Implementing and comparing various Enhancement Techniques with applications on Skin Melanoma Images

[1]Apurva S. Solanke, [2]Prapti D. Deshmukh
[1]Research scholar, [2] Principal
[1][2]Dr. G. Y. Pathrikar College Of C. S & IT, MGM University, Chhatrapati Sambhajinagar, Maharashtra.

Abstract

Among medical image processing's most difficult is automatically diagnosing skin cancer. Therefore, among the most significant objectives for is to find more effective detection approaches to reduce the error rate in detecting and evaluating a diagnosis of melanoma. The initial step in improving image quality is pre-processing, and Image enhancement is an essential and crucial phase in the image pre-processing. For specific applications and human viewers, the primary objective of image enhancement is to process an image and enhance its visual quality so that the final image is "better" than the original. It is important to improve the contrast and reduce the noise for better image quality because many images, including real-world photographs, have poor contrast and noise. The two primary techniques that enhance images are: Spatial domain method and Frequency domain method. In this paper we have compared different spatial domain techniques with the help of quality measures techniques.

Keywords: skin cancer, image enhancement, spatial domain.

1 Introduction

Digital images are used in various fields, including satellite television, medical imaging, geographical information systems, and so on. When converting an image from one format to another, such as digitizing, degradation occurs at the output. Enhancement techniques can improve degraded image quality. Image enhancement aims to reveal hidden details or improve contrast in low-contrast images. Image enhancement improves the appearance of an image by adjusting its pixel intensity. Image enhancement typically increases the contrast between objects and their backgrounds. Several image enhancing techniques have been proposed and developed[1]. Basically there are two types of image enhancement techniques i.e. spatial domain technique and Frequency domain technique. This paper discusses different spatial domain image enhancing techniques which are applied on melanoma skin cancer image, including their mathematical basis.

2 Types of Image Enhancement Techniques:

Image enhancing techniques are separated into two types:

- **Spatial Domain**: This entails improving the image by modifying individual pixels at a specified resolution depending on their spatial coordinates. Consider the original image f(x, y), transformation T can be applied to obtain the resultant or processed image g(x, y) as:

$$G(x, y) = T[f(x, y)]$$

- **Frequency Domain**: In this method, the image is enhanced by applying a Fourier Transform to the spatial domain, modifying pixels in groups and indirectly.

3.1 SPATIAL DOMAIN METHODS

Spatial domain refers to the image plane, and techniques in this category manipulate pixels directly[2].

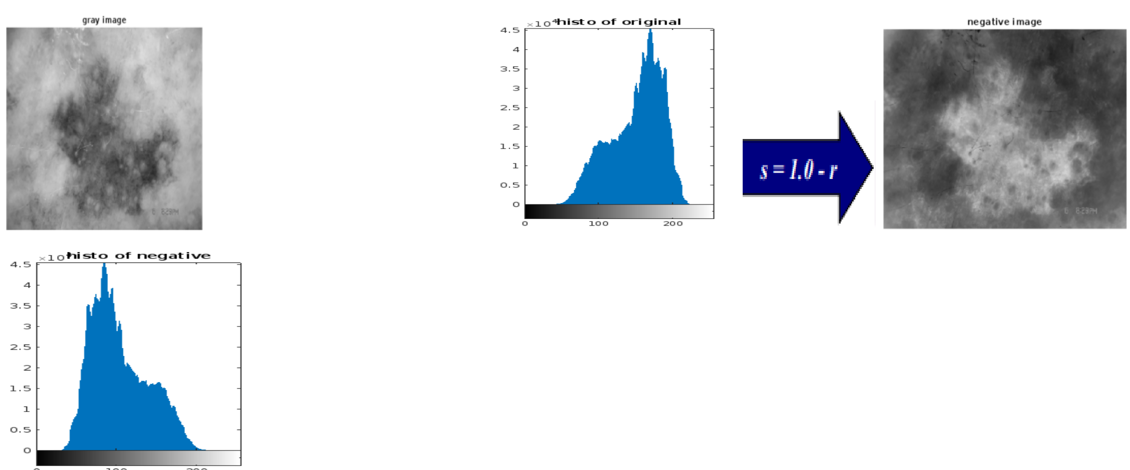
Three types of spatial domain techniques:

1. Point Processing
2. Histogram Processing
3. Neighborhood processing

3.1.1) Point processing (Intensity Transformation Function)

A) Image Negative (Digital Negative)

To make the negative version of an image, the grey level values of each pixel in the image are inverted. The primary use of image negatives is to emphasize white or grey features in dark portions of an image [3].



$$s = intensity_{max} - r$$

Figure 1. Original image and Negative image

B) Piecewise-linear Transformation

When processing grey levels in digital images, a piecewise linear transformation (PLT) uses a series of linear segments to convert input pixel values to output pixels. PLTs are created through a series of breakpoints, which are pairs of input and output pixel values. It is categorized into three categories:

a) Contrast Stretching

The contrast stretching technique improves visual contrast by expanding the range of pixel values. Contrast is defined as the difference between the intensities of two adjacent pixels. It improves an image's contrast by making dark regions darker and bright areas lighter [3].

$$A = (r - c)\left(\frac{b-a}{d-c}\right) + a$$

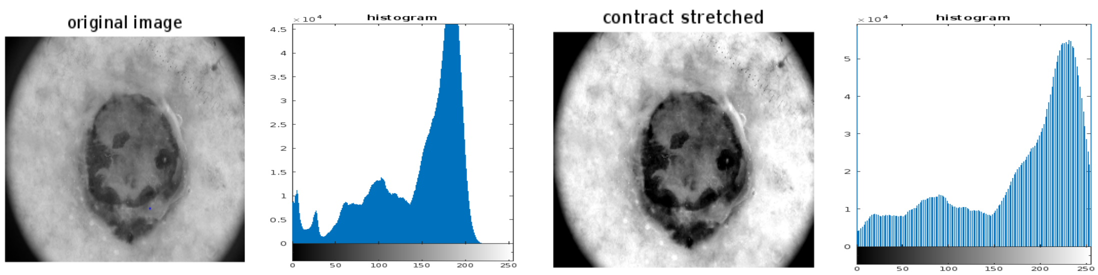


Figure 2. Original image and Contrast Stretched image

b) Grey Level Slicing (Intensity level Slicing)

Grey level slicing improves some of the original image's grey level pixels while dropping others. The core aim of this technique is to establish the greyscale levels of an image.

