POLARIZED LIGHT RESPONSES TO SCATTERER PROPERTIES: TOWARD IMPROVED TUMOUR DETECTION AND CHARACTERIZATION

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Keywords: optics, polarization, Mueller matrix, helicity, orthogonalization, tumour detection

Our recent studies have explored the influence of scatterer size and turbidity on polarized light both theoretically and experimentally [1-3]. The goal is to enhance polarimetric tumour detection and characterization since tissue turbidities change as tumours form, and cell nuclei – which interact strongly with light – often increase in size during cancer progression [4]. These studies have found that media of unique scatterer size and turbidity can be differentiated using (1) linear and circular depolarization measurements, and (2) helicity spin-direction responses of circularly polarized light (e.g., right-circular becoming left-circular or remaining the same), including their spatial dependence. We have also exploited the geometrical flipping effects of linearly polarized light, in combination with the helicity responses, to differentiate enamel-decayed teeth from normal teeth [3].

We are now polarimetrically imaging resected breast and lung tumours with two overarching aims: (1) assessing tumour margins intraoperatively to ensure gross total resection (preventing recurrence and/or secondary resection surgeries), and (2) guiding highly-sensitive mass spectrometry (MS) to cancer cell regions, avoiding 'unimportant' or problematic regions such as coagulated blood, connective tissue, and fat. MS is sensitive enough to yield a definitive diagnosis (via molecular composition analysis), however entire tissue resections cannot be analyzed quickly enough to be useful in the intraoperative setting, hence the need for polarimetric guidance [5].

Our preliminary results show that the gained insights from our earlier studies on polarization memory and orthogonalization effects potentially enable improved tumour detection, particularly in combination with Mueller matrix images. For example, we have found that large scatterers tend to preserve the helicity of circularly polarized light, whereas small scatterers tend to flip the helicity. Lipid 'scatterers' in breast tissues are smaller (and scatter less) than cell nuclei, particularly malignant cell nuclei which become enlarged. Therefore, one can then filter out low intensities of helicity preserved images and high intensities of helicity flipped images (via thresholding) to eliminate signals from lipid regions. These images can then be combined with the depolarization image (which often highlights dense cellular regions) to better delineate the tumour, as shown in Fig. 1. Retardance images can also be used to eliminate signals from collagen. Methodologies such as these will be tested on additional specimens to evaluate their feasibility.

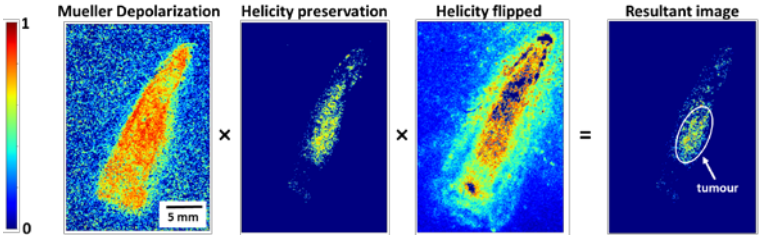

Fig. 1: Improving tumour delineation using helicity-preserved and -flipped circular polarization images of human breast resection (stage 2, thawed, ~4 mm thick), measured in reflection-mode at 632.5 nm.

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