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Morphological Improvement of Infrared Images Using Nonlinear Approach

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This paper presents a novel enhancement approach for infrared images. This algorithm combines the benefits of the top-hat transform and the nonlinear approach. The idea of this proposed algorithm is based on apply the top-hat transform on IR image. This transform gives as the image the same resolution. The non- linear approach processing is performed on the resultant image. It is known that the non-linear model processing on images is performed, to adapt the local luminance mean and the local contrast mean of IR image. Morphological Enhancement of top hat filter reinforces details in the IR image. The performance of the proposed algorithm is the contrast improvement factor (CIF) point of view. This proposed algorithm is enhanced to obtain an infrared image with the best visual details.

Keywords: Morphological Image Processing, IR Images, Nonlinear Enhancement Method,

The Proposed Enhancement Approach.

I. INTRODUCTION

Digital image processing has their applications in intelligent transportation systems like automatic number plate recognition, traffic sign recognition, weather forecasting, and in medical field for diagnosis of diseases, satellite systems, remote areas, space research etc [1]. The high quality of an image is the main requirement and may be obtained using image enhancement algorithms. The image enhancement is a visual perception. Image enhancement is the method to improve the quality of images in term of contrast, brightness and sharpness. The main objective of image is to improve an image to the processed image is more suitable for a certain set of the applications. Image enhancement is the simplest and most appealing areas of the digital image processing. The basic idea behind enhancement algorithms is to bring out detail that is obscured, and highlight certain features of interest in an image [2].

IR Imaging is a basic technology in a lot of the applications in thermal medical imaging and biomedical diagnostics devices.IR refers to the region beyond the red end of the visible colour spectrum, a region located between the visible and the microwave regions of the electromagnetic spectrum.IR images are the source of information that is mainly used in night time applications, such as night vision driver assistance systems, military applications, surveillance systems etc. Infrared image processing is a new field emerging for the evolution of night vision cameras. This evolution of night vision cameras has encouraged the research in infrared image enhancement for information extraction from these images. These images have a special nature of large black areas and small details due to the absence of the appropriate amount of light required for imaging. So, the main objective is to reinforce the details to obtain as more details as possible. The improvement of infrared images is slightly different from traditional image improvement in dealing with the large black areas and the small details [3-6]. The paper presents a new nonlinear approach for Morphological Improvement of Infrared Images .This approach is based on applying the top hat transform for Infrared Images and then performs nonlinear approach to modify the local contrast and local luminance mean in a certain method, and uses it in several of the applications [7].As IR Images have characteristic nature of large black and less details .So in this paper we develop proposed approach in image enhancement to solve this problem to strong the details of the IR images. One method to such a problem is improving and adapting the local contrast and the local luminance mean of the IR images.

The rest of the paper is organized as follows: section 2 explains Morphological Image Processing. Section 3 explains The Top-hat Transform Section 4 explains Nonlinear Enhancement Method. Section 5 presents The Proposed Enhancement Approach. Section 6 surveys the contrast Improvement Factor. Section 7 gives the experimental results. Finally, section 8 gives the concluding remarks.

II. MORPHOLOGICAL IMAGE PROCESSING

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image, such as boundaries. In any given technique, we probe an image with a small shape or template called a structuring element, which defines the region of interest or neighborhood around a pixel. Morphological methods apply a structuring element to an input image, creating an output image at the same size. The value of each pixel in the input image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighbor. Morphological operations such as erosion, dilation, opening, and closing. Often combinations of these operations are used to perform morphological image analysis [8-11]. Morphological operations apply structuring elements to an input image, creating an output image of the same size. Irrespective of the size of the structuring element, the origin is located at its center .We outline the following basic morphological operations.

