International Journal of Recent Research and Review, Vol. XII, Issue 3, August 2019
ISSN 2277 – 8322

Enhancement of Overexposed & Underexposed Image using Hybrid Technique for Surveillance and IOT Applications

Prasoon Vyas[1] Ram Lal Yadav[2]
[1]*M.TechScholar, KITE, Jaipur,* [2]*Associate Professor, KITE, Jaipur*
Email: Prasoonvyas3@gmail.com[1], ram.bitspilani@gmail.com[2]

Abstract- **Current scenario is very important for security and surveillance applications require different sorts of images as wellsprings of information for understanding and review. Image enhancement is method of put on adjusted alterations to an info image to make the ensuing image progressively alluring or to convey an improved remodel generation for up and coming mechanized image preparing strategies. Image enhancement of any underexposed or overexposed image are urgent to bring the information as removing information is exceptionally troublesome and now and again this information is totally lost. The interest of overexposed and underexposed images may be troublesome or here and there, it might be difficult to accumulate such images for identical casing. In this Paper, a calculation has been proposed which uses either overexposed image or underexposed image and still improves the nature of the image. Calculation will chip away at spatial area task and frequency space activity also. This research illustrates and compares the proposed modifies tanlog correction, histogram equalization, gamma correction and homomorphism filtering algorithm to various underexposed and over exposed images. Figure of merits such as PSNR, Entropy, and histogram have been analysed which proves the effectiveness of proposed algorithm. The proposed work has been successfully operated on underexposed and overexposed images and additionally an IOT based image acquisition system has been developed and implemented on the proposed system.**

Keywords- **Image Enhancement, tanlog, PSNR, Over exposed, Underexposed, Image Processing**

I. INTRODUCTION

Image processing used analog techniques to get hard copies of the data like Photostat and printout. The user uses large amount of data to interpret the relevant data by using visual techniques. Image processing is not confined to particular field which is just required to studied it is widely spread for the knowledge analysis purpose. Association is one of the most important tools used in the image processing for using visual techniques.The mixture personal data and collected is applied in image processing.

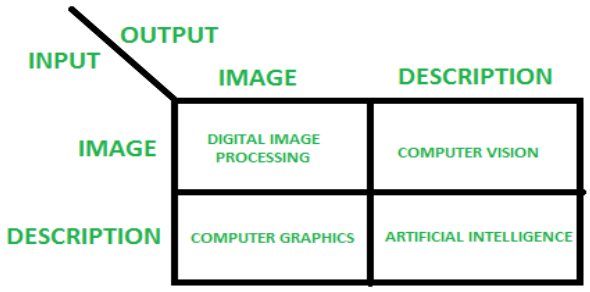


Figure 1.1: Applications of Digital Image Processing

Image Enhancement

Image enhancement is the improvement of satellite image quality without information about the wellspring of debasement. On the off chance that the wellspring of debasement is known, one calls the procedure image reclamation recently talked are iconical forms, viz., info and yield is images. Various, frequently basic also, heuristic strategies are utilized to improve images in some sense. Image reclamation expels or limits some known corruptions in an image. In many image handling

applications, geometrical changes encourage preparing. Precedents are image reclamation, where one as often as possible needs to show the corruption process as space-invariant, or the alignment of an estimation gadget, or a revision in request to evacuate a relative development among article and sensor. In all cases the first activity is to dispose of a known geometrical. The geometric correction imagery must be upgraded to improve the compelling deceivability. Image enhancement systems are typically connected to remote detecting information to improve the presence of an image for human visual investigation. The principle focal point of enhancement techniques pursues these methodology in to image segmentation, grouping and geometric changes.

Image Enhancement Techniques

This area clarifies the arranged enhancement strategy that performs concurrent differentiate alteration or Histogram Equalization, edge enhancement and de-noising the raster imagery. The Enhancement technique works in two forms of images overexposed and underexposed as given underneath. Following techniques are being implemented for image enhancement for underexposed and overexposed images.

1. Tan-Log Function: This is the highlighted and the most important section of this algorithm. The function treats the images on a pixel basis and then processes them through an analog function which generates decimal values of the order of 10 and 1/100 and to avoid them to be out of the range of UINT8 data type it is multiplied by the coefficient of tand (255)(d refers to degrees here).

$$X_r(i,j) = \sum_{i=row}^{j=col} tand\big(\log\big(Yr(i,j)\big)\big) * tand(225) \qquad 1.1$$

$$X_g(i,j) = \sum_{i=row}^{j=col} tand\big(\log\big(Yg(i,j)\big)\big) * tand(225) \qquad 1.2$$

$$X_b(i,j) = \sum_{i=row}^{j=col} tand\big(\log\big(Yb(i,j)\big)\big) * tand(225) \qquad 1.3$$

2. Manual Contrast: Contrast is the difference in luminance or color that makes an object (or its representation in an image or display) distinguishable. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. The human visual system is more sensitive to contrast than absolute luminance; we can perceive the world similarly regardless of the huge changes in illumination over the day or from place to place. The maximum contrast of an image is the contrast ratio or dynamic range.
3. Mask Operation: Mask operation deals with the implementation of the median filter in two dimensional of the processing image with separation of RGB layers. The median filter is a nonlinear digital filtering technique, often used to remove noise from an image or signal.

$$Y[m.n]=median[x(I,j),(I,j)] \quad 1.4$$

Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise also having applications in signal processing.

