Noise Filtering on Thermal Images Acquired by Modified Ordinary Digital Camera

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***Abstract*— In this paper, we report our experimentation to enhance the quality of the thermal images acquired with ordinary digital camera, after replacing the infrared stopping filter with visual stopping one. The Red, Green, Blue histograms indicate very low intensities captured by the respective sensors. Histogram stretching increased the hot objects' and the inherent noise visibility. Finally lowpass as well median filtering were applied, where the later is best for suppressing granular noise and maintaining the intended thermal images.**

***Keywords*: modified ordinary digital camera, lowpass filtering, median filtering, thermal images**

I. Introduction

Ordinary or consumer digital cameras are constructed to be most sensitive to visible light of wavelengths 400 to 700 nm. However, the actual range of the working sensors is beyond this range and covers the NIR as well as the UV wavelength proportionally. Therefore, it is worth looking into the possibility of modifying these cameras to gain thermal images.

II. The Background

Temperature is the measure of every object's thermal energy. The temperature measurement methods for objects are based on some temperature scales. Any object heat measurement is based on the thermal energy transferred from the object to the sensor, directly or indirectly via the infrared emission which is captured from a distance by special sensors. The data received from a non-contact temperature measurement appear as an image which represents the temperature distribution over the monitored object [1, 2, 3].

Naturally, infrared emission is related to the radiated heat transfer, which as an electromagnetic wave having wavelengths between the visible light and the microwave. Therefore, if we replace the thermal wave blocking hot mirror with a visual blocking filter, we expect to see the differences in the histogram patterns of the R, G, and B data which bear the information of the infrared image captured [4]. We also foresee high random noises due to low sensitivity of the RGB sensors in the IR range.

III. The Objective of the Research

The objective of the research is to improve the quality of images acquired by the modified digital camera, which is operated in near-infrared (NIR) spectrum range, based on some appropriate digital filtering scheme.

IV. The Underlying Theory

Today's digital cameras rely basically on their solid-state light sensors which generally sensitive to a wide range of electromagnetic wave spectrum beyond the visible band. Removing the residing infrared stopping filter and replacing it with a visible light one, we are left with NIR images [3, 5].

The underlying theory of the absorption of the radiation energy by a sensor is a mechanical equivalent to heat. Based on this theory, which is confirmed by laboratory experiment, mechanical energy can be in the form of kinetic and/or potential energy, while the thermal energy normally appears as radiation phenomenon. Sensors for the radiation energy convert it into the kinetic energy of the electrons. This electrons mobility in turns generated the output voltage and/or current of the sensors.

A. The Image Processing

An image processing is a process to search for information contained in an image. Fig. 1 shows a block diagram of the overall main image processing system.

Information content in an image can be enormous and various, depending on the subjects of interest. Searching for some specific information, the original image must be pre-processed, to enhance the visibility of the expected information. The end result is ready for display, storage, and/or transmission to other place [6].

Here, we attempt to utilize the sensors which are able to capture the electromagnetic radiation in the infrared (IR) wavelengths. Proper enhancement and filtering processes should be looked into thoroughly on the data acquired by the RGB sensors of an ordinary digital camera.

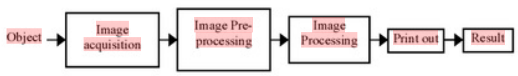


Figure 1. The block diagram of a typical diagram image processing steps.

B. The Spatial Filter

Many image enhancement techniques are based on some spatial operations performed on local neighbourhood of every input pixel. In contrast with spectral filters, spatial ones involve much less computations in reducing the interfering noises and in bringing out the intended characteristics of certain objects in the image. Therefore the smoothing effect on the noises while minimizing the blurring effect on the objects of interest should be balanced resorting to the nature of the image. Noise reduction can be accomplished by blurring with linear filters as well as by nonlinear filters [7].

