Chapter 4

Experiment

4.1 Introduction

According to the proposed AWB methods as described in Chapter 3, the following experiments were designed to evaluate the feasibility and robustness of the algorithms. The first part of all is the experiment of using the *modified* illuminant estimation method. The second is the experiment of using the 2-D scene analysis method. Following is method for solving color constancy. After that, the performance test and comparison will be also presented.

4.2 Illuminant Estimation Algorithm

An experimental system has been set up to test illuminant estimation algorithm. The flow chart is shown in **Fig. 4-1**. Via the testing results of the Gaussian Model, we found it has relation on the mean values of each categories in the normalized chroma plane. After analyzing the experimental data, we suggest that (r, b) chroma plane should be chosen to distinguish each categories. Several experiments are made to verify the proposed method, including the relation of color temperature and mean value in different normalized chroma plane and relation of the different interval color temperature in each categories. The experimental system and method are shown in the following sections.

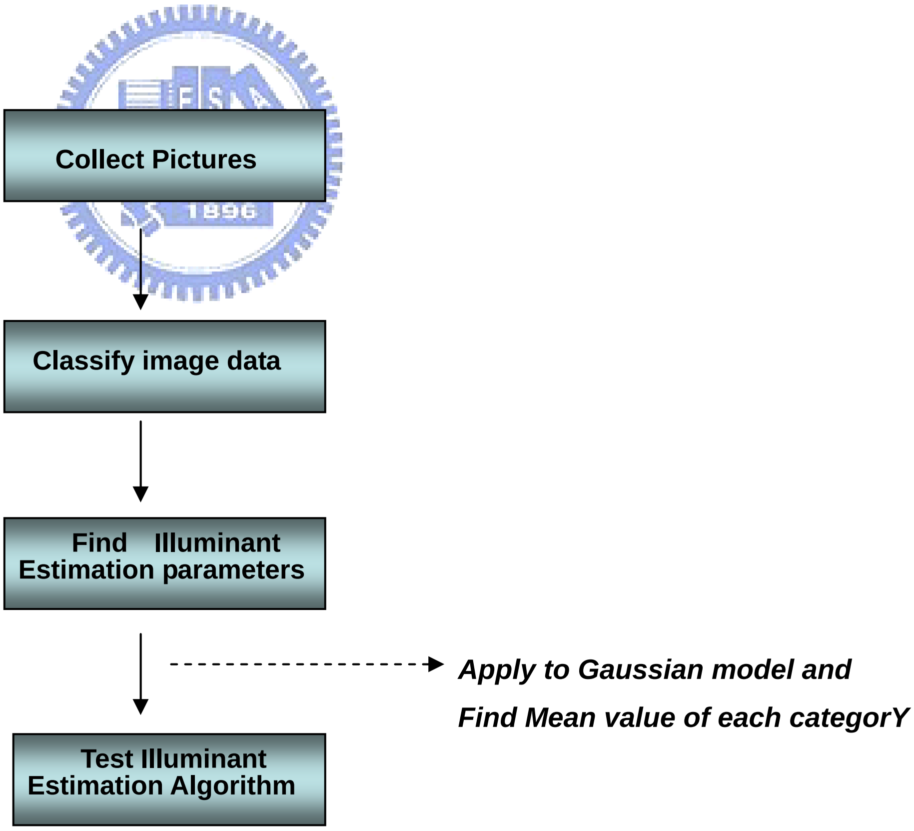

Fig. 4-1 Experimental flow chart of illuminant estimation models

4.2.1 Pictures Collecting

The DSC (Canon G5) was utilized in manual model to control the exposure parameters:exposure time (T), F-number (A) and ISO speed (S). The ISO was set at 100 to fix the light sensitivity of DSC. To avoid the image gamma effects, we took pictures with raw data format which is the original digital signal from imaging sensor. The image data include two categories：

✧ **Simulation image data**

In the illuminant estimation experiment, the simulation system has set up and illustrated in **Fig. 4-2**. Our target was Panon matching system which was 1131 different colored patches which we illuminated with a number of illuminant/filter combinations. A 5500 k solar light source was combined with Kodak color filters to obtain 15 illuminant ranging from 2800 K to 9300 K. A diffuser is placed in front of the light source to uniformize light distribution. The Chroma Meter and Minolta CS100 are used to calibrate the color temperature of light source. A DSC, Canon G5, on the manual mode is used as the platform to simulate the illuminant estimation process. The captured images are transferred into PC and analyzed through MatLab.