4. Gamma Correction*:* A non-linear transfer of signal exists between an electrical device and an optical device.

$$X(i,j) = 255 \times \left(\frac{x(i,j)}{255}\right)^{\frac{1}{\gamma}} \qquad 1.5$$

This non-linearity causes serious distortions in the intensity of image, resulting with certain areas being too dark and with certain areas being bleached out.

5. Histogram Equalization: Histogram equalization is a technique for adjusting image intensities to enhance contrast. The histogram of an image is a plot of the number of occurrences of gray levels in the image against the gray-level values.

6. Homomorphic Filter: Homomorphic filter is used to remove the multiplicative noise. Working of homomorphic filter on an input image is shown below:

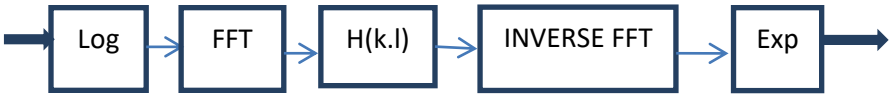


Figure 1.3: .Flow Diagram of Homomorphic Filter

Homomorphic filter will be applied only on the Underexposed image to filter out the low frequency band.

Elementary Steps in Digital Image Processing

Image Acquisition: The camera / digitizer convert the image into a form suitable for digital computer input.

Image recovery: Image recovery is the removal or minimization of degradation in the image. Image recovery is dissimilar from image enhancement. Recovery techniques typically rely only on the class or set properties of the data set, where the image enhancement technique has a higher image dependency.

Image Data Compression: Image data compression involves reducing the number of bits required to store or send images without significant loss of information.

Color Image Processing: It is gradually more chief area due to the noteworthy increase in the exercise of digital images on the Internet.

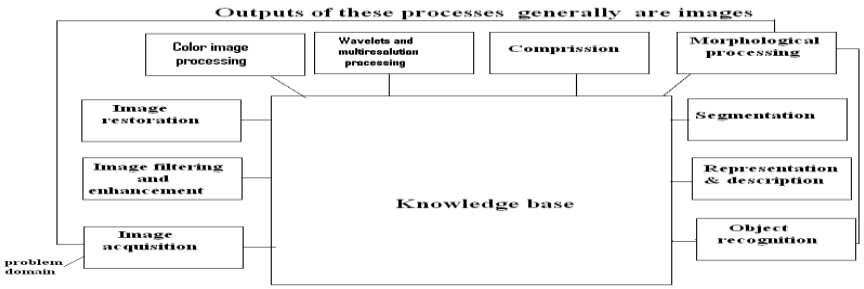


Figure 1.3: Fundamental Steps in Digital Image

Objectives of Research

The objectives of proposed work in the research is as follows-

1. To apply image processing methods for various format of images.
2. To implement image enhancement methods on underexposed and over exposed images.
3. To apply and simulate tanlog based approach for image enhancement techniques.
4. Performance analysis of simulated method using Peak signal to noise ratio (PSNR) and Mean Square error (MSE).
5. To implement proposed methodology on various format of images and comparative analysis of MSE and PSNR among them.
6. To implement Graphical user interface for the proposed image enhancement methods.

II. LITERATURE REVIEW

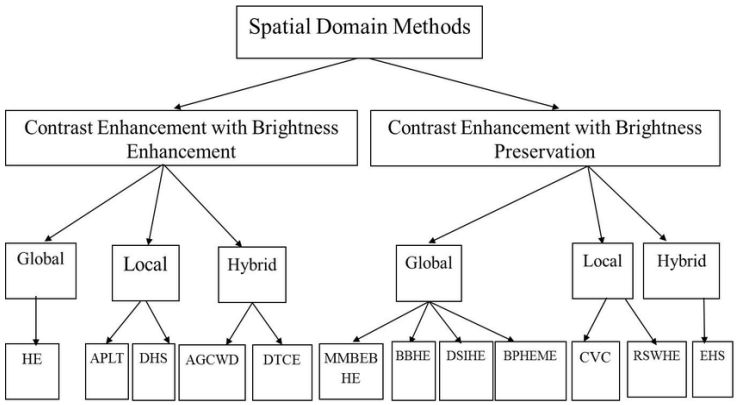


Figure 2.1: Spatial Domain Methods in Image Processing

Concentrates on improving the differentiation of various applications by safeguarding the splendour and improving the quality is an overall research issue that had been accomplished by various strategies. Different scientists have endeavoured to address this issue, yet despite everything it stays as a noteworthy issue in the zone of research. This part examines the works identified with differentiation enhancement and the subtleties of the exploration distributions intricately.

Advanced images are assuming a significant job in various applications zones, for example, video observation, Radar, Medical images and Satellite imaging. The significant worries with the gained images are their commotion and low differentiate. The difference of the image chooses the nature of the image. Differentiation enhancement is utilized to play out the modification on obscurity or daintiness of the image. It for the most part used to draw out the highlights covered up in an image or to increment the difference of low differentiation image. The region of image preparing has been done in two distinct areas, for example, spatial and recurrence spaces.

This exploration despite the fact that spotlights fundamentally on the spatial space it talks about strategy identified with the recurrence space also. As the strategies proposed in this theory are identified with histogram evening out the talks on HE are Contrast Enhancement is a standout amongst the most adequate strategies for enhancement of restorative images. Diverse differentiation enhancement strategies like Difference Stretching, Histogram Equalization, AHE, CLAHE are as of now accessible.

