# Effective multi-spectral photoacoustic imaging of prostate-specific membrane antigen (PSMA) targeted agent for aggressive prostate cancer detection

Yixuan Wu[1*], Jeeun Kang[1*], Haichong K. Zhang[2], Martin G. Pomper[1], Emad M. Boctor[1]
[1]Johns Hopkins University, Baltimore, USA, [2] Worcester Polytechnic Institute, Worcester, USA
* These authors equally contributed to this work.

## Background, Motivation and Objective

Prostate-specific membrane antigen (PSMA) is a known bio-marker for grading the malignancy of prostate cancer. In our recent study, *in vivo* photoacoustic (PA) imaging of PSMA-targeted dye presented rich optical contrast on aggressive prostate cancer with good spatial resolution. However, selecting critical wavelengths for more accurate and efficient cancer detection has yet been explored. In this paper, we present a compressive multi-spectral PA imaging with optimal wavelength. The detection accuracy relevant to the diagnostic sensitivity is highlighted.

## Statement of Contribution/Methods

A framework of simulation-aided multi-spectral PA signal is modeled to define the optimal wavelength (OW) subset. In k-Wave simulator, the spectral coloring artifact, the background noise generated from inconsistent laser energy, and the spectral white noise are synthesized with the spectral PA signal composed of random fractions of composition-of-interest (i.e., PSMA-targeted agent, Hb, and $HbO_2$) ($n$ = 30). Statistically-robust OW subset is first iteratively searched, then the relative error of PSMA-targeted agent decomposition was compared to conventional whole-wavelength (WW) superset and conventional minimal wavelength (MW) (3 wavelengths in this case). The contrast resolution on PSMA-targeted agent of WW, MW and OW were further validated in *in vivo* experiment using CD-1 mice with PSMA-targeted agent ($n$ = 3).

## Results/Discussion

From the WW superset (700 to 900 nm in step of 10 nm), our wavelength optimization method yielded the MW at (700, 780, 850) (nm) and the OW at (730, 740, 750, 780, 800, 820, 830, 840, 860, 880) (nm). In simulation, the OW significantly reduced the estimated composition error compared to WW and MW sets: 0.004±0.013% vs. 2.1%±2.1% and 0.240±0.002, respectively. Consistently, the proposed OW subset shows 10.36±27.53% and 67.73±84.46% higher contrast between $PSMA^+$ PC3-pip and $PSMA^-$ PC3-flu than those by WW and MW, respectively. Therefore, the proposed OW subset would provide effective multi-spectral PA imaging of PSMA-targeted agent to improve diagnostic specificity for aggressive prostate cancer detection. Further works will be focused on improving computational time and rigorous *in vivo* validation.

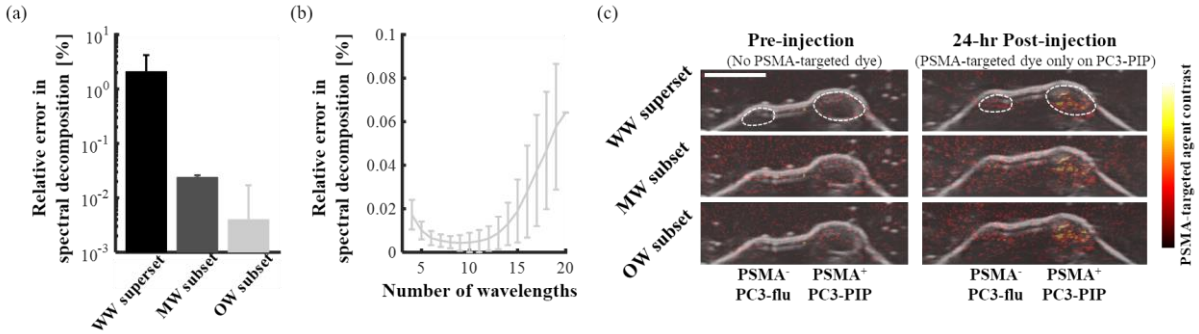


Figure 1. Comparative evaluation of whole-wavelength (WW) superset, minimal wavelength (MW) subset, and optimal wavelength (OW) subset. (a) Relative error in spectral decomposition in k-Wave simulation; (b) relative error of the OW subset when restricting the number of wavelengths; (c) *in vivo* estimation of PSMA-targeted agent contrast in pre-injection and 24-hour post-injection phases.