Chapter 1

Introduction

1.1 Introduction

As many parts of industry have been digitalized in the recent decade, the tendency of digitalization also affects camera. Although the digitalization caused the image quality of past digital still cameras (DSCs) interior to that of the film cameras, the image quality of DSCs are continuously improved due to the development of CCD/CMOS imaging sensors. In addition, DSCs are much more convenient for users than film cameras due to the advanced function of previewing images on an LCD panel, and other attractive features. Generally speaking, DSCs have three important system functions including automatic focus (AF), automatic white balance (AWB) and automatic exposure (AE) which mainly influence the quality of camera as shown in **Fig. 1-1** [1].

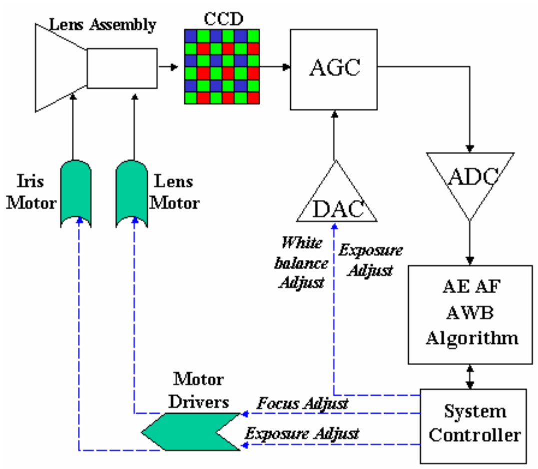


Fig. 1-1 Image pipeline stage of DSC

To record an acceptable image in the camera, AE plays a particularly important role of computing the optimized exposure parameters. The process of AE can be divided into three steps which are light metering, scene analysis, and exposure compensation as shown in **Fig. 1-2** [2].

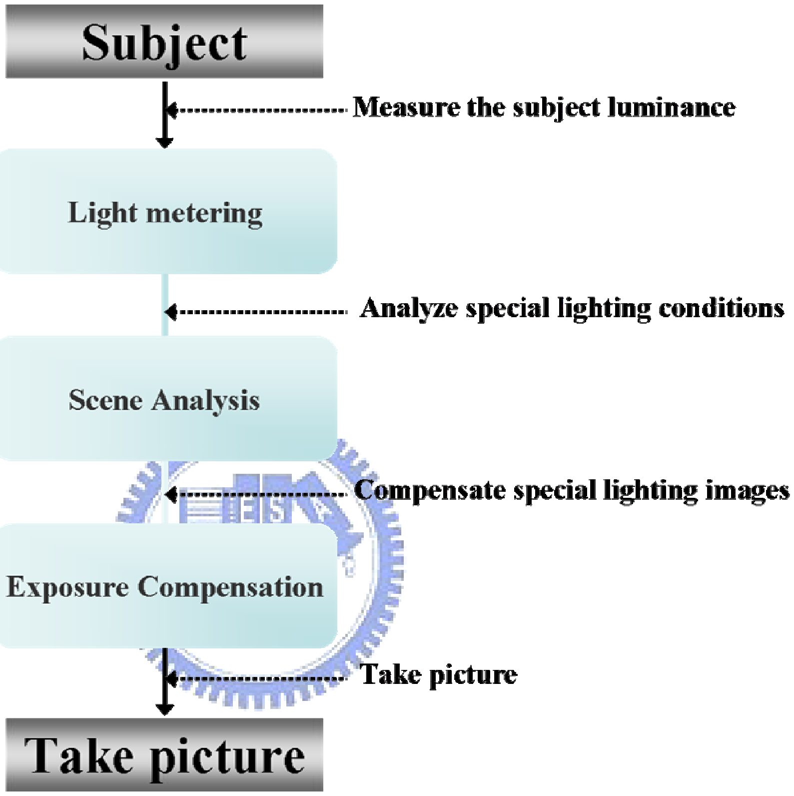
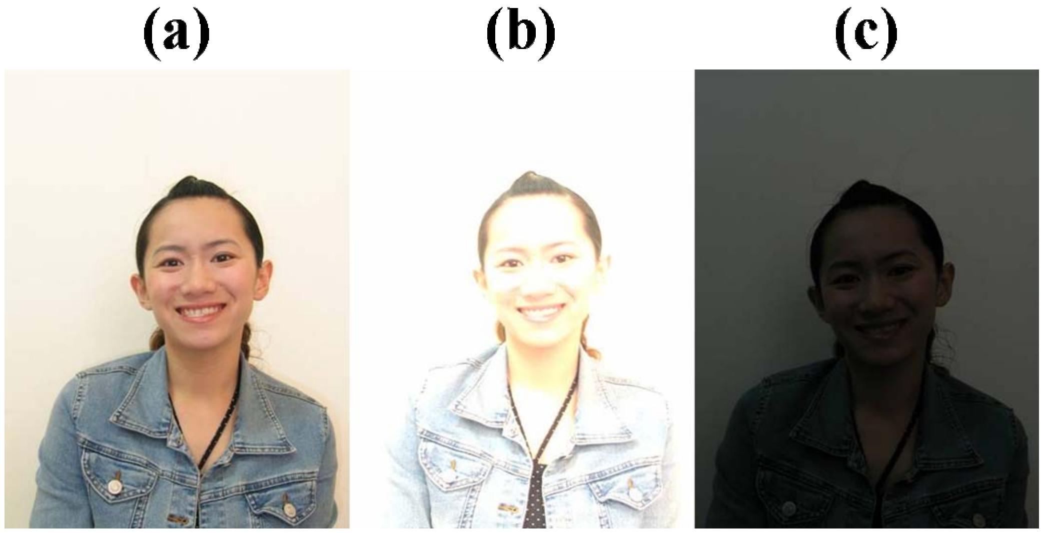