Naina Dhingra, et al 2015 proposed DWT-based image fusion algorithm is used to unit blurring to over-expose images and underexposed images. The projected method provides a synthesis image containing note worthy visual information present in the input image and a note worthy disparity enhancement.

Huang Zhijia, et al 2015 presents an effectual method to amend the histogram and enhance the difference in digital

images. The augmentation plays a vital role in digital image processing, computer vision and pattern detection.

Li Min, et al 2016 explained that image fusion can be done at diverse levels: pixel, feature, and decision level. Pixel-level image fusion refers to the processing and collaboration of information collected by various imaging sources to better understand the scene.

Mohd Azau et al 2016 described the use of hybrid gamma error correction S-type functions to enhance over-exposure and underexposed images. The requirement to improve the visibility of photographic images under extreme lighting conditions is becoming increasingly important in digital image processing. The extreme condition is that when there is no reasonable light known as underexposure, too much light is called overexposure. The current popular enhancement technique is enhanced by contrast stretching, histogram equalization, homomorphic filtering, and contrast adjustment.

ArezouSoltaniPanah et.al (2017) reviewed [5] a latest development in the applications which are non-media and have emerged very largely from past so many years. The receiver is able to detect watermark so the invisibility can be redefined and accepted in all the conditions so that can be generalized more easily. The main purpose of this paper to motivate the research in this field and solves that the research problems occurring during data mining process.

III. PROBLEM DEFINITION

In this paper, an integrated method has been proposed, which integrates homomorphic filtering, trigonometric transformation with log masking and Histogram Equalization based gamma optimization. The low intensity pixels are enhanced by Homomorphic filter. Sometimes this method is unable to calculate the accurate depth in more distorted images, therefore trigonometric transformation has been introduced to extract some hidden information from the images. The trigonometric transformation can break an image signal into low frequency. Most of the image information is hidden in low frequency band and edges are preserved in high frequency bands. So this transformation is very useful for this purpose. Log masking is used to sharpen the high frequency edges obtained from trigonometric transformation and to enhance the clarity of the image. Finally, histogram equalization based artificial bee colony optimization technique has been implemented for enhance the image contrast of the refined image as most of the distorted images have poor contrast.

IV. IMPLEMENTAION & RESULTS ANALYSIS

MATLAB stands for Matrix Laboratory. It is a very interactive software and able to perform numerical computational and visualization of data. There are various in-built functions present in MATLAB which makes it more beneficial for all fields of science and engineering.

It is high level language programming language used for performing simulations, plotting of graphs. It uses different types of control statements like if statement, while statement, for statement. The variable can be imported and exported and can be easily managed from anywhere. The programs can be debugged and executed from M-files which is default execution statement in the MATLAB. It supports high level graphics in two-dimensional and three-dimensional space. MATLB also provides the facility of high graphics for better data visualization, animation and image processing. It is very easy to design in the user defined interfaces. The MATLAB is used by the below mentioned type of users:

1. The users who are able to perform complex mathematical expressions.
2. The person who have the knowledge of algorithms and those who want to study their own performance.
3. Data Analytics for the data visualization.
4. The Application design agencies

4.1 Simulation and Results

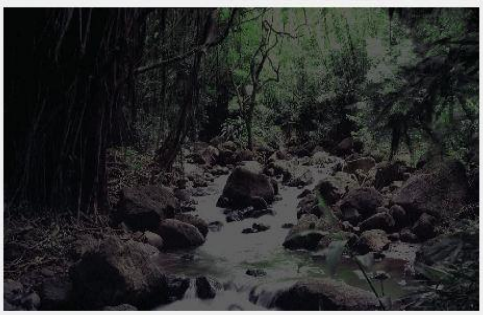
The simulated image enhancement algorithm presented here represents the image recovered after the application

of certain equations which are explained above in the proposed methodology section. The tables here shows the entropy and the standard deviation based result comparison of the underexposed and the overexposed images. The processes implemented here are manually calculated and are implemented as per the required conditions which are based over the images received. The two types of images that were accepted for this algorithm is underexposed and the overexposed.

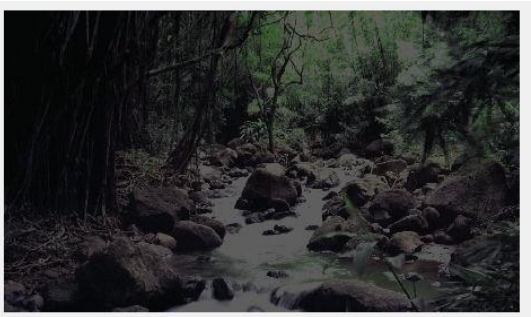
4.1.1 Implementation of Proposed System on Over Exposed Images

a

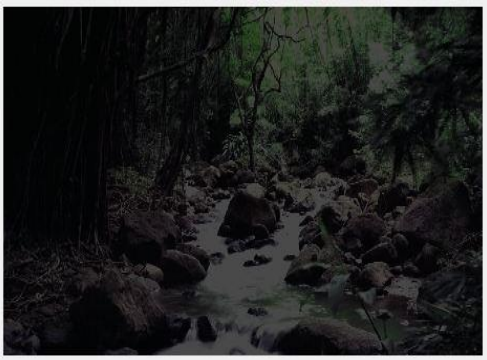
b



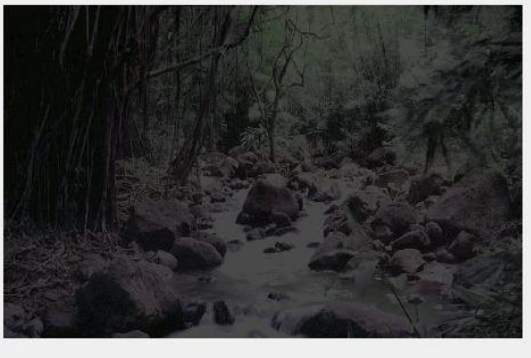
(c)



