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Comparative Study of Image Enhancement and Analysis of Thermal Images Using Image Processing and Wavelet Techniques

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Abstract

Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Thermal image enhancement used in Quality Control ,Problem Diagnostics,Research and Development,Risk Management Programme,Digital infrared thermal imaging in health care, Surveillance in security, law enforcement and defence. Various enhancement schemes are used for enhancing an image which includes gray scale manipulation, Histogram Equalization (HE), fast Fourier transform, Image fusion and denoising.Image enhancement is the process of making images more useful. The reasons for doing this include, Highlighting interesting detail in images, removing noise from images, making images more visually appealing, edge enhancement and increase the contrast of the image.

Keywords: *Adaptive filtering, Denoising, fast Fourier transform, histogram equalisation, Image enhancement, Image fusion, linear filtering, morphology, opening and closing.*

I. INTRODUCTION

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Digital image processing is used in various applications in medicines medicine, space exploration, authentication, automated industry inspection and many more areas.

II. IMAGE ENHANCEMENT AND ANALYSIS TECHNIQUES OF IMAGE PROCESSING

Image enhancement is actually the class of image processing operations whose goal is to produce an output digital image that is visually more suitable as appearance for its visual examination by a human observer

- ⬄ The relevant features for the examination task are enhanced
- ⬄ The irrelevant features for the examination task are removed/reduced
- Specific to image enhancement:

- Input = digital image (grey scale or color)

- Output = digital image (grey scale or color)

2.1. Conversion of the RGB image into GRAYSCALE image:

In RGB images each pixel has a particular colour; that colour is described by the amount of red, green and blue in it. If each of these components has a range 0–255, this gives a total of 256^3 different possible colours. Such an image is a "stack" of three matrices; representing the red, green and blue values for each pixel. This means that for every pixel there correspond 3 values. Whereas in greyscale each pixel is a shade of gray, normally from 0 (black) to 255 (white). This range means that each pixel can be represented by eight bits, or exactly one byte. Other greyscale ranges are used, but generally they are a power of 2.so, we can say gray image takes less space in memory in comparison to RGB images

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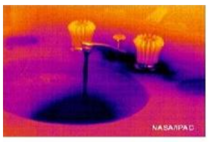
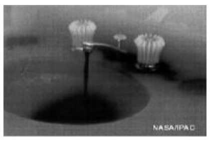


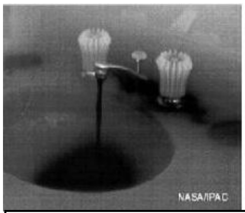
Original image (RGB image)



Gray scale image

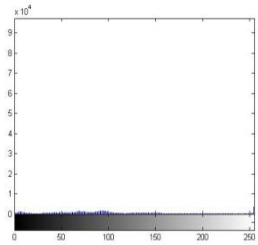
2.2 **HISTOGRAM, HISTOGRAM EQUALISATION AND CONTRAST ENHANCEMENT**

The histogram of an image shows us the distribution of grey levels in the image massively useful in image processing, especially in segmentation .The shape of the histogram of an image gives us useful information about the possibility for contrast enhancement. A histogram of a narrow shape indicates little dynamic range and thus corresponds to an image having low contrast.istogram equalization is used to enhance the contrast of the image it spreads the intensity values over full range. Histogram equalization involves finding a grey scale transformation function that creates an output image with a uniform histogramUnder Contrast adjustment, overall lightness or darkness of the image is changed. Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds A contrast stretch improves the brightness differences uniformly across the dynamic range of the image,

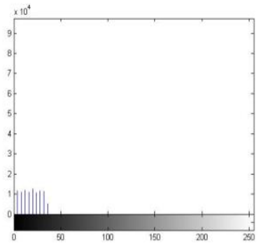


Gray scale image

Resulting image after Histogram equalisation image



Gray scale image histogram



Resulting histogram after histogram equalisation

2.3 Linear filtering and noise removal image

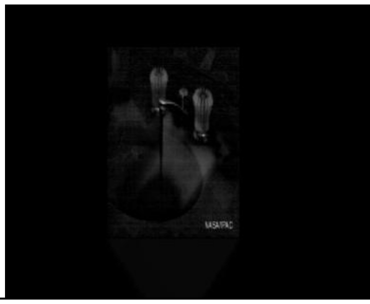
Filtering is a technique for modifying or enhancing an image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement. Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighbourhood. The noise is removed by adaptive filtering approach, often produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high-frequency parts of an image

Filtered image after the histogram

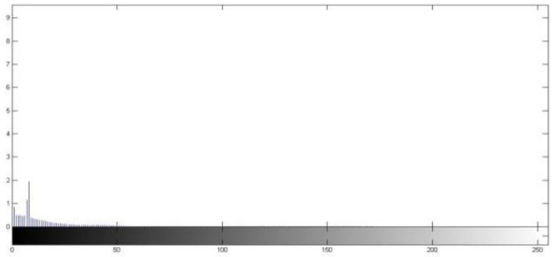
Noise removal image by adaptive filtering

2.4 Morphology:

Morphological techniques typically probe an image with a small shape or template known as a **structuring element.** The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Morphological operations differ in how they carry out this comparison. Mathematical morphology is based on geometry. The theoretical foundations of morphological image processing lies in set theory and the mathematical theory of order. The basic idea is to probe an image with a template shape, which is called structuring element, to quantify the manner in which the structuring element fits within a given image.