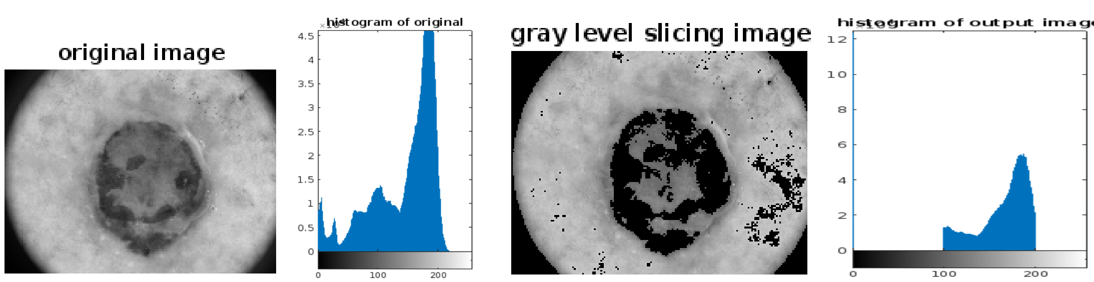


Figure 3. Original image, histogram of original image and Gray level sliced image and histogram of output image

C) Logarithmic Transformation

This transformation modifies the grey levels of image pixels. It's used to improve contrast. It is given by the equation s=c log (1+r), where s is output grey level, r is input grey level, and c is a constant. The logarithmic transformation improves image contrast, particularly in low-detail areas.

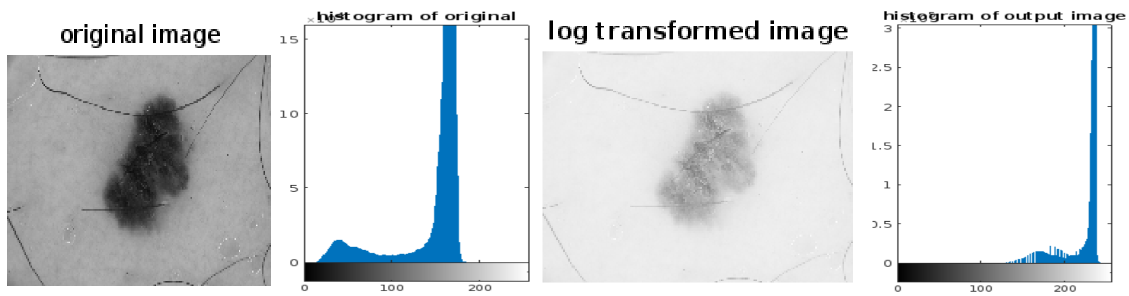


Figure 4. Original image, histogram and Log transformed image and histogram of output image

3.1.2) Histogram processing

"Histogram" is a visual representation of data distribution. An image histogram is a graphic representation of an image's pixel measure as a function of intensity. Histograms can be categorized into two types:

A) Histogram Equalization

Histogram equalization is the process of stretching an image's histogram. Histogram equalization is a method of spreading the dynamic range and ensuring that all grey levels have equal pixels. Increasing the value of grey levels at the dark end to create a more evenly flat histogram would make the image much clearer [4].

$$Gij = floor(L-1)\sum_{n=0}^{Fij} Pn$$

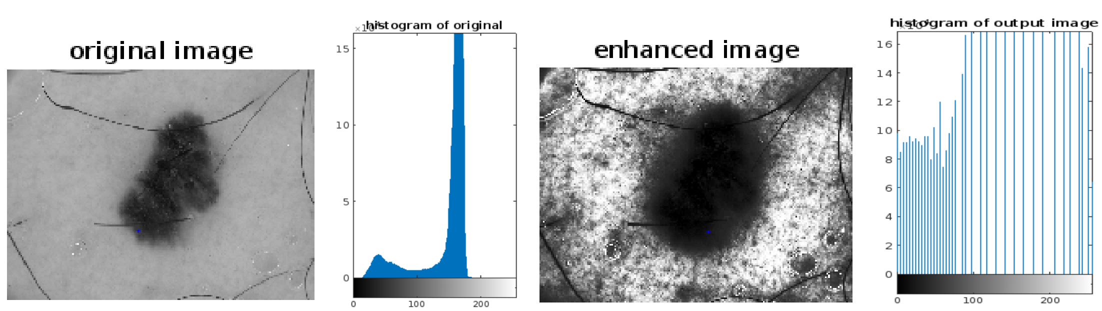


Figure 5. Original image and Equalized image and histogram of both images

B) Histogram Specification (Matching)

This method involves manually specifying the form of the histogram that the processed image should have. This method compares the grey scale distribution of one image to that of another.

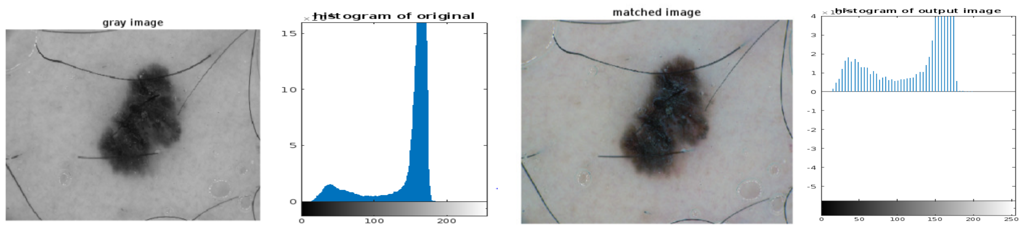


Figure 6. Original image and enhanced image and Histogram of both images

3.1.3) Neighbourhood processing:

Every pixel in an image's neighbourhood is where it functions. Filtering creates a new pixel with the same coordinates as the neighbourhood's the centre and a value determined by the filtering process. It comprises of a preset operation performed on the image pixels contained inside the neighbourhood. By using spatial filters, we can obtain smoothing directly on the image itself. It is categorized into two types.

