Tunable-frequency two-dimensional wollaston prism-based structured illumination microscope

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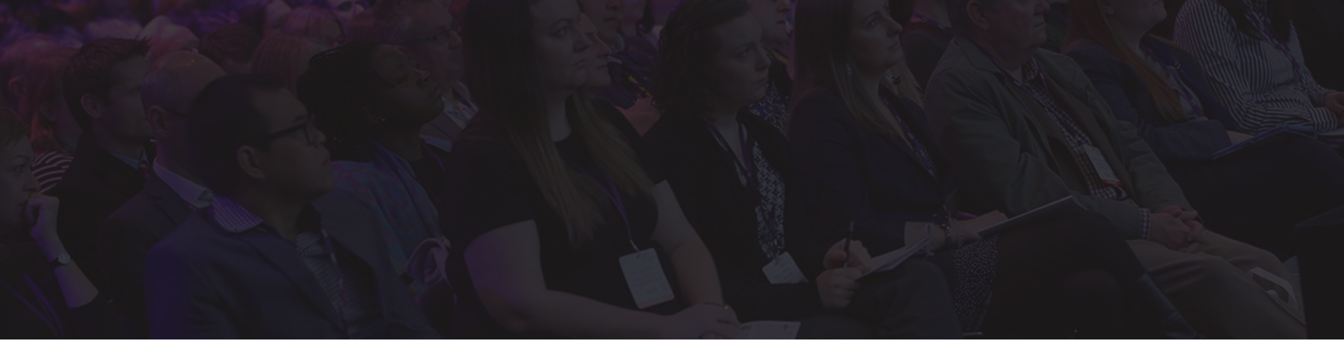
Recently, we have shown that an axially-extended two-dimensional (2D) Structured Illumination (SI) pattern can be produced by a Fresnel biprism illuminated by a spherical wavefront emerging from one incoherent linear source[1] (e.g. slit). This configuration provides a SI pattern equivalent to the one created by interfering two waves. The main advantage of using a Fresnel biprism illuminated by a slit (set at the front-focal plane of a conversing lens and the biprism is inserted between these two optical elements) is that the frequency of the SI pattern can be tuned by changing the axial position of the biprism with respect to the slit. In this work, we have experimentally validated a new incoherent-based tunable-frequency Structured Illumination Microscope (SIM) based on a Wollaston prism (WP)[3] instead of the Fresnel Biprism (FB). The SI pattern in this new configuration is generated by splitting the light emerging from an incoherent slit using a WP. Our proof-of-concept results shows that the WP-based SIM system improves the lateral resolution of the native system along a single lateral direction as predicted by theory. Although this work was not aimed for a rigorous comparison between our WP-based and FB-based systems, during the studies reported here, we observed that the proposed WP-based SIM system presents some advantages over the optimal design of our FB-based 2D-SIM implementation. The first advantage (previously predicted by a theoretical study) is that the WP-based SI pattern has a higher lateral extension (i.e., the field of view with observable fringes is greater) and is not affected by any envelope function as in the case of the FB-based SI pattern. This means that data pre- or post-processing steps are not required in obtaining reconstructed SIM images without any undesired residual fringes. However, more importantly, a significant advantage of the WP-based SI device is that it can be used with a de Sénarmont compensator to produce a continuous and accurate phase shifting of the SI pattern. Using this phase-shifting method, the WP-based SI device can phase-shift the fringes by π rad for every 90 deg rotation of the analyzer regardless of the lateral modulation frequency of the pattern. This feature allows the acquisition of raw SIM images with proper phase shifting (i.e., different from π) at each lateral modulation frequency of the SI pattern without the need of recording additional phase-shifting calibration data. Finally, the double-shot processing method developed for our FB-based SIM1 to combine Optical-Sectioned (OS) and Super-Resolved (SR) 2D-SIM images can be used with the proposed WP-based SIM system to provide optically sectioned images with SR. Because of these advantages and the continuous variation of the SI pattern's lateral modulation frequency up to the cutoff frequency of the system, we believe that the WP-based SI setup is suitable for an add-on SIM module that can be implemented in any commercial fluorescence microscope

Biography: Ana Doblas received her BS, MS, PhD degrees in Physics from the Universitat de València, Spain, in 2010, 2011 and 2015, respectively. After she finished her PhD work, she joined the Optical Coherence Imaging Laboratory under the supervision of Dr A. Oldenburg (Department of Physics and Astronomy, University of



North Caroline in Chapel Hill, U.S.A.) where she did her 1-year Postdoc. Since 2016, she is at the Department of Electrical and Computer Engineering at the University of Memphis (Memphis, Tennessee, U.S.A.). Firstly, as a Research Assistant Professor in the Computational Imaging Research Laboratory (CIRL) and since 2019 as an Assistant Professor and principal investigator of the Optical Imaging Research Laboratory (OIRL). Her current research interests are focused on optical engineering, computational optics and three-dimensional imaging with special interest in the design of novel microscopic imaging systems and their applications. Her final goal is to develop novel optical microscopes that provide us an understanding of unsolved biological questions. Although this topic requires multi-disciplinary approaches from different backgrounds such as Biology, Physics, Microscopy and Informatics, her particular focus is the development of custom optical imaging methods with some insights in image analysis tools to pursue cutting-edge research. Since 2012, she is author of 23 peer-reviewed scientific journals, her work has been presented at over fifty international conferences and she is co-inventor of two US patents.

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