Introduction to X-Ray Image Enhancement System

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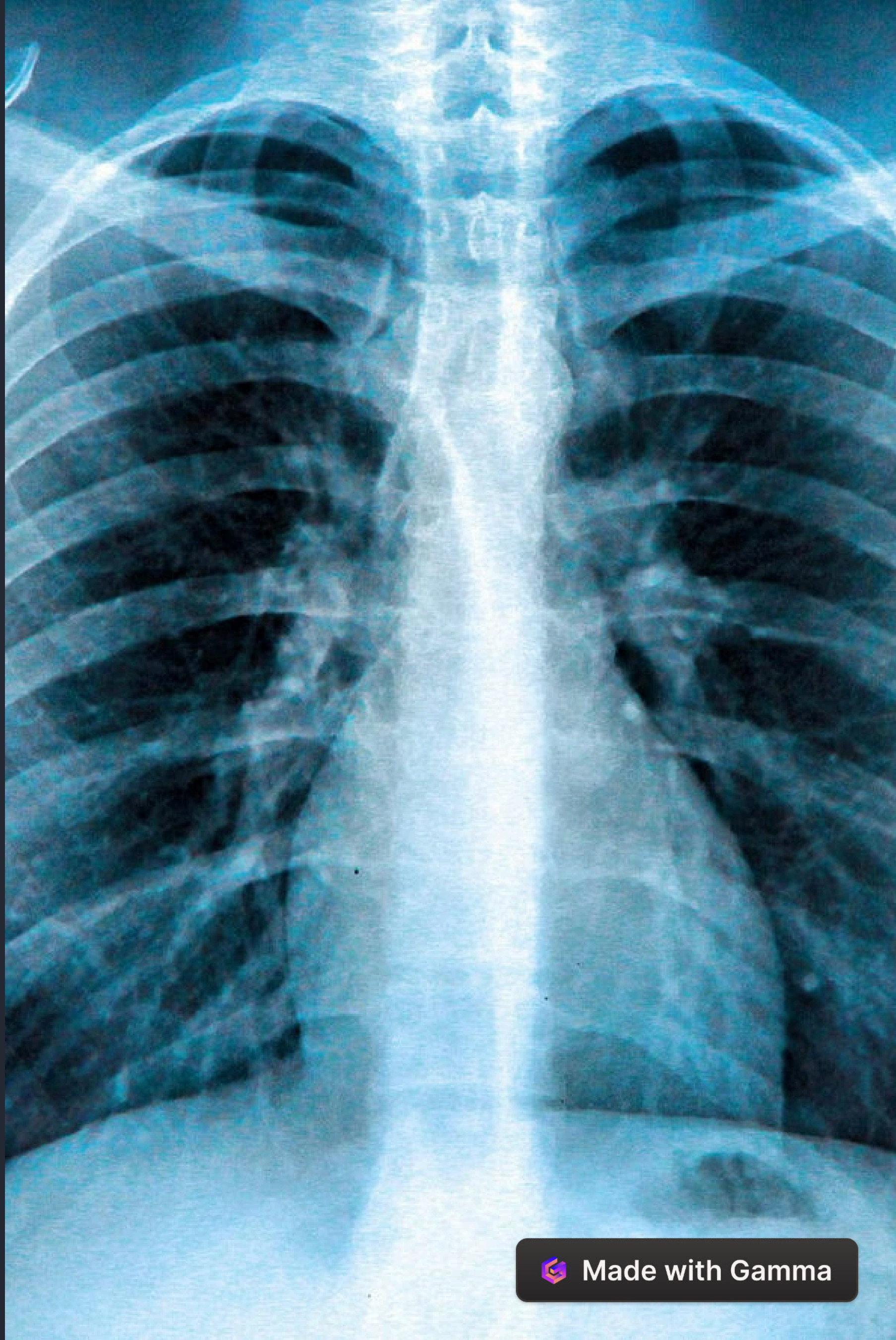