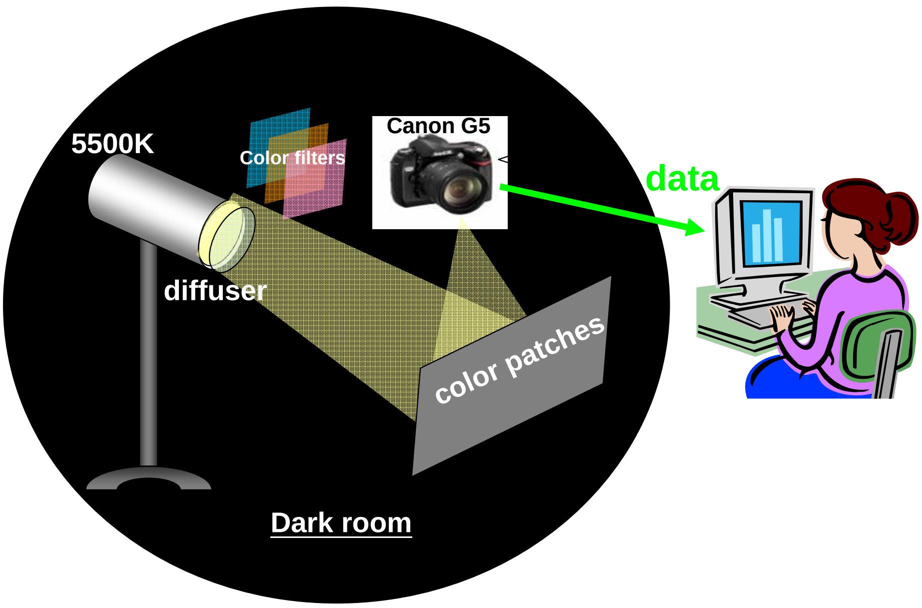

Fig.4-2 Configuration of the illuminant estimation system in simulation

✧ **Natural scene image data**

1920 natural scene pictures was collected under different weather and daytime as our image database. Our goal is to gather all kinds of color which occurs usually in camera scenes.

Scene contain：

1. Countryside view (333 scenes)
2. City street (476 scenes)
3. Market (57 scenes)
4. Sunset view(55 scenes)
5. Sea (77 scenes)
6. Sky (74 scenes)
7. Lake (48 scenes)
8. Flower and Fruit (123 scenes)
9. People with different background (365 scenes)
10. Scene contain Colorcheck(312 scenes)

4.2.2 Image Data Classification

In our experiment, we used two color temperature standards to classify image data.

✧ **Color temperature measured by Chroma Meter**

Here we use Minota c-102 Chroma Meter to capture color temperature of images.

✧ **Color temperature measured by Photoshop Cs**

Photoshop Cs is a solution to define the color temperature of images. The interface is shown in Fig.4-3. The image there for testing was captured in the sunny afternoon and color temperature is 4200 K measured by Photoshop Cs, while it is 4500 K measured by Chroma Meter.