1. Smoothing Spatial filters
2. Sharpening Spatial filters

1 Smoothing Spatial filters:

These are typically used to blur (or smooth) images and reduce image noise. Blurring with linear and nonlinear filters can accomplish this. These filters aim to reduce noise in an image by averaging the intensity values of pixels in a neighbourhood. There are 3 types of Smoothing spatial filters:

Mean Filter:

Replaces each pixel with the average of its neighbors. Good for reducing random noise.

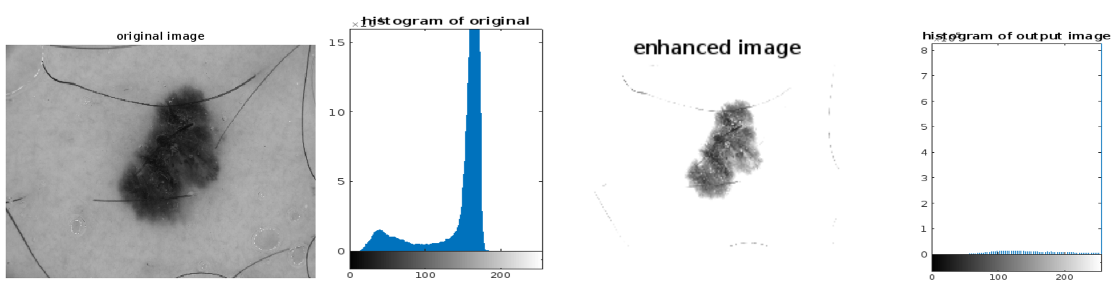


Figure 7. Original image and resultant image and histogram of both image

Median Filter : Replaces each pixel with the median of its neighbors. More robust to impulsive noise.

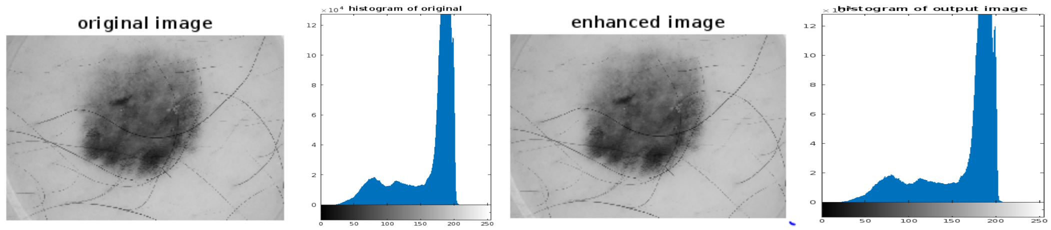


Figure 8. Original image, resultant image and histogram of both image

Gaussian Filter : Applies a Gaussian function to the neighbourhood, giving more weight to closer pixels. Efficient for removing Gaussian noise.

$$g(x,y) = \frac{1}{2\pi\sigma^2} . e^{\frac{-(x^2+y^2)}{2\sigma^2}}$$

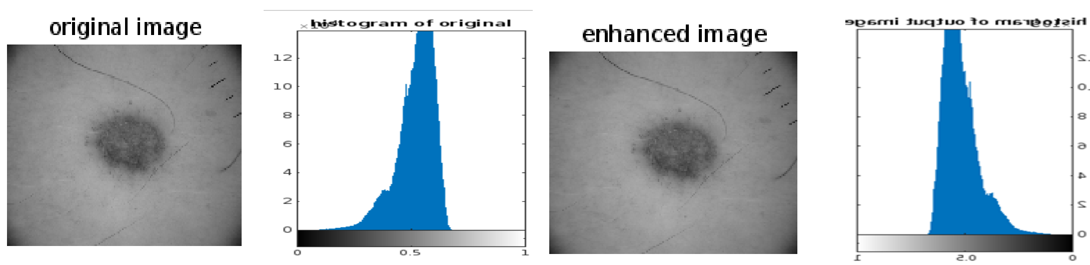


Figure 9. Original image, resultant image and histogram of both image

2 Sharpening Spatial Filter:

These filters enhance edges and high-frequency details in an image. Examples include:

1. **Unsharp masking :**

   Calculates the gradient magnitude in horizontal and vertical directions, highlighting edges.

2. **Laplacian filter:**

   Measures the second derivative of intensity, emphasizing edges and fine details.

3 Result and Discussions:

We used statistical measures such as mean and standard deviation to compare the quality of the improved image. Mean and standard deviation of image enhancement given in below graph and table.