(d)



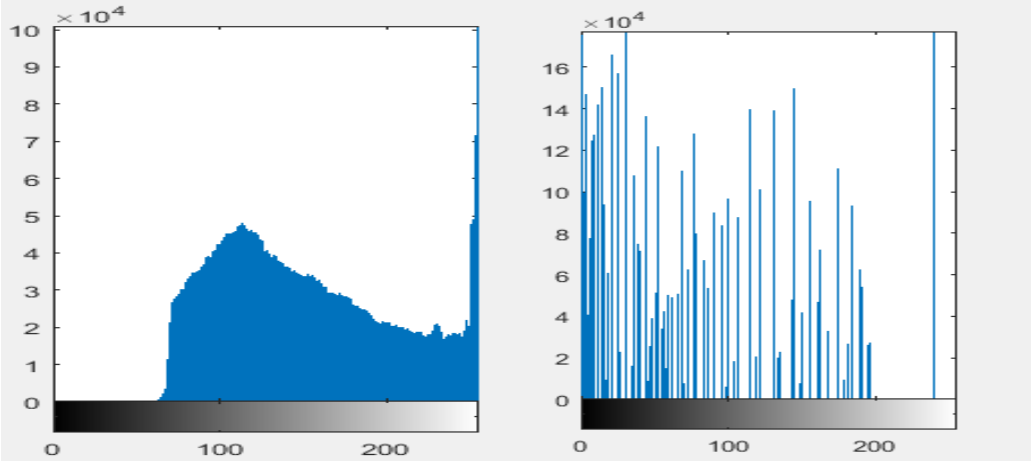
(e)



(f)

(g)

Figure 4.1: Implementation on Overexposed Image (a) Original Image (b) Input Image after tanlog process (c)Manual contrast enhanced image (d)Median filtered Image (e) Gamma Corrected Image (f) Manual Histogram Equalized Image (g) Output Image (Enhanced by CDF)



(a) (b)

Figure 4.2: (a) Histogram of Input Image (Overexposed) (b) Histogram of processed output Image

4.1.2 Summary of Results-Image Sample-1

For Overexposed Image the value of Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE) values are as shown below:-

PSNR of the input image with respect to original image = 11.4050

PSNR of the output image with respect to original image = 15.9778

RMSE of the input image with respect to original image = 68.59

RMSE of the output image with respect to original image = 40.52

Table 4.1
Entropy after applying different Techniques on Overexposed Images

Entropy image tanlog	4.3144
Entropy image Contrast Enhancement	5.8759
Entropy image Median Filter	5.8427
Entropy image Gamma Correction	5.4592
Entropy image Manual Histogram Equalization	5.3404
Entropy image after CDF	5.8806

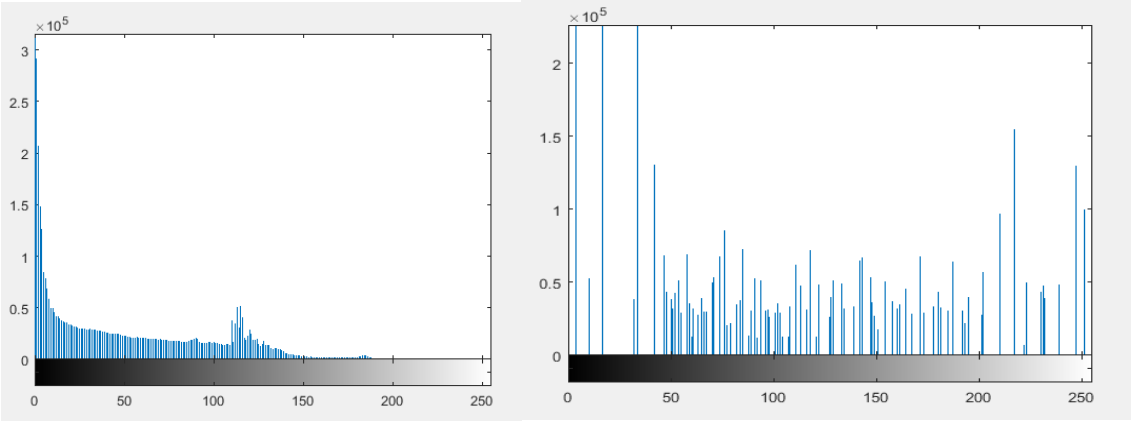
Table 4.2

Absolute Standard Deviation after applying Different Techniques on Overexposed Images

Absolute Standard deviation image tandlog	49.0491
Absolute Standard deviation image Contrast Enhancement	25.7775
Absolute Standard deviation image Median Filter	25.8804
Absolute Standard deviation image Gamma Correction	32.1905
Absolute Standard deviation image Manual Histogram Equalization	35.4531
Absolute Standard deviation image Homomorphic Filter	22.9043

4.1.3 Implementation of Proposed System on Under Exposed Images

Figure 4.3: Implementation on Under Exposed Images. (a) Underexposed Input Image (b) Input Image after Tanlog process (c) Manual contrast enhanced image (d) Median filtered Image (e) Gamma Corrected Image (f)Manually Histogram Equalised Image (g) Homomorphic Filtered Image (h) Output Image (Enhanced by Cumulative Distributive Function)