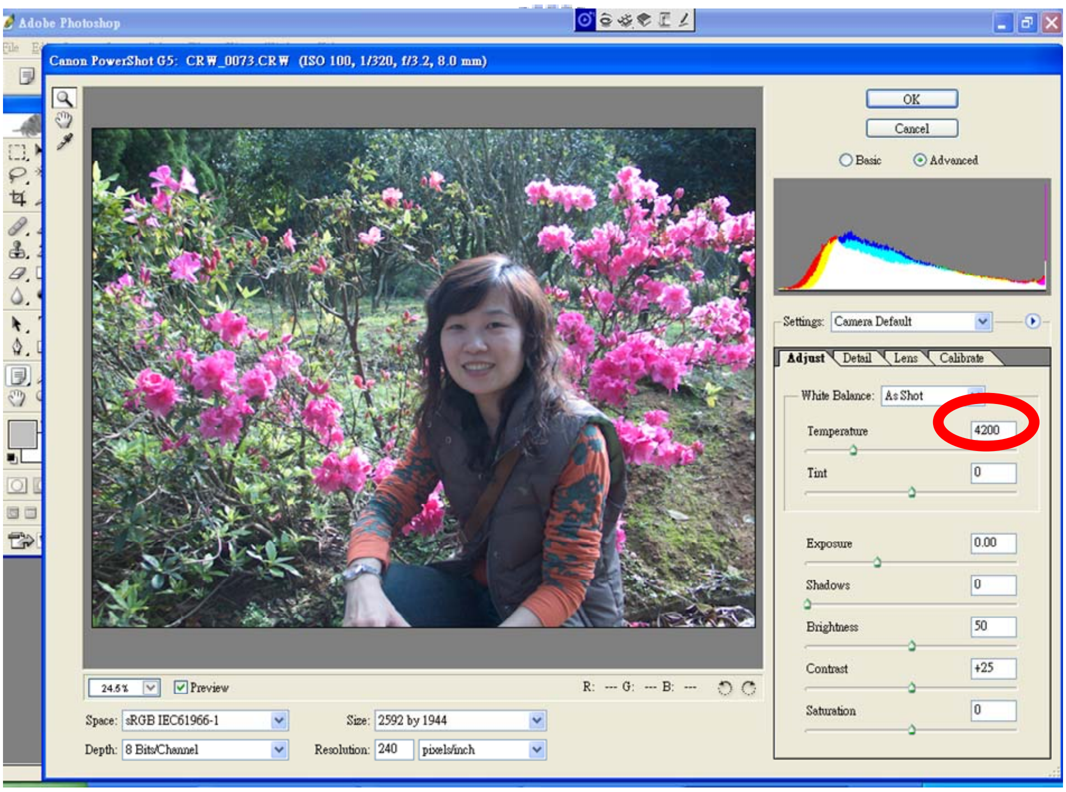

Fig.4-3 The Interface of Photoshop Cs

4.2.3 Illuminant Estimation Parameters

After image classification, the parameters used in illuminant estimation should be evaluated. We input each category in order, transform raw to BMP format and estimate the pixel values. In order to reduce the noise, we clipped pixels whose values are over 240 and also excluded any pixel whose R, G, or B pixel value, was 5 or less. Therefore, The gray levels of image was roughly 5 to 240. Use this information to have statistic data and build a chromaticity probability distribution for each category which are classified as light sources with color temperature. Finally, by using the equation (3-5), we can get mean values and covariance matrix to be used as illuminant estimation parameters.

