CHAPTER I

INTRODUCTION

Overview

This is a research of how to obtain a color image by using a black-and-white (b/w) image input device to which knowledge of *additive color system* and *image processing* is applied. The main objective of this research is to generate a color image from three sets of intensity data of its primary color components (red, green, and blue -- *RGB*). These RGB intensity data were acquired by capturing a color picture using a black-and-white image input device with a set of RGB filters applied. The process was performed separately for each filter. Since each selected filter had its own limitation and characteristics, some techniques of image processing, especially *histogram modification*, were then used to calibrate the data before the color mixing was performed.

This research resulted in a development of BW2COLOR, a software to compose color images with a b/w image input device. There were several special features added to the BW2COLOR software, including *pseudo coloring*, *brightness* and *contrast* adjustment, and an image viewer. Pseudo colors could be assigned to a gray scale image by a heuristic approach of *gray-level-to-color transformation* technique. The image viewer was employed for viewing an image in three display modes, including normal, *inverse* (or *negative*), and gray scale. The BW2COLOR software supports most VGA and super VGA (SVGA) adapters, such as Trident and Tseng Labs, and most display adapters with Video Electronics Standard Association (VESA) standard capability.

The color images acquired from a color image input device were used as references in comparison with the output color images of this research method to measure the color quality. A measurement scheme of color image quality was designed and a tool to measure color distortion was also developed and used in this research.

Background

As many b/w image input devices are still in use and the users sometimes want to obtain color images, enabling the use of these b/w devices to input color images will be of great benefit. Moreover, the methods developed in this research can be applied to image input devices that cannot acquire color images at present. Though the feasibility study indicated that achieving images of good color quality is possible, there was still high color distortion on the output images. Thus, this research was conducted to improve the quality of the output images.

The underlying idea of this research will be described briefly here. The human eye is capable of seeing colors that are made up of the three primary colors, RGB. If the intensities of each primary color on a source picture are measured, they can be used to generate a color image. Firstly, the input to the b/w image input device is filtered to be mostly each primary color at a time. By capturing a picture three times, the three images containing intensity information of each primary color can be acquired. The information can then be processed to generate a color image. Thus, additional materials, including filters and a calibration card,* are required to make the input of the b/w input device contain mostly one primary color at a time and to calibrate data sets respectively.

In order to compare the output image with the image from a color image input device, quality measures for a color image and a tool for measuring distortions of a color image from a reference image were also developed.

Since assigning colors to a gray scale image can improve the appearance to the human viewer, another approach of coloring a gray scale image by pseudo coloring was also developed.

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* Calibration card is a card to be used for adjustment of the gray values in the gray scale image to compensate for changes that a filter has made to those values on capturing an image using a b/w image input device.

Objectives

1. To develop a procedure to obtain a color image by mixing three images that were acquired via a black-and-white image input device together with each of the RGB filters.
2. To develop a measurement scheme of color image quality.
3. To develop a method of assigning pseudo colors to a gray scale image for the purpose of maintaining continuity and perceived brightness of colors.
4. To study brightness and contrast modification for color images.
5. To develop a software to compose color images by color mixing and pseudo coloring with brightness and contrast adjustment tool.

Feasibility Study

The feasibility study of this research was completed earlier under Ms. Nongluk Covavisaruch's supervision as a senior project on the topic of "Getting color image using black-and-white scanner" [1] in the Department of Computer Engineering, Chulalongkorn University in the second semester of the 1992 academic year. The project was conducted on a system of a PC, a VGA/SVGA monitor and a b/w scanner, a prototype version of BW2COLOR, with RGB filters and a b/w calibration card as additional materials. This feasibility study demonstrated that it was possible to achieve close-to-real colors from this color mixing process.

The operation of the prototype system developed in this study can be illustrated with Fig. 1.1. The major characteristic of the system is that a filter detects a specific color. This process involves the collection of three images for a b/w calibration card by applying each of the RGB filters. The characteristics of these three images are then stored in *Filter*

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[1] Pradit Pinyopasakul, "Getting color image using black-and-white scanner" (Bachelor's Project Report, Department of Computer Engineering, Chulalongkorn University, 1993).

Characteristic File. Furthermore, to achieve a color image from a source color picture, the user must collect three images of the picture by again applying each of the RGB filters. The data contained in these images was assumed to have been an intensify form of the information from each of the RGB components. Finally, the output color image was generated by applying three gray scale images and reapplying Filter Characteristic File into the *Color Mixing Process*.

The example output images from this prototype system in comparison with the images from a color scanner can be seen in Fig. 1.2. Clearly, the results indicated a high degree of feasibility though the output images were highly distorted. Please note that these two examples are from feasibility study and not the final product of this research.

