"Research is to see what everybody else has seen, and to think what nobody else has thought" ~ Albert Szent-Gyorgyi (Hungarian Biochemist, 1937 Nobel Prize for Medicine, 1893-1986)

Chapter 1

INTRODUCTION

This is an exciting time for color scientists and engineers engaged in display engineering and consumer video applications. We are witnessing a rapid and significant development in terms of state-of-the-art display technologies. This becomes more evident if we compare activities within the other segments of the imaging industry, for example printing, camera manufacturing etc, with those within the display industry. In terms of emerging technologies today, video and display industry is well ahead of others, and is likely to outpace the growth in other industries in the next several years to come.

Video processing has come a long way since the time of analog video, achieving picture quality that was unthinkable even in the early nineties. Color plays a vital role in achieving such quality. With the advent of novel digital display technologies, color processing is increasingly becoming a key aspect in consumer video applications that demand vivid, crisp and natural pictures without any visual artifacts. Larger screen size, higher luminance and higher resolution of today's displays require sophisticated color and image reproduction techniques. For any color scientist or engineer responsible for developing high-end color processing methods and algorithms suitable for various consumer video applications, it is important to keep abreast with all these latest development in display technologies.

At the same time, any future development efforts in color video processing must recognize the potential for improvement in color reproduction capabilities of various emerging display technologies as well as the more conventional ones. To this end, it will be important to bring fresh perspectives to the concept of color processing in a typical video processing chain in consumer video systems. Knowledge earned from years of color science and vision research must be applied in an effective manner while taking into account practical limitations in specific application context. More than ever before, there is a need today for concerted developmental efforts, and a close collaboration between the video researchers and color scientists.

1.1 Thesis Objective

The principal goal of this thesis research was twofold. The first goal was to evaluate various published color and contrast enhancement algorithms, and develop a novel algorithm that meets the objective of enhancing color and contrast in images and videos in an effective and coordinated manner. The second goal was the development and implementation of a psychophysical technique for the visual evaluation of color image and consumer video quality. Attaining these goals, it was assumed, would help build new knowledge specific to color processing and color quality management methods in consumer video.

1.2 Research Hypothesis

The main objective in color and contrast enhancement in video processing is to achieve the best possible combination of colorfulness and contrast in an efficient manner. Typically, the use of independent algorithms for color and contrast enhancement results in sub-optimal enhancement, and cumbersome tune-up. It was hypothesized that an integrated algorithm could help enhance

color and contrast in a more effective and coordinated manner. However, the fundamental hypothesis of this research was that color processing in a perceptually meaningful way would lead to superior image and video quality and this could be demonstrated through a properly designed visual experiment comparing results from various methods.

1.3 Thesis Organization

This thesis starts with a discussion on various aspects of color video processing in Chapter 2. Color specifications in various video standards, including color primaries and color coding standards are discussed. Various processes involved in a typical video processing chain in consumer video applications are reviewed. To appreciate the state of the art, the working principles for various modern display devices, as well as special video processing techniques employed in some of these devices are described.

In Chapter 3, various methods for determining and assessing the video quality are reviewed. These are categorized as engineering and psychophysical, based on their methodology. Several publications on subjective assessment of video quality are also reviewed.

Several previously published methods for color and contrast enhancement are discussed in Chapter 4. The development of the new algorithm is discussed, starting with the working requirement, the color space chosen for the development, and a description of the three key components of the algorithm.

Four published methods for color and contrast enhancement were implemented to evaluate their performance as well as to determine the most appropriate enhancement strategy for the new algorithm. Further, two existing color and contrast enhancement algorithms typical of consumer video applications were provided by the research sponsor. A quantitative performance analysis of these six algorithms and the newly developed algorithm was conducted. Chapter 5 contains the details of this analysis.

Chapter 6 contains a detailed description of the psychophysical experiments performed on the outputs of the two proprietary algorithms and the new algorithm, and an analysis of the results. Both still images and image sequences were used in the experiments. All aspects of the design of the visual experiments are discussed in this chapter, including display characterization, experimental setup, test images and video clips, viewing conditions and experimental method.

Finally, Chapter 7 contains concluding remarks and summarizes the research findings by outlining some key aspects relevant for the development of an effective color and contrast enhancement method for images and video applications.