The procedure to calculate parameter values is as follow：

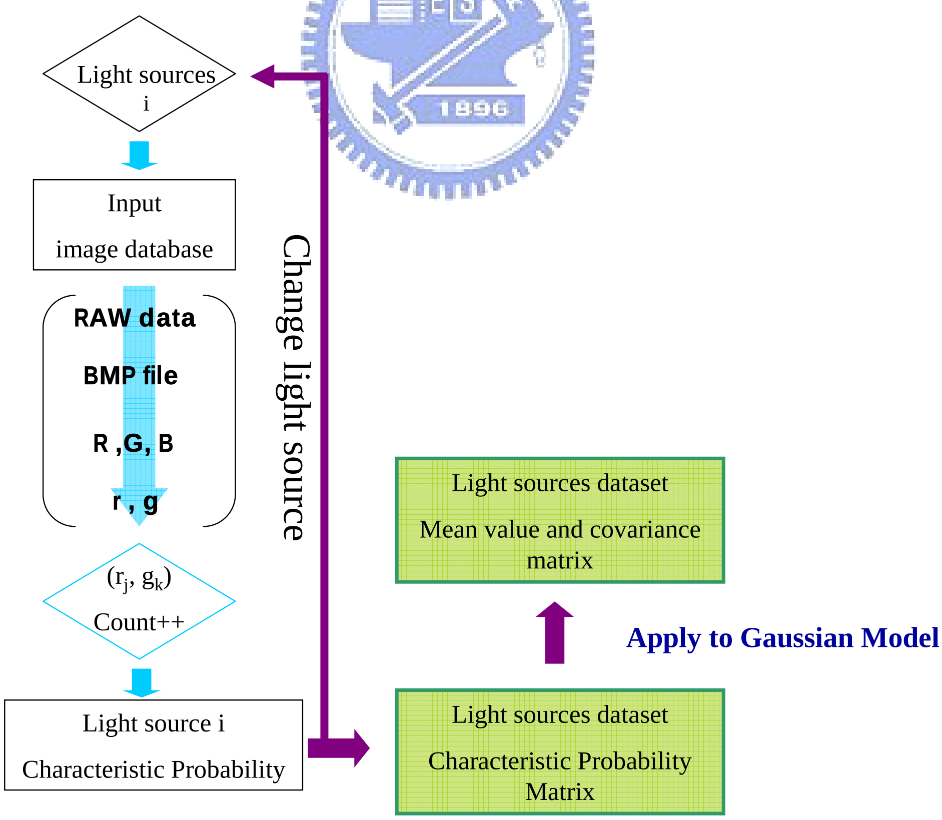

Fig.4-4 The flow chart for getting illuminant estimation parameters

First, image pictures have been classified by illuminant color temperature. Following we transform raw to BMP format and calculate the pixel values to determine which image colors are present in the images which are classified to the same group.Then, this information is coded in probability distribution and characterize as Gaussian parameters. So as the other illuminant color temperature groups.

To obtain the pixel values and luminance (Y) of images, we choose NTSC standard formula that is as follows:

$$r=R/(R+G+B) \qquad \textbf{(4-1)}$$

$$b=B/(R+G+B) \qquad \textbf{(4-2)}$$

$$g=G/(R+G+B) \qquad \textbf{(4-3)}$$

$$Y = 0.229R + 0.587G + 0.114B \qquad \textbf{(4-4)}$$

Where r, g, b are normalized gray values in the R, G and B pixels, respectively.

4.3 The illuminant of 2-D Scene Analysis

To implement our scene analysis in the practical application, the simulations for optimized results are performed. The flow of the analysis process is shown in **Fig. 4-5**. Initially, we collected a lot of pictures under various conditions. A simulation system was set up to find the optimal color temperature by the learning via the classified image data. Then, the performance of the proposed algorithm was tested through the simulation of AWB process on PC and compared with other white balance methods. Here, both of Euclidean distance and Mahalanobis distance methods, were applied to analyze the desired images whose illuminant we wish to estimate.