(a) (b)

Figure 4.4: (a) Histogram of Input Image (Underexposed) (b) Histogram of processed output Image

4.1.4 Summary of Results-Image Sample-2

For Underexposed Image the value of Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE) values are as shown below:-

PSNR of the input image with respect to original image = 12.7715
PSNR of the output image with respect to original image = 19.4340

RMSE of the input image with respect to original image = 58.88
RMSE of the output image with respect to original image = 26.91

Table 4.3
Entropy after applying Different Techniques on Underexposed Images

Entropy image tanlog	4.5187
Entropy image Contrast Enhancement	4.8859
Entropy image Median Filter	4.8959
Entropy image Gamma Correction	4.6060
Entropy image Manual Histogram Equalization	4.8506
Entropy image after homomorphic filter	5.9105
Entropy after CDF	6.1932

Table 4.4
Absolute Standard Deviation after applying Different Techniques on Underexposed Images

Absolute Standard deviation image tanlog	13.5968
Absolute Standard deviation image Contrast Enhancement	16.6961
Absolute Standard deviation image Median Filter	16.9718
Absolute Standard deviation image Gamma Correction	24.9976
Absolute Standard deviation image Manual Histogram Equalization	31.604
Absolute Standard deviation image Homomorphic Filter	22.808
Absolute Standard deviation after CDF	30.8438

4.2 Comparative Assessment on Various Samples

The simulated image enhancement algorithm presented here represents the image recovered after the application of certain equations which are explained above in the proposed methodology section. The tables here shows the

entropy and the standard deviation based result comparison of the underexposed and the overexposed images. The processes implemented here are manually calculated and are implemented as per the required conditions which are based over the images received. The comparative assessment of proposed technique on various samples are discussed as follows:

Table 4.5

Entropy after applying different Techniques on various Overexposed Images

Entropy analysis	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Sample-6	Sample-7	Sample-8	Sample-9
Entropy image tanlog	3.1860	3.4835	4.4184	3.8855	4.1746	3.9245	4.4692	4.2306	4.3144
Entropy image Contrast Enhancement	4.6776	4.6798	5.7189	5.1762	5.7410	5.1437	5.8940	5.8346	5.8759
Entropy image Median Filter	4.6341	4.6647	5.7105	5.1552	5.7166	5.1051	5.8283	5.7662	5.8427
Entropy image Gamma Correction	4.4266	4.3303	5.3926	4.9382	5.5009	4.8101	5.4970	5.5484	5.4592
Entropy image Manual Histogram Equalization	3.7740	4.5404	5.3333	4.9044	5.3132	4.7279	5.5537	5.3751	5.3404
Entropy image after CDF	4.0265	4.6838	5.5661	4.8668	5.4179	4.7660	5.6767	5.4351	5.4806

Table 4.6

Absolute Standard Deviation after applying Different Techniques on Various Overexposed Images

Deviation Analysis	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Sample-6	Sample-7	Sample-8	Sample-9
Absolute Standard deviation image tanlog	54.9542	55.8951	49.0491	46.0173	48.6578	64.4761	50.7246	44.9884	48.9351
Absolute Standard Deviation image Contrast Enhancement	33.4584	29.0223	25.7775	26.7696	28.0467	39.9133	33.4306	26.7939	27.8428
Absolute Standard deviation image Median	33.4841	29.0324	25.8804	27.1144	28.1581	40.1733	33.999	27.3081	28.3651
Absolute Standard deviation image Gamma Correction	39.2663	36.9481	32.1905	30.7585	32.1006	45.7771	37.8499	30.7503	33.8027
Absolute Standard deviation image Manual Histogram Equalization	49.6524	43.8009	35.4531	27.2727	30.8445	49.4552	36.7985	28.8458	35.5099

Absolute Standard deviation image	11.2972	15.635	22.9043	34.1338	27.6825	12.6323	21.0657	28.1268	21.8250

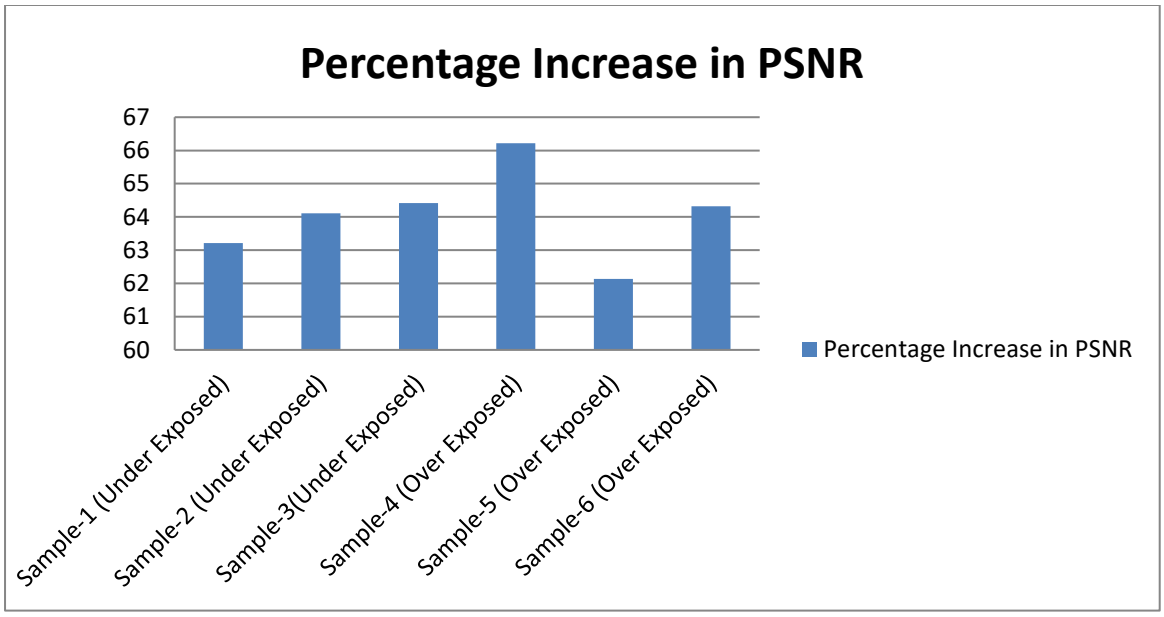
The above presented results and the algorithm has shown some vital improvements for the field of the image enhancement algorithm, the other methodologies which were used earlier are dependent over the certain database of the images. The proposed work is improved in terms of the timing as well as it generates the output image in 0.03 seconds on an average basis which can further be improved by reducing the complexities of the filter algorithms such as the holomorphic filter and also the use of the different filters can also be considered as sometimes the image might exhibit the imaginary component missing as the image undergoes the Fast Fourier Transformation.

