

High throughput calculation of local spatial autocorrelation length for label-free diagnosis of tissue biopsy

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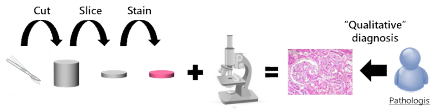
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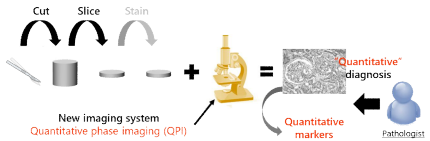
INTRODUCTION

Standard breast tissue diagnosis



Problems in standard tissue diagnosis
 ✓ Variation in staining quality
 ✓ Inter-observer variability

Breast tissue diagnosis using QPI



Label-free and quantitative diagnosis.

New quantitative markers

QPI are sensitive to sub-wavelength fluctuations in refractive index map in both space and time.

Purpose

We propose a new quantitative marker of sub-wavelength morphological alteration "local spatial autocorrelation length" and its calculation method and demonstrate classification between benign and malignant breast tissue

Sub-wavelength morphological information

(1) Disorder strength

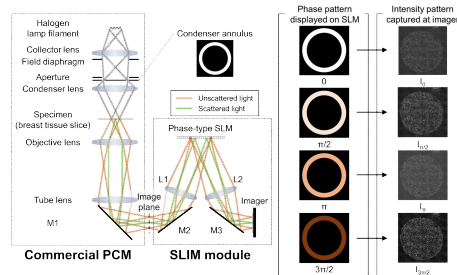
→ see poster 10503-81, H. Subramanian, et al., Opt. Lett., 34, 518 (2009), and W. J. Eldridge et. al., Biophysical Journal 112, 692 (2017).

(2) Local spatial autocorrelation length

Tissue	Local correlation length
Background	0
Disordered	Short
Not disordered	Long

METHODS

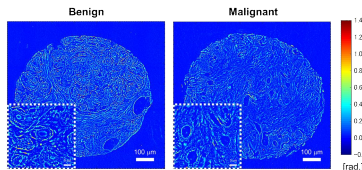
Spatial Light Interference Microscopy (SLIM)



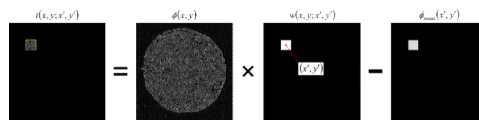
G. Popescu: Quantitative Phase Imaging of Cells and Tissues: McGraw Hill, 2011.

Imaging target

- ✓ Breast tissue microarray (TMA)
- ✓ Thickness = 400 μm
- ✓ Diagnosed as either benign or malignant by pathologist
- ✓ 20 benign and 20 malignant cores are used for analysis
- ✓ UIUC - IRB Protocol Number 13900



Local spatial autocorrelation length



$$\Gamma(x, y; x', y') = t(x, y; x', y') \otimes t(x, y; x', y')$$

Calculating local correlation length map, $\rho(x', y')$, for all (x', y') needs very strong calculation power and very long time...

New definition of $\rho(x', y')$

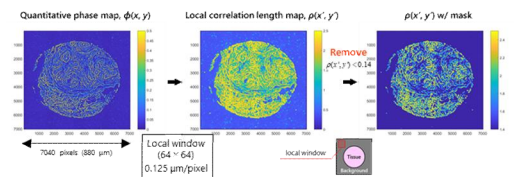
$$\rho(x', y') = 2\pi \frac{\iint |t(x, y; x', y')|^2 dk_x dk_y}{\sqrt{\iint \left| \frac{\partial}{\partial x} t(x, y; x', y') \right|^2 + \left| \frac{\partial}{\partial y} t(x, y; x', y') \right|^2 dk_x dk_y}}$$

Points

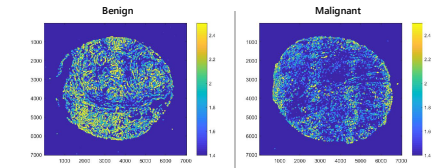
- Local correlation length is defined as variance of normalized local correlation function.
- The product of variances of Fourier-pair functions becomes 2π .

RESULTS

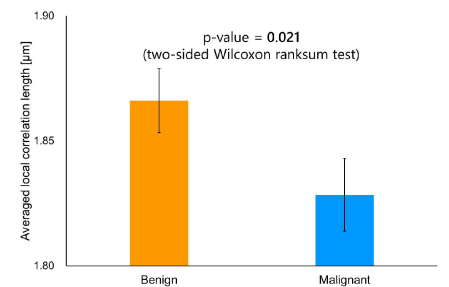
Procedure



Disorder strength map



Benign and malignant breast tissue screening



CONCLUSIONS

- We proposed to use the local spatial autocorrelation measured from QPI as a quantitative marker of malignancy and provided its fast calculation method.
- We demonstrated the classification between benign and malignant breast cores by local correlation length and obtained the result showing its effectiveness.