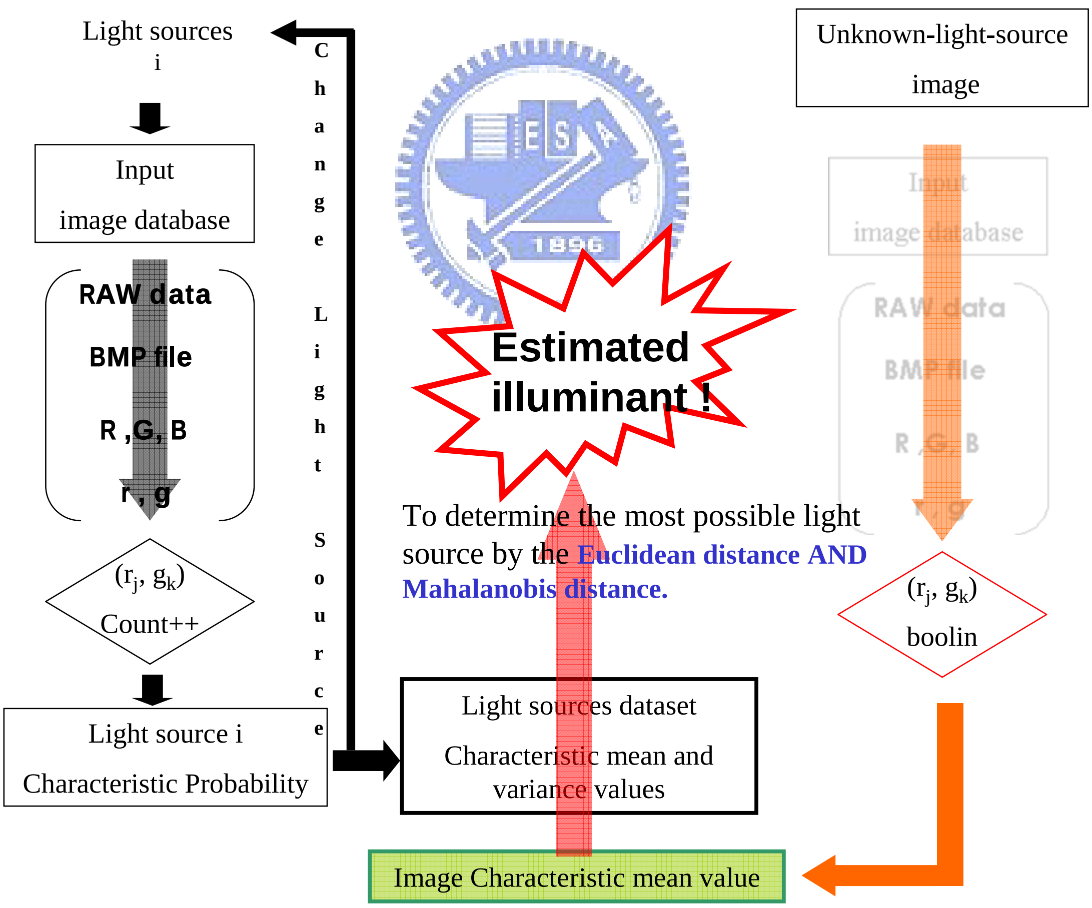

Fig. 4-5 The flow chart of illuminant estimation of unknown images.

Given a characteristic mean and variance values of database and an image whose illuminant we wish to estimate, we perform the following steps. First, we transform raw to BMP format and calculate the pixel values to determine which image colors are present in the image. This information is coded in probability distribution and characterize as Gaussian parameters. Then, we determine a measure of the correlation between the image data and each of possible illuminants. The simply expression of a correlation is as Euclidean distance and Mahalanobis distance. For example, if $\underline{a}$ and $\underline{b}$ are vector of mean value, they are strongly correlated if $(\underline{a}-\underline{b})^{\wedge 2}$ is small. As result, an estimation of the unknown illuminant can be obtained.

4.4 Solving for Color Constancy

The simulation system was set up as illustrated in **Fig. 4-6**. Our target was Macbeth color checker with 24 color matte which we illuminated with a number of illuminant/filter combinations. A 5500 k solar light source was combined with Kodak color filters to obtain 15 illuminants ranging from 2800K to 9300k. A diffuser was placed in front of the light source to uniformize light distribution. The Chroma Meter and Minolta CS100 were used to calibrate the color temperature of light source. A DSC, Canon G5, on the manual mode was used as the platform to simulate the illuminant estimation process. The captured images were transferred into PC and analyzed by MatLab.

The process for solving color constancy is described as follow:

Step 1: The original image data (Raw data) of gray card under 15 illuminants from camera (Canon G5®) were gathered. At the same time, the color temperature of illuminants were extract from Chroma meter and Photoshop CS software.

Step 2: Forcing each gray card to have the same gray value in each R, G, B channel, by doing this, we can get R, B gain via corresponding color temperature to implement color constancy.

