STUDIES IN IMAGE EVALUATION

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PREFACE

The evaluation of the performance of an optical system has been an activity of importance because of the nonrealizability of an ideal optical system. In the realistic cases, the presence of wave front aberrations, surface defects on the optical components, the turbulent media, departures from the extreme coherence conditions and the finite number of the cycles present in the test charts are among the important factors which affect the system performance and need attention. Therefore, one's interest grows to know as to what will be the limit within which the departures from the ideal conditions will be tolerable and how successfully the system will perform the required imaging task. The fundamental parameter describing the imaging ability of an optical system is the image of a point source (point spread function). However, the point spread function by itself is of little interest, but there are criteria to assess the performance, derivable from the knowledge of the point spread function and are frequently used in the studies of the system performance.

Also, quite frequently, the methods in assessing the imaging ability of systems have been to simulate the task in the laboratory by making a choice of the standard test targets. Now, the imaging capability is judged by the efficiency of the optical system to pass the spatial frequency components of the object to the final image. The degree of transmission of the spatial frequencies from the object to the image plane gives an objective measure of the image quality in an incoherently illuminated system. Such studies of frequency response for the performance assessment of the optical systems have now widely been accepted as the most powerful technique.

The author has made investigations on the performance assessment of various optical systems based on above performance criteria. The investigations are classified in five chapters and are briefly reviewed below.

The first chapter is related to the studies of limit of resolution as affected by the surface quality of the optical components of the common type of interferometers. The surface defects are mainly due to the errors of polishing and curvature of the plates. Their presence on the optical components results in the fringe broadening and decrease in the peak transmission. In some cases, the shift in peak intensity of the fringe from its integral order position is also observed. In the resolution studies we have made use of Rayleigh and Sparrow criterion of resolution.

Another important situation when the resolution of two point objects is affected is the presence of partial coherence between them. The point objects have been considered to have different intensities as, such studies find application in holographic reconstruction. This makes the subject matter of the second chapter. In the third chapter, the study of the diffraction images under partially coherent illumination has been made for the cases when the optical system suffers from spherical aberration, longitudinal sinusoidal vibrations and amplitude and phase fluctuations in media.

In the fourth chapter, use is made of the fourier techniques to calculate the square and triangular wave response of different optical systems of interest. However, it is assumed that the test charts are the periodic objects of infinite cycles which however, is not the case in practice. Therefore, in the fifth chapter the minimum number of cycles have been determined which should be present in the test chart, so that it may effectively represent an infinite cycle object.

The work done by the author has appeared in the ~~form of~~ following publications:

1. Sparrow limit of spectral resolution in reflection echelon and Fabry-Perot interferometers having surface imperfections.
   Appl. Opt. 9, 2326 (1970)

2. Performance of a michelson interferometer with asymmetric surface defects distribution.
   Applied Optics 13, 1553 (1974)

3. Transmission Profile of a Fabry-Perot Interferometer suffering from asymmetric surface defects.
   Nouv. Rev. Optique. 5, 237 (1974)

4. On the limit of resolution of an achromatic microscope objective.
   Atti della Fond. G. Ronchi 25, 57 (1970)

5. Two point resolution in partially coherent light, Optics Communication, 3, 269 (1971)

6. Partially space coherent diffraction of a circular aperture in the presence of spherical aberration. Nouv. Rev. d'optique applique, 2, 29 (1971)

7. Partially space coherent diffraction by a circular aperture in the presence of longitudinal vibrations. J. of Optics (In Press)

8. Effect of Inhomogenities in the medium on the diffraction images of periodic rectangular and triangular-wave objects. Physics Letters, 31A, 323 (1970)

9. Information loss due to attenuation of a signal by scattering or absorption across a gap. Atti della Fond. G. Ronchi, 28, 33 (1973)

10. Performance analysis of photodiodes and phototransistors operating in photon integration mode. International J. of Electronics, 35, 713 (1973)

11. Images of truncated sinusoidal and square-wave objects formed by a nonuniformly illuminated slit aperture. Atti della Fond. G. Ronchi, 29, 207 (1974)

12. Images of truncated sine and square-wave objects formed by a polarizing microscope with crossed nicols.
Nouv. Rev.Optique, (In Press)

13. Diffraction images of truncated triangular wave objects formed by a polarizing microscope with crossed nicols.
Applied Optics 13, 1768 (1974)

The following additional work done by the author has not been included in the thesis:

14. Effect of partial coherence on the resolution of a microscope.
Optica Acta, 17, 839 (1970)

15. Effect of partial coherence on the resolution of a microscope - II. Annular aperture at the condenser.
Optica Acta, 18, 547 (1971)

16. Resolution and detection of incoherent objects seen through the back-ground limited system suffering from the defects of focus and spherical aberration.
J. of Physics D-Applied Physics, 6, 408 (1973)

17. Effect of sinusoidal transverse vibrations on the performance analysis of optical systems in the presence of back-ground noise
Atti della Fond. G. Ronchi, 29, 7 (1974)

18. Analysis of image forming properties of a fiber assembly used as a dynamic scanner.
J.Opt.Soc.Am., 60, 1017 (1970)

19. Diffraction images of truncated objects formed by an apodized circular aperture.
Nouv. Rev. Optique, 4, 221 (1973)

20. Diffraction images of truncated sine, square and triangular-wave periodic objects formed by an optical system with shaded aperture.
J. of Optics, 2, 8 (1973)

21. Diffraction images of truncated periodic objects formed by a diffraction limited imaging system with an annular aperture
Indian J. Pure and Appl. Physics, 12, 138 (1974)

22. Images of truncated triangular objects formed by an apodized slit aperture.
Optica Acta., 20, 995 (1973)

23. A method of improving the OTF of an astigmatic circular aperture
Optica Acta. 21, 801 (1974)

24. Phase characteristic function of holographic images of objects in parabolic motion.
Appl.Opt. 12, 887 (1973)

25. On application of Holographic subtraction to time average hologram interferometry of vibrating objects,
Appl.Opt., 12, 2236 (1973)

26. Application of holographic addition to time average hologram interferometry of constant velocity motion.
Applied Optics, 13, 720 (1974)

27. Analysis of damped Oscillations by Time-Average holographic interferometry using thin phase recording emulsions.
(Presented at the symposium on Quantum and Opto-Electronics at BARC, Bombay, Feb.24-28, 1974).

28. A quadruple - exposure technique in stroboscopic holographic interferometry.
Applied Optics, 13, 2468 (1974)

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