Quantum Computing for Tomographic Image Reconstruction #27

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Description

We aim to improve the tomographic image reconstruction technique to produce high-quality images using fewer measurements and a low signal-to-noise ratio. Our goal is to reduce patient discomfort and radiation exposure in clinical imaging. To achieve this objective, we propose using a quantum computer and associated hybrid methods (or any better proposal) for solving the ill-posed inverse problem of tomographic reconstruction.

We are extensively testing that the quantum algorithm can be a better solution than the classical methodology. There is a result demonstrating that their method produces accurate reconstructed binary and integer-valued images of up to 32×32 pixels, competing with traditional reconstruction algorithms while being more robust to noise and producing accurate results from a few projections. This work will help us prepare the quantum algorithm for later large-scale implementation.

More detail about previous research:

https://arxiv.org/pdf/2212.01312.pdf
(Research work done by adiabatic quantum computer)

Deliverables

Research Paper

Mentors details

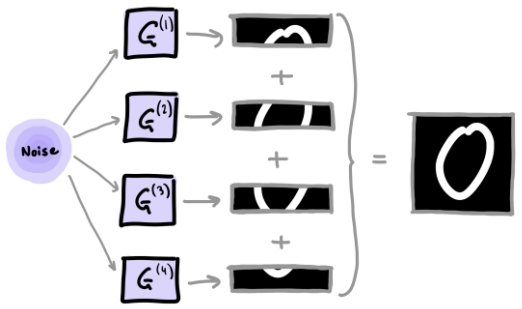
- Mentor 1
  - Name: Kuan-Cheng (Louis) Chen
  - GitHub ID: **@Louisanity**
  - What they do: Quantum Computing Researcher at Imperial College London
    Linkedin: https://www.linkedin.com/in/louis-chen-801214109/
- Mentor 2
  - Name: Tai Yue Li
  - GitHub ID: **@Tim-Li**
  - What they do: Quantum Computing Researcher (Postdoctoral) at NSRRC

Type of mentees and Collaborator

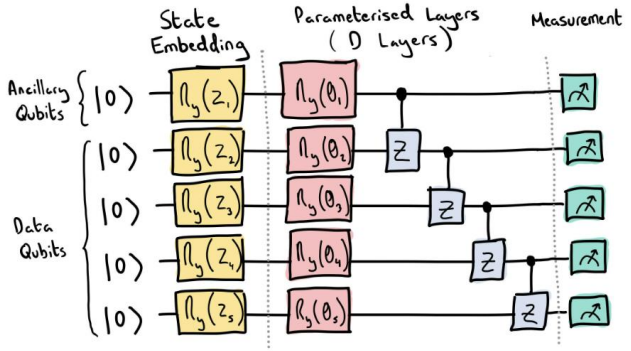
- Collaborator 1: **@Vaishakgkumar**
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing
- Collaborator 2: Duong Do
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing
- Collaborator 3: Thembelihle Dlamini
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing
- Collaborator 4: Reem Abdel-Salam
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing
- Mentee 1: **@MiikaVuorio**
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing
- Mentee 2: **@SiddharthaMorales**
  - Required: Required: Time to work on the project (~10 hours/week)
  - Nice to have:
    - Experience in Machine Learning (and/or) Image Processing

