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Histogram Slicing to Better Reveal Special Thermal Objects

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***Abstract*—**In this paper, an experimentation to enhance the visibility of hot objects in a thermal image acquired with ordinary digital camera is reported, after the applications of lowpass and median filters to suppress the distracting granular noises. The common thresholding and slicing techniques were used on the histogram at different gray levels, followed by a subjective comparative evaluation. The best result came out with the threshold level 115 and the number of slices 3.

***Keywords*—**enhance, thermal image, thresholding and slicing techniques, granular noise, hot objects.

I. Introduction

THERMAL images acquired with a modified ordinary digital camera bear granular noises due to the overstretching of the naturally very low intensity levels. Smoothing with a lowpass spatial and median filters reduce sufficiently the visibility of these noises as well as the appearance of the hot objects.

To expose better the thermal objects of interest another nonlinear filters should be explored which do not demand complex or lengthy computations. For this, the merit of Histogram Slicing Scheme should be looked into experimentally.

II. The objective of the research

To probe further the practicability as well as the usefulness of a consumer digital camera to obtain thermal images after some standard image preprocessing, viz. The histogram stretching to enhance their overall visibility, filtering to reduce the unwanted interference as well as to increase the noticeability of the residing objects of interest.

In this case, the objects of interest are those at temperatures higher than the background. Understanding that ordinary consumer digital cameras are manufactured to record objects which emit and or reflect only visual light, the photosensors are expected to give low output in the thermal electromagnetic radiation range.

Therefore the research objective is to explore further and to find the appropriate image processing techniques to utilize the ordinary consumer digital cameras to acquire meaningful thermal images.

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III. The Underlying Theory

Point operations are zero memory operations where a given gray scale level $u \in [0, L]$ is mapped into a gray scale $v \in [0, L]$ according to a transformation $v = f(u)$ [1].

A. Contrast Stretching

Low-contrast images occur often due to poor or nonuniform lighting conditions or due to nonlinearity or narrow dynamic range of the imaging censor. Figure 1 shows a typical contrast stretching transformation, which can be expressed as the following equations

$$y = \begin{cases} \alpha u, & 0 \le u < a \\ \beta u + (1 - \dfrac{1}{b-a}) v_a, & a \le u < b \\ \gamma u + (1 - \dfrac{1}{L-b}) L, & b \le u < L \end{cases}$$

where: $\beta = \dfrac{V_b - V_a}{b - a}$ and $\gamma = \dfrac{L - V_b}{L - b}$

The slope parameter β of the transformation is chosen greater than unity in the region of stretch, whilst α and β are less than 1. The parameters *a* and *b* can be obtained by examining the histogram of the image, where particular parts of interest in the image reside.

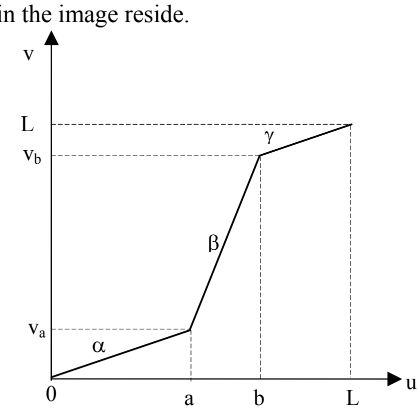


Fig. 1 Contrast stretching piecewise linear transformation curve for intensity range between a and b [1].

B. Thresholding

Thresholding is a special case of clipping where $a = b \overset{\Delta}{=} t$ and the output becomes binary (Figure 2). Thresholding creates binary images with $v_1 = 0$ (black) and $v_2 = 255$ (white). This process is applied generally for image segmentation purposes.

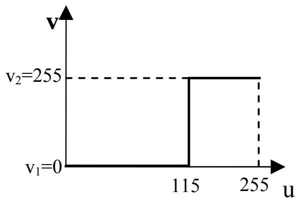


Fig. 2 Thresholding transformation curve [1].

C. Gray-level slicing

Highlighting a specific range of gray levels in certain ranges is often desired. There are several ways of doing gray-level slicing, but most of them are the variations of two basic themes. One approach is to increase the contrast among certain gray-level ranges to discriminate further objects of interest in the image. Figure 3 shows a slicing curve at four gray-levels a, b, c, and d.

