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Optics and photonics — Optical transfer function — Principles of measurement of modulation transfer function (MTF) of sampled imaging systems

Optique et photonique — Fonction de transfert optique — Principes de mesure de la fonction de transfert de modulation (MTF) des systèmes de formation d'image échantillonnés

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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ISO 15529 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This third edition cancels and replaces the second edition (ISO 15529:2007) which has undergone a minor revision to include measurement and test procedures for aliasing of sampled imaging systems.

Introduction

One of the most important criteria for describing the performance of an imaging system or device is its MTF. ISO 9334 covers the conditions to be satisfied by an image system for the MTF concept. These conditions require that the imaging system be linear and isoplanatic.

For a system to be isoplanatic, the image of a point object (i.e. the point spread function) must be independent of its position in the object plane to within a specified accuracy. There are types of imaging systems where this condition does not strictly apply. These are systems where the image is generated by sampling the intensity distribution in the object at a number of discrete points, or lines, rather than at a continuum of points.

Examples of such devices or systems are: fibre optic face plates, coherent fibre bundles, cameras that use detector arrays such as CCD arrays, line scan systems such as thermal imagers (for the direction perpendicular to the lines), etc.

If one attempts to determine the MTF of this type of system by measuring the line spread function of a static narrow line object and calculating the modulus of the Fourier transform, one finds that the resulting MTF curve depends critically on the exact position and orientation of the line object relative to the array of sampling points (see Annex A).

This International Standard specifies an “MTF” for such systems and outlines a number of suitable measurement techniques. The specified MTF satisfies the following important criteria:

— the MTF is descriptive of the quality of the system as an image-forming device;

— it has a unique value that is independent of the measuring equipment (i.e. the effect of slit object widths, etc., can be de-convolved from the measured value);

— the MTF can, in principle, be used to calculate the intensity distribution in the image of a given object, although the procedure does not follow the same rules as it does for a non-sampled imaging system.

This International Standard also specifies MTFs for the sub-units, or imaging stages, which make up such a system. These also satisfy the above criteria.

A very important aspect of sampled imaging systems is the “aliasing” that can be associated with them. The importance of this is that it allows spatial frequency components higher than the Nyquist frequency to be reproduced in the final image as spurious low frequency components. This gives rise to artefacts in the final image that can be considered as a form of noise. The extent to which this type of noise is objectionable will depend on the characteristics of the image being sampled. For example, images with regular patterns at spatial frequencies higher than the Nyquist frequency (e.g. the woven texture on clothing) can produce very visible fringe patterns in the final image, usually referred to as moiré fringes. These are unacceptable in most applications if they have sufficient contrast to be visible to the observer. Even in the absence of regular patterns, aliasing will produce noise-like patterns that can degrade an image.

A quantitative measure of aliasing can be obtained from MTF measurements made under specified conditions. This International Standard defines such measures and describes the conditions of measurement.