Histogram Characterizations of Infrared Images Captured By a Modified Digital Camera

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Abstract

The histogram of image data, which exhibit their respective pixel’s value distributions, represents the specific characteristics to acquire the expected associated information. The infrared beams range the wavelengths from 0.78 µm to 1000 µm which substantially longer that the visible light, which can be detected by an ordinary digital camera with an addition of a visual light blocking filter.

The colors of the obtained image basically associated with those received by the camera’s R, G, B sensors, which in turn are expected to contain the relevant infrared radiation energy from the caught objects.

The results of our experiment show that different visible light filter modifies the histogram patterns significantly, but with similar basic pattern.

**Keywords:** histograms, infrared light, filter.

Introduction

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 non-directly via the infrared emission which is captured from a distance by special sensor. The data received from a non-contact temperature
measurement appear as an image which represents the temperature distribution of the monitored object.

Naturally, infrared emission is related to the radiation heat transfer, which as an electromagnetic wave having wavelengths between the visible light and the microwave. Therefore, if we use different filters for the visible light, we could see the differences in the histogram patterns of the images spread R, G, and B data which bear the information infrared image captured.

The objectives of the research
The objectives of the research is to require some information about objects captured by an ordinary camera which is operated in infrared spectrum range based on the distribution patterns of the respective R, G, and B histograms.

Literature Review
Today’s digital cameras rely basically on their solid-state light sensors which generally sensitive to a wide ranges of electromagnetic wave spectrum beyond the visible band. Replacing the infrared stopping filters with some visible light ones, we have investigated the resulting captured images by these cameras.

The underlying theory of the absorption of the radiation energy by a sensor is mechanical equivalent of 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 sensor.

Fundamental of radiation
The mathematics used to explain the main step of modern thermograph radiation theory. The Planck quantum theory assumes that the radiation is developed by a packet of discrete energy which called photon or quanta. The value of quanta depends on the radiation wavelength. The total energy per quantum, \( E \), received by multiple with Planck constant, \( h = 6.6256 \times 10^{-34} \), and radiation, \( \nu \), in cycle per second. In 1905, Albert Einstein presented quanta is particle that move in light velocity, \( c = 2.9979 \times 10^8 \) m/s. If the photon moves in light velocity, then its compliance with relativity theory, \( E^2 = c^2p^2 \), and momentum each photon \( p = E/c = h/\lambda \), photon frequency could be determine by divide light velocity with particle wavelength \( \nu = c/\lambda \). Substitute to momentum, have equation:

\[
E = \hbar \nu = \hbar c/\lambda \tag{1}
\]

Equation (1) shows that value of energy emission depend on wavelength or frequency. Shortest wavelength has highest energy per quantum photon (Fig.1). IR wavelength has range of between 0.78 \( \mu \)m to 1000 \( \mu \)m. IR area divided in three areas, i.e. near infrared (0.78-3.0 \( \mu \)m); middle infrared (3-30 \( \mu \)m); and far infrared (30-300 \( \mu \)m). Human eyes only can see little fraction of energy spectrum that emission by sun
Histogram Characterizations of Infrared Images Captured

(Visible light) [1]. However, if human wants to “see” IR radiation emission for all part (organic and an-organic), then effectively is conduct in the dark condition. Although can’t see by human eyes, but IR radiation could detection as warm on the skin, and even IR radiation of object that have temperature lower than ambient could capture because sense more cool [1, 5, 7].

![Electromagnetic wave spectrum](image)

**Figure 1:** Electromagnetic wave spectrum.

**Image Processing**

Image processing is a process to search information that contain in an image. Fig. 2 shows block diagram overall main image processing system. Information that content in an image can big amount and various, depend on subject (subjective). Searching information, original image must be preprocessing, for enhance this image, because imperfect acquisition system or receiving data and have noise.

The opposite with preprocessing part, in the end image processing have display, storage, and/or giving processing product to direct subject or transmitted to other place [3, 4]

Developing image processing technique is so far, from software or hardware aspect. Beside that, range of image acquisition is so wide, i.e. using sensor-sensor that able to capture frequency or IR wavelength. If in visible light area divided three frequency areas, then in IR area divided in 12 areas.

Histogram is the basic of processing technique in the multi spatial range. Histogram manipulation is effectively used to enhance an image. Image histogram is histogram grey level with range [0, L-1] with discrete function $h(r_k) = n_k$, when $r_k$ is grey $k$-th and $n_k$ is image value pixel in grey level $r_k$ (Gonzalez, 2008). That is can used to define histogram R, G, and B.
Absorber filter
Absorber filter use to capture infrared light, because the absorber filter can absorb visible light [6]. Absorber filter make from celluloid film that burn in the sunlight [2]. Other absorber filter that fabricated is Hoya R72 and Hoya RM90. Those filters have characteristic table that can show in Figure 3 (Hoya R72) and Figure 4 (Hoya RM90). Figure 3 shows filter Hoya R72 can pass light with range wavelength 680nm—800nm, so it hasn’t use for monitoring an object that have wavelength longer than 800 nm. Filter Hoya RM90 can use for capturing light with wavelength 640nm—2400nm (near-infrared until middle infrared area) (Fig. 4).

**Figure 2:** Block diagram image processing system.

**Absorber filter**
Absorber filter use to capture infrared light, because the absorber filter can absorb visible light [6]. Absorber filter make from celluloid film that burn in the sunlight [2]. Other absorber filter that fabricated is Hoya R72 and Hoya RM90. Those filters have characteristic table that can show in Figure 3 (Hoya R72) and Figure 4 (Hoya RM90). Figure 3 shows filter Hoya R72 can pass light with range wavelength 680nm—800nm, so it hasn’t use for monitoring an object that have wavelength longer than 800 nm. Filter Hoya RM90 can use for capturing light with wavelength 640nm—2400nm (near-infrared until middle infrared area) (Fig. 4).

