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Congress Abstract

Computational Signal-Processing Framework for Multichannel Fiber-Optic Biosensor Data Analysis in Cancer Cell Detection

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Introduction: Fiber-optic biosensors generate complex, multichannel interferometric data affected by baseline noise and drift, which must be filtered and converted into standardized performance metrics before they can support cancer cell detection claims. Our group's fiber-optic biosensing programme uses two recognition strategies — a surface plasmon resonance anti-CD44 immunosensor and a PDA-based molecularly imprinted polymer sensor — for TNBC cell lines detection, yet both rely on the same challenge: extracting reliable calibration data from noisy, multi-channel wavelength-shift signals. To address this gap, a computational signal-processing framework was developed and validated that applies baseline correction and noise filtering, automatically identifies high-sensitivity spectral channels, fits calibration curves, and computes limit of detection, coefficient of determination, repeatability, and selectivity, and was applied to quantify and compare the two TNBC biosensor platforms.

Materials and Methods: A computational/analytical approach was applied to previously acquired experimental data. Raw transmission spectra from 8-channel quasi-random extrinsic interferometric fiber-optic sensors were used: (1) the SPR-based anti-CD44 immunosensor exposed to HCC1806 TNBC cells and HEK293 control cells, and (2) the PDA-based MIP sensor exposed to HCC1806 and MDA-MB-231 TNBC cells. Raw spectra were first denoised using a 5th-order Butterworth filter combined with baseline subtraction to correct for high-frequency noise and baseline drift prior to peak identification. For each channel, a custom peak/valley-detection algorithm implemented in MATLAB identified interference fringes and tracked wavelength position across cell concentrations. The sub-range with the steepest slope was selected as the optimal operating range per sensor. Calibration curves were fitted by linear regression, with the coefficient of determination (R^2) as fit quality. Limit of detection (LoD) was calculated as 3σ of the blank response divided by calibration slope. Repeatability was assessed as coefficient of variation across replicates; selectivity by comparing target-cell versus non-target/control responses.

Results and Conclusions: The developed computational framework successfully processed multichannel interferometric data from both the SPR-based immunosensor and the MIP-based biosensor, automatically identifying high-sensitivity spectral channels and extracting calibration-based performance metrics — including limit of

detection, coefficient of determination, repeatability, and selectivity — for each. Filtering with the Butterworth and baseline-subtraction steps improved spectral clarity by suppressing high-frequency noise and drift, yielding calibration curves with higher sensitivity and improved linearity. This provided a consistent, standardized basis for comparing the two recognition strategies and demonstrates the framework's potential as a common analytical backbone for future fiber-optic biosensor platforms in oncology, extendable to currently unanalyzed sensor datasets.

Keywords: Biosensing Techniques; Antibodies; Polymers; Cell Line; Triple Negative Breast Neoplasms