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Importance of Artificial Intelligence & Biophotonic Techniques in Point of Care Diagnostocs of Hiv/Aids

Anubha D*

Independent researcher and analyst, India

***Corresponding author:** Anubha Dubey, Gayatri Nagar, Katni, 483501, MP, India, Email: anubhadubey@rediffmail.com

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Abstract

Bio photonics is a branch of science dealing with the interaction of light in biological substances such as tissues and cells at scales ranging from microns to the nano-level. This quality of biophotonics leads to understand hidden knowledge of cell-cell interaction, cell-tissue interaction and so-on. It needs to be more explore in HIV/AIDS for treatment and diagnosis. Artificial Intelligence based predictive models help to develop such chips which are cost effective, ready to use and require less time for diagnosis. These photonics based methods also need to develop therapeutics for HIV.

Keywords: Biophotonics; Artificial intelligence; Therapeutics; HIV

Introduction

Advancement in technology is of need today. With the growing cutting edge technology, diagnosis and treatment time is reduced. Bio photonic technology is one of them. The discipline of bio photonics deals with the interaction of light, or electromagnetic radiations with living organisms and biologically active macromolecules such as proteins(hemoglobin),nucleic acids (DNA and RNA), and metabolites (glucose and lactose). In both high (x ray) and low (radio frequency (RF) energies the body is almost transparent, this allows the non-invasive imaging of the internal structure of organs and bones. This focused light of lasers with colors can be used for a wide variety of unique therapeutic interventions of specific regions of organs and tissues.

HIV (human immunodeficiency virus) detection in biological samples is critical. Recently an optical biosensor is patented that is able to detect the virus a week after being infected, with a total test time of 4 hours and 45 minutes thereby allowing clinical results to be obtained on the same day [1]. The biosensor combines micromechanical silicon structures with gold nanoparticles, both functionalize with p24-specific antibodies. The gold nanoparticles have optical resonances known as Plasmon's, which are capable of scattering light very efficiently. Micromechanical structures are excellent mechanical sensors capable of detecting interactions as small as intermolecular forces. The combination of these two structures produces both mechanical and optical signals that amplify one another, producing remarkable sensitivity to detect the p24 (protein marker for HIV) [2].

Detecting and quantifying biomarkers and viruses in biological samples have broad applications in early disease diagnosis and treatment monitoring. It has been demonstrated that a label-free optical sensing mechanism using nanostructured photonic crystals (PC) can capture and quantify intact viruses (HIV-1) from biologically relevant samples [3,4].

Bio photonics and Artificial Intelligence Techniques

With the applications of optics and photonics, various methods are developed by spectrophotometer, microscopy, and lasers etc. for disease diagnosis in not only molecular level but also in tissue level. Some of them are described below:

• **Hyper spectral Imaging (HSI):** It is also called imaging spectrometer which involves various medical applications specifically in image guided surgery and diagnosis of diseases. It has been assumed that the scattering, fluorescence and absorption properties of tissues vary as the disease progresses. Therefore, the transmitted, reflected, and fluorescent light from tissue has been captured by HIS having quantitative diagnostic data. Which can be used by artificial intelligence based machine learning techniques to interpret HIV disease and use of ART in particular time [5].

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• **Diffuse optical Imaging:** This technique is classified in two groups:

a) Diffuse optical topography---If the tissue optical properties get modified after a period of time, there are possibilities for the photon to reach same detector by altering the measurable intensity. A 2D topographical data set can be constructed by measuring the changes between every set of source and detector. This helps to study HIV at a tissue level [6].

b) Reconstructed topography—the absorption changes determined by high resolution images leads to production of 3D reconstruction of the image. It is usually done via the detection of the absorption distribution, where the data measured is matched with simulation results of numerous absorption distributions inside the 3D images. Hence, the recording of the signal at various distances between source and detector is essential and measured [7]. These results would be used input for Artificial Intelligence based machine learning techniques for disease diagnosis in particular stage as well as molecular level of HIV infection is well understood.

• **Diffuse optical tomography:** This techniques needs computed tomography in reconstructing the 3D images where recording of sequence of tissue measurements is performed. The 3D image has to be acquired from various angles which will give complete information of HIV affected cells/tissues [8].

• **Lasers:** Its better if Lasers system is used with sensor control. Because sensor controlled laser systems are of focus in the field of therapy. This was previously used in treating cancer. But it can be used for monitoring of HIV infection spread in body.

• **Flow Cytometer (FC):** A flow cytometer is a machine driven instrument that can be used to examine single cell properties i.e., allow only one cell to be analyzed at a time. It can be used to measure the cell granularity, cell size, and to quantify various cell components that include newly synthesized DNA and the total DNA, the number of specific cell surface receptors, gene expression as the amount of messenger RNA for a particular gene, and amounts of transient signaling events and intracellular protein in living cells. Hence FC is most adaptable to study HIV features. It is used in diagnosis of HIV disease as well as its progression [6].

• **Fluorescent Markers:** A significant feature of Bio photonics involves the visualization and detection of cells and tissues. Which includes injection of fluorescent markers, into a living system, to follow dynamics of a cell and drug delivery? This visualization and detection of fluorescent markers can be counted and effect on living system is shared by AI based ML techniques. By this method cell reaction and drug delivery to tissues are monitored in specific time. This can be used in Fluorescence lifetime imaging microscopy (FLIM). The information obtained by FILM is used in local environment sensing, detection of molecular interactions, detection of conformational changes, discrimination of multiple labels or background removal, tissue characterization by auto fluorescence and characterization and quality control of new materials. All these parameters based study are required for input data of machine learning techniques. And our expected outcome would able to predict which parameter is best for study cell based interactions of HIV. Confocal microscopy and multiphoton microscopy are also found to be suitable for HIV cells. Because in multiphoton microscopy, instantaneous absorption of two incident photons from a pulsed infrared laser source is observed. So this will helpful in how a particular HIV infected cell response [7].