Abstract

This paper presents an advanced system of X-ray image enhancement using three main algorithms: Contrast Limited Adaptive Histogram Equalization (CLAHE), Unsharp Masking (UM) and High-Frequency Emphasis Filtering (HEF). CLAHE directly addresses this issue by improving local contrast that uniformly amplifies noise and preserves important structure details. Unsharp Masking performs sharpening of images through improved visibility of fine detail and edges by enhancing its high frequency components.High-Frequency Emphasis Filtering on the other hand further enhances these high-frequency components leading to increased sharpness and clarity in these images. When combined together, they have a compound effect thus resulting into X-ray pictures with greatly improved contrast, sharpness and detail resolution levels as well. Experimental evaluations verify this efficacy of the system hence indicating its capability to increase diagnostic accuracy in medical imaging significantly. By adopting such an integrated approach, key details are more visible thus allowing health workers to make more accurate appraisals of them.

Existing System :

Bilateral Filtering: Effective at noise reduction while preserving edges, useful for smoothing images but is not efficient as HEF

Anisotropic Diffusion: Excellent at increasing contrast while preserving edges through selective smoothing but not as efficient UM

Gamma Correction: Adjusts brightness and contrast to match human visual perception, but CLAHE is more focused on bringing the details out of it

Proposed System:

CLAHE:

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a digital image processing technique that enhances local contrast by dividing an image into small regions, applying histogram equalization to each, and limiting contrast amplification. This adaptive method effectively enhances details across varying regions while preventing noise amplification, commonly used in medical imaging.

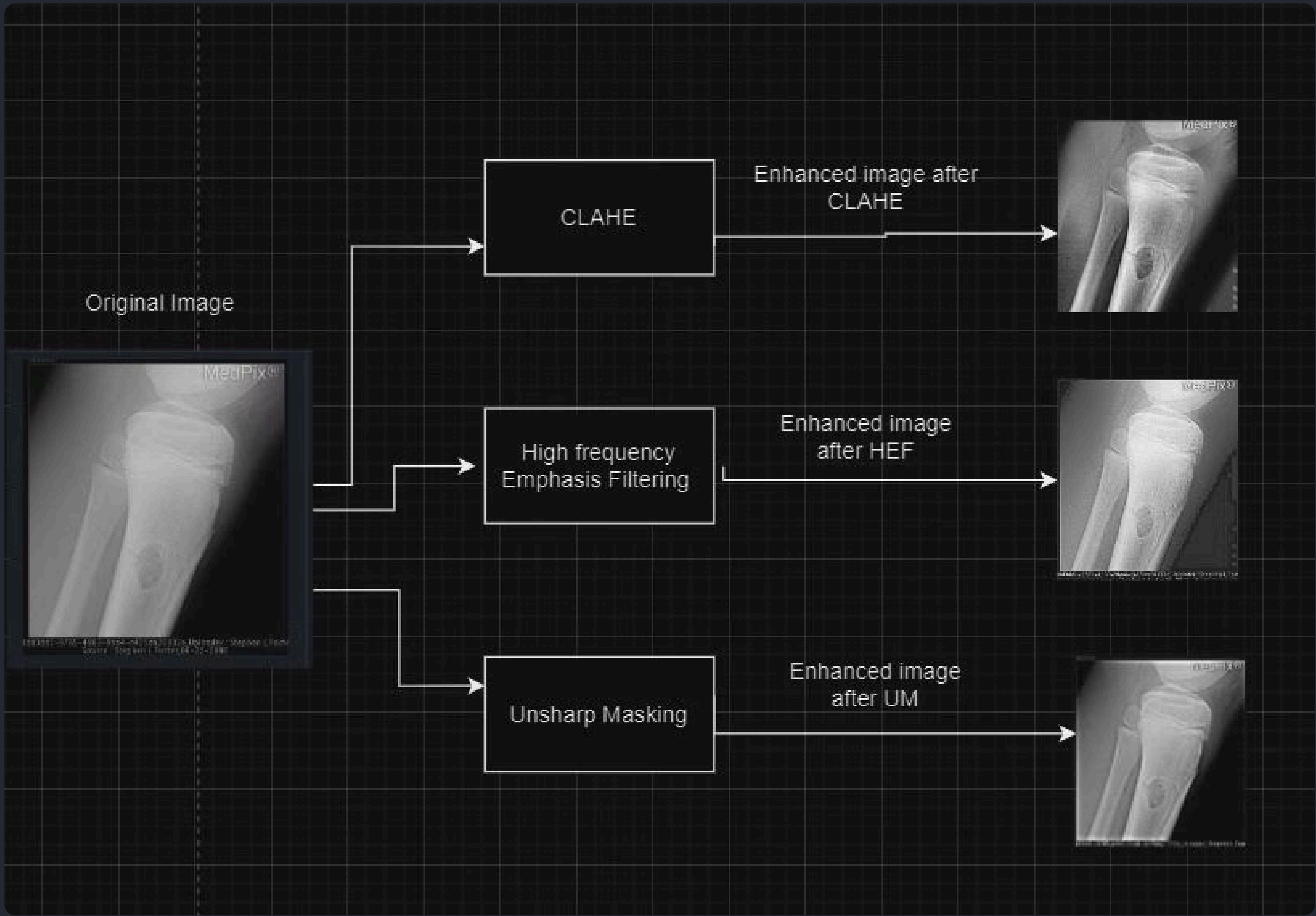
UM:

Unsharp Masking (UM) is an image sharpening technique used to enhance edges and fine details. It involves creating a blurred version of the original image, subtracting it to isolate edges, and adding the result back to the original. UM effectively increases contrast around edges, improving image clarity and sharpness.

HEF:

High-Frequency Emphasis Filtering (HEF) is an image enhancement technique that enhances high-frequency components while preserving low-frequency structures. It achieves this by applying a filter that boosts high-frequency details, enhancing edge sharpness and fine details. HEF improves image clarity and aids in feature identification, commonly used in medical imaging.

SYSTEM ARCHITECTURE:



Challenges in X-Ray Image Quality

1 Low Contrast

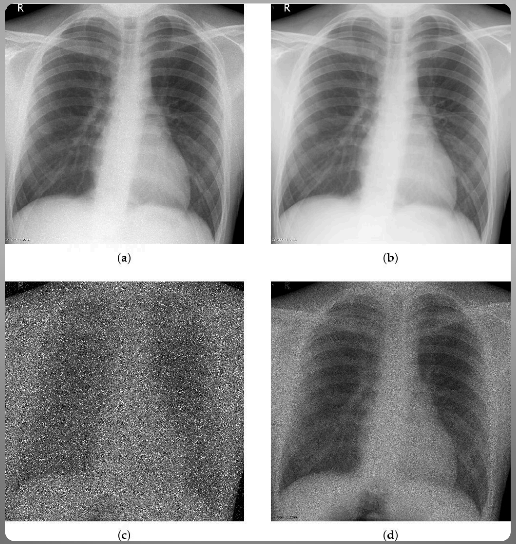
X-ray images can suffer from low contrast, making it difficult to distinguish between different tissues and structures.

2 Noise and Artifacts

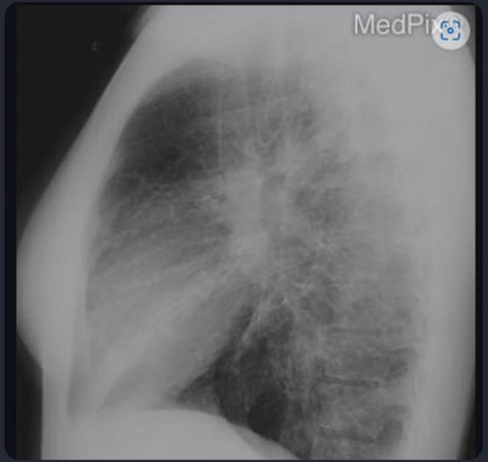
X-ray images are susceptible to various types of noise and artifacts that can obscure important details.

3 Varying Tissue Densities

The wide range of tissue densities captured in a single x-ray image can make it challenging to optimize visibility for all regions.



