Journal of Vibration Engineering

Registered

Infrared ImageEnhancement UsingNearest Neighborhood Contrast Pixel Matching

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Abstract—**Theinfraredimagesarelowcontrastimagesand due to the imaging environment, the details in the image may appear fuzzy. So, in order to address this problemand also to provide images which is noise-free has been proposed an infrared image enhancement technique dependent on nearest neighborhood contrast pixel matching. In which the original image is pre-processed by filtering the noise in the image. Secondly, the edge information is extracted without being lost by fractional edge detection. Saliency weight mapping is done to avoid the loss of sensitive pixels. Then, by applying thealgorithm, initial pixel contrast mapping is done. Finally, the image is reconstructed to obtain the enhanced image. The analysis has higher average value of peak signal-to- noise ratio compared to other approaches. Moreover, the enhancedresultsshowthattheimageshavebeenenhanced with higher quality and noise-free indicating our method achieves better performance than other methods.**

Keywords- Image Enhancement, Low contrast image enhancement, Nearest Neighbourhood pixel matching, Contrast mapping.

I. INTRODUCTION

Generally, image processing is the process of extractingthe necessary details from an image with less details to examine. The main applications of infrared imagery are target detection in military, marine recovery, detection of faulty circuit connection, space research and many more. Thecaptureofsuchimagesmaynotbeclearandthetexturedetails may be fuzzy because the infrared radiation may get affected bythermalradiationintheatmospherewhenthetargetandthe sensors are far away from each other. So, image enhancement becomes aneed,to getan imagewhichisclear andthetexture informations are not fuzzy.

The proposed method has an infrared image enhancement techniquethataddressesthechallengeofunclearandfuzzy details in infrared images. Our method is based on a nearest neighborhood contrast pixel matchingalgorithm. In this technique,animagewithlowestclarityisenhancedtoahigher quality image with better resolution. Many approaches for infrared image enhancement has been developed which includes deep convolutional neural network method [1], adaptive histogram equalization [2], plateau histogram [3], adaptive histogram partition and brightness correction [4], saliencymapfusion[5],etc.But,ourproposedalgorithmhasa different approach which is, nearest neighborhood contrast pixel matching algorithm where each pixels are padded and thentheaverageofthenearestneighbourhoodpixelsare taken and replaced with the central contrast pixel, in order to enhance the infrared image.

In our proposed algorithm, the flow of the process is as follows. The first step ispre-processed from the input image and fractional edge detection [6] is done to remove unwanted details and noise from the image. Then, pattern analysis takes place followed by initial contrast mapping and saliency mapping [7] are done to avoid the loss of sensitive pixels. After that, the main process, nearest neighborhood pixel matching technique is done to the present output image followed by contrast mapping. The enhanced output image is then reconstructed, so that the final output image will not lose any necessary details. The peak-signal-to-noise ratio (PSNR), mean squared error (MSE) and root mean squared error (RMSE) are measured to understand the efficiency of the output image. Comparing to other methods, our proposed method is considered to be the best at infrared image enhancement.

II. RELATEDWORK

The most straightforward and visually appealing aspect of all digital image processing methods is image enhancement. The main objective of image enhancement is to bring out elementsthatareconcealedin animageorto increase contrast

in low-contrast images. Every time a picture is transformed from one form to another, like when it is digitalized, there is some kind of output degradation. In order to process images, contrast is a crucial component. The most straightforward and visually appealing aspect of all digital image processing methods is image enhancement. The basic goal of image enhancementistorevealhiddendetailsinanimageortoboost low contrast images'contrast. Every time an image is changed from one format to another.

Examples of the initial infrared images and their enhanced impacts in various settings are provided. The pictures are of poor quality, with muddled details and little contrast, which lessenstheimage'svisual impact and affects viewers' ability to identify and comprehend the target. The infrared pictures that our technique improved are displayed in Figures 1 and 2.

Figure 1. Original image
Figure 2. Enhanced image

The enhanced infrared (IR) images exhibit notable improvements such asincreased contrast, enhanced texture details, and improved visualeffects,resultingina more comfortable viewing experience. Thus, image enhancement has attracted more and more attention from researchers [1]–[5].

An important method for improving the clarity of the picturesin a system is imageenhancement. Theprimary goals of image enhancement are to improve contrast in low contrast images and to reveal details that are hidden in the picture. Using the histogram equalisation method, it is possible to significantly increase the brightness and contrast of poor-quality IR pictures.