• **Targeted molecular imaging:** It involves analyzing micron-level biological processes. It is used to analyze the shape and role of the molecular system by generating the signals incident from the molecules. Therefore the produced image describes the 3-D spatial distribution of the targeted molecules in the tissue, specifies the diagnostic data at the molecular level, and shows the functional cell properties. These properties are essential to study HIV infected cells at molecular level with its functionality opens new avenues of HIV [8].

Other methods like optical trapping, second harmonic trapping, and cell transfection are used to explore in case of HIV.

Artificial intelligence makes our computer to solve the complicated problem by training and testing the data given by us. Hence our intelligence and computer learning intelligence works together to develop the model or our knowledge for better use.

Machine learning which evolved from pattern recognition and computational learning theory, is able to construct algorithms that can learn and make predictions with data. There are many machines learning software tools. We use decision tree induction algorithms and Naïve bayes algorithm of WEKA software package [6] to classify and compare a given HIV data set. CD4+count and IL-10,p24, IFN- biomarkers were used to determine diagnosis and screening of HIV/AIDS [9,10]. There interaction and progression during HIV course was detected by above discussed bio photonics methods:

• **Decision tree:** A decision tree (or tree diagram) is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. Another use of decision trees is as a descriptive means for calculating conditional probabilities. In data mining and machine learning, a decision tree is a predictive model; that is, a mapping from observations about an item to conclusions about its target value. More descriptive names for such tree models are classification tree (discrete outcome) or regression tree (continuous outcome). In these tree structures, leaves represent classifications and branches represent conjunctions of features that lead to those classifications. The machine learning technique for inducing a decision tree from data is called decision tree learning, or (colloquially) decision trees [11,12]. With the help of symptoms of HIV infection, and above mentioned biomarkers, a decision tree model is developed which would tell whether the person is infected with HIV and is in which stage. Accordingly anti-retroviral therapy will started. As this is very fast and accurate it can be used in POC diagnostics for HIV/AIDS.

• **Naïve-bayes:** This classifier is a simple probabilistic classifier based on applying Bayes' theorem with strong (naive) independence assumptions. A more descriptive term for the underlying probability model would be "independent feature model". In simple terms, a naive Bayes classifier assumes that the presence (or lack of presence) of a particular feature of a class is unrelated to the presence (or lack of presence) of any other feature Depending on the precise nature of the probability model, naive Bayes classifiers can be trained very efficiently in a supervised learning setting. In many practical applications, parameter estimation for naive Bayes models uses the method of maximum likelihood [13,14].

Other machine learning algorithms are also used based on the data provided by bio photonics techniques and accordingly model development and validation can be done for further investigation.

Discussion and Result

Above methods including applications of fluorescence spectroscopy, Raman spectroscopy, surface enhanced Raman spectroscopy. Multifocal optical tweezers, pico- and femto second lasers are being studied;

- For investigating HIV molecular interactions as in receptor-drug and receptor –ligand, analyzing signal cascades and cellular mechanic properties.
- For identifying HIV specific antigens and receptors
- For HIV cell mapping
- For identifying particular HIV cellular state.
- for metabolic product distribution in the HIV infected cells
- For description of extracellular matrices in HIV infection
- For membrane perforation, cell surgery, and optical knock out.
- Important in point of care diagnostics
- Many studies are going on for optical technologies. Studies are being conducted related to the use of nanoparticles and pulsed lasers for treatments of diseases like HIV/AIDS [15,16].

Bio photonics for Point of Care (POC) diagnostics of HIV: The laser driven lab on chip approach which has the potential of converting any test to a point of care POC diagnostic format. Since infectious diseases such as HIV/AIDS are still a major cause of mortality, particularly in the developing world, invention of POC diagnostics could reduce the burden of disease. Improvement of current HIV diagnostics to incorporate immediate viral load testing would have a massive impact in informing treatment decisions and management. Knowing exactly when to start antiretroviral treatment and monitoring its effectiveness may help alleviate some of the current challenges endured by HIV/AIDS patients, such as the development of viral resistance. It is a need to develop such a device which would be cost effective and low resource settings. The design of a cell sorting microchip, coupled with super-resolution imaging and spectroscopic techniques could pave a way into the invention of highly

specific HIV-1 diagnostic tools [7,17,18]. If the kit is developed which not only shows viral load also gives genotype information then it would be breakthrough and innovative research in the field of HIV/AIDS therapeutics. Here the issues of accuracy cost and time were important for the purpose of the research based on POC of HIV/AIDS being a serious disease. To resolve the issues Artificial intelligence based machine learning techniques are required to overcome the problem.

Concluding Remark and Future Prospects

Bio photonics techniques increase the chances for understanding the HIV disease better at molecular level. With the handshake of AI techniques, biomedical scientists will be able to provide environment friendly techniques as they are fast and economical, accurate and reliable to use. The data of molecular analysis of Bio photonics techniques are very diversified which need to be handled properly for further investigation, here AI based methods are very helpful for understanding the HIV mechanism far better. Diagnostic and therapeutic techniques available for HIV/AIDS are need to be improved. This will bring major insights for beneficial of mankind. Most importantly it would be very cost effective and reachable to all the medical centers so nobody would die in absence of treatment.

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