

Quan-AlzhCare: Hybrid Quantum Generative Adversarial Network For Enhanced Diagnosis Of Alzheimer's Disease

#466

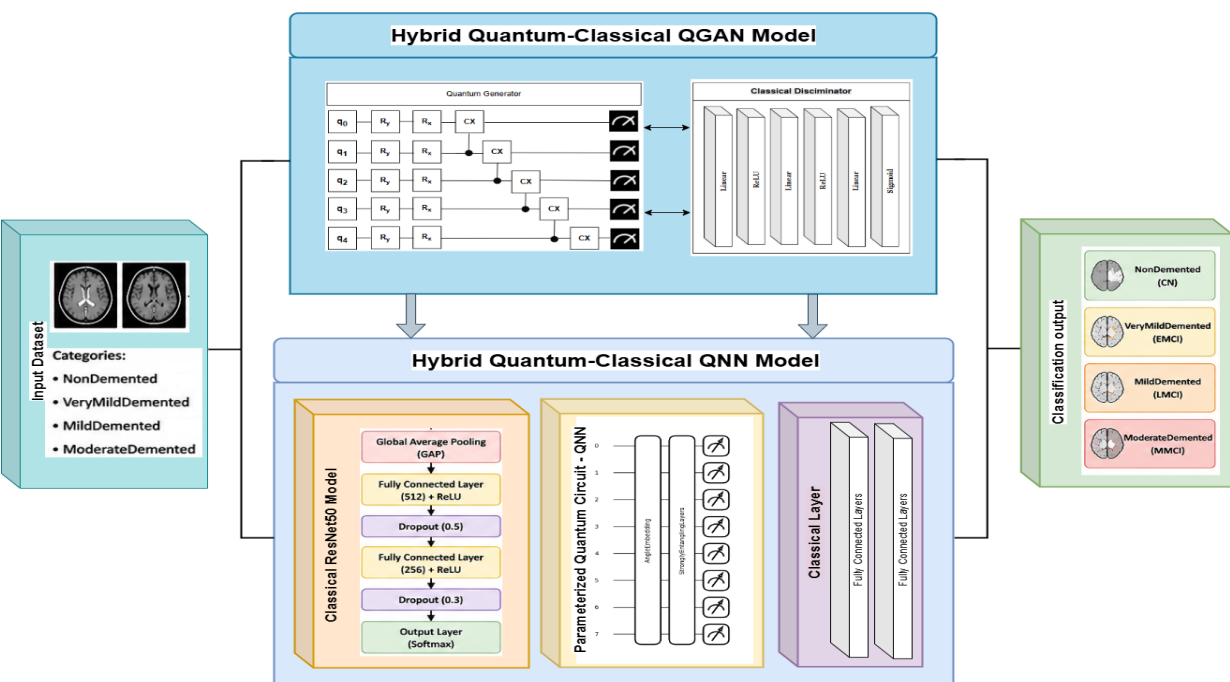
