Time-domain signal averaging to improve microparticles detection and enumeration accuracy in a microfluidic impedance cytometer

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Abstract

Microfluidic impedance cytometry is a powerful system to measure micro and nano-sized particles and is routinely used in point-of-care settings disease diagnostics and other biomedical applications. However, small objects near a sensor's detection limit are plagued with relatively significant background noise and are difficult to identify for every case. While many data processing techniques can be utilized to reduce noise and improve signal quality, frequently they are still inadequate to push sensor detection limits. Here, we report the first demonstration of a novel signal averaging algorithm effective in noise reduction of microfluidic impedance cytometry data, improving enumeration accuracy and reducing detection limits. Our device uses a 22 μm tall microchannel and gold coplanar microelectrodes that generates an electric field, recording bipolar pulses from polystyrene microparticles flowing through the channel. In addition to outlining a modified moving signal averaging technique theoretically and with a model dataset, we also performed a compendium of characterization experiments including variations in flow rate, input voltage, and particle size. Multi-variate metrics from each experiment are compared including signal amplitude, pulse width, background noise, and signal-to-noise ratio (SNR). Incorporating our technique resulted in improved SNR and counting accuracy across all experiments conducted, and the limit of detection improved from 5 μm to 1 μm particles without modifying microchannel dimensions. Succeeding this, we envision implementing our modified moving average technique to develop next generation microfluidic impedance cytometry devices with an expanded dynamic range and improved enumeration accuracy. This can be exceedingly useful for many biomedical applications, such as infectious disease diagnostics where devices may enumerate larger-scale immune cells alongside sub-micron bacterium in the same sample.

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