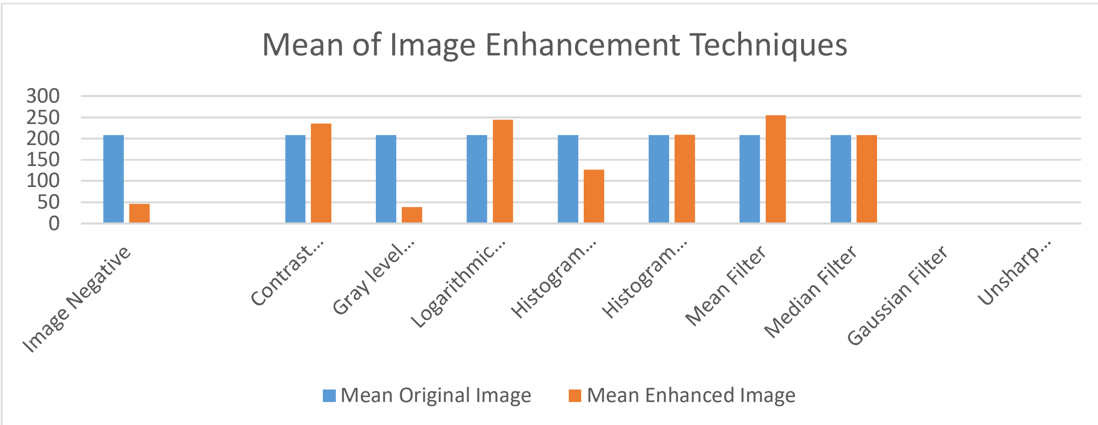


Figure 10. Mean of original and different image enhancement techniques

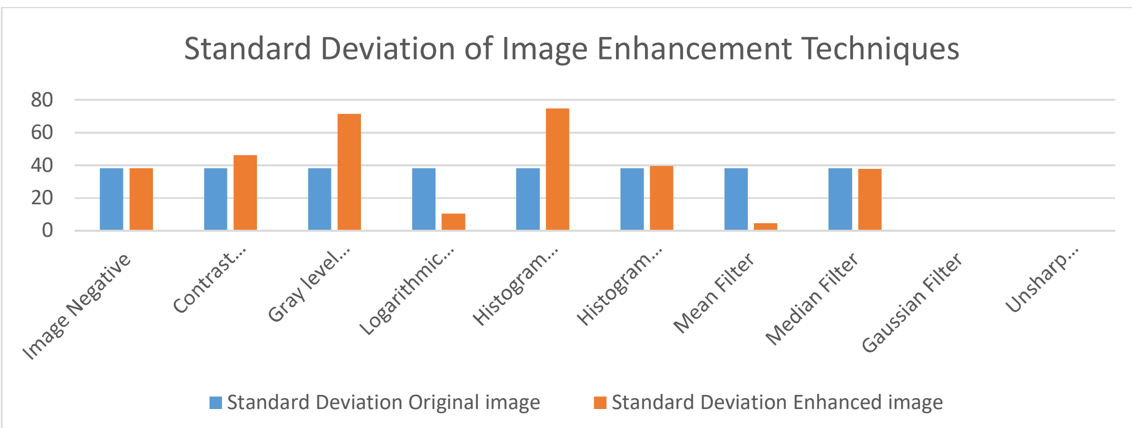
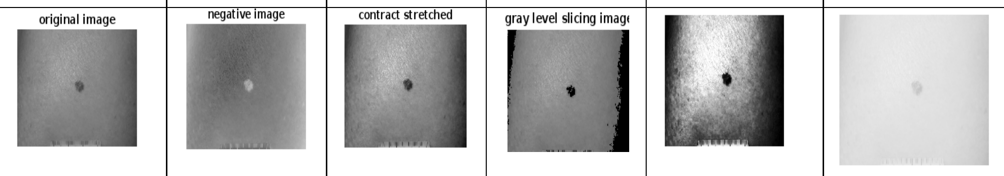
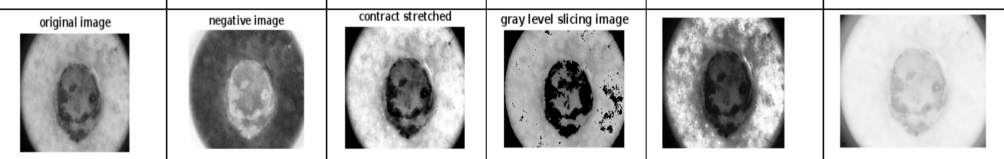
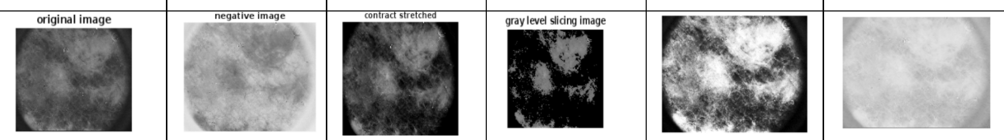
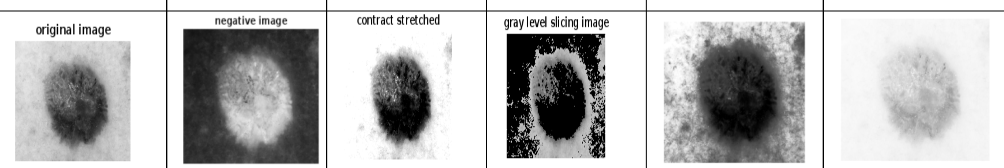
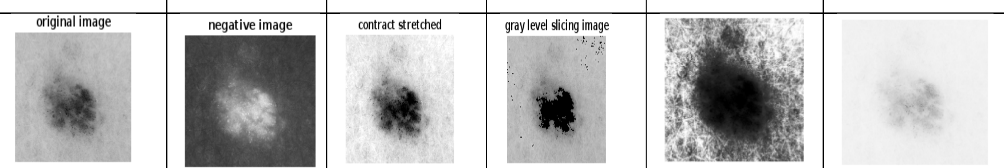
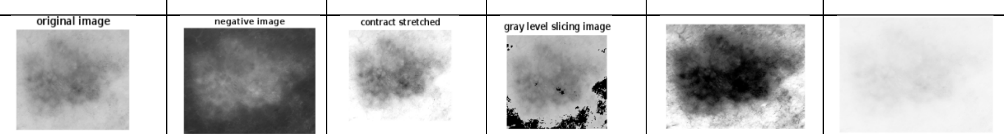
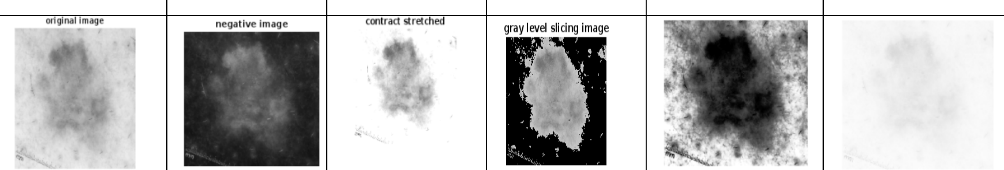


Figure 11. Standard deviation of original and different image enhancement techniques