4.3 Comparative Analysis of PSNR and MSE for Over Exposed Images and Under Exposed Images

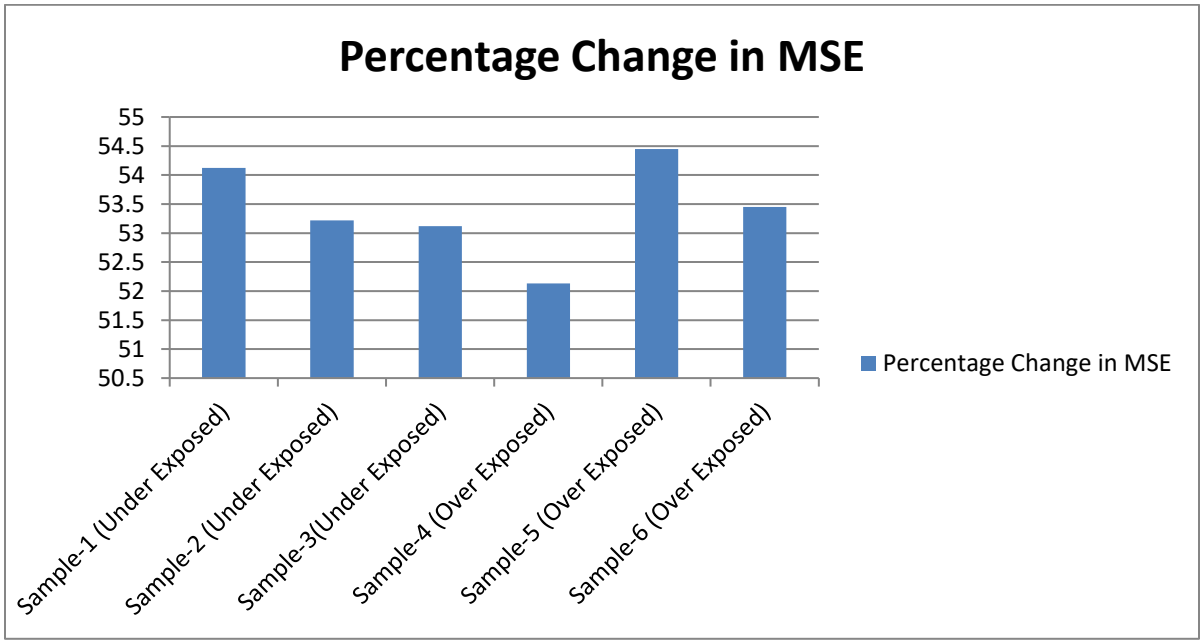
The above discussed algorithm has been applied to over expose and Under Exposed Images simultaneously. It was found that there was significant increase in PSNR (Peak Signal to Noise Ratio) after the application of algorithm. Similarly there was significant change in Mean Square Error (MSE) for the respective images after the application of algorithm. Brief analysis of algorithm has been explained in Table.

Table 4.7
Analysis of Changes in PSNR and MSE

Type of Image	Percentage Increase in PSNR	Percentage Change in MSE
UnderExposed	63.21	54.12
Under Exposed	64.11	53.22
Under Exposed	64.42	53.12
Over Exposed	66.22	52.13
Over Exposed	62.14	54.45
Over Exposed	64.32	53.45



(a)



(b)

Figure 4.5: (a) Graph showing Percentage Increase in PSNR (b) Graph showing Percentage Increase in MSE

4.4 Implementation of Graphical User Interface for Proposed System

As the program involved multiple steps and multiple function files. For ease of access we have implemented graphical user interface (GUI) for the proposed system. The snapshot of GUI is given in Figure below. This GUI involves the processing of the program in simple steps by creating executive launch icons which can be accessed by user without any inconvenience.

