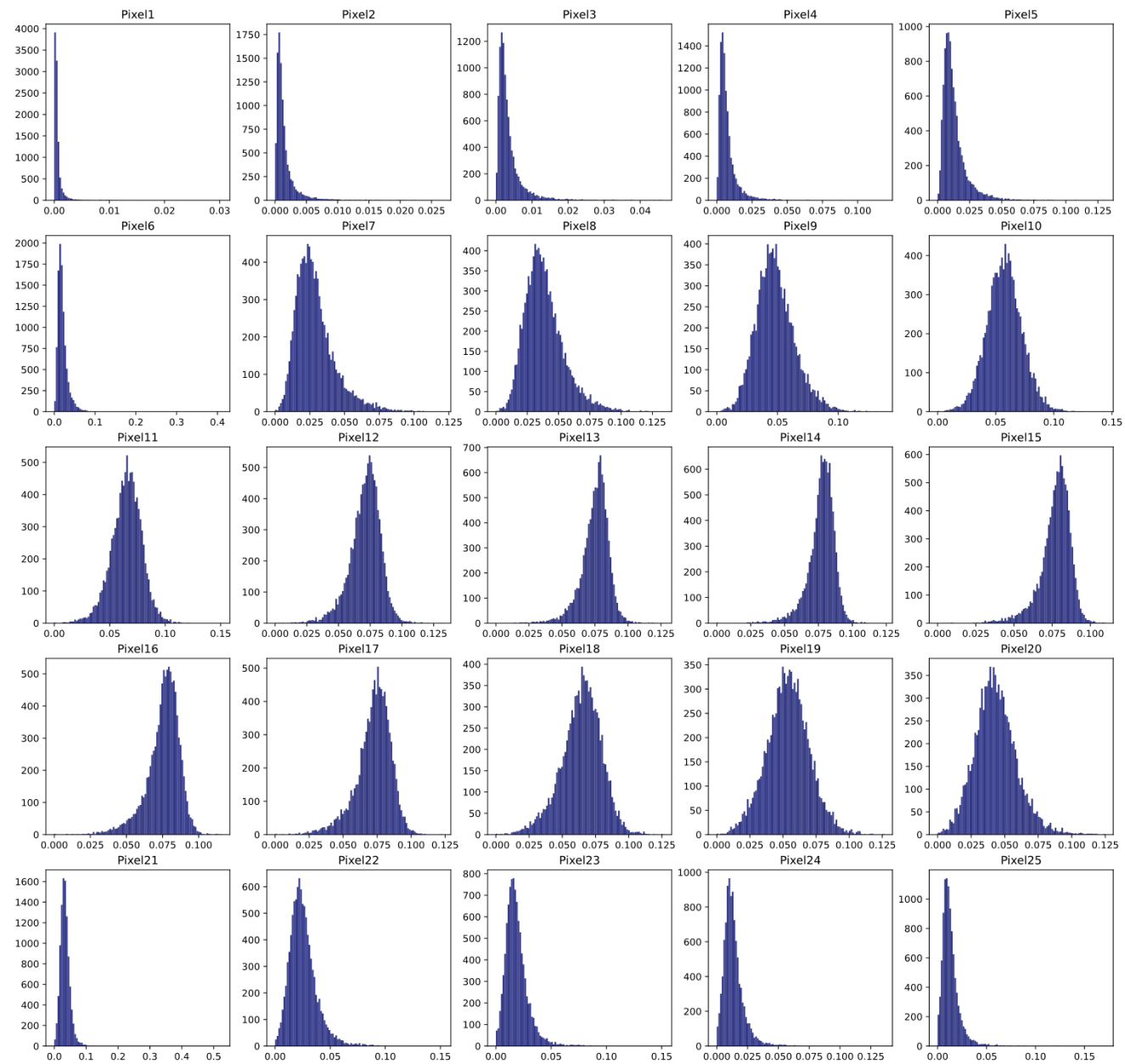
