TECHgium® 8th Edition Virtual POC Round

CT Image Denoising

PID_1544

L&T Technology Services


Jeet Nakrani


Mayank Kathane


Shubham Vishwakarma

College Name - *Mukesh Patel School of Technology, Management and Engineering (NMIMS), Mumbai*

Challenge Statement

Understanding the Problem

In medical imaging, particularly brain CT scans, image quality is often compromised by two prevalent types of noise:

1. Poisson Noise:

- Originates from the statistical nature of photon detection during image acquisition.

2. Periodic Noise:

- Caused by interference from electronic and mechanical components in the CT scanner.

Challenge Requirement

The objective is to develop a **software tool** capable of:

1. **Reading and displaying CT brain scans** in DICOM format.
2. **Designing an algorithm** that reduces Poisson and periodic noise effectively.
3. Enhancing image clarity while preserving essential diagnostic information, leading to **more accurate diagnoses**.

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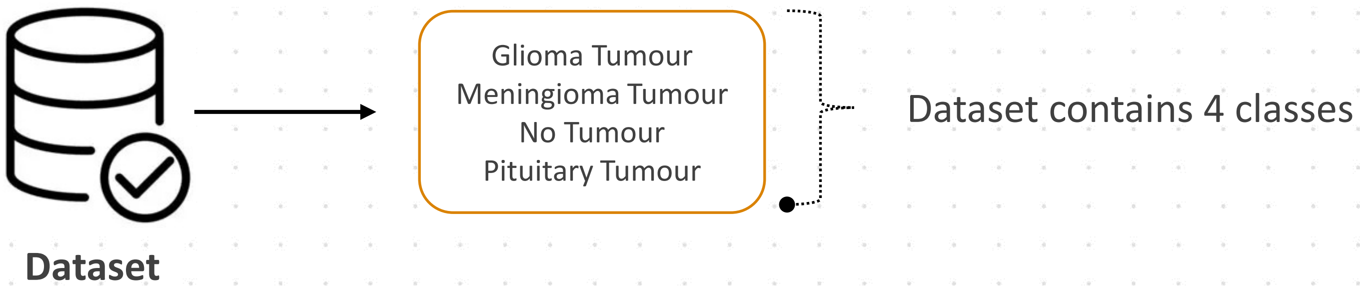
Concept / Scope of solution

- **Autoencoder Architecture:** The use of a denoising autoencoder that learns both spatial and feature representations of CT images is an innovative approach, enabling automatic noise removal while preserving critical image details for diagnosis.
- **DICOM Integration:** Handles CT scans in their native DICOM format, maintaining medical data integrity.
- **Medical Diagnostics:** Enhances clarity in CT scans for better detection of pathologies such as tumors, hemorrhages, or structural anomalies in the brain.
- **Adaptability & Scalability:** Potential to extend the solution to other imaging modalities (e.g., MRI) or apply it to real-time CT imaging workflows.



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Feedback from Presentation Round and its Use

- **GUI – User-Friendly:** Implemented an intuitive interface for easy navigation and better user engagement
- **Minimal Loss in CT Scan Images:** Ensured high-quality image handling through optimized compression and error-free data processing
- **Deployment:** Streamlined solution deployment across multiple platforms, enabling wider accessibility
- **Multiple Images Upload:** Added batch upload functionality for handling multiple images simultaneously
- **Download Option:** Provided a direct download feature for results, enabling offline review and further analysis

SWOT Analysis

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STRENGTH

- High-quality noise reduction (Poisson & periodic noise)
- DICOM compatibility for seamless integration
- Automated & efficient – reduces manual intervention
- Scalable – adaptable to MRI, ultrasound, etc.

WEAKNESS

- High computational demand (requires GPUs)
- Data dependency – needs large, high-quality datasets
- Potential artifacts – risk of altering critical medical details