Some of the X-ray images :



UM VS HEF VS CLAHE

Unsharp Masking (UM) :

Unsharp masking is one of a technique used in image processing to improve the visual clarity and highlight important details. Unsharp masking is a linear filter that is capable of amplify high frequencies of an image. For blurring the image it uses Gaussian Filter, Median Filter, Maximum Filter, Minimum Filter.

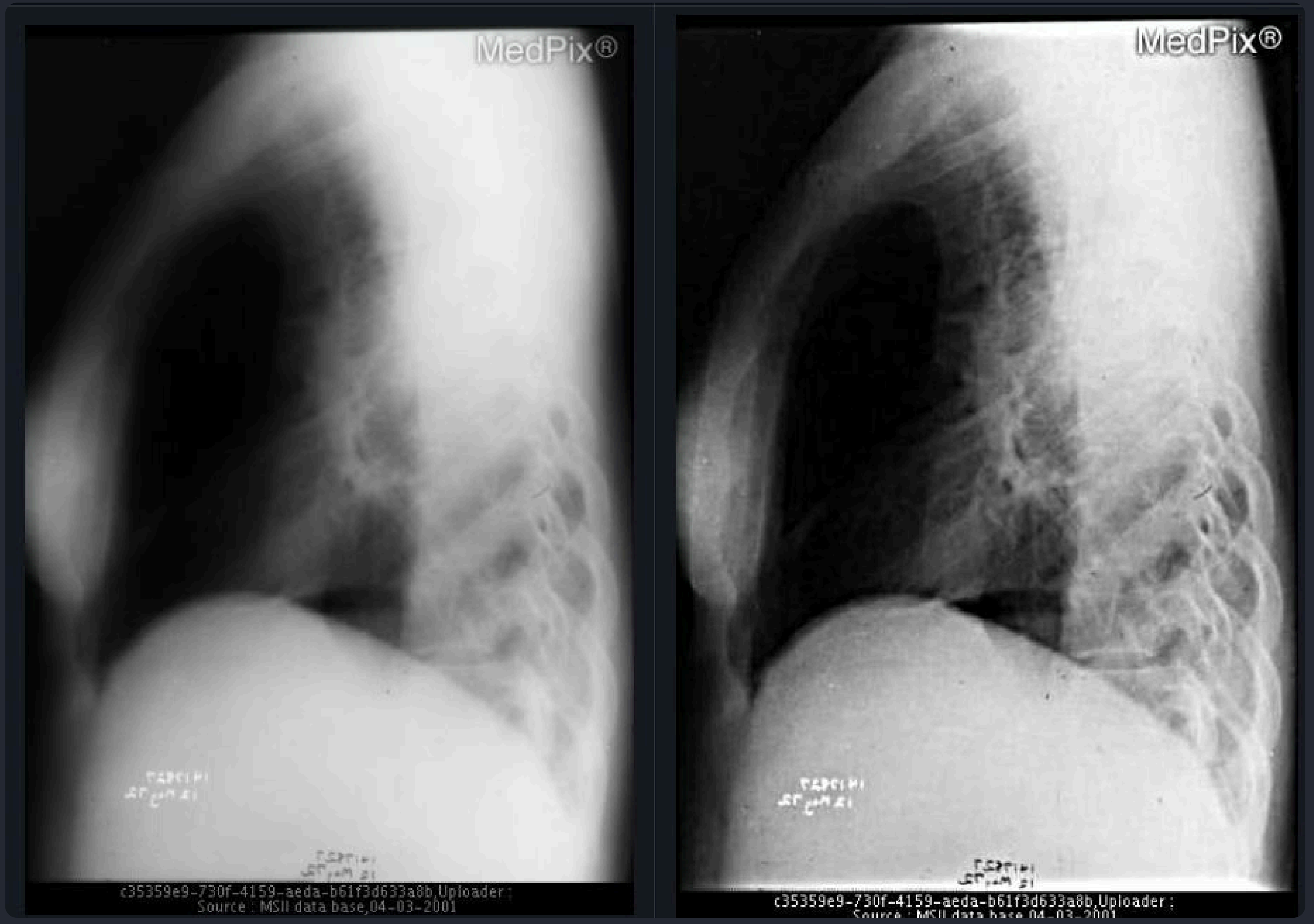
Steps Involved in UM:

