Milestone 2 Report – Medical Image Enhancement

AI-Powered Enhanced EHR Imaging & Documentation System

Team B – Infosys Springboard Virtual Internship

1. Introduction

The "AI-Powered Enhanced EHR Imaging & Documentation System" is a multi-stage project designed to improve clinical workflows through automation and AI-driven analysis. The system aims to enhance medical imaging, generate clinical notes automatically, and assist in assigning ICD-10 codes. Milestone 2 specifically focuses on creating an automated **Medical Image Enhancement Module** that prepares raw images for AI-based processing in future milestones.

Medical images such as X-rays, CT scans, and MRIs often contain noise, uneven contrast, and blur caused by hardware limitations, low radiation dose, or patient movement. These issues reduce diagnostic clarity and increase the workload on radiologists. The enhancement module developed in this milestone improves the quality of these images, making them clearer and more interpretable for both clinicians and AI models.

This report covers the complete work undertaken in Milestone 2, including techniques used, implementation, code structure, outputs generated, and the way the module integrates with the overall system.

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2. Objective of Milestone 2

The primary objective of Milestone 2 is to design, implement, and document a **robust medical image enhancement pipeline** that:

1. Improves the visual quality of radiological images
2. Removes noise without damaging anatomical structures
3. Increases contrast in soft-tissue regions
4. Sharpens important clinical features
5. Works for various medical imaging modalities
6. Supports both single-image and batch processing
7. Produces verifiable and reproducible results
8. Prepares enhanced images for use in AI-driven tasks in Milestone 3

This enhancement module will serve as a preprocessing engine for the rest of the system.

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3. Data Sources and Preparation

During Milestone 2, the team collected open-source medical imaging datasets suitable for testing enhancement algorithms.

3.1 Datasets Used

The following datasets were referenced:

- **Kaggle Chest X-ray Dataset** (Normal vs Pneumonia)
- **NIH Chest X-ray Dataset**
- **CT and MRI sample datasets** from Kaggle and PhysioNet
- Team-created small test datasets for faster testing

These datasets contain real medical imaging and represent different quality levels, making them ideal for evaluating enhancement.

3.2 Preprocessing Steps

Before enhancement, the following preprocessing steps were carried out:

- Converted all images to .png or .jpg
- Loaded images as **grayscale** (medical imaging is intensity-based)
- Removed corrupted or unreadable files
- Organized dataset structure:

/Medical_Imaging_Data

/Xray

/CT

/MRI

/Ultrasound

/sample_input

/sample_output

This clean and structured dataset ensures consistent testing of the enhancement pipeline.

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4. Enhancement Techniques Implemented

Milestone 2 required the development of a complete enhancement pipeline that includes denoising, contrast improvement, and sharpening. These operations were implemented using **OpenCV** and tested on various medical images.

4.1 Denoising — Fast Non-Local Means

Denoising removes grain or random noise without damaging important structures.

- Function used: cv2.fastNlMeansDenoising()
- Eliminates random noise
- Retains edges and soft tissue details
- Works well for X-rays and CT scans

This step makes the later enhancements more accurate and clean.

4.2 Contrast Enhancement — CLAHE

Contrast Limited Adaptive Histogram Equalization (CLAHE) improves local contrast.

- Function used: cv2.createCLAHE()
- Enhances soft-tissue visibility
- Prevents over-amplification of noise
- Ideal for medical imaging

After applying CLAHE, anatomical details such as lung fields, soft tissues, and bone structures become clearer.

4.3 Sharpening — Unsharp Mask

Sharpening increases clarity by highlighting edges.

- Uses Gaussian blur + edge amplification
- Makes boundaries like ribs, lungs, skull edges more visible
- Helps doctors and AI models detect abnormalities

4.4 Combined Enhancement Pipeline

The final enhancement pipeline is:

Denoise → CLAHE → Sharpen

This ensures:

- Clean images
- Improved brightness and contrast
- Well-defined anatomical structures

This pipeline is implemented in enhance_demo.py.

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5. Implementation and Code Developed

Two major Python scripts were developed to fulfil the milestone requirements.

5.1 enhance_demo.py – Single Image Enhancement

This script takes one input image and produces multiple outputs to demonstrate each enhancement stage.

Outputs generated:

- original.jpg
- denoised.jpg
- clahe.jpg
- sharpened.jpg
- combined_enhanced.jpg
- comparison.jpg (side-by-side Original vs Enhanced)

Purpose:

- Demonstrates the pipeline clearly
- Easy for evaluators to verify
- Helps in debugging and parameter tuning

5.2 batch_enhance.py – Batch Enhancement Tool

This script processes **all** images inside a folder and enhances them automatically.

Folder structure created:

output/

originals/

enhanced/

comparisons/

Purpose:

- Replicates real hospital workflows (many images per day)
- Saves time
- Makes enhancement scalable

5.3 Folder Structure in GitHub

The milestone has been organized in GitHub as:

/Milestone2_Image_Enhancement

/code

enhance_demo.py

batch_enhance.py

requirements.txt

/sample_input

/sample_output

REPORT_MILESTONE2.pdf

README.md

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6. Results and Observations

6.1 Visual Improvements

The enhanced images show:

- Significant reduction in noise
- Improved visibility of lungs, bones, and tissues
- Sharper outlines
- Better contrast in low-intensity regions

6.2 Clinical Benefits

- Radiologists can interpret images more easily
- Abnormalities become clearer
- Supports AI classification and segmentation
- Reduces misinterpretation caused by low-quality images

6.3 Example Observations

- Chest X-rays become brighter and smoother
- CT scans show more defined boundaries
- MRI images gain clarity in darker regions

The enhancement pipeline is stable, reproducible, and practical.

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7. Limitations Identified

While the enhancement works well, the following limitations were recorded:

- Over-sharpening may create halo effects if parameters are too high
- CLAHE may exaggerate noise in some regions
- Very low-quality images cannot be fully corrected
- Enhancement does not replace clinical judgment

These limitations will be considered while integrating with AI models in the next milestone.

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8. Conclusion

Milestone 2 successfully delivered a complete, functional, and well-documented Medical Image Enhancement Module. The enhancement pipeline improves diagnostic clarity by reducing noise, enhancing contrast, and sharpening anatomical structures. The module includes both individual image enhancement and batch processing capabilities, making it scalable for clinical settings.