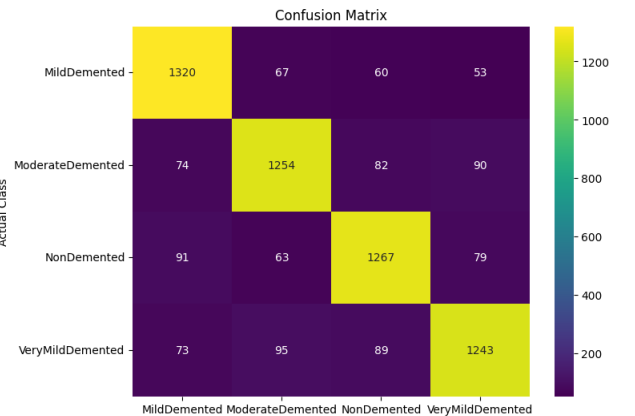
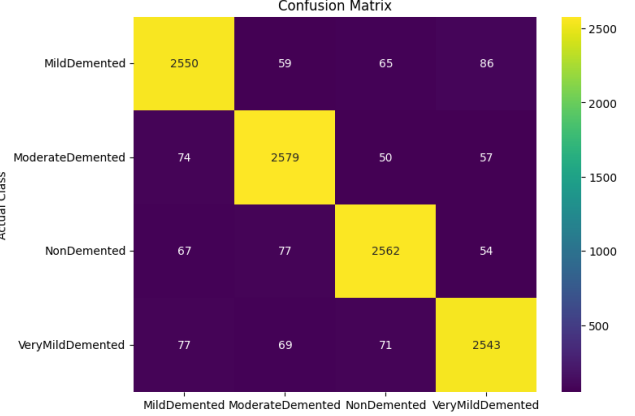
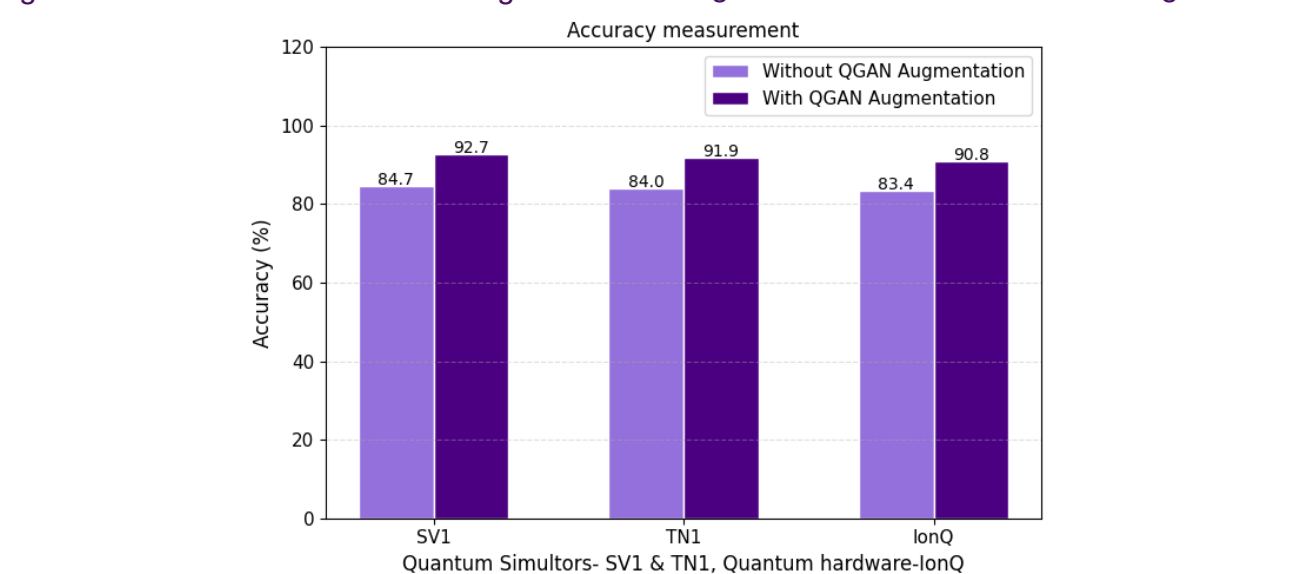
Presenter’s Name: Hamil Stanly