The choice of the new gray levels should be done experimentally according to the operator's best visual perception. The number of slices on the other hand can be adjusted to fit the nature of the thermal objects and the background noises, e.g. two, three, or four.

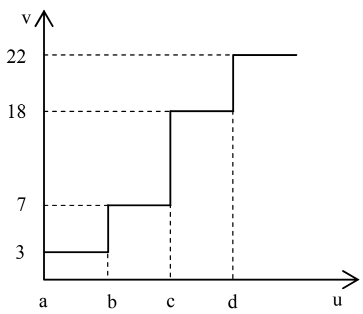
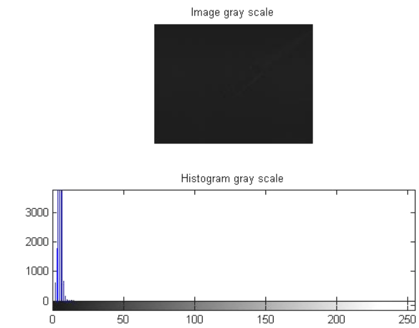


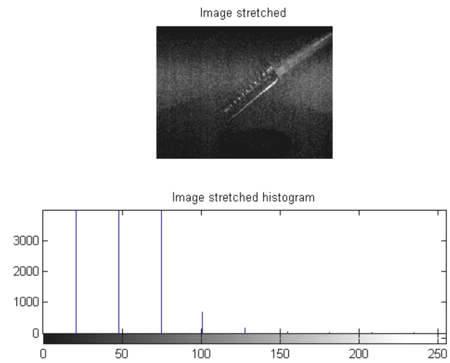
Fig. 3 Four level slicing curve at the original gray levels a, b, c, and d to gain better visibilities at the new levels 30, 77, 180, and 227, respectively.

IV. THE RESULTS OF THE RESEARCH

The results are shown in Figure 4 (a), where the object is an electric soldering iron. The original image was obtained in "total darkness", where the pixels intensity levels fall below 20 in the range up to 255. Numerical investigations show that the highest intensity level is 17, which is slightly higher than 2^4.



(a) The acquired image and its low level concentrated histogram.



(b) The hot tip of the soldering iron and the granular noise, after histogram stretching.

Fig. 4 Images and their respective histograms.

Figure 4 (b) shows the resulting histogram stretched image which show the granular noises. This is due to the excessive stretching as can be seen the widely spaced stretched histogram lines.

a) median b) lowpass c) combined median and lowpass

Fig. 5 Images after the ways of filtering.

Figure 5 shows the results of the application of median (a), lowpass (b), and combined median and lowpass (c) filtering to reduce the visibility of the annoying granular noises. Show in (a) smoother granular noise, in (b) less granular noise, and in (c) smoother and less granular noise. Blurring effects on the hot soldering tip are apparent in (b) and (c). Rougher edges are visible around the soldering tip.

a) median b) lowpass c) combined median and lowpass

Fig. 6 Image thresholding at t = 115 after the three filtering.

Figure 6 shows the effect of thresholding at t = 115 after median filtering (a), lowpass filtering (b), as well as combined median and lowpass filtering (c), where the median limits considerably the hot parts exposure and show the best effect on the granular noise, and the combined preceding filtering causes further limitation in exposing the hot parts of the soldering iron.

a) n = 2 b) n = 3 c) n=4

Fig. 7 Image median filtering and slicing with different n (number of slices).

a) n = 2 b) n = 3 c) n=4

Fig. 8 Image lowpass filtering and slicing with different n.

a) n = 2 b) n = 3 c) n=4

Fig. 9 Image combined median and lowpass filtering and slicing with different n.

In slicing the intensity levels, the increasing number of slices tend to release more details, including those caused by noises. These consequences are common with the three preprocessing filters, shown in Figures 7, 8, and 9.

V. Conclusion

A. Proper histogram slicing on thermal images obtained with a consumer digital camera can reveal better hot objects over their cooler background provided that the suited preceding filtering processes have been applied. Therefore, the nature of each thermal image should be understood properly, and the goal of the thermal imaging work is clearly defined.

B. Further and more extensive as well as intensive experiments with this low budget thermal imaging practice are hopefully can expose the merits of the ever improving quality of consumer digital camera technology.

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