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Real-time Measurement of Polychromatic Optical Transfer Function and Its Applications

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A wide variety of devices and systems exist whose main function is to generate an image. These devices and systems are used for many different purposes and find applications in many different walks of life. We are all very familiar with some of these systems such as the photographic camera (that can produce a permanent record of a scene on sensitized sheet material) and the television set (that can receive a suitably coded electromagnetic signal broadcast through space and convert it into an image). Imaging systems find applications in science, medicine, industry, defense, surveillance, space, education, leisure and a host of other areas.

If an imaging device or system is to adequately perform the task for which it is intended, it must be capable of producing images of a certain minimum quality. The ability to be able to define this quality in objective terms is of importance to the user, the designer and the manufacturer of the imaging system.

Several different parameters are required to fully specify the performance of an imaging system. Some of these are very specific to particular types of system, while others are more generally relevant. This paper is mainly concerned with one very important characteristic of all imaging devices, which is the ability to reproduce faithfully the relative intensity distribution of the original scene in the final imaging generated by the system. The parameter that is now used almost universally to describe this aspect of imaging is in fact the optical transfer function (OTF)[1,2].

For assessing the performance of an optical imaging system working under broadband illumination, the classical monochromatic merit functions, such as the point-spread function (PSF) and the OTF, should be extended to the polychromatic domain. This extension is usually carried out by the addition of a suitable number of monochromatic components weighted by the spectral radiance distribution of the source, the spectral response characteristics of the detector, the spectral transmission of the optical components of the measuring equipment and those of any spectral filters placed in the optical path. Therefore the polychromatic OTF (POTF) should be considered as a standard practical criterion to evaluate the performance of an optical system under broadband illumination[3-11].

In this paper, the polychromatic optical transfer function (POTF) as a criterion of image quality for optical systems and color displays under actual working conditions is presented. First, we present the theory of the monochromatic OTF and the POTF of optical imaging systems such as a camera lens and principles of their measurements in detail.

We show definitions and mathematical relationships for the poly-color modulation transfer function (PMTF) of the color display system. And a method for evaluating the image quality of color LCD monitors by using the PMTF is presented. We also propose a method for simulating the PMTF of the LCD monitor by using three bar targets with different amplitudes.

We propose the analysis of the polychromatic modulation transfer function (PMTF) for evaluating the image quality of the color LCD monitor. And we introduce compact synthetic equipment that can obtain the chromaticity (x, y), luminance, and MTF of the color monitor simultaneously. We also measure the variations of the luminance, chromaticity (x, y), and PMTF of a thin-film-transistor (TFT) LCD monitor for off-axis viewing angles. The experimental results of a color LCD monitor made in Korea are presented.

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