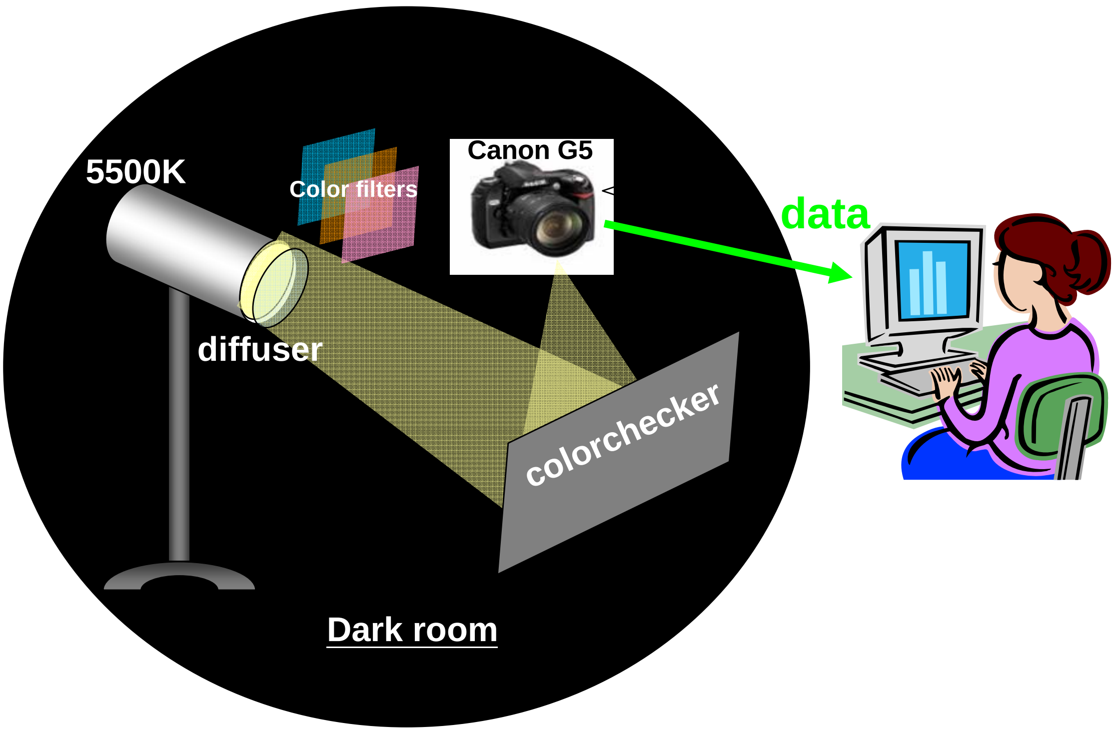

Fig. 4-6 The simulation system for solving color constancy

4.5 Performance Test

To examine the performance of our scene analysis method, we have simulated the AWB process by using a DSC (Canon G5) to take picture in different lighting conditions.

The schematic diagram of the simulation system is shown in **Fig. 4-8**

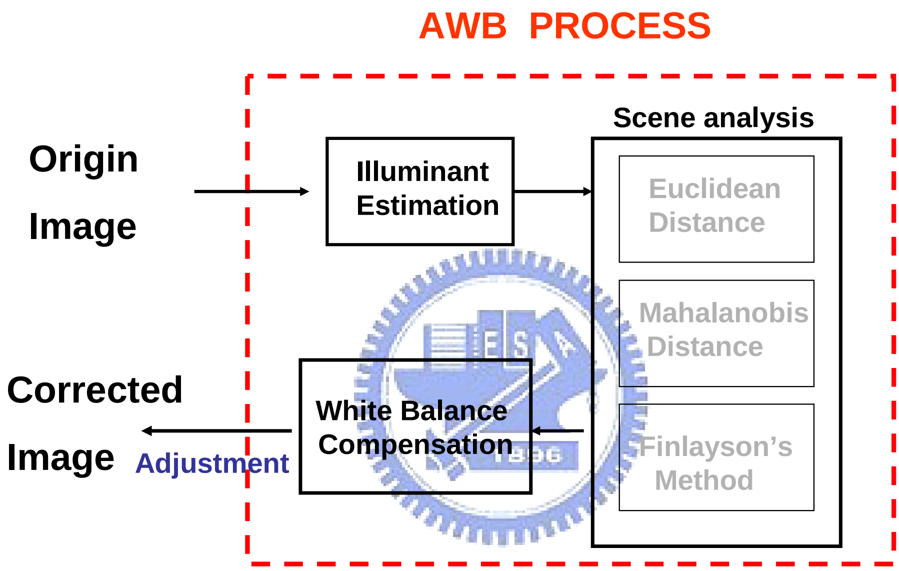

Fig. 4-8 Schematic diagram of AWB simulation system

In the simulation, each scene is pictured with different color temperature from 2500k to 9300k, and the captured images are analyzed by our scene analysis method to evaluate the compensation amount. The compensation amounts are determined by the scene analysis process and used to adjust the white balance parameters verified by basic gray world method. By using the pictures with a serial color temperature values, the simulation of AWB process is performed. The white balance methods for comparisons are listed in **Table 4-1**.

Table 4-1 Comparisons of different white balance methods and their picture settings, Automatic white balance = AWB, Automatic Focus= AF, test camera = Canon G5

White Balance Method	Picture Setting
Gray world	AWB, AF, flash off, aperture priority, fixed ISO speed
Finlayson's method	AWB, AF, flash off, aperture priority, fixed ISO speed
Canon G5 solution	AWB on, AF on, flash off, Fixed ISO speed
Our optimal method	AWB, AF, flash off, aperture priority, fixed ISO speed

4.6 Summary

We have presented the experimental systems and experimental methods of illuminant estimation algorithm and 2-D scene analysis method. In addition, the performance test and the comparison of different white balance method are also illustrated. The experimental results and discussions will be given in next chapter.