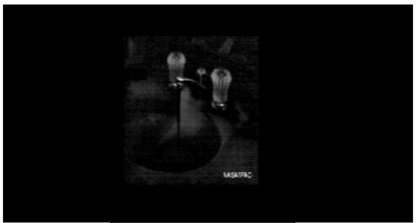
output = I – B, where output is the image obtained after the removal of non-uniform background (B) from greyscale image (I) uniform background throughout the image



Output histogram of the above image

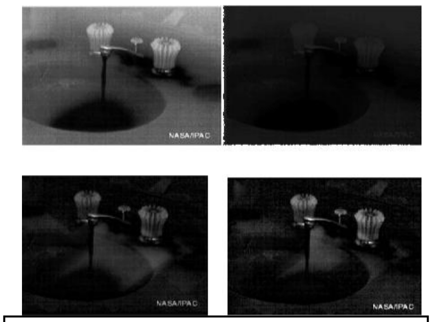
2.4. FFT transforms:

FFT function is an effective tool for computing the discrete Fourier transform of a signal. In Fourier transform it actually changes the domain of the image. In this we get the restored image after taking the inverse FFT. The FFT contains information between 0 and fs; however, we know that the sampling frequency must be at least twice the highest frequency component. Therefore, the signal's spectrum should be entirely below fs/2, the Nyquist frequency.



FFT image

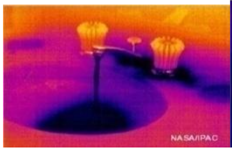
III. RESULTS FROM IMAGE PROCESSING TECHNIQUES:

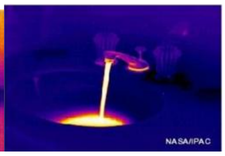


(a) Gray scale image (b) resulting image after histogram equalisation (c) image after morphological operation (d) restored image after the fft transform

IV. VARIOUS TECHNIQUES OF WAVELET:

Wavelet analysis is capable of revealing aspects of data that other signal analysis techniques miss aspects like trends, breakdown points, discontinuities in higher derivatives, and self-similarity. Furthermore, because it affords a different view of data than those presented by traditional techniques, wavelet analysis can often compress or de-noise a signal without appreciable degradation. There are so many techniques to enhance an image that I have used in this to enhancement. There are two thermal images on that I have applied enhancement methods:





4.1 IMAGE FUSION:

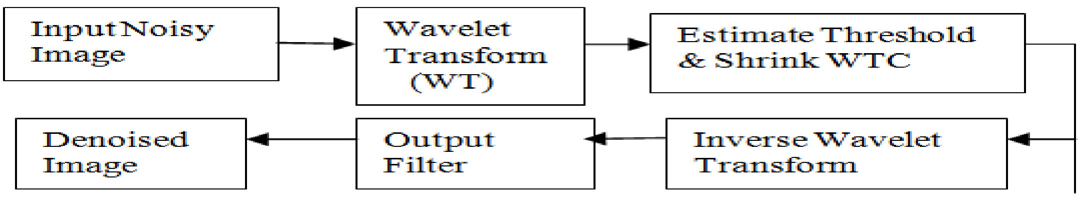
In general, the problem that image fusion tries to solve is to combine information from several images (sensors) taken from the same scene in order to achieve a new fused image, which contains the best information original images The wavelets-based approach is appropriate for performing fusion tasks for the following reasons:

[1] It is a multiscale (multiresolution) approach well suited to manage the different image resolutions. In recent
[2] Years, some researchers have studied multiscale representation (pyramid decomposition) of a signal and
[3] Have established that multiscale information can be useful in a number of image processing applications including the image fusion.
[4] The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information.
[5] Such coefficients coming from different images can be appropriately combined to obtain new coefficients, so that the information in the original images is collected appropriately.
[6] Once the coefficients are merged, the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved.
[7] Hence, the fused image has better quality than any of the original images

4.2 DENOISING IMAGE:

The image usually has noise which is not easily eliminated in image processing. According to actual image characteristic, noise statistical property and frequency spectrum distribution rule, people have developed many methods of eliminating noises, which approximately are divided into space and transformation fields The space field is data operation carried on the original image, and processes the image grey value, like neighbourhood average method, wiener filter, centre value filter and so on. The transformation field is management in the transformation field of images, and the coefficients after transformation are processed. Then the aim of eliminating noise is achieved by inverse transformation, like wavelet transform. Successful exploitation of wavelet transform might lessen the noise effect or even overcome it completely.
The general wavelet denoising procedure is as follows:

- Apply wavelet transform to the noisy signal to produce the noisy wavelet coefficients to the level which we can properly distinguish the PD occurrence.
- Select appropriate threshold limit at each level and threshold method (hard or soft thresholding) to best remove the noises.
- Inverse wavelet transforms of the threshold wavelet coefficients to obtain a denoised signal



Block diagram of Image denoising using wavelet transform.