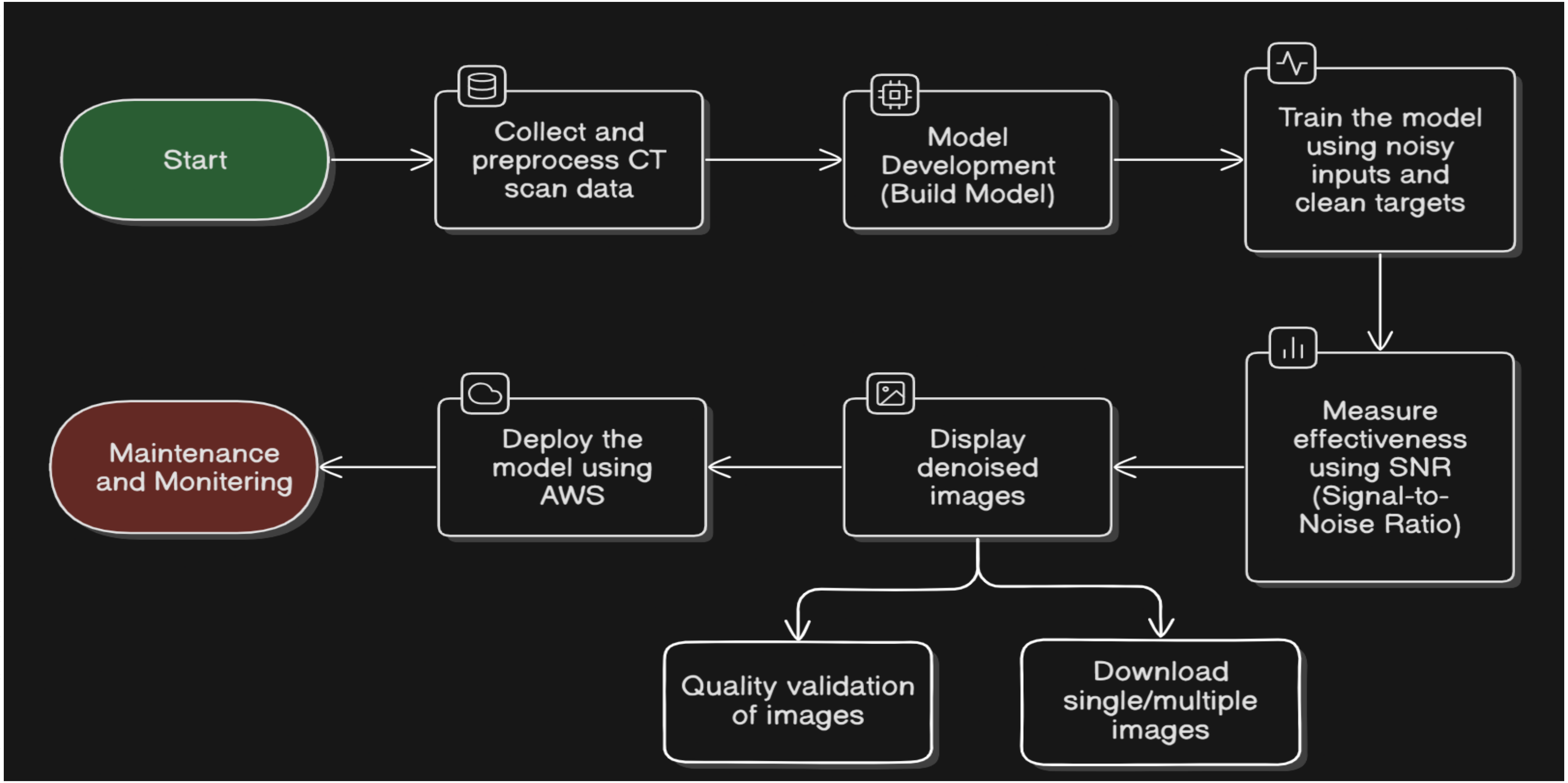
OPPORTUNITIES

- Integration with PACS (Picture Archiving and Communication System) & hospitals
- Real-time processing with optimized models
- Expansion to other medical imaging modalities