Using bi-interval histogram equalisation with details, HaoxizngLuet al.[2] focused on improving the contrast of infrared images by using multi-scale convolution to enhance the image details, taking the maximum intra-class varianceand the minimum inter-class variance as the fitness function and solving it by genetic algorithm.

Chen, Feiran, Jianlin Zhang, and others [8] proposed a novel approach for showing high-dynamic-range infrared images on conventional display apparatus with adequate contrast and distinguishing detail information.

1. To maintain the weak global characteristics in different sections of the image, the original normalised image is translated into numerous brightness levels using an adaptive gamma transformation method.
2. Using the multiscale guided filter, the images in the various brightness sections are split into a base layer and

detail layers independently. The nuances of each photograph are enhanced individually.
3. The enhanced pictures are combined in each brightness level to create an image with all of the world features ofthe original image.

Image fusion using the laplacian pyramid and wavelet transform technique is thecentre of Mukane,Shailendrakumar, and Ghodake et al[9] .'s study. The primary driver behind the suggestion of this approach is recent developments in the area of image fusion techniques. MSE, NAE, and PSNR are used to gauge the performance of the picture fusion method.

Asamoah et al. [10] concentrate on three contrast enhancement techniques for image enhancement, namely Histogram Equalization (HE), Adaptive Histogram Equalization (AHE), and Contrast Limited Adaptive Histogram Equalization (CLAHE). These techniques are then compared using the eight (8) quality image measurement metrics.

B ACHAR, Swathi, M S, Sannidhan, and BHANDARI, Abhir have conducted a comparative analysis of quality measures for a number of image improvement approaches, including contrast modifications, histogram equalization, adaptive histogram equalization, and unsharp masking [11]. The results are then contrasted with different metrics for measuring image quality, including the peak signal-to-noise ratio (PSNR), mean squared error (MSE), and structural similarity index (SSIM).

According to Lal, S., and Chandra, M. [12], a useful algorithm that has two major phases is displayed forenhancing the contrast of natural images. 1) The sigmoid function is modified to analyse the low-quality picture. 2. Using the CLAHE (Contrast Limited Adaptive Histogram Equalization) technique, pictures acquired from the result of the previous step are once more handled to improve contrast.

Based on the observation of HE, Stark, J. A. et al.[13] suggested AHE (Adaptive Histogram Equalization), a novel methodforenhancing imagecontrast.Here, avitalcomponent known as the cumulation function was utilised to construct a grey-level mapping of the image from the HE.

A review of different techniques for evaluating image clarity was given by Ruikar, J. D., et al. in their article [14]. Along with the initial picture, a different database was made that contained twelve variations of the same image. Eleven picture quality measures were applied to the aforementioned database, resulting in an estimated image quality score.

III. PROPOSEDSYSTEM

Imageenhancement is amethodforenhancing images that involves modifying digitalimages so that theresults arebetter suited for exhibition or additional image analysis. Consequently, it is a crucial pre-processing stage that is employed in vision systems and numerous picture processing apps. The primary goal of image enhancement is to make changestoimagesthatmakethevisualmaterialeasierfor

humans or machines to recognize. The figure in this paper's structureforthesuggestedpictureenhancementtechnique.The primarygoalofthisresearchistousetheclosestneighborhood pixelmatchingmethodtoproduceadrawingofhigherquality, and to assess the enhanced sketches' improved sketch quality metrics. The block diagram for the proposed system is shown below in the figure 3

We divided this method into several blocks. Firstly, the edges of the image are detected because those pixels are very importantpixelsforfurtherprocessingbuttopreventthisedge
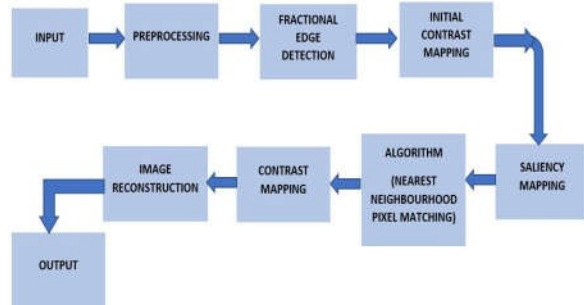
informationLaplacian operator is used. Secondly, initial contrast mapping is done to the pre-processing block where nearest neighborhood contrast pixel matching algorithm is applied.Then,sensitivepixelsoftheinputimagearecalculated by using filter and finally, final contrast mapping is applied to the infrared image where nearest neighborhood contrast pixel matching algorithm is applied.