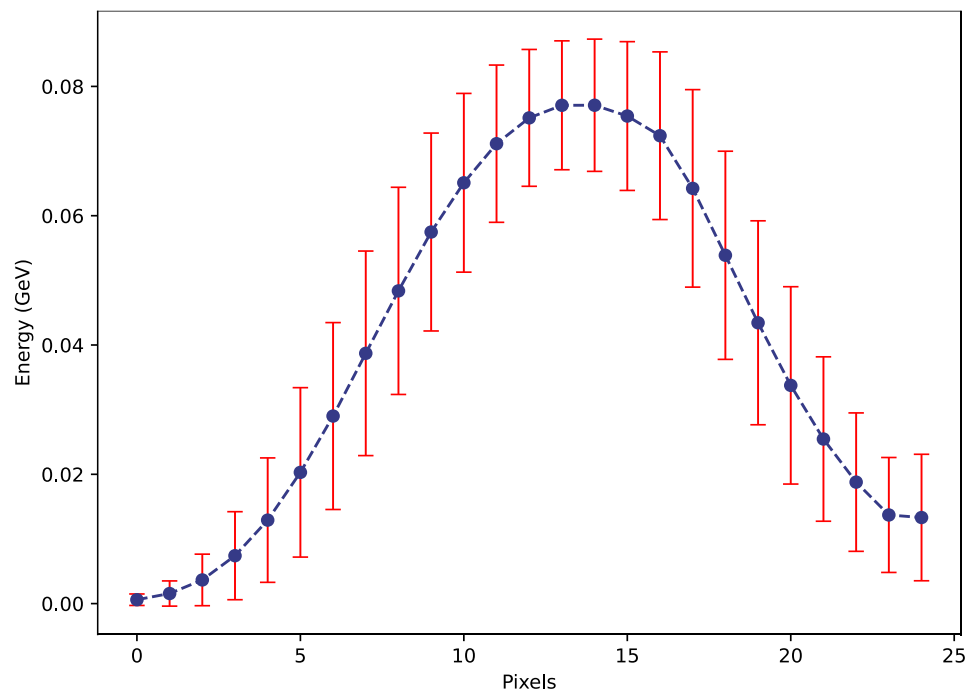


