Terahertz refractive index-based morphological dilation: A strategy towards improving breast conserving surgery

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Preliminary investigations have shown that breast cancer tissues have higher refractive index profiles than healthy tissues in the terahertz band [1]. However, these variations were observed for tissues with a structural homogeneity of about 90%. Thus, when studying areas where the structural homogeneity is drastically lower than the one aforementioned -typically around the tumour area-, the refractive index alone does not allow a rigorous demarcation between healthy and malignant tissue. As a result, it raises delicate question on the exact spatial extent of the tumour. In order to facilitate the spatial delineation of the tumour, a pixel-by-pixel classification based on the extraction of the tissue refractive index map, directly after surgery, followed by morphological dilation was investigated [2]. The method consists of establishing an initial diagnosis based on the refractive index of each pixel at 550-GHz by means of an inverse electromagnetic problem. A refractive index threshold is then defined so that pixels exhibiting a refractive index higher than the threshold are classified as malignant while others are considered as benign pixels. The preliminary classification is followed by morphological dilation. Such a process is operated from pixels previously classified as malignant. Hence, malignant zones are progressively spread over the neighbourhood. Doing so allows one to overcome the aforementioned class-overlapping limitations. A schematic of the process is given in Fig. 1, for an arbitrary dilation shape. The respective confusion matrices, as well as the receiver operating characteristic curves for each combination of a refractive index threshold and dilation shapes, have been extracted. For the best case, the process of morphological dilation enhanced the effectiveness of the diagnosis by about 33%. Diagnosis images will be presented and discussed during the presentation.

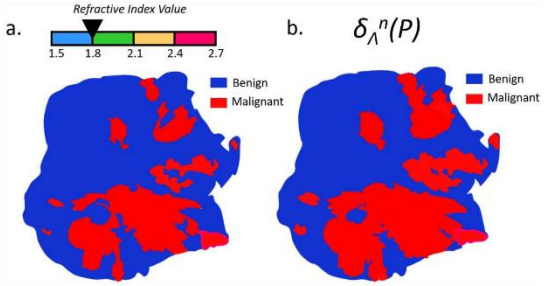

Fig. 1: Principle of morphological dilation applied on a tissue binary refractive index map. a: Binary refractive index map set at 1.8. b: Morphological dilation applied to the binary refractive index map with an arbitrary dilation operator.

References:

[1] Ashworth, P. C., Pickwell-MacPherson, E., Provenzano, E., Pinder, S. E., Purushotham, A. D., Pepper, M., & Wallace, V. P. (2009). Terahertz pulsed spectroscopy of freshly excised human breast cancer. *Optics express*, *17*(15), 12444-12454.

[2] Cassar, Q., Caravera, S., MacGrogan, G., Bücher, T., Hillger, P., Pfeiffer, U., ... & Mounaix, P. (2021). Terahertz refractive index-based morphological dilation for breast carcinoma delineation. *Scientific reports*, *11*(1), 1-16.