Figure3.BlockDiagram

A. Pre-processing

The primary goal of pre-processing is to raise the image's quality so that it may be examined more thoroughly. Pre-processingallowsforthesuppressionofundesirabledistortions and the enhancement of features required for a certain application. Here, Median filter is used which is used to removenoiseandtopreservetheedgeinformationoftheinput image.Byusingmedianfilter,weareseparatingnoisefromthe image which is displayed as a noise co-efficient data and the filtered data is shown separately. The output of the pre-processing block is shown in the figure below.

Figure3.NoiseCo-efficientdataFigure4.Filtereddata

B. EdgeDetection

Theconceptofedgedetectionisusedtodetectthepresence andlocationofedgesbyvaryingtheintensityofanimage.In

image processing, various operations are used to detect edges. It can detect variations in grey levels, but it responds quickly when noise is detected. Edge detection is a critical task in imageprocessing.Edgedetectionisthemaintechniqueusedin sceneanalysis,picturesegmentation,andpatternidentification. The edge points of a picture are extracted using this filter. An picture undergoes sudden alterations when the edge contours across the brightness of the image. To retrieve the boundary informationfrom an input image by takinginitial pixelweight map and 2Dkernel matrix is convoluted with the inputimage. The output of the fractional edge detection block is shown in thefigure5 below.

Figure5.Fractionaledgedetection

C. NearestNeighbourhoodcontrastPixelMatching Algorithm

In this block, each pixel of the image are padded individually and then, the weighted average of the nearest neighborhoodpixelsistakenwhichisreplacedwiththecentral pixel of the pixel which is padded within the nearest neighborhood of the considered pixel.

D. ContrastMappingandSaliencyMapping

Contrast mapping may be a strategy utilized in picture handling to map one set of gray levels within the picture to modern values through gray-level transformation. Saliency mappingmaybeawaytomeasurethespatialbackboneof aparticularlessonineachpicture.Asaliencyoutlineisbuiltby utilizingtheslopesoftheyieldofanimageovertheinput. Here, initial contrast mapping, saliency mapping and final contrastmappingaredonetoextractthesmoothimagepassing through several levels of mapping technique which are shown in the below figure 6, figure 7 and figure 8.

Figure6.Initialcontrastmapping

Figure7.Saliencymapping   *Figure8.Finalcontrast mapping*

E. ImageReconstruction

In the image reconstruction block, the edge details and necessary information that are extracted previously are convolutedwiththeprocessedimagetogetalosslessenhanced image with high clarity and better resolution. Image reconstruction is simply known as resolution enhancement because the processed image lacks necessary details such as edge information which are added to it before producing the final enhanced output image. The image reconstruction part is very important because without this process the final output image would be vague and incomplete.

F. FinalEnhancedOutputImage

Figure9.FinalEnhancedOutputImage

Thefinalenhancedimageshownbelow,clearlyshowsthat there is no noise in the image and the clarity of the image has improved highly with better resolution. The fuzzy details presentintheoriginalimagehasbeenremovedwheretheedge detailsare extractedin thepre-processingblock and theimage is processed throughout the other blocks. Then, the necessary details with edge information are convoluted and the final enhancedoutputimageisproduced.Thefinalenhancedimage is shown is below figure 9.

IV. QUANTITATIVEANALYSIS

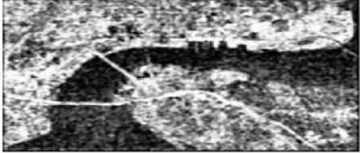| PSNR	58.5981
MSE	0.0897
RMSE	0.2996

Theperformanceofthis algorithmismeasuredby quantitativemetricssuchasPSNR,MSEandRMSEwhichare used to compare with other algorithms. Quantitative analysis for above original and enhanced images is tabulated below.

Table 1.Performanceparametersforproposedmethod

A.Comparisonwithotheralgorithm

In this study, we conducted enhancement experiments on three distinct scenes to evaluate the effectiveness of our approach. For all three scenes the original images and the enhancedimagesofbothouralgorithm(NNCPM)andexisting algorithm (ABHE) were compared and analyzed. In below tables the comparison of ABHE algorithm with NNPCM algorithm on all three images are shown along with their respective PSNR, MSE, and RMSE values.

