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Raman Optofluidics

Optofluidics, the integration of optics and microfluidics, enables novel sensing and actuation strategies. In this work, we combine Raman spectroscopy and hyperspectral imaging with microfluidic systems for precise control and delivery of liquid samples in three applications. First, we achieved ABO blood typing using Raman spectroscopy without sample preparation, delivering results in 60 seconds [1]. A machine learning model trained on spectra from 300 whole blood samples (drawn directly from EDTA tubes) achieved over 90% pairwise classification accuracy (ROC AUC) and detected at least 38 blood-related traits with an average ROC AUC of 0.74. The accuracy scaled with training set size, suggesting clinical relevance is feasible with 100,000 samples. Second, we developed a microfluidic cell for high-throughput Raman analysis of both transparent and opaque fluids using 3D hydrodynamic focusing [2], which improves measurement efficiency and reduces photodegradation compared to fused silica capillaries. The cell also enables parallel lamination of two distinct flows, allowing simultaneous excitation via line illumination and real-time monitoring of mixing or reactions. Third, we are developing a label-free, high-resolution (4D) molecular profiler for real-time, localized detection of unlabeled molecules in 3D environments, such as ex vivo tissues and advanced in vitro models, supporting research in tissue engineering, drug development, and controlled release systems.

References

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