Quantum Computing Project Proposal

📋 STUDENT INFORMATION

Group Name: PET-Q Pioneers

Domain: Healthcare and drug discovery

Project Title: PET scan Alzheimer's early detection problem

Date: February 5, 2026

🎯 THE PROBLEM (medical imaging)

Describe the problem you're addressing:

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Early detection of Alzheimer's Disease is critical for effective clinical intervention, yet traditional diagnostic methods often fail to identify the condition in its earliest stages when treatment is most beneficial. While **classical deep learning** models like Convolutional Neural Networks (CNNs) are currently used to analyze brain scans, they rely on **localized receptive fields and deterministic pooling** that frequently suppress or discard subtle, weak biomarkers such as mild cortical thinning. Furthermore, classical computers struggle to efficiently represent the **high-dimensional feature dependencies** found in complex neuroimaging data and often face issues with **overfitting** when training data is scarce. Consequently, many early-stage cases are misclassified because these classical frameworks lack the representational capacity to preserve the delicate neuroanatomical signals required for a reliable diagnosis.

Classical Computer Approach:

Classical computers approach Alzheimer's detection primarily through Artificial Intelligence (AI) and Deep Learning (DL) frameworks, specifically using Convolutional Neural Networks (CNNs) to analyze brain imaging data like MRI and PET scans. These models operate using localized receptive fields to identify patterns in the images and rely on deterministic pooling operations—such as max-pooling or average-pooling—to reduce the complexity of the data. To prepare the data, classical systems use conventional augmentation strategies based on simple geometric or intensity variations. However, these classical pipelines are often considered suboptimal for early detection because their deterministic nature frequently suppresses or discards weak but critical biomarkers, such as mild hippocampal atrophy or diffuse cortical thinning, leading to a higher risk of misclassifying patients in the earliest stages of the disease.

🌀 QUANTUM THINKING SHIFT

How does quantum thinking change your perspective on this problem?

- **Quantum thinking changes how we detect Alzheimer's by moving away from the "localized" and "deterministic" constraints of classical computing toward a more network-level, probabilistic approach!**

Reason 1. From Localized to Network-Level Analysis ***

Classical frameworks, specifically Convolutional Neural Networks (CNNs), analyze images using localized receptive fields. This means they look at small, isolated patches of an image, which can fail to capture the "distributed and network-level pathology" of Alzheimer’s Disease.

- **The Quantum Shift: By utilizing entanglement, quantum convolutional layers can model non-local correlations across distant brain regions. This allows the model to see the brain as an interconnected network, better aligning with how the disease actually affects the organ.**

2. From Deterministic to Probabilistic Preservation

In classical computing, deterministic pooling (like max-pooling) is used to simplify data, but it frequently suppresses or discards weak biomarkers, such as mild hippocampal atrophy or diffuse cortical thinning.

- **The Quantum Shift: Quantum thinking introduces probabilistic retention through amplitude amplification. Instead of simply deleting "weak" data, quantum pooling preserves subtle neuroanatomical signals that might be clinically informative, ensuring they are not lost during the analysis process.**

3. Impact on Diagnostic Performance

This shift from rigid classical constraints to high-dimensional quantum representations leads to significant improvements in clinical reliability:

- **Higher Sensitivity: Hybrid quantum models have shown a 4% to 17% increase in sensitivity, reducing the chances of misclassifying patients who actually have the disease.**
- **Increased Accuracy: By using Quantum-Enhanced Neural Network Architectures (QENNA) and dressed quantum circuits (DQN), researchers have achieved up to 93% accuracy, outperforming state-of-the-art classical models.**
- **Robust Data: Quantum techniques like Quantum Generative Adversarial Networks (QGANs) and quantum random walks help generate high-fidelity synthetic scans, addressing the issue of scarce training data that often limits classical AI.**

Ultimately, this transition allows for the detection of subtle neuropathological changes that classical systems are mathematically incapable of efficiently encoding.

Before Learning Quantum Computing: [What did you think was the only way to solve this problem?]