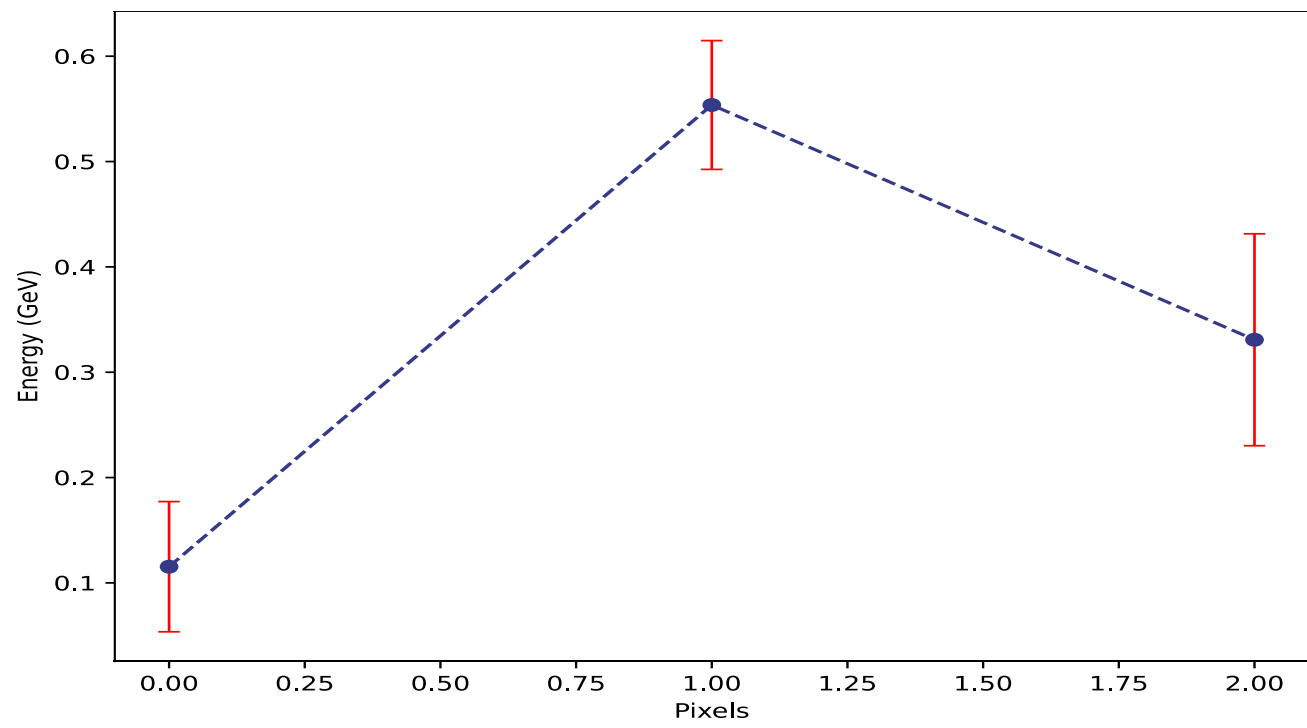
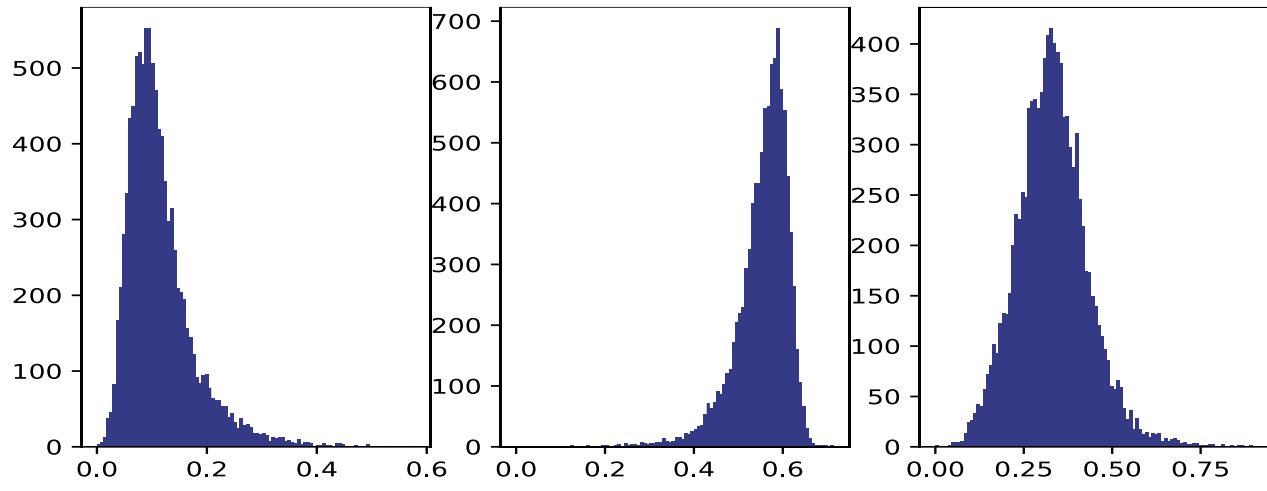
DATA ANALYSIS

