Statistical Properties of Clipped Speckle Pattern and Its Applications to Optical Correlator

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The present thesis is concerned with a fast and precise correlation measurement using binarized speckle signals. In this paper, the statistical properties of clipped speckle signals are investigated and the implementation of an optical nonlinear correlator is presented based on them.

The accuracy of the peak detection in speckle correlation technique is studied by using a computer simulation. The computer simulation for various optical systems shows that the clipping technique has the advantage of the accurate peak detection of the speckle cross-correlation function.

The differences of the accuracy of the peak detections among logical AND, logical NOR, logical XOR, and clipped intensities of 1 and -1 for the clipped correlation are studied theoretically and experimentally. The obtained results show that the accuracy of the peak detections varies depending on the intensity threshold level and the employed logical operations. However, it is proved that the logical XOR and $(1, -1)$ operations are equivalent to each other.

To calculate the correlation function of a two-dimensional speckle intensity, the method of the optical parallel processing is employed. For this purpose, the intensity and phase modulation characteristics of a liquid crystal television (LCTV) as a spatial light modulator are investigated. The effects of the binarization for the speckle signals on the diffraction efficiency are also discussed theoretically and exprimentally. Based on the results, the optical correlators for speckle interferometry are proposed by using LCTVs and nonlinear Optic RAM detectors.