INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	SANTANU KONWAR
Roll Number	:	136121029
Programme of Study	:	Ph.D.

Thesis Title: Performance Enhancement in a Modal Wavefront Sensor and its Application to Free Space Optical Communication.

Name of Thesis Supervisor(s)	:	Prof. Bosanta Ranjan Boruah
Thesis Submitted to the Department/ Center	:	Yes
Date of completion of Thesis Viva-Voce Exam	:	02-11-2019
Key words for description of Thesis Work	:	Wavefront, wavefront aberration, Zernike modes, wavefront sensor, model wavefront sensor, computer generated holography, inter-modal cross talk, and free space optical communication.

SHORT ABSTRACT

Wavefront is a fundamental feature of a light beam. It can be defined as the surface constructed by the loci of points having the same phase or the points that correspond to equal optical path lengths starting from the source. When a coherent light beam such as a laser beam passes through certain medium or gets reflected by certain surface, the wavefront of the light beam gets modified in such a way that the modification is characteristic of the transmitting medium or the reflecting surface. Thus a plane wavefront after being transmitted by the medium or after being reflected by the surface may get distorted. Such distortions which are nothing but deviations in the phase profile from an ideal plane wavefront are termed as wavefront aberrations. Wavefront aberration if introduced may result in loss of information carried by the beam and it requires removal of the aberration to extract the original information. On the other hand the aberrations introduced by a reflecting surface can provide information regarding the profile of the surface roughness. The setup to measure the wavefront of a light beam is known as wavefront sensor. There is an important type of wavefront sensor called the modal wavefront sensor that can provide a direct estimation of the strength of the orthogonal aberration modes present in a beam of light. One of the most widespread used modal wavefront sensors is the bias beam based modal wavefront sensor which is based on estimating the strength of an aberration mode by measuring the difference in the central focal intensities of two bias beams. The two bias beams are two copies of the same incident beam with the addition of a certain aberration to the phase profile in the case of one and the subtraction of the same aberration from the phase profile in the case of the other. The bias beam based modal wavefront sensor provides direct measurement of the aberration mode strengths and has found applications in diverse areas. However, the output of the basic modal wavefront sensor has a limited range of linear response and the output gets effected by inter-modal cross talk. Holographic version of the modal wavefront sensor is easily implementable using a liquid crystal spatial light modulator (LCSLM). However, beams diffracted by the LCSLM is observed to be susceptible to temperature dependent wandering which degrades the performance of the sensor. In this thesis the issue of beam wandering associated with an LCSLM is first investigated and a means to minimize

such beam movement is proposed. We then implement an LCSLM based modal wavefront sensor that has improved beam stability. We then investigate the issue of inter-modal cross talk by developing a theoretical expression for quick quantitative estimation of the cross talk and results are verified experimentally. We then introduce a multiplex hologram based modal wavefront sensor that facilitates measurement of multiple aberrations with an enhanced linear response range and immunity from inter-modal cross talk. The proposed sensing scheme can perform without effecting the sensitivity and the sensing speed. The thesis ends with an application of our proposed wavefront sensor in free space line of sight optical communication system.