ENHANCEMENT OF INFRARED IMAGE: A REVIEW

PRATIK G. ANGAITKAR*, PROF KHUSHBOO SAXENA
Department Of Information Technology (M-Tech), Technocrats Institute Of Technology, Bhopal, M..P. India

Abstract-This paper provides an up-to-date critical survey of enhancement of infrared images by two popular algorithms namely spatial and spatiotemporal homomorphic filtering (SHF and STHF) based upon a infrared imaging model. Although spatiotemporal homomorphic filtering may reduce the number of iterations greatly in comparison to spatial one for a similar degree of convergence by making explicit use of the additional information provided temporally, the enhanced results from SHF are in general better than those from STHF. To provide this comprehensive survey we have not only focused on concept of infrared image but also two enhancement techniques are presented and discussed along with their advantages and disadvantages
Key words -- Infrared Images, Image Enhancement, Additive Wavelet Transform, Homomorphic Enhancement, Spatiotemporal homomorphic filtering.

I. INTRODUCTION

Infrared (IR) light is electromagnetic radiation with a wavelength longer than that of visible light, measured from the nominal edge of visible red light at 0.74 micrometers, and extending conventionally to 300 micrometers. These wavelengths correspond to a frequency range of approximately 1 to 400 THz,[1] and include most of the thermal radiation emitted by objects near room temperature. Microscopically, IR light is typically emitted or absorbed by molecules when they change their rotational-vibrational movements. Images received through various infrared (IR) devices in many applications are distorted due to the atmospheric aberration mainly because of atmospheric variations and aerosol turbulence [1] [2].

A. CIE division scheme

The International Commission on Illumination (CIE) recommended the division of infrared radiation into the following three bands:

- IR-A: 700 nm–1400 nm (0.7 µm – 1.4 µm, 215 THz - 430 THz).
- IR-B: 1400 nm–3000 nm (1.4 µm – 3 µm, 100 THz - 215 THz).
- IR-C: 3000 nm–1 mm (3 µm – 1000 µm, 300 GHz - 100 THz).

B. Sub-division scheme

A commonly used sub-division scheme is:

- Near-infrared (NIR, IR-A *DIN*).

0.75-1.4 µm in wavelength, defined by the water absorption, and commonly used in fiber optic telecommunication because of low attenuation losses in the SiO_2 glass (silica) medium. Image intensifiers are sensitive to this area of the spectrum. Examples include night vision devices such as night vision goggles.

- Short-wavelength infrared (SWIR, IR-B *DIN*):

1.4-3 µm in wavelength, water absorption increases significantly at 1,450 nm. The 1,530 to 1,560 nm range is the dominant spectral region for long-distance telecommunications.

- Mid-wavelength infrared (MWIR, IR-C *DIN*)

Also called intermediate infrared (IIR): 3-8 µm in wavelength. In guided missile technology the 3-5 µm portion of this band is the atmospheric window in which the homing heads of passive IR 'heat seeking' missiles are designed to work, homing on to the Infrared signature of the target aircraft, typically the jet engine exhaust plume.

- Long-wavelength infrared (LWIR, IR-C *DIN*):

8–15µm in wavelength. This is the "thermal imaging" region, in which sensors can obtain a completely passive picture of the outside world based on thermal emissions only and requiring no external light or thermal source such as the sun, moon or infrared illuminator.

Far infrared (FIR): 15 - 1,000 µm NIR and SWIR is sometimes called "reflected infrared" while MWIR and LWIR is sometimes referred to as "thermal infrared." Due to the nature of the blackbody radiation curves, typical 'hot' objects, such as exhaust pipes, often appear brighter in the MW compared to the same object viewed in the LW.

Infrared images received through various infrared (IR) devices. In many applications images are distorted due to the atmospheric aberration mainly because of atmospheric variations and aerosol turbulence [1], [2]. New algorithmic strategies have been presented to enhance the visual quality of IR images. The idea is to model the IR image pixels as an input output system with IR image as the input and a 'similar' optical image as the output.