QISKIT QAMP23' DEMO

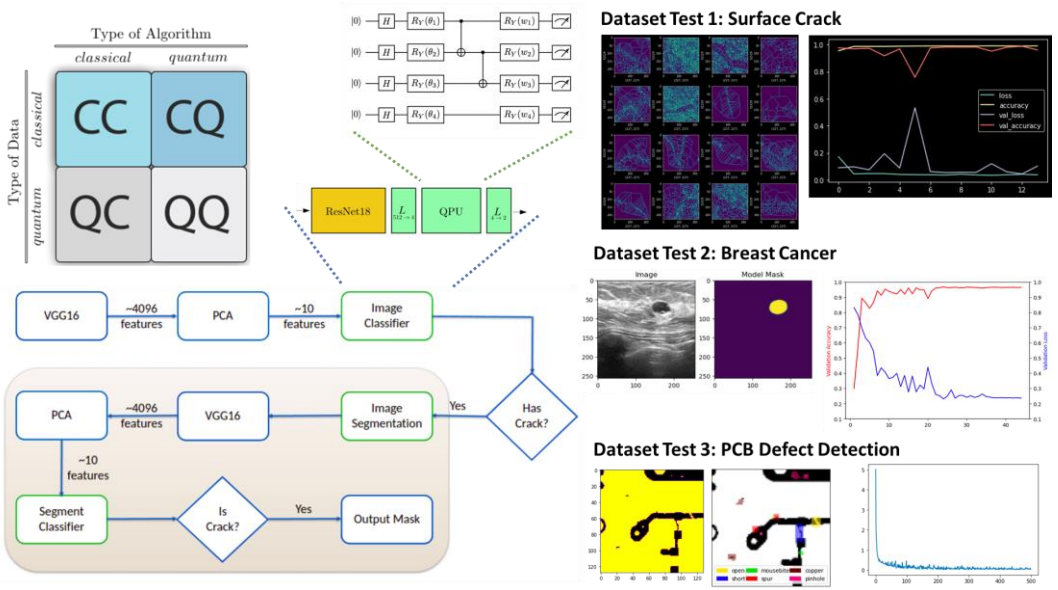
1) State Embedding



2) Parameterized Layers

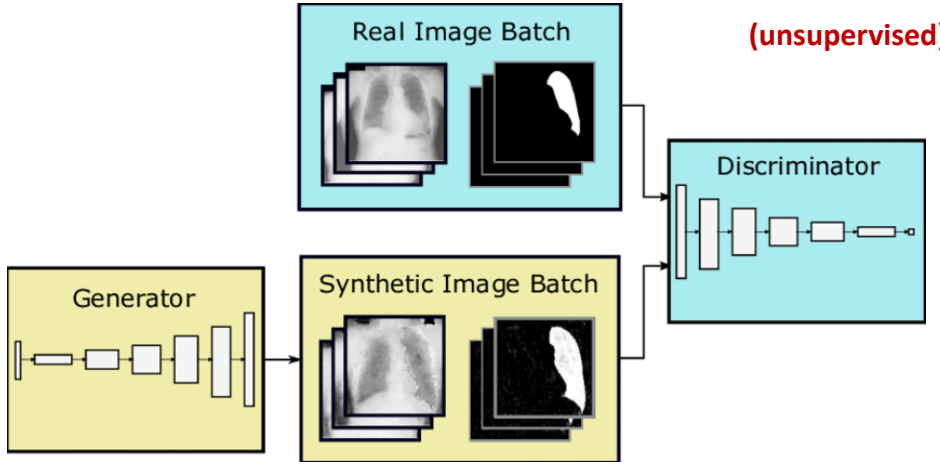


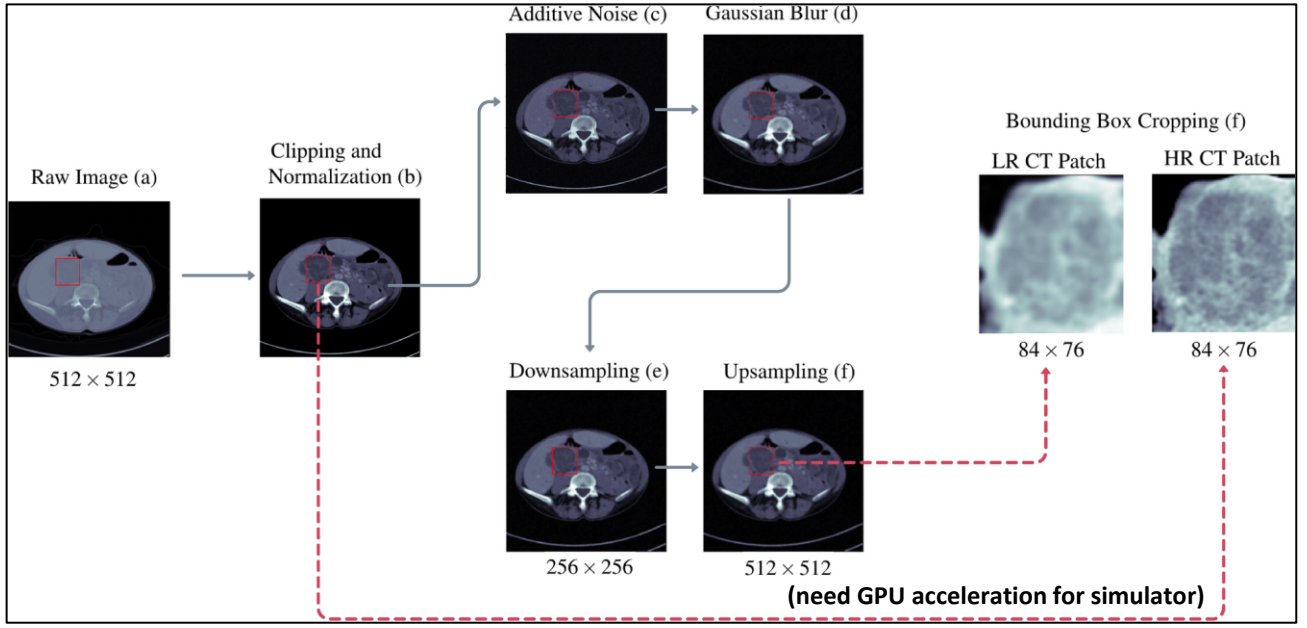
➢ Hybrid Classical-Quantum Segmentation Algorithm (supervised)



Pramanik, Sayantan, et al. "A quantum-classical hybrid method for image classification and segmentation." *2022 IEEE/ACM 7th Symposium on Edge Computing (SEC)*. IEEE, 2022.

➢ QGAN architecture incorporating the segmentation mask (unsupervised)