C. The Spatial Lowpass Filtering

The output of smoothing linear spatial filter is simply the average or weighted average of pixels within a filter mask. The size of the mask and the distribution of the weight values are to be found experimentally to guarantee high value of the resulting SNR (signal to noise ratio). Figure 2 shows the main hardware blocks used.

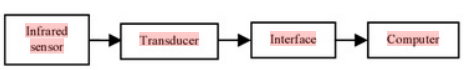


Figure 2. The four hardware blocks in our research.

D. The Median Filtering

The algorithm for median filtering requires arranging the pixel values in a window in increasing or decreasing order and picking the middle value [7]. A median filter has the following properties:

1) It is nonlinear filter. Thus for two linear sequences x(m) and y(m)

$$\text{median}\{x(m) + y(m)\} \neq \text{median}\{x(m)\} + \text{median}\{y(m)\}$$

2) It is useful for removing isolated lines or pixels while preserving spatial resolutions.

Its performance is poor when the number of noise pixels in the window is greater than or half the number in the window.

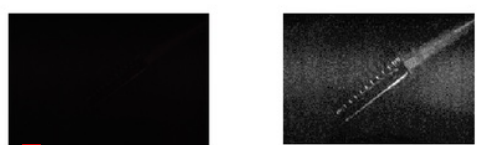
V. THE RESULTS OF THE RESEARCH

The results of our experiments are shown in Figure 3(a) and (b), where the distinct object is an electric soldering iron with its stand where the hot parts range around 50°C. The original image was obtained in “total darkness”.

Figure (a) shows the original image acquired with IR Hoya R72 filter which exhibits “total darkness”. Figure (b) after contrast stretching, which shows clearly the hot parts of the soldering iron set and the granular noise.

To focus on the image section where the brightest and the darkest parts represent the extreme conditions we zoomed to 16×16 pixels to show the sizes of the granular noises, as shown in Figure 4(a). Figure 4(b) shows the result after the application of a 3×3 gaussian lowpass spatial filtering window, while Figure 4(c) shows the result with 3×3 median filter, where the latter is better in suppressing the granular noise and maintaining the bright object. A combined filtering, where the 3×3 median filter was followed by the 3×3 gaussian lowpass one, compromises the noise suppressing effect and the blurring on the bright object, as shown in Figure 4(d).

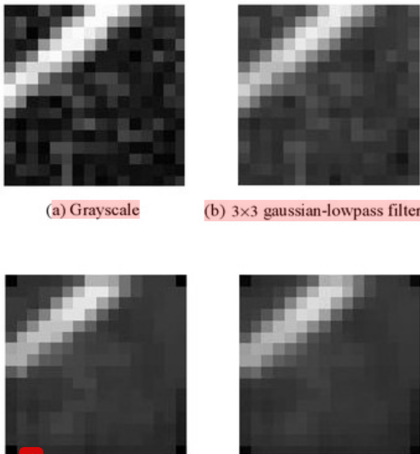
Figure 5 gives the whole 192×256 pixels image which presents the expected final result of the enhancement process.



(a) The Original Image.

(b) The image after a proper contrast stretching

Figure 3. Soldering iron image in the absence of visible light.



(a) Grayscale (b) 3×3 gaussian-lowpass filtered

(c) 3×3 median filtered (d) 3×3 median + 3×3 gaussian-lowpass filtered

Figure 4. Zoomed 16×16 pixels images.

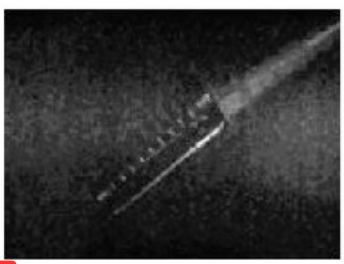


Figure 5. Soldering iron with 3×3 median filtered.

VI. CONCLUSION AND SUGGESTION

A. *The Conclusion*

The result shows that 3×3 median filter is better than 3×3 gaussian-lowpass spatial filtering window.

B. *The Suggestion*

This research could be continuing with further images processing research to get image thermal objects based on pseudo-colouring.

VII. REFERENCES

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