1. Creates a Blurred Version of the Original Image
2. Subtract the Blurred Image from the Original Image
3. Add the Difference Back to the Original Image

$$sharpenedimage = originalimage + amount * unsharpedmask$$

$$unsharpedmask = originalimage - blurredimage$$

Results: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High-frequency Emphasis filtering (HEF) :

High-frequency Emphasis filtering is a technique that uses Gaussian High Pass Filter to emphasis and accentuate the edges. The edges tend to be expressed in the high-frequency spectrum since they have more drastic changes of intensity.

Steps involved:

1. It applies a gaussian high pass filter into it.
2. The image has to go through the Fourier transformation and the filter function is calculated onto it.
3. After the inverse transformation we will have filtered image. Secondly, the contrast of the image will be adjusted with simple Histogram Equalization

$$sharpenedimage = (originalimage + (GaussianHighpassFilter)) * (HistogramEqualization)$$

Results of HEF:

Original Image	Enhanced Image
	

Contrast Limited Adaptive Histogram Equalization (CLAHE):

Contrast Limited Adaptive Histogram Equalization is the most advanced image enhancement technique used to improve the contrast of images .It enhances the local contrast of an image, making details more visible, while preventing over-amplification of noise.

Steps Involved:

1. Convert the images to grayscale and then normalize
2. Divide the Image into Small Regions
3. Apply Histogram Equalization to Each Tile
4. Clip the Histogram
5. Redistribution of Clipped Pixels
6. Bilinear Interpolation
7. Combine the Tiles

Implementation of CLAHE for X-Ray Images

Window Size Optimization

The size of the rectangular region around the pixel to be processed

Clip Limit Adjustment

The clip limit parameter controls the amount of contrast enhancement, and it should be tuned based on the specific characteristics of the x-ray image.

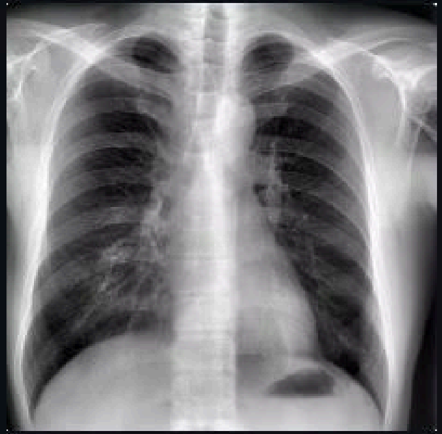
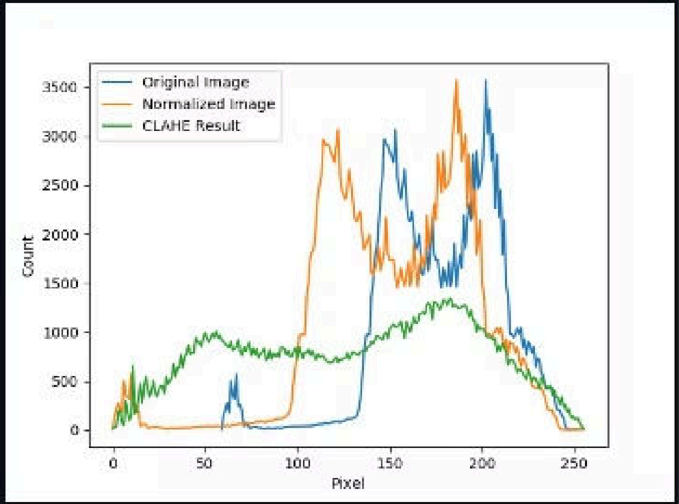
Iterative Processing

Applying CLAHE iteratively can further improve the image quality by gradually enhancing the contrast and reducing noise.