Fig. 1-2 Main steps of AE process

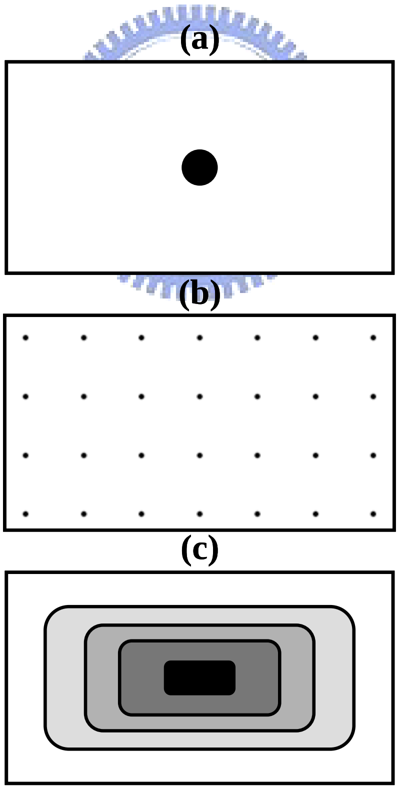
1.2 Light Metering

The main objective of light metering is to measure the luminance of photographic scene appropriately. According to the measured luminance, the preset exposure parameters can immediately be extracted, and the proper exposed image can be obtained. If the light metering system does not work well, the pictures may be underexposed or overexposed. An overexposed picture looks bleached out and an underexposed image looks too dark as shown in Figs. **1-3(b)** and **(c)**, respectively. Therefore, a proper light metering system is significant in the AE process.

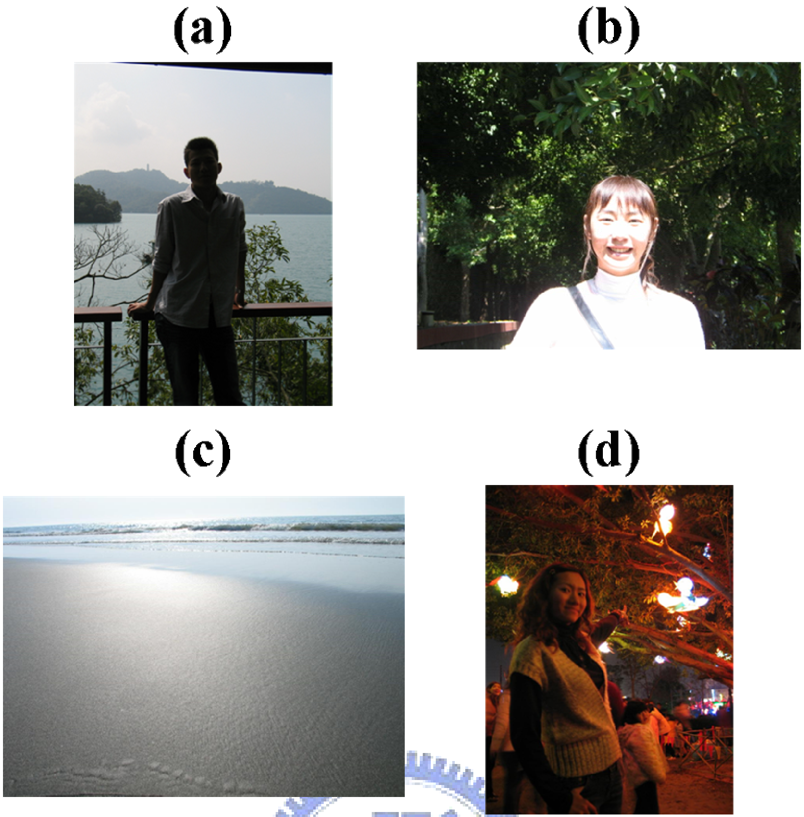
There are three fundamental modes in the light metering systems which are spot metering, mean metering, and center-weighted metering modes [3]. The advantage of spot metering mode (**Fig. 1-4 (a)**) is that only a small area of the scene is measured to calculate exposure parameters; thus the proper exposure can be determined as expert users wish. However, the spot metering mode is hard to determine the metering target for popular consumers. On the other hand, the mean metering mode (**Fig. 1-4 (b)**) which measures the whole scene on average is widely used in consumer cameras, but it is easily failed in special lighting conditions such as backlighting, strong frontlighting due to the large luminance difference between the main object and the background as shown in **Figs. 1-5 (a)** and **(b)**. To adapt various conditions the center-weighted mode (**Fig. 1-4 (c)**) was proposed, which can measure not only the main object but also the background and put more weighting on the main object region to compensate the large luminance difference. In this mode, the location of main object is limited around the center of the scene. [4] In order to take picture easily, there should be an intelligent algorithm to analyze the scene to improve the light metering accuracy.