II.1 MORPHOLOGICAL EROSION

Morphological erosion operation sets a pixel at (i, j) to the minimum over all pixels in the neighborhood centered at (i, j).

$$f \ominus b] = \min_{(s,t) \in b}(i+s, j+t) \qquad (1)$$

Where f is original image and b is structuring element

II.2 Morphological Dilation

Morphological dilation operation sets a pixel at (i, j) to the maximum over all pixels in the neighborhood centered at (i, j). Morphological dilation operation enlarges bright regions and shrinks dark regions.

$$f \oplus b] = \max_{(s,t) \in b}(i+s, j+t) \qquad (2)$$

Where f is original image and b is structuring element

II.3 MORPHOLOGICAL OPENING

Morphological Opening on an image is defined as the erosion operation followed by the dilation operation. Morphological Opening can remove small bright spots (“salt”) and connect small dark cracks. We can simplify the image structure while avoiding the shrinkage effects of erosion by performing the dilation operation after the erosion operation. The resulting operation is called Opening:

$$f \circ b = (f \ominus b) \oplus b \qquad (3)$$

Where f is original image and b is structuring element and ○ denotes the opening operation.

II.4 MORPHOLOGICAL CLOSING

Morphological Closing on an image is defined as the dilation operation followed by the erosion operation. Closing can remove small dark spots (pepper) and connect small bright cracks. In order to simplify the image structure while avoiding the expansion effects of dilation, one can perform an erosion operation after the dilation operation. The resulting operation is called closing

$$f \bullet b = (f \oplus b) \ominus b \qquad (4)$$

Where f is original image and b is structuring element and • denotes the closing operation.

III. THE TOP-HAT TRANSFORM

In mathematical morphology and digital image processing, top-hat transform is an operation that extracts small elements and details from given images. The top-hat transform is defined as the difference between the input image and its opening by some structuring element, Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others[12].

The top-hat transform of the original image is given by this equation:

$$T_{hat}(f) = f - f \circ b \qquad (5)$$

Where f is original image and b is structuring element and ○ denotes the opening operation.

Properties of the top-hat transform that the top-hat transform returns an image, containing those objects or elements of an input image that are smaller than the structuring element and are brighter than their surroundings.

IV. NONLINEAR ENHANCEMENT METHOD

An image can be used represented as two parts as following equation [3, 6] :

$$f(n1, n2) = f_L(n1, n2) + f_H(n1, n2) \quad (6)$$

$f(n1, n2)$ is original infrared image, $f_L(n1, n2)$is local luminance mean,$f_H(n1, n2)$ is local contrast.

To improving the IR image, then, is to increase$f_H(n1, n2)$and decrease$f_L(n1, n2)$.the local luminance mean is modified by a nonlinearity resulted $f'_L(n1, n2)$ and local contrast is modified by multiplication factor $k\ (f_L)$resulted $f'_H(n1, n2)$. The specific functional form of $k\ (f_L)$ depends on the particular application under consideration, and $k\ (f_L) > 1$represents the local contrast increase while $k\ (f_L) < 1$ represents local contrast decrease. This modification used as follow takes a larger $k\ (f_L)$and choose the nonlinearity taking into account $f_L(n1, n2)$change and $f_H(n1, n2)$ increase. This method adapts the local contrast and the local luminance mean in a specific method. The results are combined to obtain the improved infrared image, $g(n1, n2)$ with the best details as in the following equation [9]:

$$g(n1, n2) = f'_L(n1, n2)\ f'_H(n1, n2) \quad (7)$$

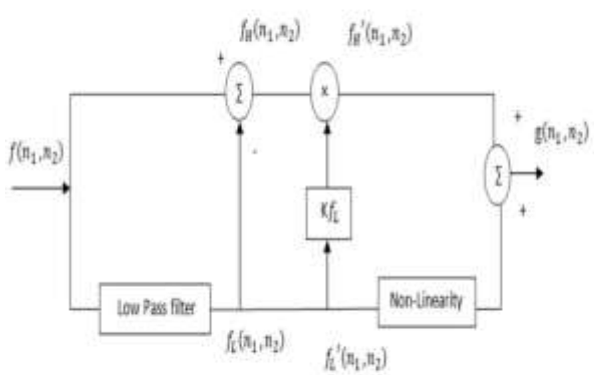

Fig. 1: Block Diagram of the Nonlinear Enhancement Method

V. THE PROPOSED ENHANCEMENT

In this approach, we merge the benefits of the top-hat transform and the nonlinear Enhancement Method First, the IR image is performed using the top hat transform. Then, the transformed IR image is processed, using the nonlinear approach to reinforce its details. These steps of the proposed approach can be summarized as follows.