Author Names: Hamil Stanly¹, Rajkumar K.¹, Riji Paul², Mercy Shalinie S¹.

¹Department of CSE, Thiagarajar College of Engineering, Madurai-625015, India

²Software Development, ECS Business Solutions Pvt. Ltd., Thiruvananthapuram- 695010, India.

Keywords: Alzheimer’s disease, QGAN, Hybrid Quantum-Classical framework, QNN, ADNI, Prediction

INTRODUCTION	METHODS	RESULTS	CONCLUSIONS	REFERENCES																																																																											
- Alzheimer’s disease also referred to as dementia is a progressive neurodegenerative ailment that affects the central nervous system and is commonly seen in the 60-plus age group. - Dementia affects about 57 million individuals globally, ranking as the seventh greatest cause of death, and is anticipated to affect 78 million people by 2030, incurring societal costs over US\$1.3 trillion annually. - Health care data, including Alzheimer’s disease are limited due to concerns about privacy, sensitivity, and data protection regulations. - Data augmentation serves as a primary solution to limitations in the medical data availability. - Generative Adversarial Network (GAN) is a generative AI tool used to generate a number of samples, facilitating data augmentation. - Quantum Machine Learning (QML) offers Quantum Generative Adversarial Network (QGAN), a quantum inspired classical GAN which applies quantum principles like superposition and quantum entanglement to process massive, high-dimensional datasets in the Noisy Intermediate-Scale Quantum (NISQ) era that is more efficient than classical GANs. - The design of classical-quantum models for data augmentation, followed by training on a Quantum neural networks (QNNs) can facilitate better classification of Alzheimer’s disease.	- The ADNI dataset with four classes, namely the mild, moderate, non demented, and very mild demented, is fed as input to the proposed model as shown in Fig 1.  Fig 1: Architecture of Quan-AlzhCare model - The proposed method comprises two models, namely the hybrid quantum-classical QGAN and the hybrid quantum-classical QNN model. - The hybrid QGAN comprises two models: the quantum generator and the classical discriminator, which play a minimax adversarial game to generate new samples. - The quantum generator is designed as a parameterised quantum circuit (PQC), and the classical discriminator comprises classical neural network layers. Together, they perform data augmentation. - The hybrid QNN model comprises classical layers for image feature extraction and dimensionality reduction. The quantum PQC learns the rich feature representations and applies trainable quantum transformations to perform efficient classification.	 Fig 2: Confusion matrix – Before Augmentation  Fig 3: Confusion matrix – After Augmentation  Fig 4: Comparison of accuracy with simulators & hardware <table><caption>Table I: Class-wise comparison of performance metrics</caption><thead><tr><th>Class</th><th>Precision</th><th>Recall</th><th>Specificity</th><th>F1-score</th></tr></thead><tbody><tr><td>Mild Demented</td><td>92.12%</td><td>92.39%</td><td>97.36%</td><td>92.25%</td></tr><tr><td>Moderate Demented</td><td>92.63%</td><td>93.44%</td><td>97.52%</td><td>93.03%</td></tr><tr><td>Non Demented</td><td>93.23%</td><td>92.82%</td><td>97.75%</td><td>93.02%</td></tr><tr><td>Very Mild Demented</td><td>92.81%</td><td>92.13%</td><td>97.62</td><td>92.47%</td></tr></tbody></table> <table><caption>Table II: Comparison with different models</caption><thead><tr><th>Method</th><th>Accuracy</th><th>Precision</th><th>Recall</th><th>F1-score</th></tr></thead><tbody><tr><td>Classical ResNet50 Model</td><td>83.00%</td><td>82.00%</td><td>77.00%</td><td>98.00%</td></tr><tr><td>Proposed Without Augmentation</td><td>84.73%</td><td>84.72%</td><td>88.00%</td><td>86.33%</td></tr><tr><td>Proposed with Augmentation</td><td>92.70%</td><td>92.12%</td><td>92.39%</td><td>92.25%</td></tr></tbody></table> <table><caption>Table III: Comparison with related work</caption><thead><tr><th>Related Work</th><th>Accuracy</th><th>Precision</th><th>Recall</th><th>F1-Score</th></tr></thead><tbody><tr><td>DiaMond [1]</td><td>76.46 %</td><td>76.76%</td><td>75.39%</td><td>75.53%</td></tr><tr><td>3D-CNN [2]</td><td>92.89%</td><td>91.99%</td><td>92.54%</td><td>92.21%</td></tr><tr><td>BIFPN3dViT [3]</td><td>89.13%</td><td>90.38%</td><td>88.19%</td><td>89.07%</td></tr><tr><td>PBVP [4]</td><td>89.70 %</td><td>69.40%</td><td>91.90%</td><td>79.10%</td></tr><tr><td>Proposed</td><td>92.70%</td><td>92.12%</td><td>92.39%</td><td>92.25%</td></tr></tbody></table>	Class	Precision	Recall	