- Dataset contains the outputs of calorimeter
- Records of 10000 events
- Each event has 25 pixel wide data, hence the shape is (10000, 25)

- Mean data of an event seems to follow a distribution
- But data of each pixel follows it's own distribution
- We can simulate this data by learning the distribution of each pixel



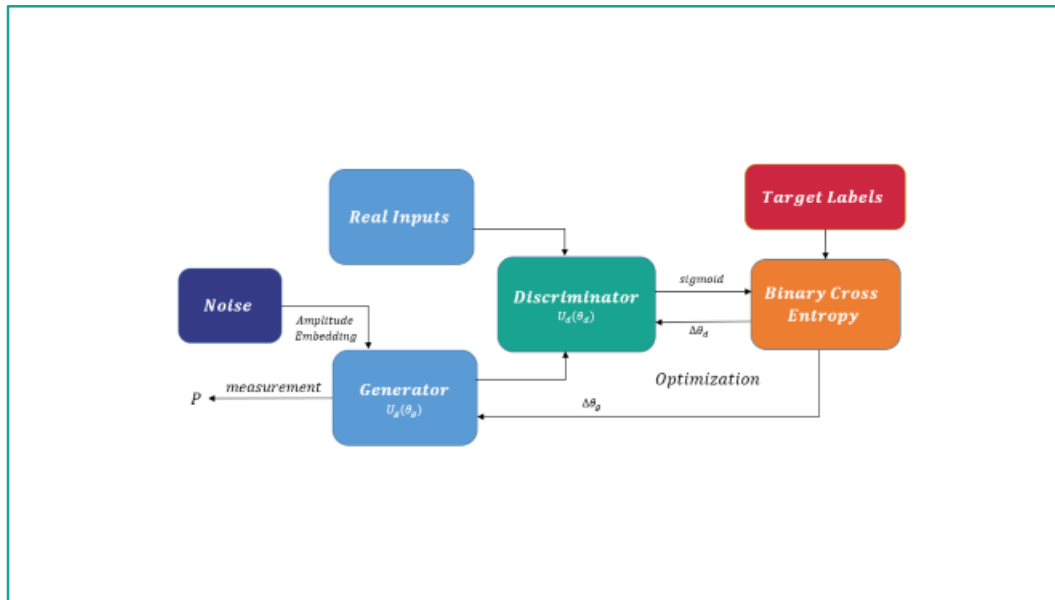




GENERATIVE MODELS

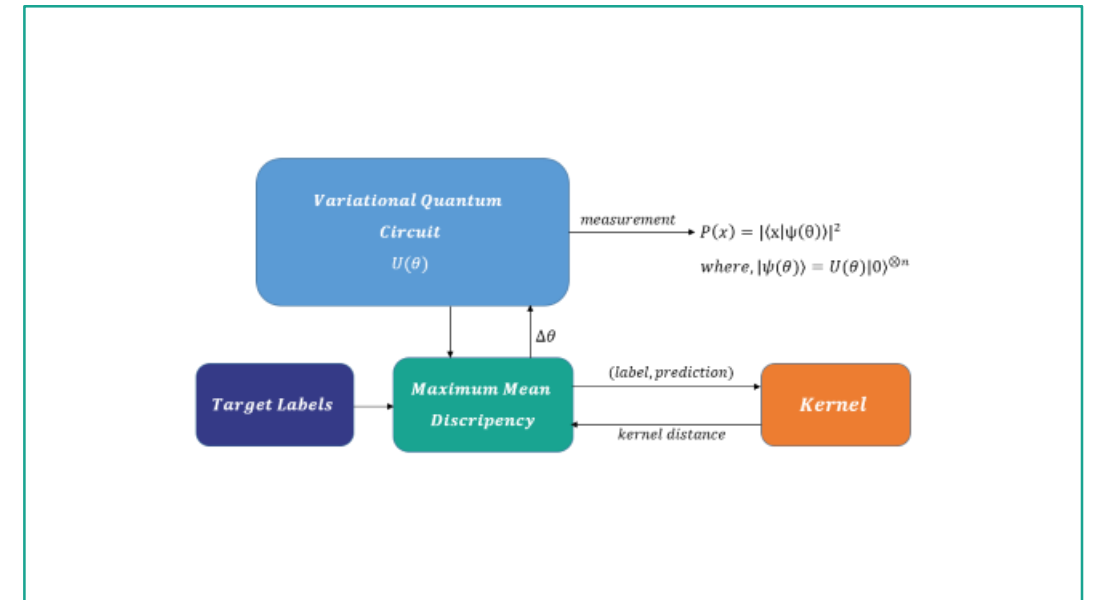
CV Quantum GAN (CVQGAN)

