Digital Moiré: Techniques and Applications

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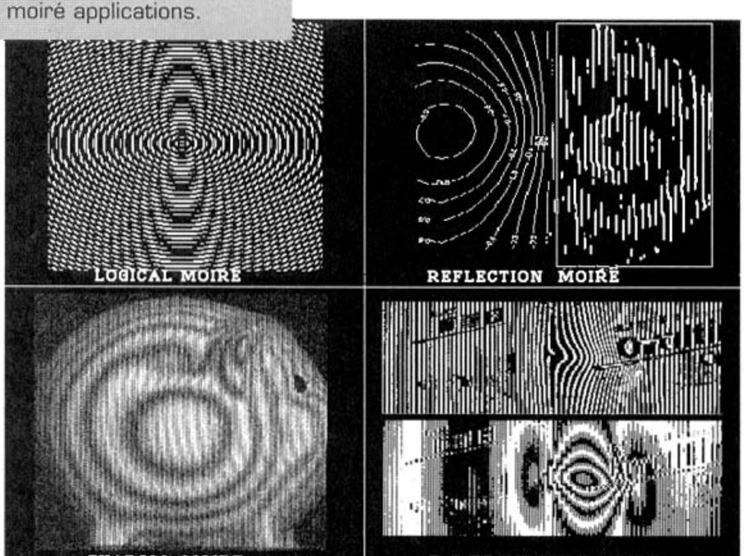
Moiré methods are a versatile set of techniques for in-plane and out-of-plane displacement and deformation measurement, topographic and shape determination, and slope and curvature contouring. The basis of these moiré methods are gratings. Deformation of the specimen cause distortions in the grating lines. Visualization of these distortions are enhanced using the moiré effect that is achieved by superposing the deformed specimen grating on a reference grating representing the undeformed state of the specimen. Based on the manner in which the specimen deformation influences the specimen grating distortion, various moiré methods have evolved.[1] The sensitivity of moiré methods are primarily determined by the pitch of the grating. Although highest sensitivity (corresponding to smallest grating pitch) is desired in some applications, there are many instances in which the pitch of grating varies from one application to the next. Thus, a stack of gratings with different pitch has to be readily available. Computer generated gratings provide this added versatility. However, to realize most of the moiré techniques, these gratings have to be appropriately displayed. Novel schemes and routines are thus developed to fully exploit the potential of these gratings in digital moiré applications.[2,3]

The figure below demonstrates the use of computer gratings in digital moiré methods. Logical operators are used to generate digital moiré between a digitized deformed specimen grating and a computer generated reference grating. Since the reference grating is computer generated, it can be readily shifted and, thus, aids in the logical moiré pattern analysis using either the COnventional Moiré Fringe ORdering Technique (COMFORT) or the more powerful Phase Shifting And Logical Moiré (PSALM) method. Using simulated specimen and reference gratings, logical moiré becomes a versatile teaching tool. A simple set of programs implementing these features are available on request.

Typical examples of digital moiré applications.



Reflection moiré can be realized in a variety of ways. The simplest approach is to use the computer monitor itself to display the computer grating. Analysis can also be achieved in a variety of ways due to the ability to modulate the generating grating. The figure shows the logical moiré of a centrally loaded clamped plate and the resulting analyses using PSALM. Shadow moiré requires displaying the computer grating on a transparent panel. The commercial liquid crystal display (LCD) panel is adopted for this purpose. Because of the poor contrast of gratings on this panel particularly to oblique illumination, a novel rapid fringe enhancement scheme was devised[4] to produce the high contrast fringes.

Projection moiré uses an LCD projector to superimpose the computer grating onto the specimen surface. As with reflection moiré, the versatility of computer gratings enables many different approaches for the projected grating analysis. In the figure, however, a novel setup is shown that uses a pulsed structured diode laser to illuminate a cylindrical can on a rotating stage which generates an "unwrapped" projected grating that can then be analyzed using PSALM.

ACKNOWLEDGMENT

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The Telescopes of Galileo

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Very little is known about the origins of optical engineering. Spyglasses first appeared in the early seventeenth century; they were made of two spectacle lenses at the ends of a tube, one for the farsighted viewers, the other for the nearsighted viewers. Galileo then undertook the development of the working telescope.

The only lenses that remain from Galileo's telescopes are housed at the Science Museum of Florence and have been tested using modern optical techniques.[1] In particular, the objective lens used by Galileo to discover the Medici