		Mean		Standard Deviation	
Sr. No.	Image Enhancement Techniques	Original Image	Enhanced Image	Original image	Enhanced image
1	Image Negative	208.30	46.70	38.23	38.23
2	Contrast Stretching	208.30	235.95	38.23	46.21
3	Gray level slicing	208.30	38.61	38.23	71.37
4	Logarithmic Transformation	208.30	244.68	38.23	10.65
5	Histogram Equalization	208.30	127.24	38.23	74.77

6	Histogram Matching	208.30	209.57	38.23	39.57
7	Mean Filter	208.30	254.59	38.23	4.60
8	Median Filter	208.30	208.29	38.23	37.96
9	Gaussian Filter	0.82	0.82	0.15	0.15
10	Unsharp Masking	0.80	0.80	0.20	0.21

Table 1: Result of Different Image Enhancement Techniques

<table>
<tr><th>Sr. No.</th><th>Original image</th><th>Image Negative</th><th>Contrast Stretching</th><th>Gray Level Slicing</th><th>Histogram Equalization</th><th>Log Transformation</th></tr>
<tr><td>1</td><td colspan="6">
</td></tr>
<tr><td>2</td><td colspan="6">
</td></tr>
<tr><td>3</td><td colspan="6">
</td></tr>
<tr><td>4</td><td colspan="6">
</td></tr>
<tr><td>5</td><td colspan="6">
</td></tr>
<tr><td>6</td><td colspan="6">
</td></tr>
<tr><td>7</td><td colspan="6">
</td></tr>
</table>

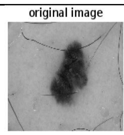
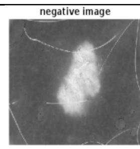
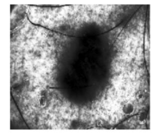
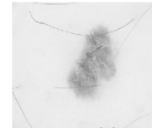
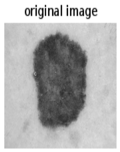
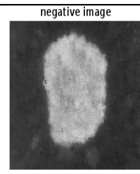
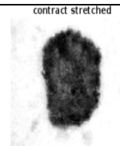
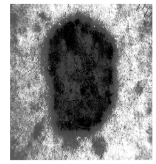
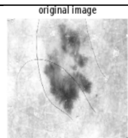
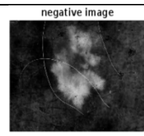
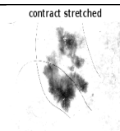
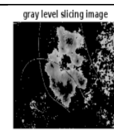
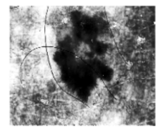
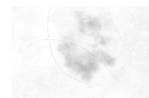
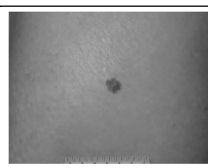
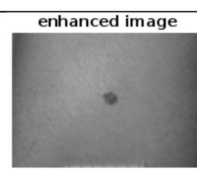
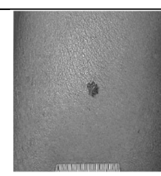
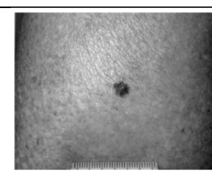
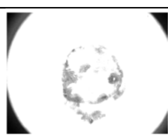
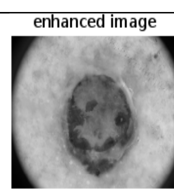
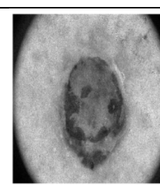
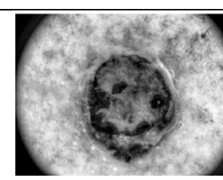
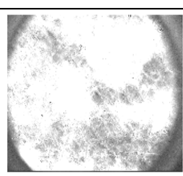
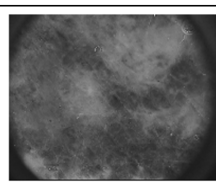
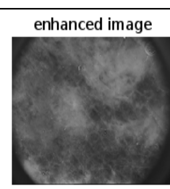
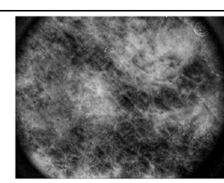
8						
9						
10						

Table 2: Image Enhancement Techniques on different images from dataset

Sr. No.	Mean Filter	Median Filter	Gaussian filtering	Unsharp masking	Laplacian filter
1					
2					
3					