Image-Specific Tuning

The CLAHE algorithm may require different parameter settings for different types of x-ray images to achieve optimal results.

Results of CLAHE:

Original	WS: 100, CL: 150, IT: 1	Histogram
		

Advantages of Using CLAHE for X-Ray Enhancement

Improved Contrast

CLAHE effectively enhances the contrast of x-ray images, making it easier to visualize and interpret the underlying structures.

Noise Reduction

The contrast limiting feature of CLAHE helps to suppress noise and artifacts, resulting in cleaner and more informative x-ray images.

Adaptability

CLAHE can be tailored to work well for a variety of x-ray imaging modalities and anatomical regions by adjusting the algorithm parameters.

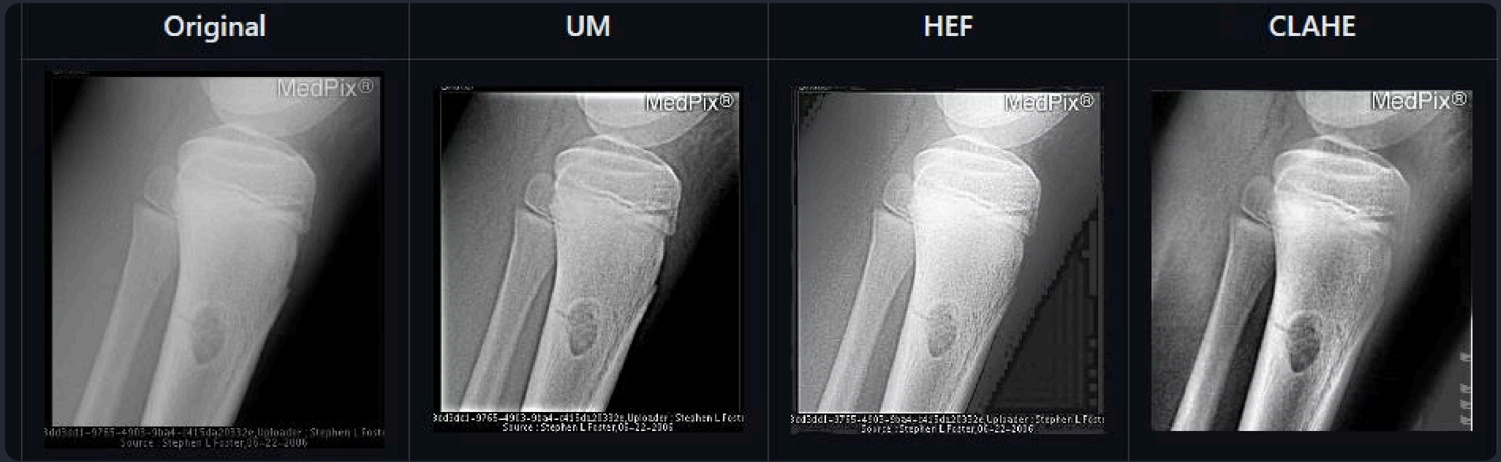
Computational Efficiency

The CLAHE algorithm is relatively fast and can be implemented in real-time, making it suitable for clinical applications.

Comparison to Other Enhancement Techniques

Technique	Contrast Improvement	Noise Suppression	Computational Complexity	Run time
HEF	Low	High	Medium	Medium Fast
Unsharp Masking	Medium	Medium	Medium	Fastest
CLAHE	High	High	High	Slowest

Comparison of UM, HEF, CLAHE (images)



Conclusion and Future Enhancement

1

Improved Diagnostics

CLAHE-enhanced x-ray images provide better visibility and clarity, leading to more accurate diagnoses and improved patient outcomes.

2

Automated Analysis

The enhanced image quality from CLAHE can enable more sophisticated computer-aided detection and analysis algorithms.

3

Personalized Optimization

Future research may focus on developing adaptive CLAHE algorithms that can automatically optimize parameters for each individual patient's needs.

4

Improved Runtime

With the help of artificial intelligence, we can improve the run time even faster than the previous model.

(b)

(e)

(h)

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THANK YOU