Fourteenth International Conference Zaragoza-Pau on Mathematics and its Applications
Jaca, September 12–15th 2016

Orthogonal basis for the Optical Transfer Function

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SUMMARY

Complex *Zernike polynomials* are used, among others, in the extended Nijboer-Zernike theory for the computation of optical Point-Spread Functions (PSF), as they can represent the complex pupil function that is both the amplitude and phase of a wavefront at the (circular) pupil plane. Optical image quality is fully determined by the PSF or alternatively by its Fourier transform, the Optical Transfer Function (OTF). It is common to measure either the PSF or the OTF (and often only its modulus, the MTF, is available), but then the wavefront cannot be retrieved in general. Therefore, a compact description of the wavefront as a set of Zernike or similar coefficients is not available in these cases. Thus, we propose systems of orthogonal functions q_n to represent OTFs characterized by including the diffraction-limited OTF as the first basis function $q_0 = \text{OTF}_{\text{perfect}}$. To this end we apply a powerful and rigorous theoretical framework based on applying the appropriate change of variables to well-known orthogonal systems. Here we depart form spherical harmonics or Legendre polynomials for the particular case of rotational-symmetry. Numerical experiments with different examples show that the number of terms necessary to obtain an accurate linear expansion of the OTF mainly depends on the image quality. In the rotationally symmetric case we obtained a reasonable accuracy with around 10 basis functions, but in general for cases of poor image quality the number of basis functions may increase and hence affect the efficiency of the method. Other potential applications, such as new image quality metrics are also discussed.

Keywords: Optical transfer functions, Metrics, Optical testing, Numerical approximation and analysis

AMS Classification: 33C45, 78A

References

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