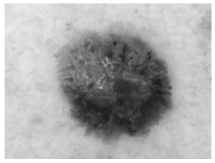
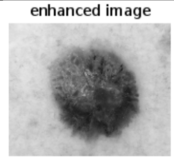
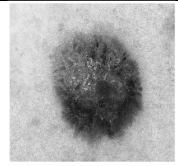
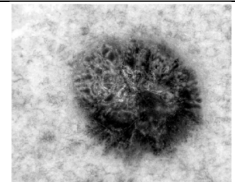
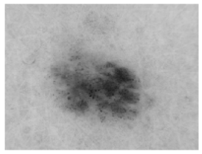
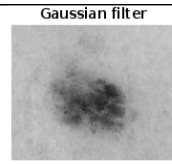
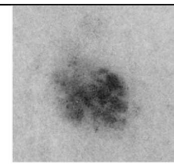
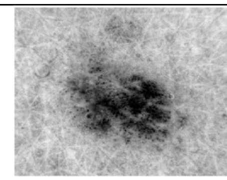
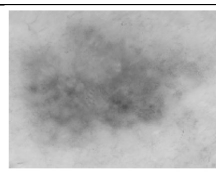
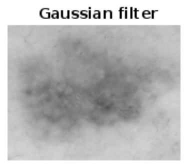
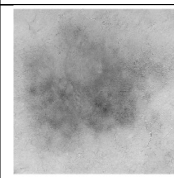
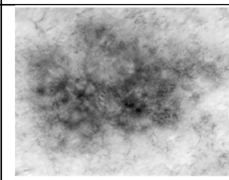
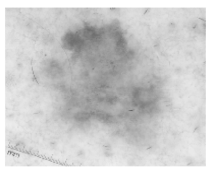
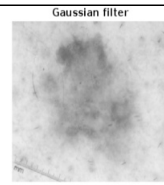
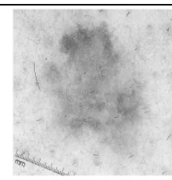
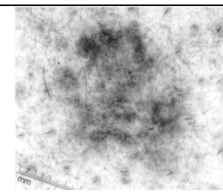
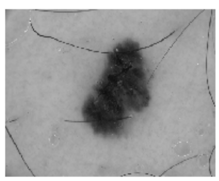
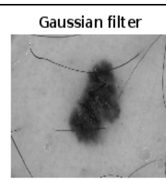
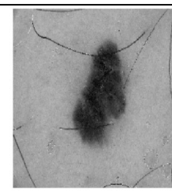
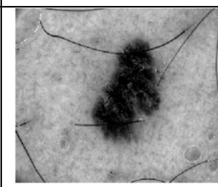
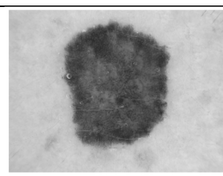
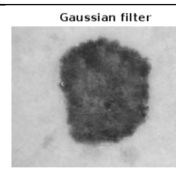
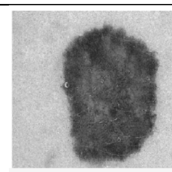
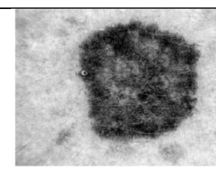
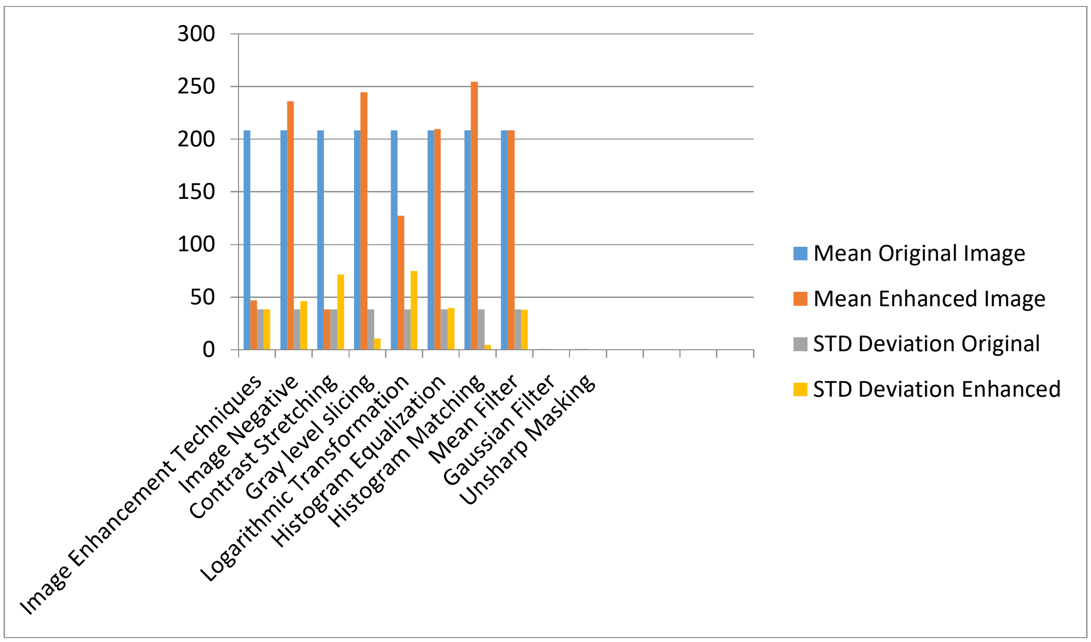
4					
5					
6					
7					
8					
9					

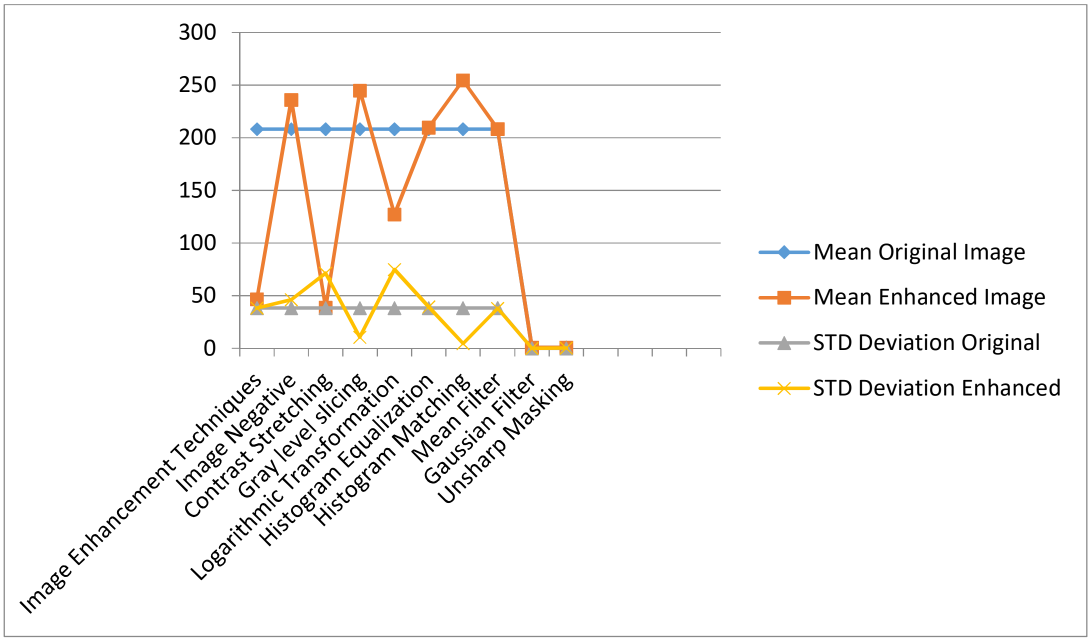
Table 3: Image Enhancement Techniques on different images from dataset