**Figure 3:** Characteristic Hoya R72.

**Figure 4:** Characteristic Hoya RM90.
Research Method

Equipments of this research are: digital camera, object, absorber filter visible light lens (made by self, Hoya R72, and Hoya RM90), personal computer (PC), software MatLab V 6.2, and software Ms-Office 2003.

Research’s steps are:

a. Developed research’s equipment (Figure 5),
b. Captured object using digital camera that installed absorber filter lens,
c. Transferred object that recording in memory card camera to PC,
d. Processed captured images in order that we have image histogram red, green, and blue (RGB) level.

![Figure 5: Equipment Research Circuit.](image)

Result of the Research

Results of this research are images histogram (Fig. 6—Fig.11) for same object at the same condition and table peak RGB level (see Table 1).

Image acquisition is conducting in dark room, using digital camera, without flash, ISO 100. This condition is basic condition using are references for successive data.

Figure 6 shows image histogram RGB without absorber filter lens (i.e. visible light histogram) has peak of red level intensity $7 \times 10^4$ on byte 55, peak of green level intensity $15 \times 10^4$ on byte 20, peak of blue level intensity $12.5 \times 10^4$ on byte 20.

Figure 7 shows image histogram RGB of digital camera equipped with single absorber filter lens (made by researcher) has peak of red level intensity $2 \times 10^4$ on byte 255, peak of green level intensity $15 \times 10^4$ on byte 25, and peak of blue level intensity $12.5 \times 10^4$ on byte 255.

Figure 8 shows image histogram RGB of digital camera equipped with double absorber filter lens (made by researcher) has peak of red level intensity $2.1 \times 10^4$ on byte 255, peak of green level intensity $0.65 \times 10^4$ on byte 40, and peak of blue level intensity $0.85 \times 10^4$ on byte 255.

Figure 9 shows image histogram RGB of digital camera equipped with single absorber filter lens (made by researcher) has peak of red level intensity $1.55 \times 10^4$ on byte 255, peak of green level intensity $0.65 \times 10^4$ on byte 50, and peak of blue level intensity $0.85 \times 10^4$ on byte 255.

Figure 10 shows image histogram RGB of digital camera equipped with filter Hoya R72 (R72). R72 passes light with wavelength between 680nm—800nm. Figure 10 shows image histogram RGB has peak of red level intensity $16 \times 10^4$ on byte 255, has peak of green level intensity $7 \times 10^4$ on byte 10, and has peak of blue level intensity $5 \times 10^4$ on byte 15.

Figure 11 shows image histogram RGB of digital camera equipped with filter
Hoya RM90 (RM90). RM90 passes light with wavelength between 640nm—2400nm. Figure 11 shows image histogram RGB has peak of red level intensity $10 \times 10^4$ on byte 255 peak of green level intensity $4 \times 10^4$ on byte 10, and peak of blue level intensity $4 \times 10^4$ on byte.

Fig. 7, Fig. 8, Fig. 9, and Fig 11 have similar form, differences only the value of peak and intensity each level. Fig. 11 shows that the histogram has highest peak intensity, so that information that Hoya RM90 tends passed image with red level. Histogram in Fig. 7—Fig. 9 shows intensity red level have peak same relatively $(1.55 \times 10^4—2.1 \times 10^4)$ on byte 255, but in blue level have peak between $0.7 \times 10^4$ to $0.85 \times 10^4$ on byte 255. These show image captured with digital camera equipped absorber filter made by researcher passes red level and blue level, but similar with RM90.

Fig. 7—Fig. 11 show cutting intensity red level consequence filtering visible light after filter lens equipped on the digital camera, so its to influence number of pixels and intensity red level image object. Using absorber filter lens we have result different pattern image histogram RGB level if comparing with digital camera without filter.

**Figure 6:** Image histogram RGB without absorber filter lens.  
**Figure 7:** Image histogram RGB with single absorber filter lens.  
**Figure 8:** Image histogram RGB with double absorber filter lens.  
**Figure 9:** Image histogram RGB with six absorber filter lens.
Table 1: Peak red level (R), green level (G), and blue level (B).

<table>
<thead>
<tr>
<th>No.</th>
<th>Object</th>
<th>Position</th>
<th>Height ($\times 10^4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R  G  B</td>
<td>R  G  B</td>
</tr>
<tr>
<td>1</td>
<td>Without absorber filter lens</td>
<td>55 20 20</td>
<td>7 15 12.5</td>
</tr>
<tr>
<td>2</td>
<td>Single absorber filter lens</td>
<td>255 25 255</td>
<td>2 0.6 0.7</td>
</tr>
<tr>
<td>3</td>
<td>Double absorber filter lens</td>
<td>255 40 255</td>
<td>2.1 0.65 0.85</td>
</tr>
<tr>
<td>4</td>
<td>Six absorber filter lens</td>
<td>255 50 255</td>
<td>1.55 0.65 0.85</td>
</tr>
<tr>
<td>5</td>
<td>Hoya R72</td>
<td>255 10 15</td>
<td>6 7 5</td>
</tr>
<tr>
<td>6</td>
<td>Hoya RM90</td>
<td>255 10 10</td>
<td>10 4 4</td>
</tr>
</tbody>
</table>

Conclusion and Suggestion

Conclusion
The result shows that different absorber visible light filter modifies the histogram pattern significantly different.

Suggestion
This research could be continuing with research about infrared light with other infrared devices.

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References