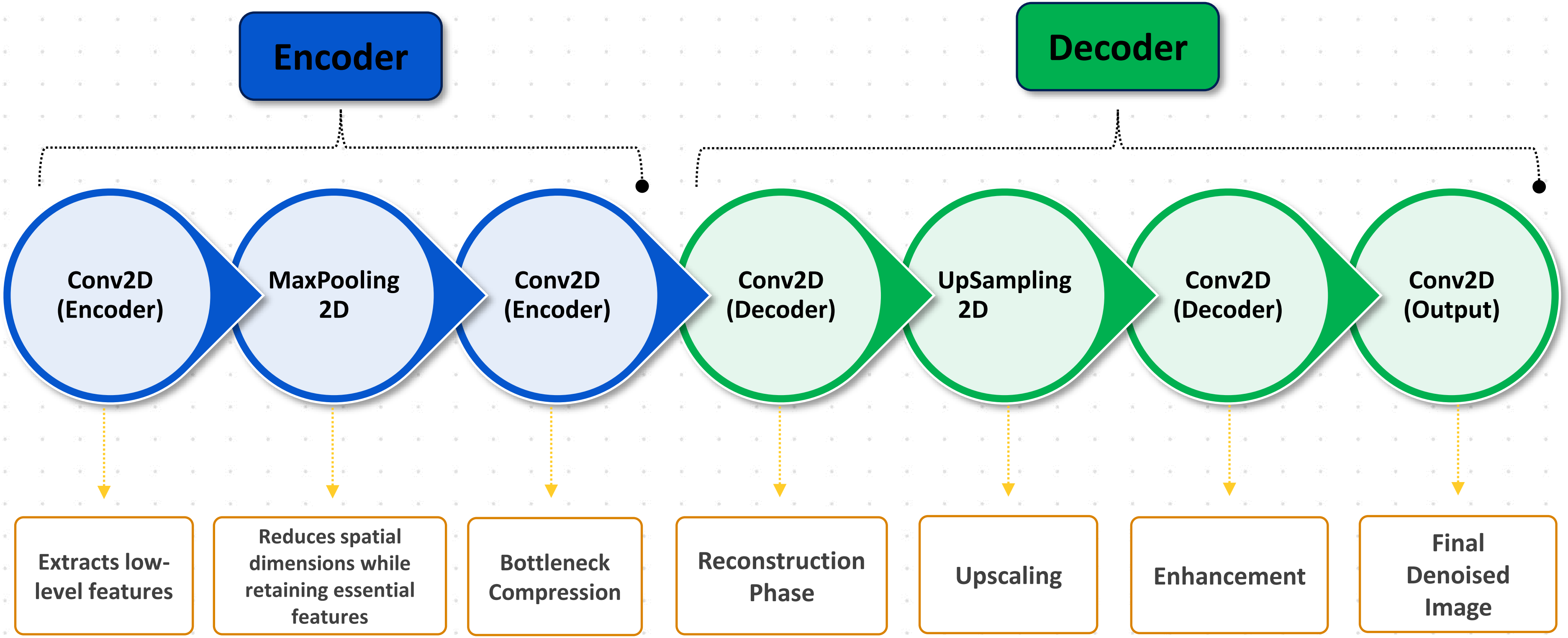
THREATS

- Regulatory & ethical concerns (HIPAA, GDPR)
- Resistance to AI adoption by radiologists
- Competitor AI-based solutions in medical imaging

Implementation (1/2)



Implementation (2/2)



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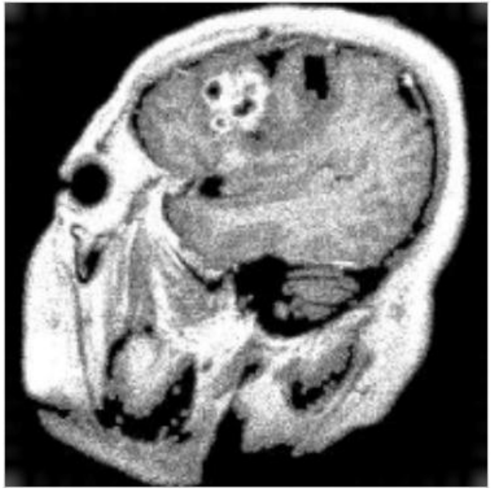
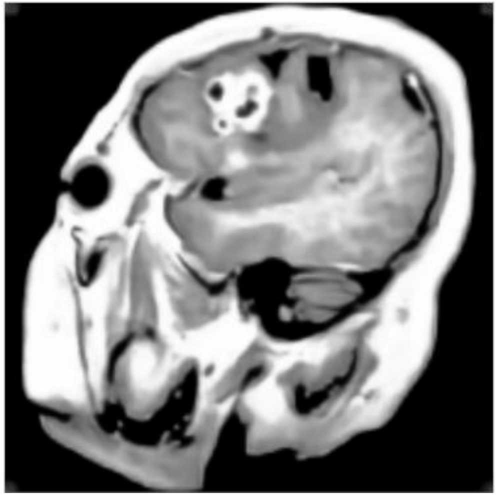
Testing / Analysis (1/2)

Original Image



SNR: 0.98 dB

Denoised Output



SNR: 18.91 dB

SNR Improvement: Increased from 0.98 dB (original) to 18.91 dB, enhancing image quality

Testing / Analysis (2/2)

	precision	recall	f1-score	support
0	0.50	0.50	0.50	4
1	0.50	0.50	0.50	6
2	0.00	0.00	0.00	4
3	0.33	0.40	0.36	5
accuracy			0.37	19
macro avg	0.33	0.35	0.34	19
weighted avg	0.35	0.37	0.36	19