The additive wavelet transform is the technique for enhancing the image and getting more information due to applying this technique. First decomposes an image into subbands using the "a' trous" filtering approach [6–8] in several consecutive stages. The low pass filter used in this process has the following mask for all stages [8].

$$H = \frac{1}{256}\begin{pmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{pmatrix}$$

Each difference between filter outputs of two consecutive stages is a subband of the original image. We can use these subbands for further processing using homomorphic enhancement Technique. An image can be used represented as a product of tow components as in the following equation [9]:

f (n1, n2) = i (n1, n2) r (n1, n2)………(1)
where, f(n1, n2) is the obtained image pixel value, i(n1, n2) is the light illumination incident on the object to be imaged and r(n1, n2) is the reflectance of that object. It is known that illumination is approximately constant since the light falling on all objects is approximately the same. The only change between object images is in the reflectance component. If we apply a logarithmic process on Eq. (1), we can change the multiplication process into an addition process as follows:

log(f (n1, n2)) = log (i ((n1, n2)) + log (r (n1,n2))………(2)
The first term in the above equation has small variations but the second term has large variations as it corresponds to the reflectivity of the object to imaged. By attenuating the first the higher frequency subbands. The homomorphic enhancement algorithm uses for transforming these details to illumination and reflectance components. Then the reflectance components will be amplified showing the detail and clearly. Finally a wavelet reconstruction process is performed to get more informative, enhanced infrared image based on characteristics such as scale, shape, texture, pixel value dynamic range, pixel value statistical distribution, spatial frequency, brightness, and contrast differences.
The enhancement of infrared images is slightly different from traditional image enhancement in dealing with the large black areas and the small details. So suggested approach aims at separating the details in different subbands and processing each subband, separately. We have found that the additive wavelet transform is a powerful tool in image decomposition. If the infrared image is decomposed using the additive wavelet transform, the details can be separated into the higher frequency subbands. Due use the homomorphic enhancement algorithm for transforming these details to illumination and reflectance components.

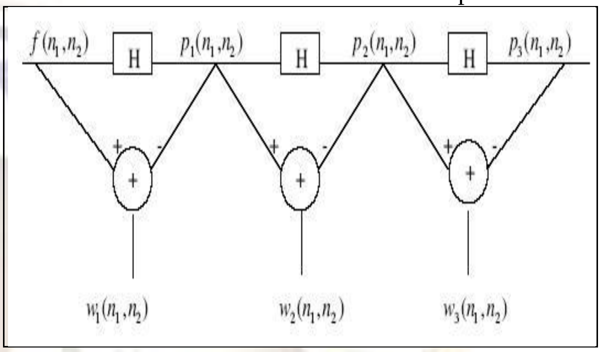

Fig. 1. Additive wavelet decomposition.

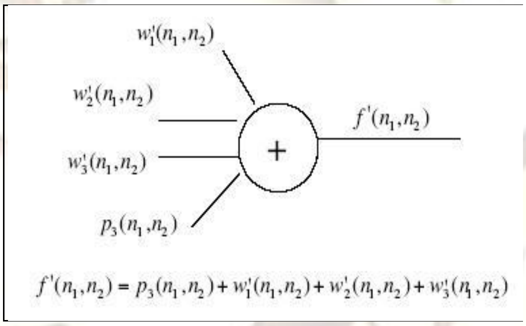

Fig. 2. Wavelet reconstruction.
The reflectance components are amplified showing the details and clearly. Finally a wavelet reconstruction process is performed to get an enhanced infrared image with much more details.

II. LITERATURE REVIEW

The two algorithms called spatial and spatiotemporal homomorphic Filtering i.e. SHF and STHF were designed. The second one makes explicit use of the temporal information provided by the image sequence so that an enhancement faster than that obtained by utilizing the spatial homomorphic Filtering was obtained. STHF will spend much lower iterations and much fewer time to obtain a resulting images for a similar degree of convergences the enhance images are in general not as good as those from SHF.

Dim target detection is particularly challenging because standard techniques such as spatial, thresholding, and edge detection can fail due to the lack of contrast between target and background. To detect targets in clutter, there must be a set of characteristics that can be exploited to separate targets from clutter. Separation can be based on characteristics such as scale, shape, texture, pixel value dynamic range, pixel value statistical distribution, spatial frequency, brightness, and contrast differences.

Qi, H. and J. F. Head [1] suggested that Wavelets have demonstrated some effectiveness for target detection. Traditionally, there are four primary applications of wavelet-based methods to target detection: These are as Follows:

- Wavelets as edge detectors.
- Using wavelets to separate targets from clutter based on scale differences.
- Using wavelets as approximate matched filters.
- Capturing target dynamic range differences using wavelet filters.