Table2.ComparisonofABHEwithNNCPMalgorithm

	Adaptive Bi-Interval Histogram Equalization	Nearest Neighbourhood Contrast Pixel Matching
Original Image		
Enhanced Image		
PSNR	57.7324	62.2985
MSE	0.1104	0.0383
RMSE	0.3323	0.1957

From table 2., The original infrared image is characterized by low brightness, poor visual quality, and insufficient prominence of detail features. However, by employing the NNCPM algorithm, the image undergoes enhancement, resulting in significantly improved quality compared to the ADHE method. The disadvantage of ADHE is it will too brighten the original image but that not the case in NNCPM algorithm. The higher the PSNR, thebetterthe quality of the compressed,orreproduced,picture.Theconditiontodecide thePSNR'sesteemisgiveninEquation1.ThePSNRvalue 68.7579 which is higher than the existing shows that our method has better performance. The lower the value of MSE andRMSE,thelowertheerror.Theequationtodetermine

MSEandRMSEvalueisgiveninequation2andequation3.In abovetable,the MSEand RMSEvaluesofourmethod isvery low which shows that the image enhanced is noise-free.

From table 3., we can see that the image enhanced by ADHE have overexposure and the edges are blurred resulting inimageblurring.Meanwhile,theimageenhancedbyNNCPM algorithm has higher quality compared to ADHE and the blur has been removed. Our method makes the image smoother by enhancingthefuzzydetails.ThePSNRvalue60.6731whichis higher than the existing shows that our method has better performance. In addition, the MSE and RMSE values of our method is very low which shows that the image enhanced is noise-freeindicatingithasbetterperformance.

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Table3.ComparisonofABHEwithNNCPMalgorithm
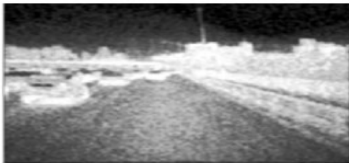
	Adaptive Bi-Interval Histogram Equalization	Nearest Neighbourhood Contrast Pixel Matching
Original Image		
Enhanced Image		
PSNR	57.7087	60.6731
MSE	0.1110	0.055689
RMSE	0.3332	0.235985

		Adaptive Bi-Interval Histogram Equalization	Nearest Neighbourhood Contrast Pixel Matching
Table4. Comparison of ABHE with NNCPM algorithm	Original Image		
	Enhanced Image		
	PSNR	57.7263	68.7579
	MSE	0.1106	0.0086
	RMSE	0.3326	0.0930

Page No: 6

In above table 4, ready to see that the picture upgraded by the ADH calculation isn't self-evident, and the brightness is stilldim,demonstrating that thepicturequality isstilllow. On theotherhand, theimageenhancedbyourmethod NNCPMis prominent, clear and the details are processed with brightness and high quality. The PSNR value 62.2985 which is higher than the existing shows that our method has better performance. In addition, the MSE and RMSE values of our method which are very low or nearly zero which shows the image has less error than other.

V.   .CONCLUSION

The proposed method has a novel infrared image enhancement technique, that is, the nearest neighbourhood contrast pixel matching algorithm. In this technique, an image with lowest clarity is enhanced to a higher quality image with better resolution. Many approaches for infrared image enhancementhavebeendeveloped,butourproposedalgorithm hasadifferentapproachinwhicheachpixelispaddedandthen the average of the nearest neighbourhood pixels is taken and replacedwiththecentralcontrastpixel,inordertoenhancethe infrared image. The input image is first pre-processed and fractional edge detection is done to remove unwanted details and noise from the image. Then, pattern analysis takes place followedbyinitialcontrastmappingandsaliencymappingare done to avoid the loss of sensitive pixels. After that, the main process, nearest neighbourhood pixel matching technique is done to the present output image followed by contrast mapping. The enhancedoutput imageisthen reconstructed,so

that the final output image will not lose any necessary details. The peak-signal-to-noise ratio (PSNR), mean squared error (MSE) and root mean squared error (RMSE) are measured to understand the efficiency of the output image. The proposed algorithm enhances the infrared image which is usually affectedbythermalradiationintheatmosphereandprovides a high-resolutionoutputimagewhichhelpsinunderstandingthe details in the image better. Comparing to other infrared image enhancementtechniques,ourproposedalgorithmisconsidered tobethebestwithbettertimecomplexity.Ourfutureworkwill focus on improving thistechnique to overcome the drawbacks involving scenes in which the light is too dim or too bright.

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Page No: 8