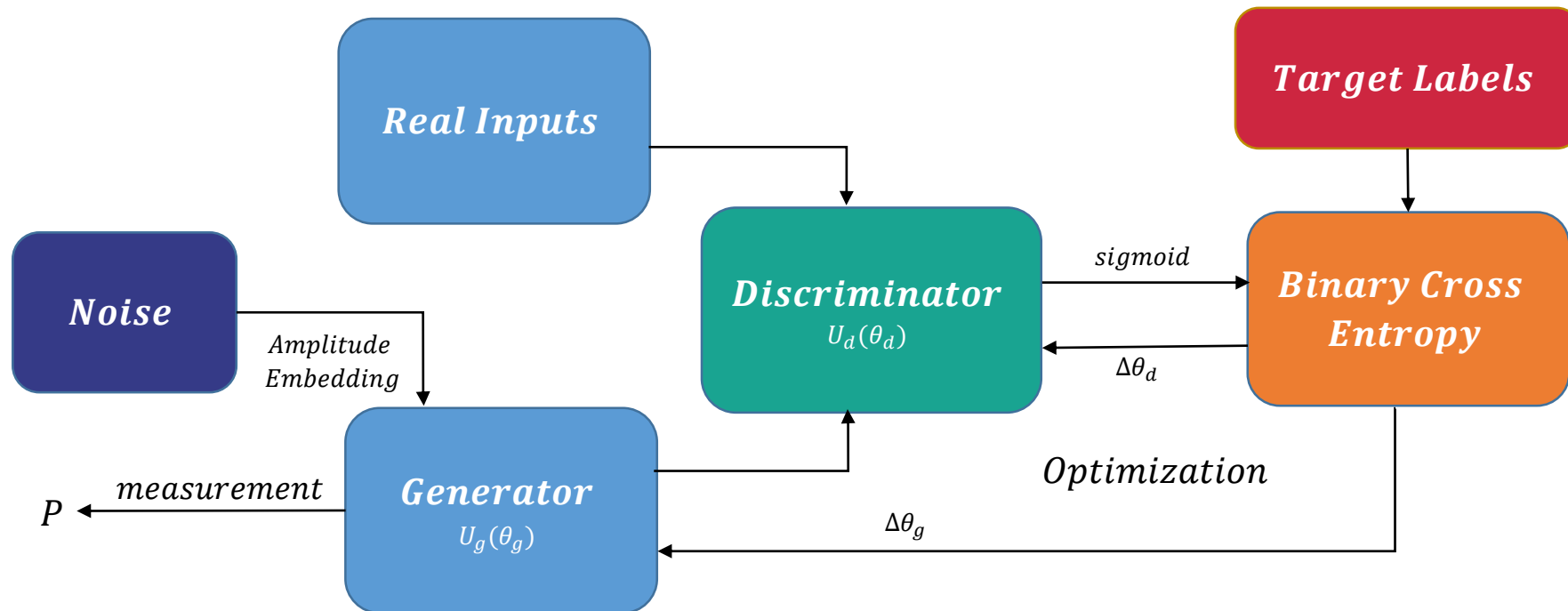
- Adversarial Training
- Both Generator and Discriminator are Quantum
- Loss Function: Binary Cross Entropy