- **Originally we believed that using traditional computers was the only way to solve this issue. But after some research we found that quantum computing is more efficent and accurate while scanning and creating images. With quantum computing, it uses amplitude amplification which in short is able to catch Alzheimer's in the early stages.**

After Learning Quantum Principles: [How has your thinking shifted? What new possibilities do you see?]

Example: Before quantum computing, I thought we had to check each drug molecule individually - there was no shortcut. After learning about superposition and interference, I realized quantum computers can test multiple molecules simultaneously and use interference to amplify the best candidates, fundamentally changing what's possible in drug discovery.

What becomes possible with quantum thinking that wasn't before?

[Describe 2-3 new possibilities]

⚛️ QUANTUM CONCEPTS I'LL USE

Check all quantum concepts that apply to your project and explain HOW each one connects:

[ ] Superposition

How it applies to my project: [Explain how being in multiple states simultaneously helps solve your problem]

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Example: Superposition allows testing all possible drug molecules at once instead of one at a time.

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[ ] Entanglement

How it applies to my project: [Explain how qubits that can't be described independently help solve your problem]

Example: In quantum cryptography, entangled qubits ensure that any eavesdropping attempt is immediately detected because measuring one qubit affects the other.

[ ] Interference

How it applies to my project: [Explain how amplifying right answers and canceling wrong ones helps solve your problem]

Example: Interference amplifies molecular structures with desired properties while canceling out poor candidates, reducing the search space dramatically.

[ ] Deutsch-Jozsa Algorithm

How it applies to my project: [Deutsc]

Example: While Deutsch-Jozsa solves a specific academic problem, it demonstrates the core principle my project uses: quantum parallelism with interference to get answers in one query instead of many.

🔬 MY PROJECT STRUCTURE

30% Technical Component

What I'll implement in code:

- **Deutsch-Jozsa algorithm circuit**
- **[Any other circuits/algorithms]**
- **Simulations and visualizations**
- **Run on IBM Quantum simulator**

Specific circuits I'll build:

1. **[Circuit 1 name and purpose]**
2. **[Circuit 2 name and purpose - optional]**

70% Conceptual Component

What I'll explain in detail:

- **My quantum mindset shift (classical → quantum thinking)**
- **How quantum principles apply to [my domain] problems**
- **Classical vs quantum reasoning comparison**
- **Real-world applications and impact**
- **What this means for the future of [my domain]**

Key explanations I'll provide:

1. **[Concept 1]**
2. **[Concept 2]**
3. **[Concept 3]**

🌍 REAL-WORLD CONNECTION

Which companies, research labs, or organizations are working on this?

[List 2-3 companies/labs and what they're doing]

Example:

- **IBM Quantum working on molecular simulation for drug discovery**
- **Google Quantum AI exploring quantum chemistry applications**
- **Moderna partnering with quantum computing companies for vaccine development**

What's the potential impact if this succeeds?

[Describe the real-world impact in 2-3 sentences]

📚 WHAT I STILL NEED TO LEARN

Questions I have:

1. **[Question 1]**
2. **[Question 2]**
3. **[Question 3]**

What I'll ask AI/NotebookLM about:

- **[Topic 1 to research]**
- **[Topic 2 to research]**
- **[Topic 3 to research]**

Resources I need:

- **Tutorial on [specific concept]**
- **Example code for [specific algorithm]**
- **Research paper or article about [specific application]**

🎤 PRESENTATION PLAN (Day 9)

1. **The Problem (30 seconds)**
    - **[Quick problem description]**
2. **Classical vs Quantum Approach (1 minute)**
    - **[How thinking shifts]**
3. **Quantum Concepts in Action (2 minutes)**
    - **[Demonstrate understanding with examples]**
4. **Technical Demo (1 minute)**

- **[Show my Deutsch-Jozsa circuit or other implementation]**

5. **Impact & Future (30 seconds)**
   - **[Why this matters]**

💭 PERSONAL REFLECTION

What excites me most about this project?

[Your answer]

What's the biggest challenge I expect?

[Your answer]

How does this project represent my quantum thinking journey?

[Your answer]

📝 NOTES & IDEAS

Additional thoughts, ideas, or things to remember:

[Use this space for brainstorming, random ideas, or important notes]

Last Updated: [Date]

Status: [In Progress / Ready for Review / Finalized]