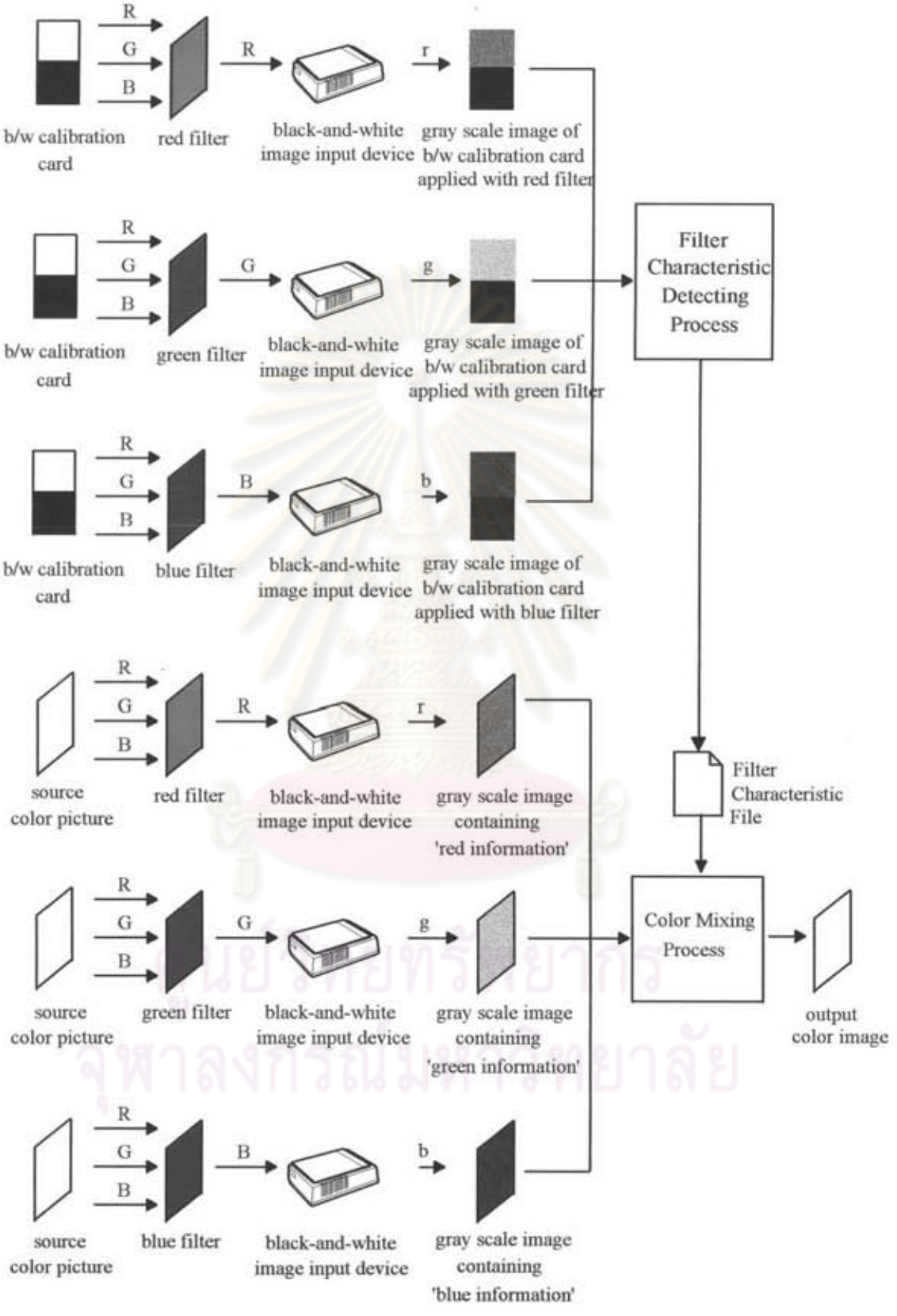

Fig. 1.1 Operation of the prototype system

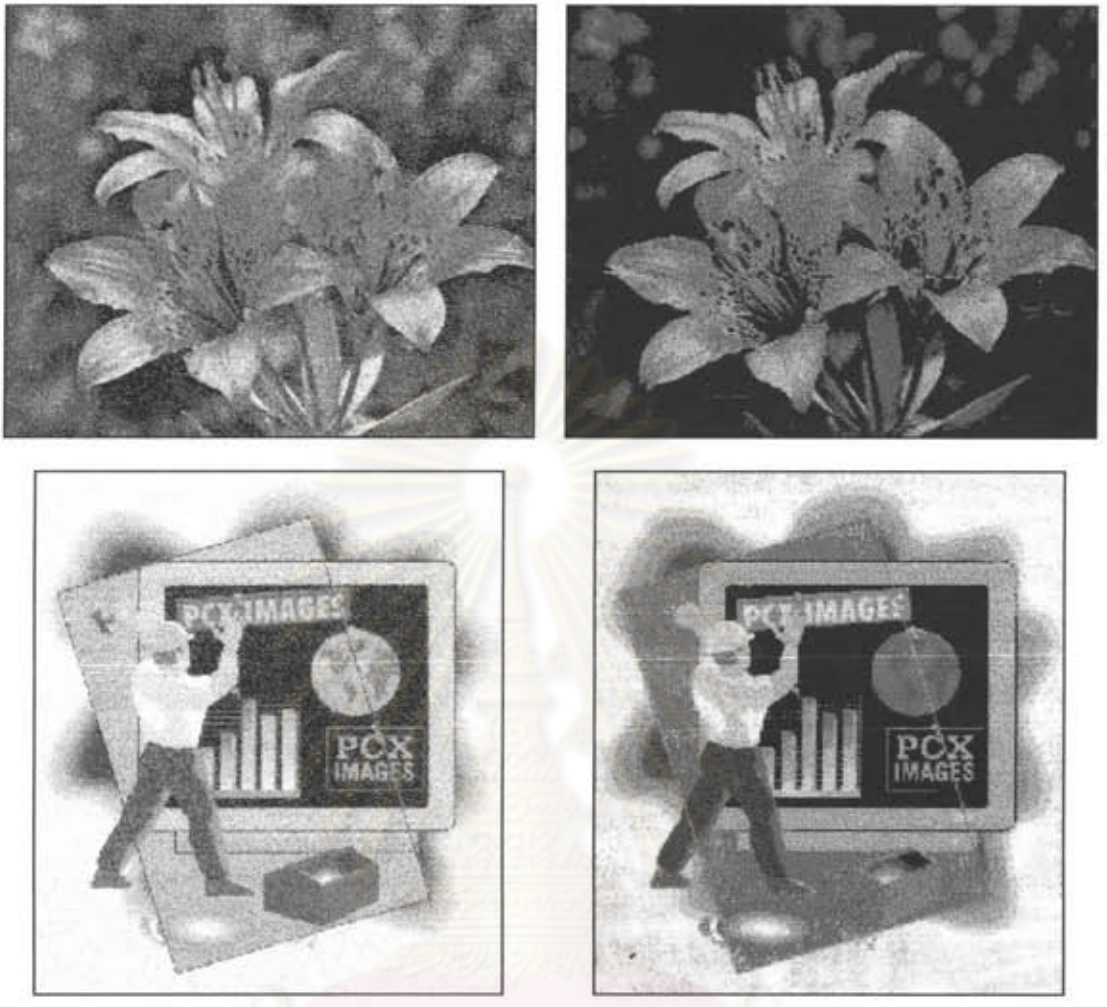

Fig. 1.2* Comparisons of the images obtained by a color image input device (on the left) to those obtained by a b/w image input device (on the right)

Scope

1. RGB filters and a b/w calibration card were used as additional materials to assist a b/w image input device in acquiring intensity information of each of primary colors.
2. The input and output images of the software were in PCX** format.

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* The flower images were from a calendar. The drawing images were from an advertisement leaflet.

** PCX is a widely supported image file format developed by ZSoft Corporation.

3. A software tool for composing a color image from three gray scale images containing RGB intensity information was developed.
4. A software tool for assigning pseudo colors to a gray scale image was developed.
5. An interactive tool for adjusting the brightness and/or contrast of a color image was developed.
6. A software tool for measuring color image quality by comparing an output image to a reference image was developed.
7. The computer program compilers exploited were the Turbo C version 2.0 [2] and the Borland C++ version 3.1[3]
8. The software developed for use on an IBM compatible PC with VGA or SVGA adapter.

Research Procedure

1. The study of color theories and image processing techniques.
2. The design of a calibration card.
3. The selection and testing of a variety of sources for gray bands of the calibration card, such as color chart for printing, color chart of enamel.
4. The selection and testing of a variety of filter types, such as cellophane, acrylic glass.
5. The design of a procedure to collect RGB intensity data and to form the relationship between the intensity data obtained from the b/w image input device and the RGB intensities on the source color picture.
6. The design of a procedure to measure the effect of each of the RGB filters in use on capturing color images using a b/w image input device.

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[2] "Turbo C version 2.0," Computer program compiler produced by Borland International, California, 1988.

[3] "Borland C++ Version 3.1," Computer program compiler produced by Borland International, California, 1992.

7. The design of a method for constructing the LUT to be used with the output color image composed from RGB intensity data.
8. The design of a procedure for composing a color image using a b/w image input device, additional materials, and a software tool.
9. The development of a software for composing color images.
10. The study of pseudo coloring techniques as well as the development of a pseudo coloring tool.
11. The study of color image enhancement techniques and the development of a brightness and contrast adjustment tool.
12. The development of the measuring tool for color image quality and distortions of color images.
13. The testing and correction of the software developed.
14. The composition of a user manual for the software.
15. The summary of the research and composition of this thesis.

Benefits of This Research

1. The software for composing color images from RGB intensity data obtained by a b/w image input device has been developed.
2. A tool for pseudo coloring has been developed.
3. A brightness and contrast adjustment tool has been developed
4. A measuring tool for color image quality has been developed.