Editorial

Artificial intelligence and Medical Parasitology: Applications and perspectives

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Artificial intelligence (AI) is a leap in modern life. Medicine is one of the most benefited scientific fields from AI. Infectious diseases, including parasitic infections, are increasing despite modern life cautious patterns. Strategies implemented and planned for AI in developing countries can simplify decisions in parasitic medical issues such as predicting epidemic foci, easy diagnosis and understanding the mechanisms of parasitic diseases. Besides, by the help of pre-exiting datasets, AI is prospering in the field of understanding drug resistance, drug targets detection, design of new drugs, and teaching Medical Parasitology as well. The aim of the present editorial is to enlighten the reader with different applications of AI in parasitology and the scope of possible future perspectives.

Keywords: artificial intelligence; artificial neural networks; deep malaria; machine learning; SMILES; telemedicine; Viola-Jones.

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INTRODUCTION

The AI area of computer science developed since the 1950s with a hallmark concept known as the machine learning (ML). The latter can help operate a designed algorithm to use big-data inputs to train artificial neural models, as well as the artificial neural networks (ANNs), and how to set the most accurate output in a high throughput manner. This ML training of ANNs can finally lead to autonomous interneuron corrections of various hidden outputs to design an output that depends on several contexts already learnt by these neurons[1,2]. A particular indispensable field in the ML is deep learning (DL). This is a neural-based computational system that is modified and corrected through predictions that are continuously adjusted according to input data. Hence, ANNs can learn how to make autonomous corrections and predictions according to data input[3]. In this context, AI represents a leap in the field of medicine, including Medical Parasitology. This applies in several aspects as detection of parasites in different biological samples, infection control, drug targets detection and design of new drugs, and of course teaching Parasitology.

Application of AI in Parasitology

1. Decision making

Developing countries, especially in Africa, suffer the consequences of serious infectious diseases (IDs) as lowered productivity and decreased active healthy-life years. Thus, governments set an authorized document specific for each country or group of countries for the use of AI in management of several aspects of IDs. This is known as the National AI strategy that manipulates the opportunities and challenges for the use of AI. One of Africa's AI opportunities is Precision Medicine, which is a new field of medicine that personalizes disease management to the patient's ecological, genetic and molecular makeup. An example is the nuclear magnetic resonance-based haemozoin detection as a rapid test for monitoring antimalarial resistance[2]. Other examples of AI applications following the latter strategy involve the epidemics' prediction, drug discovery and high throughput and specific diagnosis of IDs[4].

Malariometric studies were implemented in Africa to facilitate decision-making and disease-response measures to eliminate malaria. These studies depend primarily on collecting vast amounts of data input including diseases prevalence, the rate of new cases, the vector population in a given area, and the compliance to different control measures as net usage, insecticides and treatment of cases[5]. In recent years, prediction of epidemic foci was indispensable for the incitement of several infectious diseases. By AI, several model algorithms help in this aspect. One of the most famous models is the autoregressive integrated moving average prediction model (ARIMA), which is a statistical analytical model that uses a series of data to identify the future trends. For predicting ID, the ARIMA model was used for infections that occur in cyclic or repeated patterns. It can predict future outbreaks by filtering out 'high-frequency noise' i.e. (unnecessary information) in the data. It integrates dynamic relationships and updates the model based on recent events. In the scope of parasitic infections ARIMA represented a disease simulation model for malaria intervention strategies using datasets as PlasmoDB and Malaria Atlas Project[6].

2. Laboratory diagnosis

Identification of parasites in different samples can be simplified by using artificial neural network classifier or convolutional neural networks that depend on pattern recognition of objects by mining or extracting data from vast inputs. Host Response to Microbe

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Analysis (Hrma.N.2.0.) is an automated image analysis program using state-of-the-art ML and AI algorithms to analyse pathogen growth and host defensive behaviours. The prediction of the degree of growth of intracellular parasites as *T. gondii* and *Plasmodium* spp. by ANNs depends on deep learning of big-data input known as the Zooniverse Project. Besides, the algorithm helps the study of host-parasite interactions as parasite killing, extracellular behaviours of the parasite, and the invasion rates[7].

In 2001, computer algorithm employing digital image processing and artificial neural networks classifier was used to identify parasitic eggs in stool samples including *A. lumbricoides, T. trichiura, C. philippinensis, C. sinensis, P. westermani, D. latum* and *Taenia* spp. These were identified according to size, shape, and shell smoothness[8].

The Viola-Jones algorithm was designed to use 'Haar-like' features (digital image features), followed by integral image creation, and identifying the image finally using an Ada-Boost trained classifier. This algorithm was used for fast and sensitive detection of *Leishmania* spp.[9]. Another example is the Mcell Net which is a DL-enabled high throughput system to detect *G. lamblia* and *Cryptosporidia* spp. in water samples[10].

