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Mini-Review Article

Artificial Intelligence in Medical Microbiology

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Abstract

Artificial intelligence will slowly revolutionize diagnostic medical Microbiology as well as Microbiology research. It is already finding many applications in this context both for disease diagnosis and for disease monitoring. It remains to be seen how Artificial Intelligence shapes diagnostic medical Microbiology in course of time.

Key Words: artificial intelligence (AI); medical microbiology; learning

Introduction

Artificial intelligence or AI is defined as a set of rules or algorithms which allow computers (also called the artifice) to make decisions with features that simulate human intelligence. Intelligence means an ability to learn, or to alter underlying computer code to enhance future task performance. A significant advance in the AI field has been the development of complex, multi-layered AI architectures known as deep learning algorithms [1].

The present scientific world is living in the age of artificial intelligence. Right from voice command to creating powerpoints and automatic operations in various sectors, AI is dominating the show in today's scientific world. So medical microbiology is also not exempted from the advancements of AI.

Some applications of AI in medical Microbiology are delineated as follows:

(a) Remote sensing: Artificial Intelligence has found its use in remote sensing. Artificial Intelligence (AI) can improve the analysis of large areas of interest. It can also help classify objects, and detect land use. It can also help in data fusion, cloud removal, and spectral analysis of environmental changes [2]. Hence it may be applied to detect hotspots of new infections or outbreaks. Artificial intelligence and remote sensing can be used to create Computer Vision models which helps us understand the data better. Images collected by satellites or unmanned aerial vehicles (UAV) can provide near real-time reports for large scale sized areas with complex feature distribution like the transition of electric power grids to a digital twin, agriculture, urban planning, climate change, disaster management, transportation, and wildlife conservation.

(b) Machine learning (ML): One of the best examples is that machine learning models, such as deoxyribonucleic acid (DNA) sequencer, can analyze the genomic sequences of bacteria and viruses to predict their propensity for mutations and resistance to specific drugs, guiding clinicians in selecting the most effective treatment options [3]. Adaptive AI algorithms can be designed to be plastic and to evolve over time as the machine "learns." This subset of AI algorithms is termed "machine learning" (ML)[4]. In the clinical laboratory, a simplistic form of ML is linear regression, which is used to predict standard curves for instrument calibration. In regression analyses, we provide the computer a simple equation and ask it to optimize the values of one or several variables (i.e., derive rules) to achieve a best-fit representation (i.e., a prediction) for a two-dimensional dataset (i.e., a graph of analyte concentration vs. assay readout).

(c) Early pathogen detection: AI-powered algorithms are invaluable in quickly and effectively detecting microbial pathogens in clinical samples. These algorithms can recognize specific patterns or genetic markers associated with many pathogens. This rapid and accurate detection of pathogens helps in immediate therapeutic interventions, thus significantly reducing the risk of infection growth [5].

(d) Real-time monitoring of microbial populations: The ability of AI to analyze real-time data is pivotal in monitoring microbial populations within healthcare facilities. By continuously tracking and assessing changes in the microbial populations, AI can rapidly identify any deviation from baseline patterns.

(e) CNN (convoluted neural networks) has been employed for automated interpretation of blood culture Gram stains. Several key aspects of future use of AI in clinical microbiology can be obtained from this study. The authors used a CNN, which excels at image categorization. However, training such a complex network is computationally intensive, typically requiring specialized infrastructure. In AI from Gram stain, subtle distinctions in organism shape and size can be differentiated. This suggests that with further training therapeutically important diagnostic distinctions could likely be made between organisms with similar Gram stain morphologies. For instance, identification of Gram-positive diplococci suggestive of pneumococci, short Gram-positive rods suggestive of Listeria, or minute Gram-negative coccobacilli suggestive of Francisella or Brucella spp.

(f) Parasitology: In addition to observation of bacterial smears, there is lot of potential for use of AI in parasitological diagnostics, with almost all published efforts thus far dedicated to malaria. The reference standard for Plasmodium detection and speciation is microscopic observation of stained thick and thin blood smears [1].

Advantage of AI over conventional techniques in diagnostic Microbiology:

Artificial intelligence (AI) has revolutionized the field of diagnositic microbiology by providing more precise and current findings. AI analyzes data, pattern recognition, and diagnostic processes more rapidly. It is imperative for early identification of disease, advancement of treatment, custom treatment, and epidemic monitoring [6]. AI-powered algorithms have totally changed the field of diagnostic Microbiology by examining vast datasets of microbial information and identifying patterns and irregularities which would be challenging for human analysts to diagnose quickly and accurately. This capacity for pattern recognition is particularly critical in the early detection of infectious diseases, where rapid identification of viruses and their transmission patterns can determine effective containment strategies [6].

An Illustrative image of machine learning is given below.