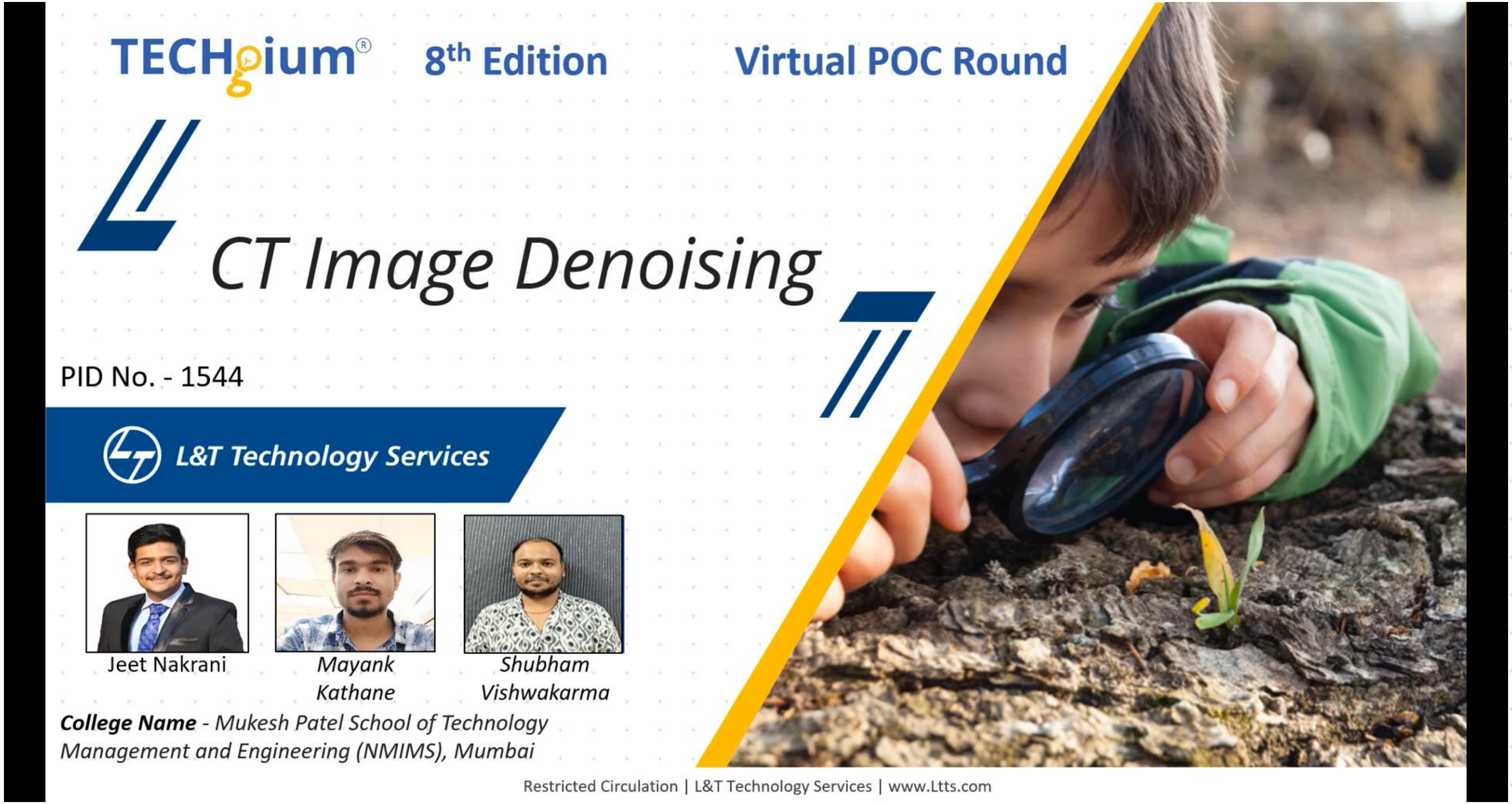
Noisy Image

	precision	recall	f1-score	support
0	1.00	0.75	0.86	4
1	0.86	1.00	0.92	6
2	0.75	0.75	0.75	4
3	0.80	0.80	0.80	5
accuracy			0.84	19
macro avg	0.85	0.82	0.83	19
weighted avg	0.85	0.84	0.84	19

Denoised Image

- **Denoising Evaluation:** Processed 19 noisy CT scan images through the model, resulting in increased SNR, indicating improved image quality.
- **Disease Prediction Validation:** Developed a separate classification model to predict disease presence and type using both noisy and denoised images.
- **Performance Comparison:** Generated a classification report comparing model accuracy on noisy vs. denoised images.
- **Key Insight:** The model extracts features more effectively from denoised images, leading to better classification accuracy and improved disease prediction.