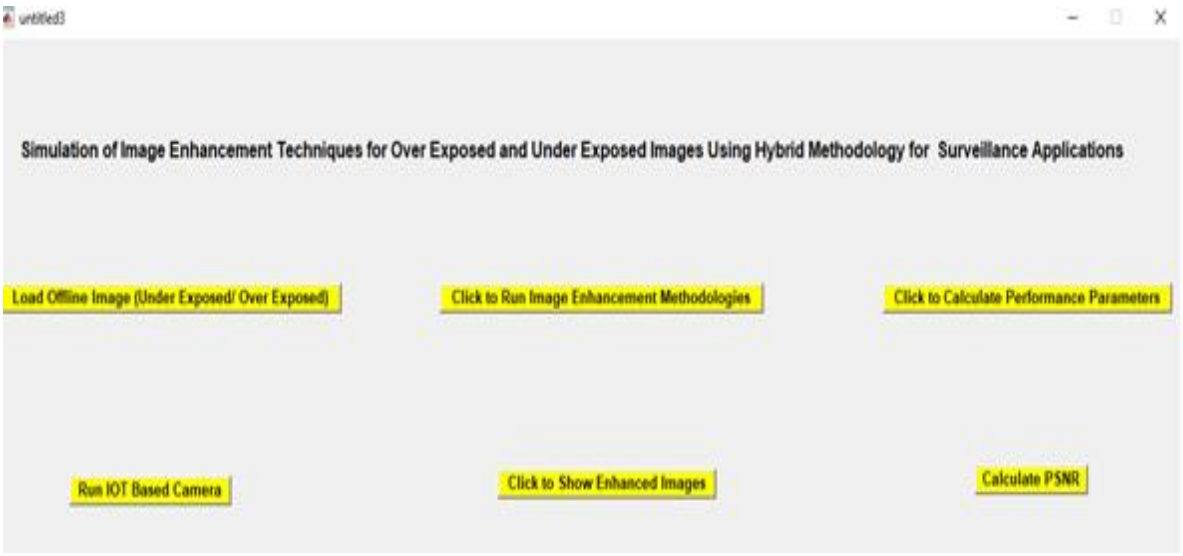


Figure 4.6: Image of Graphical User Interface

V. CONCLUSION & FUTURE SCOPE

Conclusion

Now a day's applications require various kinds of images as sources of information for interpretation and inspection. Image enhancement is technique of put on altered modifications to an input image to create the subsequent image more attractive or to deliver an improved renovate production for upcoming automated image processing techniques. Image enhancement of any overexposed image are critically crucial to fetch the information as extracting information is very difficult and sometimes this information is completely lost. There have been few papers which discusses the image enhancement algorithms using the fusion technique of underexposed and overexposed images. However the demand of overexposed and underexposed images might be difficult or sometimes it may be impossible to gather such images for exact same frame. In this paper an algorithm has been proposed which uses either overexposed image or underexposed image and still improves the quality of the image. Algorithm will work on spatial domain operation and frequency domain operation as well.The above presented result and the algorithm has shown some vital improvements for the field of the image enhancement algorithm, the other methodologies which wereused earlier are dependent over the certain database of the images. The proposed work is improved in terms of the timing as well as it generates the output image in few seconds on an average basis which can further be improved by reducing the complexities of the filter algorithms such as the homomorphic filter and also the use of the different filters can also be considered as sometimes the image might exhibit the imaginary

component missing as the image undergoes the Fast Fourier Transformation.

Future Scope

There are certain future aspects of the proposed algorithm:-

1. This proposed algorithm can be compared with soft computing based algorithms on the various parametric values.
2. This algorithm can be improved by using more secure channel algorithms.

REFERENCES

[1] Dhingra, Naina, AmitaNandal, MeenuManchanda, and Deepak Gambhir. "Fusion of fuzzy enhanced overexposed and underexposed images." Procedia Computer Science 54 (2015): 738-745.

[2] Z. Ji-hua, Z. Ning, C. Lei, F. Ru-yu, T. Bin and Q. Qing-Jun, "Research of space-object detection and tracking simulation system based on HLA," Proceedings of 2012 2nd International Conference on Computer Science and Network Technology, Changchun, 2012, pp. 1-5.doi: 10.1109/ICCSNT.2012.6525878

[3] Zhu, Zhiqin, Yi Chai, Hongpeng Yin, Yanxia Li, and Zhaodong Liu. "A novel dictionary learning approach for multi-modality medical image fusion." Neurocomputing 214 (2016): 471-482.

[4] Azau, Mohd, and MohdAzrin. "Enhancement of Over-Exposed and Under-Exposed Images Using Hybrid Gamma Error Correction Sigmoid Function." PhD diss., Universiti Putra Malaysia, 2007.

[5] Panah, ArezouSoltani, Ron Van Schyndel, TimosSellis, and Elisa Bertino. "On the properties of non-media digital watermarking: a review of state of the art techniques." IEEE Access 4 (2016): 2670-2704.

[6] Zhang, Wen-Hui, Xiaoya Jiang, and Yin-Mingzi Liu. "A method for recognizing overlapping elliptical bubbles in bubble image." Pattern Recognition Letters 33, no. 12 (2012): 1543-1548.

[7] Muñoz-Ramirez, David-Octavio, VolodymyrPonomaryov, Rogelio Reyes-Reyes, VolodymyrKyrychenko, Oleksandr Pechenin, and Alexander Totsky. "A robust watermarking scheme to JPEG compression for embedding a color watermark into digital images." In 2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies (DESSERT), pp. 619-624. IEEE, 2018.

[8] Morel, Jean-Michel, and Guoshen Yu. "ASIFT: A new framework for fully affine invariant image comparison." SIAM journal on imaging sciences 2, no. 2 (2009): 438-469.