Added New Table

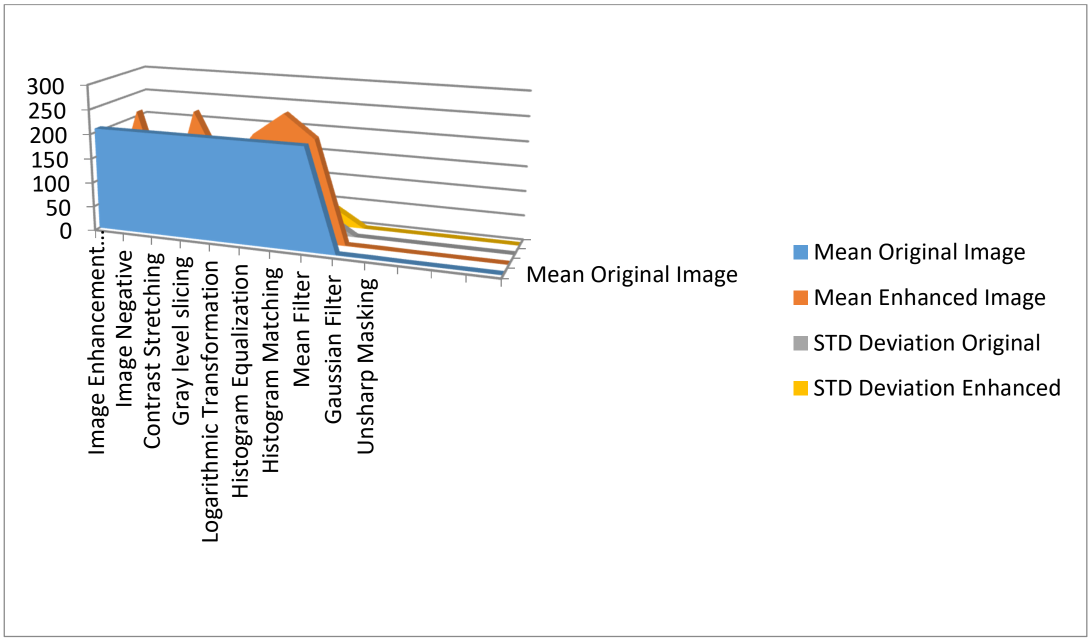
		Mean		Standard Deviation	
Sr. No.	Image Enhancement Techniques	Original Image	Enhanced Image	Original image	Enhanced image
1	Image Negative	208.30	46.70	38.23	38.23
2	Contrast Stretching	208.30	235.95	38.23	46.21
3	Gray level slicing	208.30	38.61	38.23	71.37
4	Logarithmic Transformation	208.30	244.68	38.23	10.65

5	Histogram Equalization	208.30	127.24	38.23	74.77
6	Histogram Matching	208.30	209.57	38.23	39.57
7	Mean Filter	208.30	254.59	38.23	4.60
8	Median Filter	208.30	208.29	38.23	37.96
9	Gaussian Filter	0.82	0.82	0.15	0.15
10	Unsharp Masking	0.80	0.80	0.20	0.21





	Mean Original Image	Mean Enhanced Image	STD Deviation Original	STD Deviation Enhanced
Image Enhancement Techniques	212	235.7	38.23	38.23
Image Negative	210.3	235.95	38.23	46.21
Contrast Stretching	209.4	38.61	38.23	71.37
Gray level slicing	230.9	244.68	38.23	10.65
Logarithmic Transformation	228.3	127.24	38.23	74.77
Histogram Equalization	218.8	209.57	38.23	39.57
Histogram Matching	208.3	254.59	38.23	4.6
Mean Filter	208.3	208.29	38.23	37.96
Gaussian Filter	0.82	0.82	0.15	0.15
Unsharp Masking	0.8	0.8	0.2	0.21


300
250
200
150
100
50
0
Image Enhancement...
Image Negative
Contrast Stretching
Gray level slicing
Logarithmic Transformation
Histogram Equalization
Histogram Matching
Mean Filter
Gaussian Filter
Unsharp Masking
Mean Original Image
Mean Original Image
Mean Enhanced Image
STD Deviation Original
STD Deviation Enhanced