POC Demo



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[Video Link]

High Level plan for converting POC to MVP

Aspect	POC	MVP	Upgrades / Actions
Algorithm & Model	Basic autoencoder with minimal tuning on a small dataset.	Enhanced model robustness and improvements (e.g., real-time denoising, additional features).	• Scale training with diverse data. • Explore alternate architectures and refine loss functions.
Data Handling	Limited DICOM integration and curated dataset.	Automated data pipelines handling larger, diverse datasets with augmented data and integrated PACS connectivity.	• Implement automated preprocessing and labeling. • Ensure data quality and compliance checks.
User Interface	Minimal UI/CLI for demonstration purposes.	Full-fledged, intuitive GUI integrated into clinical workflows with functionalities such as batch uploads, visualization, and download options.	• Develop a user-friendly interface. • Integrate with existing hospital systems.
Infrastructure	Limited cloud/GPU resources; manual deployment.	Scalable, automated cloud or on-premises HPC deployment with CI/CD pipelines and real-time monitoring.	• Upgrade compute resources. • Automate deployment and monitoring for continuous improvement.
Compliance & Security	Basic anonymization and internal protocols.	Robust regulatory compliance (e.g., HIPAA/GDPR) with enhanced data security measures, audits, and documentation.	• Engage in security audits. • Formalize compliance processes and documentation.
Testing & Validation	Preliminary tests with manual validation.	Comprehensive testing including performance evaluation, user acceptance, and clinical validation.	• Expand test cases and validation protocols. • Gather structured feedback from clinical users.

Cost for POC vs MVP

Cost Category	PoC (₹)	MVP (₹)	Description
Data Collection	NA	20,000+	Costs for obtaining and preprocessing CT scan datasets.
Computational Resources	NA	30,000 - 50,000	Cloud GPU usage, servers, and storage for training and validation.
Testing & Validation	NA	15,000 - 25,000	Costs associated with evaluating model performance (SNR calculation, validation).
Deployment & Maintenance	~ 1,500 - 2,000	40,000 - 1,00,000+	Deployment on servers, maintenance, and updates.
Personnel	NA (self/research)	1,50,000+ per month	Salaries for data scientists, engineers, and developers involved in the project.

Note: -
The above cost estimate is approximate and may vary based on project scope, resource availability, and specific requirements.

Total POC Estimated Cost: **₹1,500 - ₹2,000**

Total MVP Estimated Cost: **~ ₹2,50,000+**

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Result / Conclusion

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Significant Noise Reduction & SNR Improvement:

The model effectively reduced Poisson and periodic noise while preserving critical medical details, enhancing the Signal-to-Noise Ratio (SNR) for superior image quality.

Disease Prediction Enhancement:

A classification model demonstrated improved feature extraction and disease prediction accuracy using denoised images.

User-Friendly Solution:

Integrated a GUI with batch image upload and download options for easy usability.

Potential for Expansion:

The solution can be adapted to other medical imaging modalities (e.g., MRI) and real-time CT workflows.

References

- List of research papers or articles on CT image denoising, Autoencoders, and related deep learning techniques.

  - Larrue, Tara, etal.”Denoising Videos with Convolutional Autoencoders.”(2018).
  - Xie, Junyuan,LinliXu, and EnhongChen. ”Image denoising and in painting with deep neural networks.” Advances in neural information processing systems. 2012.
  - Dabov, Kostad in , etal. ”BM 3D image denoising with shape-adaptive principal component analysis.”SPARS’09-Signal Processing with Adaptive Sparse Structured Representations.2009.
  - Image Denoising based on Deep Learning – Zeyu Li https://drive.google.com/file/d/1sJKonZFW6PhQg4-AKRriazfPnhD1v_m3/view
  - Brief review of image denoising techniques - Linwei Fan1,2,3, Fan Zhang2,Hui Fan2 and Caiming Zhang1,2,3 - https://drive.google.com/file/d/1TA43lQucTmFZyyxK1AGY5-3-pwXDB7yq/view

- Reference to any medical imaging databases used (e.g., Kaggle).
- TensorFlow/Keras Documentation for model implementation.
- Dataset - https://www.kaggle.com/datasets/sartajbhuvaji/brain-tumor-classification-mri

THANK YOU

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