3) Non-Linear Transform

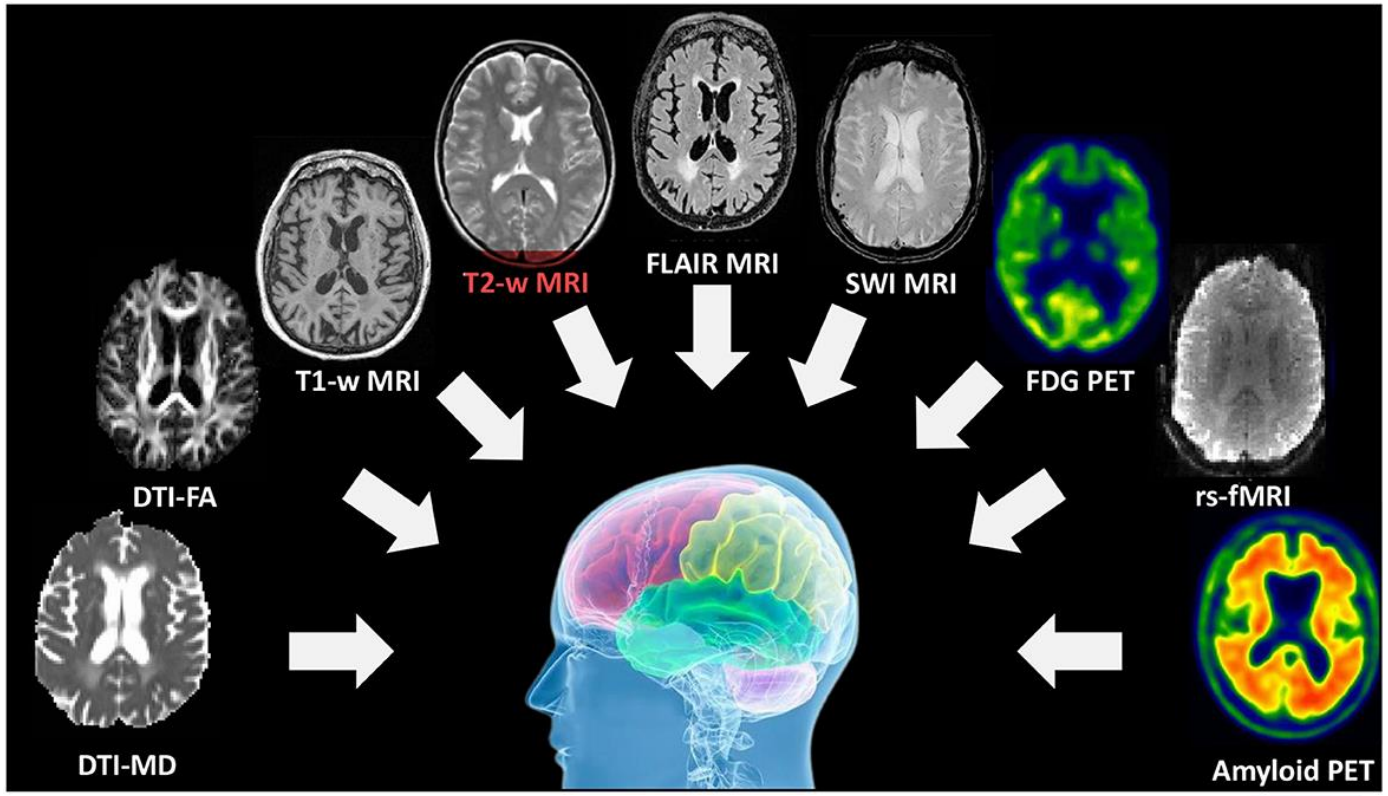
$$\rho(z) = \frac{\mathrm{Tr}_{\mathcal{A}}(\Pi \otimes \mathbb{I}|\Psi(z)\rangle\langle\Psi(z)|)}{\mathrm{Tr}(\Pi \otimes \mathbb{I}|\Psi(z)\rangle\langle\Psi(z)|))} = \frac{\mathrm{Tr}_{\mathcal{A}}(\Pi \otimes \mathbb{I}|\Psi(z)\rangle\langle\Psi(z)|)}{\langle\Psi(z)|\Pi \otimes \mathbb{I}|\Psi(z)\rangle}$$

4) Post Processing

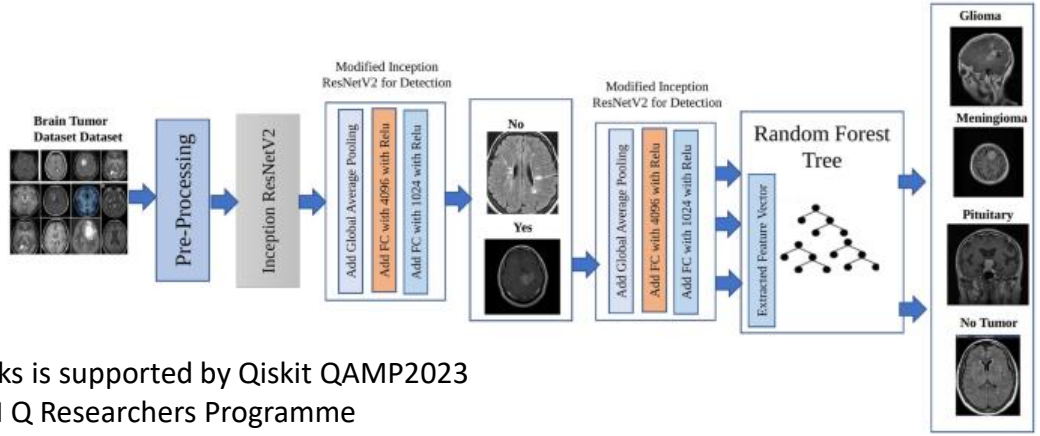
$$\tilde{\boldsymbol{x}}^{(i)} = \frac{\boldsymbol{g}^{(i)}}{\max_k \boldsymbol{g}_k^{(i)}}$$