4.3 COMPRESSED IMAGE:

Images require much storage space, large transmission bandwidth and long transmission time. The only Way currently to improve on these resource requirements is to compress images, such that they can be transmitted quicker and then decompressed by the receiver.In image processing there are 256 intensity levels (scales) of grey. 0 is black and 255 are white. Each Level is represented by an 8-bit binary number so black is 00000000 and white is 11111111. An image Can therefore be thought of as grid of pixels, where each pixel can be represented by the 8-bit binary Value for grey-scale."Image compression algorithms aim to remove redundancy in data in a way which makes image reconstruction possible." This basically means that image compression algorithms try to exploit redundancies in the data; they calculate which data needs to be kept in order to reconstruct the original image and therefore which data can be 'thrown away'. By removing the redundant data, the image can be represented in a smaller number of bits, and hence can be compressed

Two fundamental components of compression are redundancy and irrelevancy reduction.

- Redundancy reduction aims at removing duplication from the signal source (image/video).
- Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS).

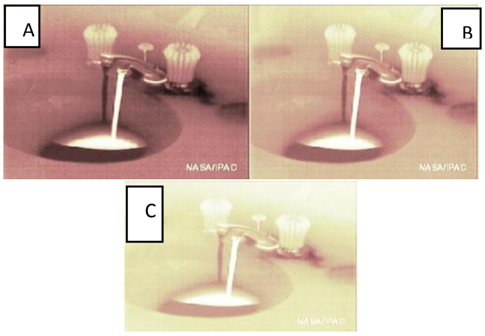
(A) By global Thresh holding method: balance Sparsity norm Retained energy=99.90, No. of zeros=93.64

(B) By global Thresh holding method: remove near zero Retained energy=100 No. of

(c) By global Thresh holding method: balance Sparsity norm (sqrt)
Retained Energy=99.99
No. Of zeros=91.91

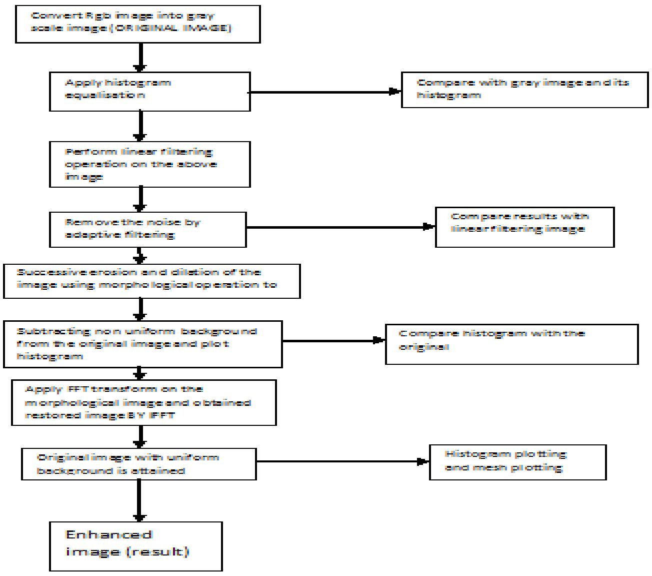
(d) By level thresh holding:
scarce low
Retained energy=100%
No. of zeros= 61.51%

V. RESULTS FROM WAVELET TECHNIQUES:



(a) Fusion image (b) denoised image(c) Compressed image

VI. PROPOSED FLOW CHART OF IMAGE PROCESSING:



VII. COMPARATIVE RESULTS

The result obtained from the wavelet techniques is better than the image processing techniques. The image gets enhanced using wavelet techniques in comparison to image processing. The enhancement of an image is easy through wavelet as in comparison to the image processing. The denoised image and compressed image is also better and is easy to obtain result through wavelet by using graphical user interface.

VIII. CONCLUSION

This work highlights the successful application of wavelet based methods for analysis of thermal images. Although in wavelet, global thresholding can be used successfully to compress images it is difficult to find a global threshold that will give near optimal results because of how the different detail sub signals differ. Global Thresholding leads to unnecessary energy losses in order to obtain a certain compression rate.

Therefore it is more logical to use local thresholds. The image processing work indicates that histogram equalization technique can't be used for images suffering from non-uniform illumination in their backgrounds specifically for particle analysis purposes as this process only adds extra pixels to the light regions of the image and removes extra pixels from dark regions of the image resulting in a high dynamic range in the output image.

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