# Single shot interferogram analysis for optical metrology

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We report a novel constrained optimization method for single shot interferogram analysis. The unknown test wavefront is estimated as a minimum L2-norm squared solution whose phase is constrained to the space spanned by a finite number of Zernike polynomials. Using a single frame from standard phase shifting datasets, we demonstrate that our approach provides a phase map that matches with that generated using phase shifting algorithms to within $\lambda/100$ rms error. Our simulations and experimental results suggest the possibility of a simplified low-cost high quality optical metrology system for performing routine metrology tests involving smooth surface profiles. 

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## 1. Introduction

Interferometry is a widely used tool for many applications such as optical testing and quality control. Typical interferometric methods for optical metrology currently use an in-line Fizeau configuration where the wavefront reflected from an unknown surface interferes with the wavefront reflected from a null surface [1,2] and the measurement of the unknown optic profile can be performed by estimating the phase from the interference data. Several approaches for phase estimation exist in the literature of which the most commonly used approaches are the phase shifting and the Fourier transform methods. In the phase shifting method [3], multiple interferogram frames with known phase shifts are recorded and are then processed digitally for phase estimation. While the resolution of phase map obtained with the phase shifting method is typically same as the digital array detector used for recording the interferograms, the requirement of multiple frames implies that the phase shifting method is not suitable when the metrology system is under the influence of external disturbances and vibrations. A single shot approach for interferometry is most desirable in harsh environments, e.g., real-time metrology of a part under manufacturing/polishing process, since a single short exposure interferogram frame can freeze the effects of vibrations and other ambient disturbances. The phase estimation from a single closed-fringe interferogram is, however, a difficult problem in general. Historically, the most prominent single shot technique is the Fourier transform method (FTM) [4–6] which requires introduction of carrier frequency in the interference pattern. The carrier-frequency structure of the interference pattern, however, imposes a resolution limitation in that the achievable wavefront resolution is typically lower than the resolution capability of the digital detector array used for recording the interferogram. Additionally, FTM cannot be applied to interferograms containing closed fringes, as there is no clear separation of interference terms in the Fourier

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