[9] Sawant, H. K., and MahentraDeore. "A comprehensive review of image enhancement techniques." International Journal of Computer Technology and Electronics Engineering (IJCTEE)1, no. 2 (2010): 39-44.

[10] Sundaram, M., K. Ramar, N. Arumugam, and G. Prabin. "Histogram modified local contrast enhancement for mammogram images." Applied soft computing 11, no. 8 (2011): 5809-5816.

[11] Shan, Qi, Changchang Wu, Brian Curless, Yasutaka Furukawa, Carlos Hernandez, and Steven M. Seitz. "Accurate geo-registration by ground-to-aerial image matching." In 2014 2nd International Conference on 3D Vision, vol. 1, pp. 525-532. IEEE, 2014.

[12] Taha, Ahmed Majid, Aida Mustapha, and Soong-Der Chen. "Naive Bayes-guided bat algorithm for feature selection." The Scientific World Journal 2013 (2013).

[13] Anuar, FatahiyahMohd, RossitzaSetchi, and Yu-Kun Lai. "Trademark image retrieval using an integrated shape descriptor." Expert Systems with Applications 40, no. 1 (2013): 105-121.

[14] Sneha, Kumari, Niharika Roy, AnirbanPatra, and ArijitSaha. "Watermarking in Medical Images Using Alpha Blending." IJSART 3, no. 10 (2017): 384-387.

[15] Ansari, Irshad Ahmad, Chang WookAhn, and Millie Pant. "On the security of" block-based SVD image watermarking in spatial and transform domains"." In 2018 International Conference on Digital Arts, Media and Technology (ICDAMT), pp. 44-48. IEEE, 2018.

[16] Komarov, Alexander S., and Mark Buehner. "Adaptive probability thresholding in automated ice and open water detection from RADARSAT-2 images." IEEE Geoscience and Remote Sensing Letters 15, no. 4 (2018): 552-556.

[17] Dong, Aoshuang, and Rui Zeng. "Research and Implementation Based on Three-Dimensional Model Watermarking Algorithm." In 2017 International Conference on Computing Intelligence and Information System (CIIS), pp. 277-282. IEEE, 2017.

[18] Ouyang, Nian, Xue-Qin Jiang, EnjianBai, and Hui-Ming Wang. "Destination assisted jamming and beamforming for improving the security of AF relay systems." IEEE Access 5 (2017): 4125-4131.

[19] Evsutin, Oleg, Anna Kokurina, Roman Meshcheryakov, and Olga Shumskaya. "The adaptive algorithm of information unmistakable embedding into digital images based on the discrete Fourier transformation." Multimedia Tools and Applications 77, no. 21 (2018): 28567-28599.

[20] Gill, Ritu, and Rishi Soni. "Digital image watermarking using 2-DCT and 2-DWT in gray images." In 2017 International Conference on Intelligent Computing and Control Systems (ICICCS), pp. 797-803. IEEE, 2017.

[21] Goli, Mohammad Shahab, and AlirezaNaghsh. "Introducing a new method robust against crop attack in digital image watermarking using two-step sudoku." In 2017 3rd International Conference on Pattern Recognition and Image Analysis (IPRIA), pp. 237-242. IEEE, 2017. [22] Huynh-The, Thien, and Sungyoung Lee. "Color image watermarking using selective MSB-LSB embedding and 2D Otsu thresholding." In 2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 1333-1338. IEEE, 2017.

[23] Saturwar, J. H., and D. N. Chaudhari. "Review of models, issues and applications of digital watermarking based on visual cryptography." In 2017 International Conference on Inventive Systems and Control (ICISC), pp. 1-4. IEEE, 2017.

[24] Venkateswarlu, Lendale, N. Vyaghreswara Rao, and B. Eswara Reddy. "A Robust Double Watermarking Technique for Medical Images with Semi-fragility." In 2017 International Conference on Recent Advances in Electronics and Communication Technology (ICRAECT), pp. 126-131. IEEE, 2017.

[25] Zhang, Yu, XiangzhiBai, and Tao Wang. "Boundary finding based multi-focus image fusion through multi-scale morphological focus-measure." Information fusion 35 (2017): 81-101.

[26] Heidari, M., ShadrokhSamavi, S. Mohamad R. Soroushmehr, ShahramShirani, Nader Karimi, and KayvanNajarian. "Framework for robust blind image watermarking based on classification of attacks." Multimedia Tools and Applications 76, no. 22 (2017): 23459-23479. [27] Basu, Abhishek, Subhrajit Sinha Roy, and AvikChattopadhyay. "Implementation of a spatial domain salient region based digital image watermarking scheme." In 2016 Second International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN), pp. 269-270. IEEE, 2016.

[28] Abu, NurAzman, FerdaErnawan, and NannaSuryana. "A generic psychovisual error threshold for the quantization table generation on JPEG image compression." In 2013 IEEE 9th International Colloquium on Signal Processing and its Applications, pp. 39-43. IEEE, 2013.

[29] EGuan, Tonghui, and Yonghong Chen. "A node clone attack detection scheme based on digital images in WSNs." In 2016 First IEEE International Conference on Computer Communication and the Internet (ICCCI), pp. 257-260. IEEE, 2016.

[30] Oleg Evsutin, Roman Meshcheryakov,ViktorGenrikh, Denis Nekrasov and Nikolai Yugov, “An Improved Algorithm of Digital Watermarking Based on Wavelet Transform Using Learning Automata,” 2017, IEEE