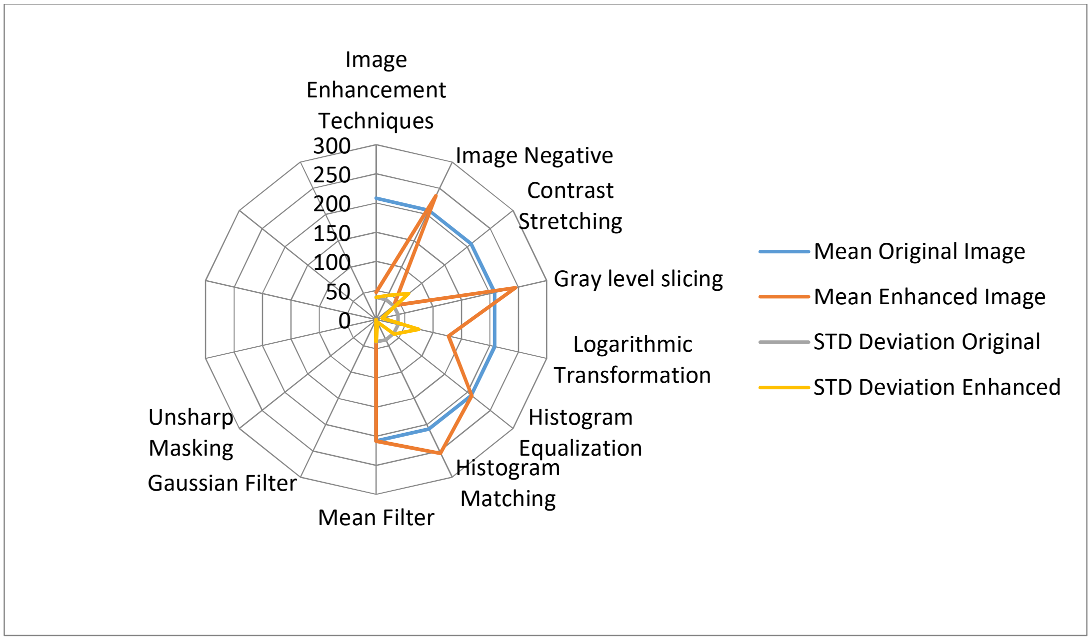
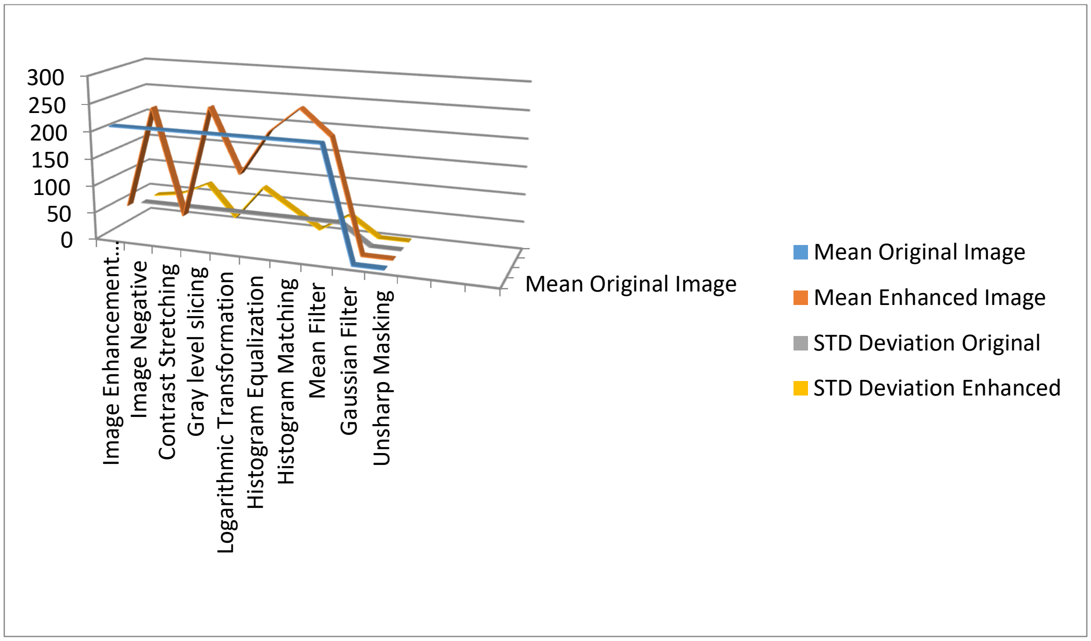


Image Enhancement Techniques
300
250
200
150
100
50
0
Image Negative
Contrast Stretching
Gray level slicing
Logarithmic Transformation
Histogram Equalization
Histogram Matching
Mean Filter
Gaussian Filter
Unsharp Masking
Mean Original Image
Mean Enhanced Image
STD Deviation Original
STD Deviation Enhanced



Conclusion

An overview of several picture enhancing methods is given in this paper. The study focuses on methods for improving the picture of melanoma skin cancer using spatial domain filtering. While frequency domain enhancement concentrates on individual objects, mainly the edges of the image, spatial domain heightening modifies the entire image by pixel manipulation. Five prefilters for hair removal and noise cancellation were evaluated and compared for performance. The image pre-processing methods required for skin cancer imaging are described in this work. Our main topic of discussion is image enhancement, which uses several filters to smooth out and minimize noise in photos. This study is beneficial for skin cancer detection system researchers. When we combine these images using enhancing techniques, we will get a better result, rather than by applying them alone. Using the above table, we exposed that applying the median filter and histogram equalization can significantly improve the skin cancer image.

References

[1] A. Bansal and N. Singh, "Image Enhancement Techniques: A Review," *Asian J. Converg. Technol.*, vol. 6, no. 2, pp. 7–11, 2020, doi: 10.33130/ajct.2020v06i02.002.

[2] M. Kalra and S. Kumar, "Various image enhancement techniques for skin cancer detection using mobile app," *IEEE Int. Conf. Comput. Commun. Control. IC4 2015*, 2016, doi: 10.1109/IC4.2015.7375681.

[3] P. Khandelwal and G. Kaur, “A Review of Various Image Enhancement Techniques,” vol. 03, no. 03, pp. 292–301, 2017.

[4] R. J. Hemalatha, B. Babu, A. J. A. Dhivya, T. R. Thamizhvani, J. E. Joseph, and R. Chandrasekaran, “A comparison of filtering and enhancement methods in malignant melanoma images,” *IEEE Int. Conf. Power, Control. Signals Instrum. Eng. ICPCSI 2017*, pp. 2704–2710, 2018, doi: 10.1109/ICPCSI.2017.8392209.

[5] Goel, R. (2021, July). The implementation of image enhancement techniques using Matlab. In *Proceedings of the International Conference on Innovative Computing & Communication (ICICC)*.

[6] PL, C. (2019). A Study on Various Image Processing Techniques. *International Journal of Emerging Technology and Innovative Engineering*, *5*(5).

[7] Qi, Y., Yang, Z., Sun, W., Lou, M., Lian, J., Zhao, W., ... & Ma, Y. (2021). A comprehensive overview of image enhancement techniques. *Archives of Computational Methods in Engineering*, 1-25.

[8] Ackar, H., Abd Almisreb, A., & Saleh, M. A. (2019). A review on image enhancement techniques. *Southeast Europe Journal of Soft Computing*, *8*(1).

[9] Janani, P., Premaladha, J., & Ravichandran, K. S. (2015). Image enhancement techniques: A study. *Indian Journal of Science and Technology*, *8*(22), 1-12.

[10] S. Khidse and M. Nagori, “A Comparative Study of Image Enhancement Techniques,” *Int. J. Comput. Appl.*, vol. 81, no. 15, pp. 28–32, 2013, doi: 10.5120/14201-2421.

[11] M. Kalra and S. Kumar, “Various image enhancement techniques for skin cancer detection using mobile app,” *IEEE Int. Conf. Comput. Commun. Control. IC4 2015*, 2016, doi: 10.1109/IC4.2015.7375681.