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Authors(s)	Ryle, James P., Al-Kalbani, Mohammed, Collins, Niamh, Gopinathan, Unnikrishnan, Boyle, Gerard, Coakley, Davis, Sheridan, John T.
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Speckle interferometric system for measuring ocular microtremor

James P. Ryle^{1,2,3}, Mohammed Al-Kalbani^{4,5}, Niamh Collins^{4,5}, Unnikrishnan Gopinathan^{1,6}, Gerard Boyle^{4,5}, Davis Coakley^{4,5} and John T. Sheridan^{1,2,3}

¹UCD School of Electrical, Electronic and Mechanical Engineering,

²Optoelectronics Research Centre,

³SFI Strategic Research Centre in Solar Energy Conversion,
University College Dublin, Belfield, Dublin 4, Ireland.

⁴Mercer's Institute for Research on Ageing (MIRA),

⁵Medical Physics and Bioengineering Department (MPBE),
St. James's Hospital, Dublin 8, Ireland.

⁶Institut für Technische Optik, Universität Stuttgart, Pfaffenwaldring 9,
D-70569 Stuttgart, Germany

email: john.sheridan@ucd.ie

Abstract: A compact optical system has been developed capable of measuring minute movements of the eye. Eye movement is simulated through the application of an electrical signal to a piezoelectric material which acts as the eye's surface. Using this device, both the amplitude and frequency components of this movement can be accurately measured.

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1. Introduction

Ocular microtremor (OMT) is a biological high frequency (up to 150Hz) low amplitude (25-2500nm peak to peak) involuntary motion of the human eye. Along with microsaccades and drift, OMT is one of the three fixational eye movements described by Adler and Fliegelman in 1934. Recent studies suggest a number of clinical applications for OMT, including monitoring depth of anesthesia during surgery, prediction of outcome in coma and diagnosis of brainstem death. Abnormal OMT frequency content is of potential diagnostic value in neurological disorders such as multiple sclerosis and Parkinson's disease.

Clinical OMT investigations to date have mostly used eye-contacting piezoelectric strain gauges. These eye-contacting systems have a number of disadvantages, both procedural and technical, especially pertinent to investigation of OMT in clinical populations. Since the probes come in contact with a mucous membrane (the sclera), they must undergo rigorous disinfection procedures prior to use. Potential discomfort due to probe contact requires that the scleral surface be topically anaesthetised. Despite anaesthesia, subjects may still experience minor discomfort during probe contact. Technical disadvantages include the likelihood of some degree of inherent mechanical damping due to probe contact, precluding accurate estimation of displacement. The development of a non-contacting optical system for OMT measurement in clinical populations is highly desirable.

In this paper, we present a new development in non contacting OMT measurement based phase-modulating speckle interferometry. The setup consists of laser diode (638 nm) with adjustable laser current, allowing for power adjustment to give safe eye exposure. The optical configuration used is that of an in-plane speckle interferometer. The laser beam is delivered by optical fibre to allow the system to be of portable. The laser beam undergoes 50% beam splitting and modulation (15kHz) using a Y-junction integrated phase modulating (Guided Color Technologies). The two beams are brought together on the sclera. The scattered speckle is detected using a high bandwidth photodiode. Next the interference signal from the photodiode is demodulated and processed to extract displacement information. The system has been tested on the bench top using a piezoelectrically vibrated target simulating the eye. It is within specification for a non contacting OMT measurement system and in vivo tests will follow.