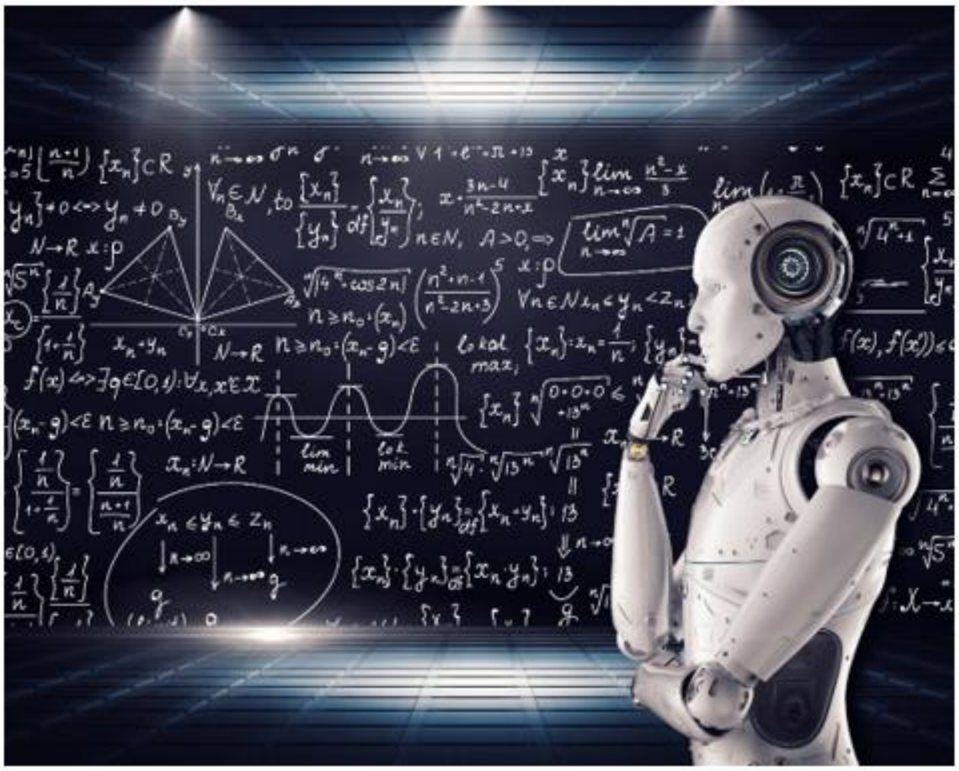

Figure 1: Machine learning. (source: Express analytics)

Early detection of pathogens:

AI- powered algorithms have been documented to be very valuable in quickly and effectively detecting microbes in various clinical samples. These algorithms have been trained to recognize specific patterns or genetic markers associated with various pathogens. This rapid and accurate detection of pathogens can help in immediate therapeutic interventions, significantly reducing the risk of spread of infections.

Newer applications of AI in diagnostic Microbiology:

One of the most exciting areas for the application of AI and ML methods in clinical microbiology is its use in whole genome sequence (WGS) data to predict antimicrobial resistance. Also, AI can now be used to read MALDI-TOF data for bacterial and yeast identification. It can also be used in automated blood culture [4].

Vibrational spectroscopy, also called Raman spectroscopy, can be used in diagnostic medical Microbiology. Currently the light signal in this application is piir and sample cannbe degraded by laser, but a combination of ML and Raman spectroscopy is used to detect changes in saliva and differentiate between COVID positives and COVID negatives.

BactLAB™ is a free application that can count bacterial colonies cultured on CompactDry™, a ready-to-use dry culture medium. This application uses Amazon Web Service (AWS) and artificial intelligence (AI) technology to enable quick and easy counting [7].

Use in AMR detection and monitoring: Emerging AMR trends can be detected by monitoring known causal resistance genes, and transmission patterns can also be revealed. These can help in identifying and controlling outbreaks caused by resistant bugs. Whole-genome sequence data, which is expanding, also helps in surveillance via AI [8].

Uses in medical mycology: Just like histopathology, AI can be used in fungal cytology. Machine learning has been able to identify antifungal drug targets, and taxonomic and phylogenetic classification of fungi based on sequence analysis is now a possibility. Real-time identification tools and user-friendly mobile applications for identifying fungi have also been discovered [9].

Use in medical virology:

AI and computational tools have now significantly enhanced diagnostic precision, therapeutic interventions, and epidemiological monitoring in medical diagnostic virology. Via in-depth analyses of notable case studies, algorithms can optimize viral genome sequencing, can help I speedy drug discovery, and also can help predict viral outbreaks [10].

Discussion:

Artificial Intelligence has modulated and modified diagnostic medical Microbiology. AI can be further adjusted to suit the needs of modern- day diagnostic Microbiology. More changes are likely to come in near future as regards application of artificial intelligence in medical microbiology. In near future, computers and clinical laboratory scientists need to work more closely together to guarantee optimal efficiency and quality in the clinical microbiology laboratory. This close collaboration between humans and machines can be expected to improve overall quality of patient care. However, one major drawback of artificial intelligence is that a large data set is needed for ML. More studies will help elucidate further roles of AI in medical microbiology.

Conclusion:

Artificial Intelligence is likely to shape the future of diagnostic Microbiology in India and also worldwide.

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