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Rapid Bacterial Identification and Antibiotic Susceptibility Testing using Raman Spectroscopy and Machine Learning

Bacterial bloodstream infections account for over 40% of death in hospitals and are one of the most expensive medical conditions in the US. Current diagnostic methods are slow and costly, due to the long bacterial culturing step required for detection, identification, and antibiotic susceptibility testing. My work utilized Raman spectroscopy for rapid culture-free, sensitive, and specific bacterial identification and antibiotic susceptibility testing. Despite such promise, Raman's clinical translation has lagged due to reproducibility issues, bulky spectroscopy equipment needs and challenges in clinically suited sample preparation.

In this talk, I will present three major milestones to address these issues by using machine learning and nanophotonics. First, we achieve high (>99%) species level classification accuracies across 30 major disease-causing bacterial species using their Raman spectra and machine learning based spectral data classification. We also demonstrate promising antibiotic susceptibility prediction on 100 patient derived *E. coli* samples with diverse response profiles to 15 major antibiotics. This is a first of its kind demonstration of a versatile and antibiotic co-incubation free susceptibility testing. Second, we enable design of lower resolution more affordable spectrometers by implementing feature recognition approaches to isolate bands of spectra that are key for the accurate classifications. Furthermore, feature recognition enables us to isolate specific spectral regions and trace biochemical origins of antibiotic resistance for fundamental bacterial studies. Third, we develop a simple liquid well setup for clinical sample handling with uniform Raman spectral enhancement using gold nanorods. This approach preserves cell viability enabling real-time cell monitoring in response to environmental perturbation such as antibiotics. My work opens the door for clinical translation of novel spectroscopy based diagnostic tools for identifying bacterial infections, viral infections such as the current COVID-19 virus, early cancer detection and drug susceptibility testing by merging machine learning and nanophotonics.

Loza Tadesse is a PhD candidate in Bioengineering at Stanford University under Prof. Jennifer Dionne. Her research develops a rapid, all-optical and label free bacterial diagnostic and antibiotic susceptibility testing system that aims to avoid the time-consuming culturing step in gold standard methods. As a medical student at St. Paul Hospital Millennium Medical College in Ethiopia, she had firsthand experience of the gravity of challenges patients and physicians face in resource limited clinical settings. This led her to develop a strong interest in engineering point-of-care medical devices. When not in lab, she is heavily involved in teaching and outreach including co-founder of a non-profit educational organization called Scifro with aim to empower the African youth to solve local problems through science and innovation. Loza is a recipient of Stanford EDGE, DARE and Agilent fellowships, and the 2019 Biomedical Engineering Society (BMES) career development award. Before coming to Stanford, she did a research stint at IBM Almaden and Los Alamos National Labs.

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Tuesday, Dec. 8, 2020, 4:00 p.m.
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