DRAFT for Poster Presentation

Analyzing the Mitochondria in Airborne Water Droplets using Laser Induced Breakdown Spectroscopy(LIBS)

Abstract

Laser induced breakdown spectroscopy (LIBS) is an spectroscopic technique that uses a ND:YAG solid state laser, CCD spectrometer, and a computer for instrument interface. Present examples exist today of mobile LIBS systems such as the ChemCam aboard the Curiosity rover on Mars and instruments made by the U.S. Army Research Lab (ARL). These systems are not cheap or readily available for public circulation. This prototype design will be fundamentally open source and constantly improved with collaboration using open access tools like github. Successful characterization of mitochondria has been demonstrated using LIBS on living cells and is used commercially as a process analytical technique (PAT). This FDA approved method is used to characterize vegetables, milk, and water quality. This paper will investigate into the design and implementation of a portable LIBS system that can be flown on various platforms and open source for public use and experimentation.

I. Introduction

The well established techniques of Laser Induced Breakdown Spectroscopy (LIBS) and the modern advances in lasers and Charged Couple Device (CCD) technology may now grant public access to the atomic realm of spectroscopy. LIBS provides a non-intrusive, low power means of analysis with zero sample preparation with resolution at the atomic level. This powerful technique developed in the 1970s can provide solutions to numerous modern problems. This study will act as a preliminary investigation into efficacy and feasibility for research at the undergraduate level to produce their own LIBS system for a wide range of uses.

This study will specifically focus on the use of LIBS as a means to analyze mitochondria localized in airborne water droplets. It should be noted that given the sensitivity of the instrumentation required for this design, that it will permit the identification of many different specimens. Mitochondria was selected as the subject due to its implications as a disease carrier in the field epidemiology. Recent outbreaks of ebola in the pneumatic form can travel in the air through water droplets and have been found to use mitochondria as a carrier host. Thus, if one were able to ablate the mitochondria in a sample of air, one would be able to confirm or deny the presence of ebola in the given sample by the atomic emission lines it characteristically produces.

II. Method and Materials

The three key components of any LIBS system are a laser, spectrometer, and a computer to run them. There are a wide range of choices when selecting a laser for this application since there is no upper bound perimeter for LIBS. Put simply, a potential laser for this application may be underpowered but not overpowered; so long as the threshold for ablation is met, the emission lines will be produced. Typically an ND: YAG solid state laser (neodymium-doped yttrium aluminum garnet; $Nd{:}Y_3Al_5O_{12}$) is used in most LIBS applications. These pulse lasers operate at a wavelength of 1064nm in the near infrared.

Once abated, the emission lines must be collected by a spectrometer to measure the resulting radiation. Typical spectrometers can be cumbersome and does not fit the portability perimeters set by this study. Instead, modern charge coupled devices(CCD) can be used as a smaller and cheaper solution for this application without sacrificing resolution. Specifically, a polychromator CCD would be ideal for this application. This device works by dispersing light in different directions in order to isolate specific parts of the electromagnetic spectrum. The use of CCDs in this application has only become possible given recent advances in technology.

Finally, a computer is required to run and capture data from the sensors. The selection of the computer is dependent upon the specific laser and CCD combination but generally speaking the computer will need at at least 1 Gb of RAM to keep up with the expironment. It is important to mention software briefly given that this study will ultimately be a collaborative open source effort. It will be vital to utilize tools like github for software prototyping to allow easy sharing and debugging. Additionally, by releasing all software on github it will allow a permanent reference for future studies to improve upon and modify to their needs.

III. Results

As a preliminary investigation, the results will primary include suggested sensors for this application and previous studies which have achieved similar results. The primary constraints for sensor selection are portability and ease of access without sacrificing resolution. One combination produced by Sepradel (model number LIBS-LAS0070) is a unit that includes a sufficient laser to ablate mitochondria paired with polychromator CCD in one kit. This platform would only require a user's computer to complete the LIBS system. This product is currently undergoing a second revision to achieve an even smaller system that would work better for this application.

Previous studies by the Army Research Labs and Alan Samuels et al.(4) have successfully measured airborne particles using LIBS. They measured bacterial spores, molds, pollens, and protein using heavily prepared samples. This platform will differ in that there will be zero sample preparation when sampling the atmosphere and demands real world testing. One such example is the of the ChemCam aboard the Curiosity rover on Mars which requires minimal sample preparation. Further instrumentation and studies will added to the final draft of this paper as they are uncovered.

IV. Discussion

The instrumentation listed above meets all technical criteria but a secondary study will be required to build and test these combinations to ultimately confirm or deny their performance. This study will claim that LIBS can successfully measure airborne diseases as demonstrated by Allen Sameuls et al. and United States Army Research Lab. It is critical that this design be as modular as possible to accommodate as many platforms as possible. A primary constraint for this system will be a small size for portability to allow a multi-platform approach. Potential platforms include high altitude balloons, drones, and fixed installations like a smoke detector.

Presently there are no means to actively track disease as it spreads in real time, we are limited to passively observing the symptoms after the disease has been contracted by living host. Several government based projects have successfully detected airborne disease using LIBS but this technology and information is not readily available for public use. The design in mind will be entirely open-source and utilize 3D printing technology to allow maximum collaboration and cooperation of the design. Collaboration will play a key role in speeding up the development of hardware and software integration to permit the most refined system possible. In the case of a pandemic, the only choice is to have a solution before the problem is presents itself. Its is vital that this system be created with a degree of haste to create a working prototype prior to an unconstrained ebola outbreak.

V. Conclusion

The availability of commercial grade lasers and CCDs now grant an opportunity for students to begin exploring and measuring the atomic universe. The modern threat imposed by ebola cannot be ignored and requires effort from all levels of education to cooperate on a solution. This study begins that effort to challenge ebola and achieve a means to publically monitor and track it. Before ebola can be stopped, we must first to know where it is and isnt. It is our duty to attempt all solutions and means to combat this disease while we maintain the privilege of health.

References

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