Abstract

The speckles, a random intensity distribution, despite being treated as noise in a coherent imaging system, are widely used in different practical applications. Techniques based on the characterization and measurement of different deterministic parameters of a speckle pattern have been developed for various application purposes. In the present thesis, different techniques based on modulation of the spatial coherence-polarization (CP) property of the speckles are proposed and experimentally demonstrated for imaging and sensing through a random scattering medium. It is shown that by modulating the polarization speckle, which are generated by propagating a superposition of two mutually orthogonally polarized beams through a birefringent scatterer, using a polarizer, the polarization information of the input beams can be retrieved. The technique is demonstrated by imaging horizontally and vertically polarized objects through a random birefringent scatterer. The off-axis speckle holography, employed for imaging through a random scatterer, is investigated in detail and it is observed that the quality of the retrieved object depends on the average number of reference speckles, and the nature of the dependency is different in the less random and completely random domains of the reference speckles.

Besides, a technique, referred as the polarization based intensity correlation, is proposed for detailed characterization of spatial CP property of the polarization speckle, and it is found that the range of the correlation of a particular polarization component depends on the average intensity corresponding to that particular polarization component. The existence of non-zero correlation between two orthogonally polarized speckle patterns, filtered from partially depolarized speckles, is also observed. Apart from the characterization, a complete control over the spatial CP property of a speckle pattern is also achieved from the superposition of two uniformly polarized speckle patterns, and it is demonstrated that the spatial degree of coherence and degree of polarization can be modulated in a sinusoidal fashion exploiting the proposed technique.

The concept the of superposition of two speckle patterns is extended to control the speckle contrast (SC), which also contains information about the spatial CP property of a speckle pattern. It is demonstrated that the SC of the superposed speckle pattern can be modulated sinusoidally by controlling the mutual orientation of the polarization vectors of the constituent speckle patterns. The proposed technique is utilised to demonstrate non-invasive, real-time tracking of rotation of polarization vector through a scattering layer, and the potentiality of the proposed technique in different non-invasive sensing applications is demonstrated by successfully retrieving the concentration of sugar solution through a scattering layer.

Keywords: *Speckle pattern, Spatial coherence-polarization, Intensity correlation, Off-axis speckle holography, Speckle imaging.*