FULL POINCARÉ ULTRA-SENSITIVE POLARIMETRY FOR MICROSCOPY

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Optical polarimetry plays important role in lots of research fields, such as remote sensing, material characterizing, or biomedical diagnosis. The precision and accuracy of such methods are of paramount importance and are particularly important in label-free microscopy.

Numerous techniques of polarimetry have been put forward in the past decades. But if we summarise their commonality, they directly or indirectly use matrix calculation to calculate the vector components of the light, and require the processes of denoising, optimization, and calibration to take place before the measurement. Those properties limit the sensing ability via the accumulation of various errors. Here, we put forward a new measurement paradigm based on a novel physical concept to circumvent such limits, hence enabling ultra-sensitive single-shot polarimetry [1]: rather than solving for the vector polarisation components in the conventional cumbersome way, we convert this complex task into an intuitive problem that is equivalent to searching for the maximum intensity point in an image. This is achieved through the use of a single vectorially structured light field. The method presents new prospects for direct vector sensing, rather than indirect estimation via a matrix calculation.

This paradigm requires a universal full Poincaré generator system, which is a type of beam modulator that can generate all polarisation states in a single beam with any pure polarised states incident. Hence, it also consists of all polarisation analyser states, rather than the few discrete states used in conventional polarimetry, enabling an image processing method for implementation of single-shot polarimetry. This approach overcomes existing limitations via simultaneous estimation of all vector components, in the following ways；1) it circumvents the systematic error amplification limit due to matrix inversion; 2) it combines the pipeline of denoising, optimization, and calibration into a single step. The performance shows exceptional precision and accuracy in polarisation sensing, at a level not achievable through reported state-of-the-art methods of snapshot polarimetry. This will be particularly useful in improving the sensitivity of polarimetric microscopes for applications such as clinical diagnosis of tissue pathology.

[1] Chao He, Jianyu Lin, Jintao Chang, Jacopo Antonello, Ben Dai, Jingyu Wang, Jiahe Cui, Ji Qi, Min Wu, Daniel S. Elson, Peng Xi, Andrew Forbes and Martin J. Booth. "Full Poincaré mapping for ultra-sensitive polarimetry" arXiv preprint arXiv: 2101.09372 (2021).