Specificity	F1-score	Mild Demented	92.12%	92.39%	97.36%	92.25%	Moderate Demented	92.63%	93.44%	97.52%	93.03%	Non Demented	93.23%	92.82%	97.75%	93.02%	Very Mild Demented	92.81%	92.13%	97.62	92.47%	Method	Accuracy	Precision	Recall	F1-score	Classical ResNet50 Model	83.00%	82.00%	77.00%	98.00%	Proposed Without Augmentation	84.73%	84.72%	88.00%	86.33%	Proposed with Augmentation	92.70%	92.12%	92.39%	92.25%	Related Work	Accuracy	Precision	Recall	F1-Score	DiaMond [1]	76.46 %	76.76%	75.39%	75.53%	3D-CNN [2]	92.89%	91.99%	92.54%	92.21%	BIFPN3dViT [3]	89.13%	90.38%	88.19%	89.07%	PBVP [4]	89.70 %	69.40%	91.90%	79.10%	Proposed	92.70%	92.12%	92.39%	92.25%	- The proposed method, Quan-AlzhCare, has shown good performance improvement in terms of accuracy and related metrics. - The hybrid QGAN model has expanded the dataset to a considerable number of samples. The augmented dataset is 1.84 times the size of the original dataset. - The hybrid QNN model has improved the classification accuracy of QNN from 84.73% to 92.70% resulting in a relative improvement of 9.41%. - Classification accuracy was measured using two quantum simulators namely the state vector-1 (SV1), and the tensor network-1 (TN1) simulators and a quantum hardware namely IonQ hardware, offered by AWS Braket. - The quantum simulator SV1 excelled in performance among the choice of simulators and hardware, resulting in 92.70% accuracy. - The proposed quantum neural network has achieved a 11.69% enhancement in accuracy compared to the standard ResNet-50 model, a classical neural network during classification.	[1] Y. Li, M. Ghahremani, Y. Wally, and C. Wachinger, "DiaMond: Dementia diagnosis with multi-modal vision transformers using MRI and PET," in Proc. IEEE/CVF Winter Conf. Appl. Comput. Vis. (WACV), Feb. 2025, pp. 107–116. [2] Rahman, Atta Ur, Sania Ali, Bibi Saqia, Zahid Halim, M. A. Al-Khasawneh, Dina Abdulaziz AlHamadi, Muhammad Zubair Khan, Inam Ullah, and Meshal Alharbi. "Alzheimer's disease prediction using 3D-CNNs: Intelligent processing of neuroimaging data." SLAS technology 32 (2025): 100265. [3] Alsubaie, Mohammed G., Suhuai Luo, Kamran Shaukat, and Weijia Zhang. "A Novel Alzheimer's Disease Classification Framework Integrating 3D CNN with Bidirectional Feature Pyramid Network and Vision Transformers." IEEE Access (2026). [4] Shim, Jae Hyuk, and Hyeon-Man Baek. "Alzheimer's Disease Classification Using Population-Referenced Brain Volumetric Percentiles."Brain Sciences 16, no.3(2026): 334.
Class	Precision	Recall	Specificity	F1-score																																																																											
Mild Demented	92.12%	92.39%	97.36%	92.25%																																																																											
Moderate Demented	92.63%	93.44%	97.52%	93.03%																																																																											
Non Demented	93.23%	92.82%	97.75%	93.02%																																																																											
Very Mild Demented	92.81%	92.13%	97.62	92.47%																																																																											
Method	Accuracy	Precision	Recall	F1-score																																																																											
Classical ResNet50 Model	83.00%	82.00%	77.00%	98.00%																																																																											
Proposed Without Augmentation	84.73%	84.72%	88.00%	86.33%																																																																											
Proposed with Augmentation	92.70%	92.12%	92.39%	92.25%																																																																											
Related Work	Accuracy	Precision	Recall	F1-Score																																																																											
DiaMond [1]	76.46 %	76.76%	75.39%	75.53%																																																																											
3D-CNN [2]	92.89%	91.99%	92.54%	92.21%																																																																											
BIFPN3dViT [3]	89.13%	90.38%	88.19%	89.07%																																																																											
PBVP [4]	89.70 %	69.40%	91.90%	79.10%																																																																											
Proposed	92.70%	92.12%	92.39%	92.25%																																																																											
CONTACT																																																																															
 HAMIL STANLY Research Scholar Department of Computer Science and Engineering Thiagarajar College of Engineering India Scan to view my ORCID profile  																																																																															