1. Apply the top hat transform to the original infrared image , $f(n1, n2)$ to obtain the transformed infrared image.
2. Apply the low pass filtering to the transformed infrared image to obtain the local luminance mean$f_L(n1, n2)$.
3. Perform a subtraction operation $f_L(n1, n2)$ from $f(n1, n2)$to obtain the local contrast $f_H(n1, n2)$.
4. Modify$f_H(n1, n2)$bymultiplying $f_H(n1, n2)$ with a scalar factor $k(f_L)$, $f'_H(n1, n2)$.
5. Modify $f_L(n1, n2)$by non linearity function, $f'_L(n1, n2)$.
6. Combine the modified local contrast and local luminance mean to obtain the enhanced infrared image $g(n1, n2)$

VI. THE CONTRAST IMPROVEMENT FACTOR

The Contrast is the difference in luminance that makes an object distinguishable. The contrast (C) of an object is defined as follows

$$C = \frac{f - b}{f + b} \quad (8)$$

Where f is the mean grey level of particular object in the image and b is the mean grey level of the background of the image.

The performance of the proposed approach is evaluated by the contrast improvement factor is defined as follows [13]

$$C_{IF} = \frac{C_P}{C_O} \quad (9)$$

Where C_P and C_O are the contrast Values of enhanced image and original image, respectively.

VII. EXPERIMENTAL RESULTS

In this section, two experiments are performed on different infrared images to test the performance of the proposed enhancement approach. The steps of the technique mentioned in section (5). For the purpose of evaluation metric for IR image quality is the contrast Improvement Factor of the IR image. The results of the first experiment are shown in Fig. (2). Part (a) gives the original IR image. Part (b) gives enhanced IR image after the top hat transform. Part (c) gives the enhanced IR image using the proposed algorithm. With comparing between Part (b) and Part (c) it is clear that the proposed enhancement algorithm has enhanced the visual quality of the processed image and the proposed algorithm has higher value than the top hat transform. The contrast Improvement Factor results are given in table (1).

A similar experiment is carried out on other infrared images and the results are given in Fig. (3).From these results, due to the darkness of IR images, it is expected that their the contrast Improvement Factor will be small and the contrast Improvement Factor of enhanced image increased.. It's shown that this algorithm has succeeded in the Improvement of the visual quality of that infrared image and the best details have been obtained. From these results, it's clear that the proposed approach has succeeded in obtaining the best results in the improvement of IR images than the top hat transform from both the visual quality and the contrast Improvement Factor points of view.

Table(1)

Quality Metrics	Experiments	Top hat Transform	Proposed Approach
C_{IF}	First Experiment	1.2388	1.7458
C_{IF}	Second Experiment	1.8591	1.9477

(a) Original IR Image

(b) IR Image after Top hat Transform

(a) Enhanced IR Image

. Fig.(2) Results of the third experiment.

(a) Original IR Image

(b) IR Image after Top hat Transform

(a) Enhanced IR Image

Fig. (3) Results of the third experiment.

VIII. CONCLUSION

The paper presented a novel Morphological approach for Improvement of Infrared Images Using Nonlinear method. This approach improve the IR images and adapts the local luminance mean of the transformed IR image and controls the local contrast as a function of the local luminance mean of the transformed IR image after the top hat transform. This feature of the algorithm is useful in a variety of application problem. For typical infrared images, it is often desirable for visual purposes to increase the local contrast. The results obtained using this algorithm reveals its high ability to enhance infrared images.

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