Figs. 1-3 (a) Normal, (b) Overexposed and (c) Underexposed images



Figs. 1-4 (a) Spot metering, (b) Mean metering and (c) Center-weighted metering modes



Figs. 1-5 Images in special lighting conditions: (a) Backlighting, (b) Strong frontlighting, (c) Highlight and (d) Dark environment

1.3 Scene Analysis

The objective of scene analysis is to classify the images taken under normal and special lighting conditions. The special lighting conditions include backlighting, strong frontlighting, dark environment, and highlight. In order to detect the backlighting image, the scene analysis methods based on sub-window information were proposed [5], [6], [7]. These methods are easily failed when the object is out of expected locations. Analysis methods based on histogram information are also proposed [8], [9]. In the proposed methods, the position of object causes no problems, but still there are some disadvantages. For the backlighting images, the main object is usually compensated to a proper brightness but the background is overexposed at the same time. Therefore, Murakami et al. proposed a new exposure control system in which the importance of background is detected according to the color information [10]. Through the evaluation of chroma and hue of each pixel in the whole picture, the background with high chroma will be emphasized and preserved suitably comparing with low chroma.

1.4 Exposure Compensation

Exposure compensation is used to correct the image brightness in special lighting conditions. There are two approaches to correct the image brightness. The first one is the flash compensation used in dark environment or strong backlighting situations. With the flash light, the luminance of the main object can be improved. If the distance between the camera and the subject is too long, the flash compensation will not work. The second one is exposure value (EV) compensation by changing the exposure time, aperture size, or ISO speed of imaging media. According to the proper amount of exposure compensation, the subjects in special lighting conditions can be preserved in good image quality.

1.5 Motivation and Objective of this Dissertation

As described above, the performance of AE system is mainly controlled by light metering, scene analysis and exposure compensation. Our objective is to improve the AE system under different lighting conditions.

In order to improve the light metering system, a luminance detection model *modified* from Kuno metering method was proposed and confirmed by experiments.

The simulations of light metering system are done under different scene luminance, and the results are compared with an ideal light meter.

In order to improve the light metering ability in special lighting conditions, a 2-D scene analysis method was proposed. In the beginning, we collect a lot of images under different lighting conditions to build the reference database. Then, the optimized parameters are derived through the simulation. According to the optimized parameters, we define the fuzzy rules for different lighting situations. The performance of the proposed method is examined by simulating the AE process under different lighting conditions. Finally, the subject in special lighting conditions can be detected through simple calculation and fuzzy inference. Thus, the performance of AE system will be improved with the proposed method.

1.6 Organization of this Thesis

This thesis is organized as follows: The theoretical background of exposure control system in film camera is presented in **Chapter 2**. First, a principle overview which includes exposure factors and well-known exposure equations are given. Furthermore, the practical system applying the exposure equations, Additive System of Photographic Exposure Control (APEX) is given. In **Chapter 3**, the traditional methods for automatic exposure and their corresponding theories are described. In **Chapter 4**, we discuss the problems we meet and explain the solution we devise. Moreover, a *modified* luminance detection model and a 2-D scene analysis method are proposed to improve the performance of AE. In **Chapter 5**, experimental flows and experimental systems are presented. In **Chapter 6**, experimental results and summaries are given. In **Chapter 7**, concluding remarks and future works are presented.