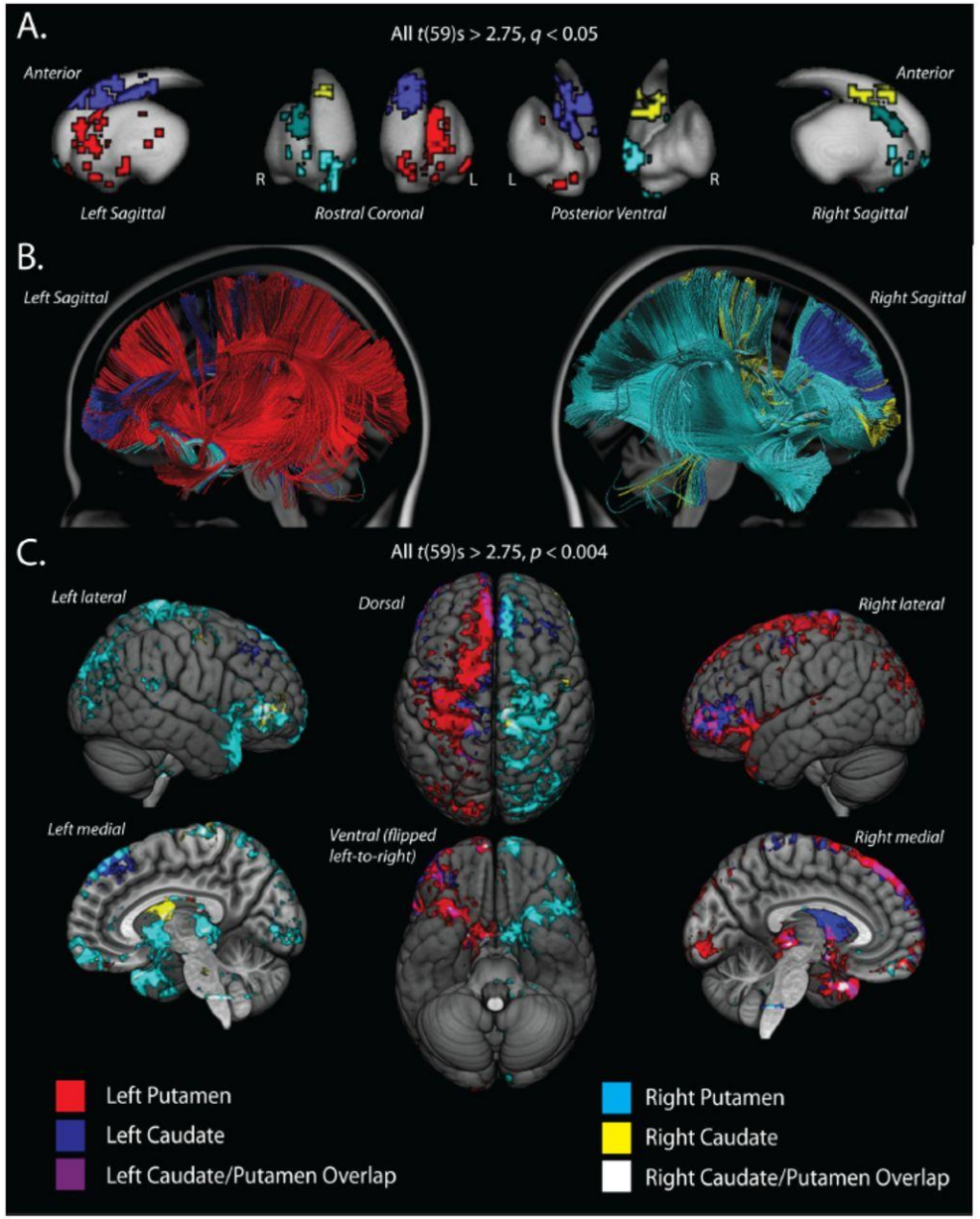
Qiskit
Elements for building a quantum future

Further works after Demo:



3D QGAN
For universal dataset:





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