Using wavelets as edge detectors assumes that target edges differ in some way from clutter edges. For example, edges from natural clutter may be more diffuse whereas edges from man-made objects such as vehicles may be harder, sharper, and more distinct. Kuruganti, P. T and H. Qi [2] and Scales, N., C. Herry, and M. Frize [3] stated as edge detectors, wavelets may be designed to capture these edge differences. Zhang, C. J., F. Yang [4] stated that targets may also differ from clutter by characteristic scales. For scale separation, a priori knowledge of target or clutter characteristic scales may be exploited. Wavelet coefficients containing significant energy at clutter scales (or non-target scales) may be filtered out.

Andreone, L., P. C. Antonello and M. Bertozzi [5] stated that wavelets can be also designed to function as approximate matched filters. For such usage, wavelet filters are designed to produce a large response when matched against a target region. Lastly, the low and high pass filters from the wavelet decomposition can be used to detect target regions of low or high pixel value dynamic range. Dim targets occur in low dynamic range regions; regions of high dynamic range can be rejected.

Image enhancement is a very popular field in image processing. Enhancement aims at improving the visual quality of an image by reinforcing edges and smoothing flat areas. Several researchers have evaded this field using different approaches such as simple filtering, adaptive filtering, wavelet denoising, homomorphic enhancement etc. All these approaches concentrate on reinforcing the details of the image to be enhanced.

Infrared image processing is a new field emerging for the evolution of night vision cameras. It also has applications in thermal medical imaging. 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 get as more image information as possible.

III. COMPARISION OF SHF, STHF And ADDITIVE WAVELATE TRANSFORM

A. Spatial homomorphic Filtering(SHF)

- IT Requires more iteration i.e. more time
- Enhance image quality is not much good.
- SHF is not uses the temporal information.

B. Spatiotemporal homomorphic Filtering (STHF)

- IT requires lower iteration i.e. less time as compare to SHF.
- Enhance Image quality is much good as compare to SHF.
- STHF is use the temporal information provided by the image.

C. Additive Wavelet Transform

- Very few Iteration as compare to SHF & STHF.
- This technique is very fast as compare to SHF & STHF.

IV. DRAWBACKS OF IR-IMAGES

- Wave length of Infrared Image is Low.
- Infrared enabled devices are not cost efficient.

V. APPLICATIONS

- **Night Vision Images**

Infrared is used in night vision equipment when there is insufficient visible light to see. Night vision devices operate through a process involving the conversion of ambient light photons into electrons which are then amplified by a chemical and electrical process and then converted back into visible light. Infrared light sources can be used to augment the available ambient light for conversion by night vision devices, increasing in-the-dark visibility without actually using a visible light source.

- **Heating**

Infrared heating is also becoming more popular in industrial manufacturing processes, e.g. curing of coatings, forming of plastics, annealing, plastic welding, print drying. In these applications, infrared heaters replace convection ovens and contact heating.

- **Communications**

IR data transmission is also employed in short-range communication among computer peripherals and personal digital assistants. These devices usually conform to standards published by IrDA, the Infrared Data Association. Remote controls and IrDA devices use infrared light-emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a silicon photodiode to convert the infrared radiation to an electric current. It responds only to the rapidly pulsing signal created by the transmitter, and filters out slowly changing infrared radiation from ambient light. Infrared communications are useful for indoor use in areas of high population density. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances. Infrared remote control protocols like RC-5, SIRC, are used to communicate with infrared.

- **Meteorology**

Weather satellites equipped with scanning radiometers produce thermal or infrared images which can then enable a trained analyst to determine cloud heights and types, to calculate land and surface water temperatures, and to locate ocean surface features. Clouds such as Stratus or Stratocumulus show up as grey with intermediate clouds shaded accordingly. Hot land surfaces will show up as dark grey or black.

VI. CONCLUSION

This review paper presents new techniques to enhancing the infrared image i.e. SHF, SHTF and additive wavelet Transform, the homomorphic enhancement. The homomorphic processing is applied to the infrared image subbands separately. Then, these subbands are merged again to reconstruct an enhanced image [8].

VII. REFERENCES

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