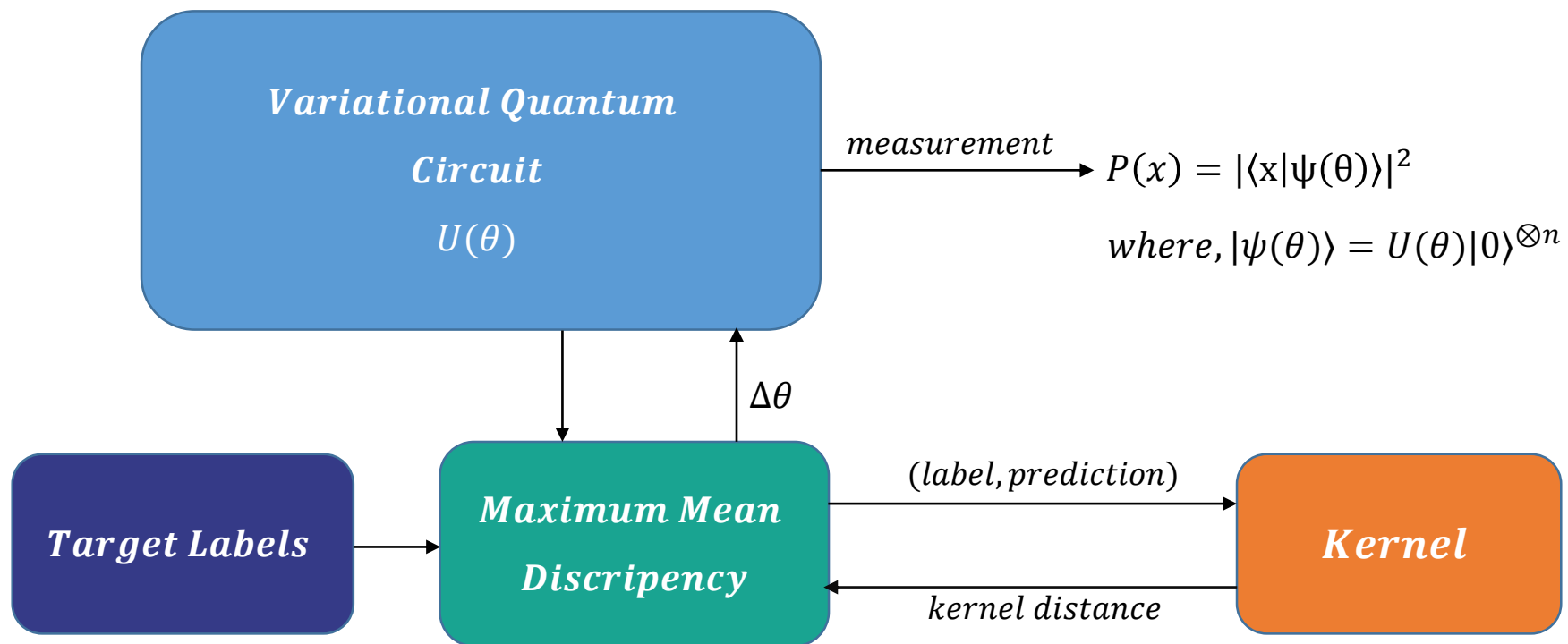


CV Born Machine (CVBM)

- Follows Born's measurement rule to generate desired probability distributions.
- Loss Functions: MMD, KL Divergence etc.

