November 4, 2015 (13:30–14:30)

VENDOR SEMINAR:

Elastic Light Scatter – A New Technology for Rapid Identification of Pathogens

Introduction and background to the elastic light scatter (ELS) technology

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Techniques for rapid identification of microorganisms cover a variety of technologies. Depending upon the use environment, certain features may be more important than others to the user. The technology we will describe has a number of advantages since it is categorized as reagent-free and is based on identification of organisms based on colony feature space. The technology is based on the use of elastic light scatter (ELS) whereby a laser beam strikes a colony on an agar plate and the resulting scatter pattern produced becomes a distinctive fingerprint for that organism. This fingerprint is created by establishing a classifier based on having a series of identified organisms and creating a number of known organisms. Once the system has been trained, the user can identify that organisms rapidly and in a reagent free manner. This workshop will outline the fundamentals of ELS technology, we will provide some insight into the core of the optics and physics of how ELS works and we will also discus how the classification technology operates. Finally we will outline applications and results of a number of tests that the technology has undergone.

The physics and optics of ELS

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The remarkable resolving power of the elastic light scatter (ELS) originates from the phenomena called the optical interference. ELS works by encoding the biological characteristics (micro- and macro-structural morphology) into optical signals of an interrogating wave front. With high coherency and nanometer wavelength, the incoming plane wave passes through the bacterial colony from top to bottom. Various physical parameters—such as refractive indices, the local density of bacteria and the individual shape of bacteria—can all influence the incoming photons. This interaction through the z-depth of the colony accumulates and finally disrupts the amplitude and phase of the incoming photons. The propagating lights will either result in constructive (bright spot) destructive interference (dark spot) based on the spatial distribution of the morphological and material characteristics. These secrets are then decoded through examination of the forward-scattering pattern. The use of a spatial light modulator (SLM) and a liquid-crystal display represents a renowned famous technique used in optical engineering to control wave front modulation. We can understand the photon-colony interaction as a “biological SLM” that changes the wave front characteristics based on the colony’s physical differences.

The principles of recognition and classification of ELS patterns

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The major difficulty posed by ELS measurements lies in deciphering the highly complicated ELS patterns formed by bacterial colonies irradiated with laser light. Even though the well-developed light-scattering theory and accompanying computational tools such as dipole-dipole approximation could be used for modeling and subsequent interpretation of the raw ELS signals, such a rigorous approach to the inverse-scattering problem remains extremely difficult and computationally expensive. This presentation will discuss a robust and rapid alternative methodology for pathogen recognition taking advantage of machine-learning (ML) and computer-vision tools for classification of ELS patterns formed by interaction between laser light and colony morphotypes. The employed classification algorithms (such as SVM, NN, etc) do not operate on raw ELS patterns, but utilize complex moments that are calculated in the polar coordinate space of the patterns as input features. The results demonstrate the use of the ML-ELS to classify colonies of *Listeria*, *E.coli,* and *Salmonella* with accuracy above 95

Summary of Applications

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Elastic light scatter has been proven to be a successful detection and identification technology for pathogen identification focusing heavily on food borne pathogens. Over the past several years during the development of the technology, the development groups have published over a dozen peer reviewed papers as diverse as the fundamental optics, computer science, and of course the microbiology. The first paper published on this technology focused on fundamental math describing the technologies needed to create a classification[(1).] Subsequent papers demonstrated an entire operating system of sample collection, analysis, classification and identification using Listera, Salmonella, Staph and Enterobacter as examples[(2).] The technology rapidly advanced to studying food contamination directly to show to ability to extract and identify food borne pathogens [(3)] and was extended to a variety of Vibrios [(4).] Salmonella [(5)] and even to portable instrument design[(6).] This presentation will walk through the past 9 years of research and development that have driven the development of this innovative technology

1. Journal of Biomedical Optics 11_3_, 034006 _May/June 2006.
2. Biosensors and Bioelectronics 22 (2007) 1664–1671.
3. Light-scattering sensor for real-time identification of *Vibrio parahaemolyticus*, *Vibrio vulnificus* and *Vibrio cholerae* colonies on solid agar plate Microbial Biotechnology (2012) 5(5), 607–620. doi:10.1111/j.1751-7915.2012.00349.x.
4. Light-scattering sensor for real-time identification of *Vibrio parahaemolyticus, V. vulnificus*, and *V. cholerae* colonies on solid agar plate" Microbial Biotechnology. 5: 607–620, 2012. doi: 10.1111/j.1751-7915.2012.00349.x.
5. Laser Optical Sensor, a Label-Free On-Plate *Salmonella enterica* Colony Detection Tool; mBio 5(1):e01019-13. doi:10.1128/mBio.01019-13.
6. Journal of Biological Engineering, 6:12-23, 2012. doi:10.1186/1754-1611-6-12.