Telemedicine is another form of AI-dependent diagnosis of infectious diseases. Soil-transmitted helminths were subject for application in the field of Medical Parasitology. Stool samples on Kato-Katz slides were examined by conventional light microscopy. The images were digitized through a microscope adaptor to be sent to Telemedicine platform for remote analysis by DL-algorithms and diagnosis. TechCyte which is an AI software platform, uses the telemedicine platform for diagnosis of intestinal protozoa. This algorithm can even screen out negative samples and increase the sensitivity of parasite detection[11].

In the era of epidemics and appearance of infectious diseases, minimizing pathogen transmission strategies are mandatory. This can be attained by AI facilitating remote infection control measures. The Internet of medical topics constitutes a mobile application for remote monitoring of patients. This is an automated approach that deals with collection, transfer and analysis of data using biosensors and cell phone applications[12]. Biosensors were fabricated for remote diagnosis of patients with malaria by the detection of *P. falciparum* lactate dehydrogenase[13].

3. Drug discovery

The drug discovery process constitutes steps of a target detected over years, optimization of lead compounds, experimental studies, and several clinical trials before the final drug approval. The main steps in the journey of AI-based drug improvement start by ML of a primary image, then processing it for classification and sorting the druggable molecules and the possible drug targets. Chosen molecules are secondarily processed by ANNs to detect the physicochemical properties of the compound by their simplified molecular input line entry strings (SMILES) that allow computer-assisted chemical structure presentation. Then, the following basic step is analysis through graph neural networks, where the molecules are presented as hidden graphs studied by layers of neurons to identify the type of atoms in the molecules. Then, ANNs work by mining and analysis of big data in order to represent an optimum output molecule[14,15].

Matched molecular pairs describe the point changes (transformations) in the structure of similar molecules as defined by Kenny and Sadowski 2005. Matched molecular pairs help identify the physicochemical differences between molecules. According to input data, AI can help in selection of optimum druggable molecules in a high throughput and accurate process, hence, cutting short the journey of drug design[15-17].

Several algorithms, as the 'deep tox' algorithms, are designed to help predict compound toxicity by data mining and ANNs[18]. Prediction of the target protein 3D structure is determined by Alpha Fold AI-based technique which determines the 3D structure of proteins by their amino acid sequence. Drug-protein interactions can be further studied by quantum mechanics. An example is FMol which is a simplified drug discovery pipeline generating SMILE molecular with AlphaSMILES, predicting protein structure with AlphaFold, and then checking the druggability. The protocol of AI-assisted drug design was proposed for 90% elimination of malaria by 2030[17].

Anti-malarial detection systems using deep learning proved to be faster than most of the traditional techniques. 'Deep Malaria' is a DL-based approach to predict the mechanism of action of antimalarial drugs using their SMILES. *In silico* screening uses ANNs, then SYBR Green fluorescence to confirm the interactions. Several 'Hit' compounds were tested and the spectrum was narrowed to one fast acting anti-falciparum compound, DC-9237[19].

4. Parasitology teaching

One of the advantages of AI is the facility provided for teaching Medical Parasitology and simplifying the possibility of remote learning through virtual libraries, virtual microscopy and telemedicine and virtual laboratories[20].

Prospective

In spite of all AI benefits, the involved ethical and legal issues should be considered. Confidentiality, consent for data usage, selection bias, approval of concerned authorities are the main items to be considered. Moreover, the robotic rights and robotic control strategies are other newly emerging topics for consideration[21]. The value of any neural network depends on the fed information and data, and it would have been impossible to produce an AI program without the freely accessible databases. Future AI is introducing new data structures and algorithms with a completely different approach to intelligence. Forthcoming AI's self-adaptive neural networks can create connections on their own processing real sensory inputs like light, sound, and touch, in the same way as the human brain so that they interpret everything they receive in the context of already studied input data that they learnt. Hence, in the near future we can find a patient dealing just with an e-doctor.

CONCLUDING REMARKS

1. Artificial intelligence comprises a machine-based learning system that can autonomously make decisions and solve problems.
2. The core of AI is a multi-layered network of artificial neurons that are designed to learn through communication channels of subjective inputs.
3. Strategies approached for AI were developed for controlled use of vast amounts of datasets to make decisions regarding parasitic infections and prediction of epidemic foci.
4. The best example of ML that was designed to predict epidemic foci of malaria is ARIMA model.
5. Viola-Jones model for diagnosis of leishmaniasis made use of Haar-like features and equations to detect *Leishmania* spp. in biological samples.
6. Artificial intelligence is a step-forward approach beyond molecular biology techniques to cut short the time needed for drug target discovery, and novel drugs development.
7. Telemedicine and virtual laboratories and microscopy made easy the remote teaching of medical parasitology.

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