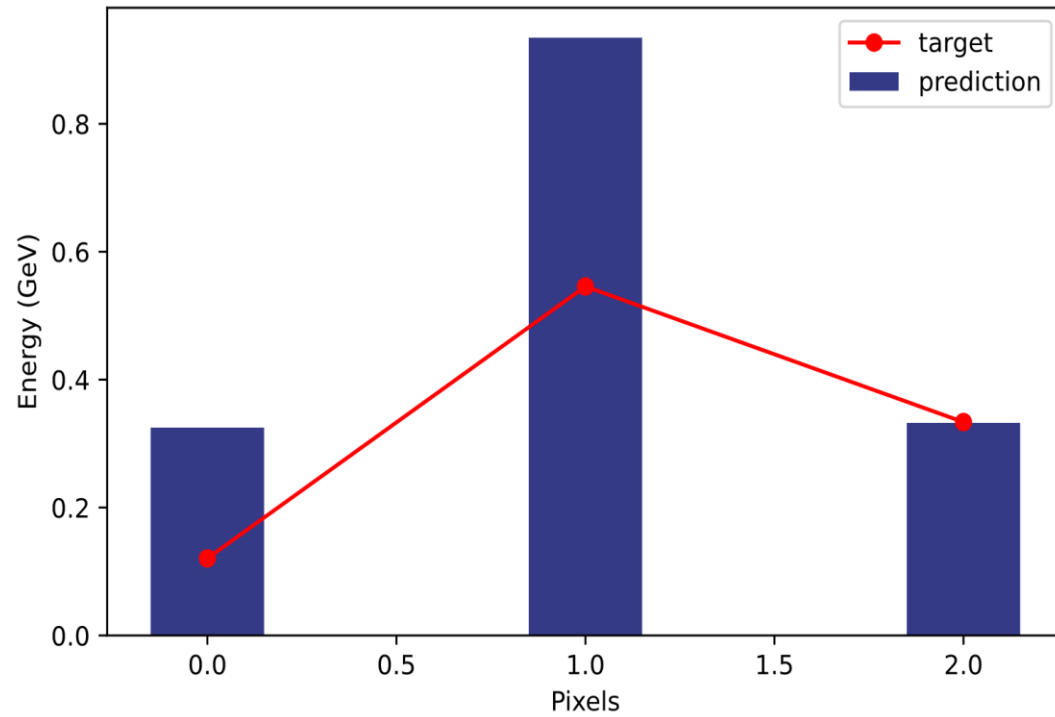




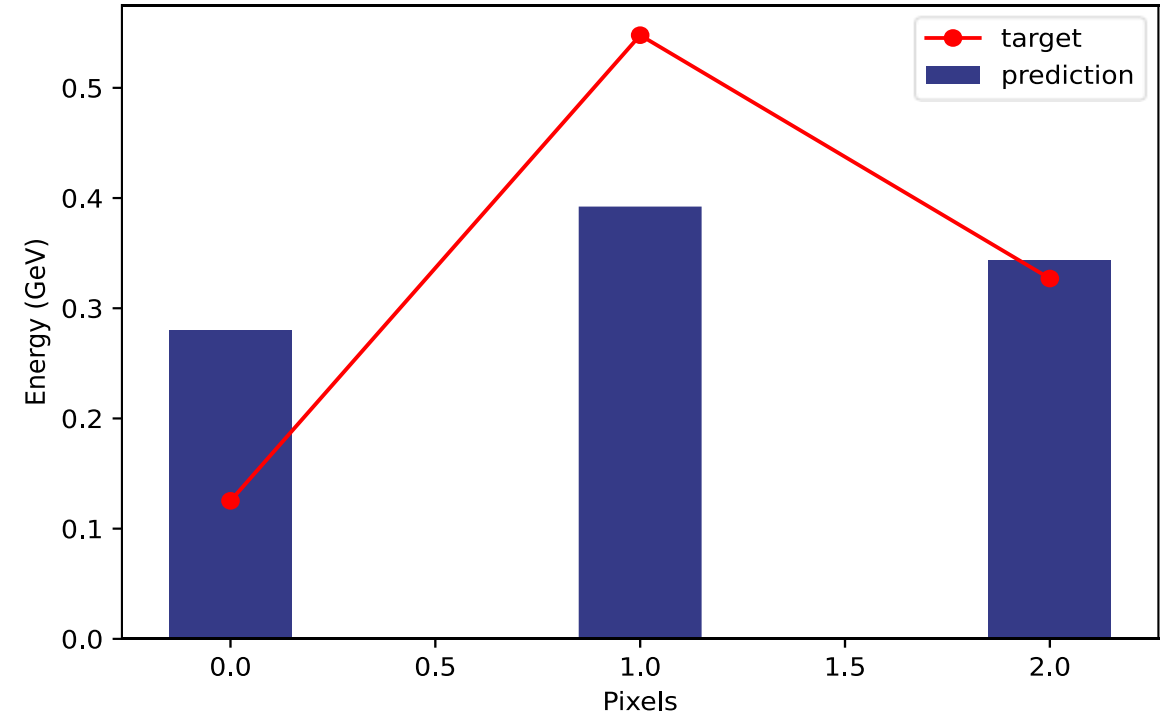


RESULTS

CVQGAN



CVBM



REFERENCES

- <https://arxiv.org/pdf/2101.11132.pdf> (CVqGAN)
- <https://arxiv.org/pdf/2011.00904.pdf> (CVBM)
- <https://arxiv.org/pdf/1804.03159.pdf> (Strawberryfields)
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- https://strawberryfields.ai/photonic/demos/run_gate_visualization.html
- <https://arxiv.org/pdf/1811.04968.pdf> (PennyLane)
- https://pennylane.ai/qml/demos/tutorial_photonic.html

Thank You!



Questions?

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