Guest Editorial

Artificial Intelligence and Medical Education

Sarwat Hussain [1], Danish Ejaz Bhatti[2]

[1]Professor, Radiology, Virginia Commonwealth University Richmond, Virginia; [2]Associate Professor, Department of Neurological Sciences, University of Nebraska Medical Center Omaha, Nebraska
Correspondence: sarwathussain@hotmail.com

Artificial Intelligence (AI) is a branch of computer sciences that uses learning algorithms to calculate probability of outcome by using Bayes theorem and other statistical methods for a given certain input (Fig.1). When the chance of an event occurring is calculated over and over again after adding new data or evidence at each step, the probability can reach the level of near certainty for given inputs. Thousands, even millions of data points are incorporated in calculating posterior probability for predictive analytics. The analytics are input neutral as programs predict the future events irrespective of the type of the data. AI has, thus, blurred the boundaries between the physical, digital, and biological worlds. The initial learning process is considered training where inputs are given to the program already marked for the expected outcome. This training information can either be highly precise or very vague allowing different degrees of freedom to the program but also increasing the burden of training. Once trained an AI algorithm is able to predict or analyze given input to suggest the required outcome with some certainty. This improves with continued training through feedback.

Artificial Intelligence (AI) is ubiquitous, affecting virtually every aspect of life either directly or indirectly. We are aware of some of the AI applications, others we are not. The term AI was first introduced by McCarthy at Dartmouth college, New Hampshire, in 1956. But recently, AI has become a commonly used modality in science, business, education, aeronautics, arts, defense and government affairs to name a few. In the last several years, there has been exponential growth in AI applications. In 2016, AI added $ 600 million to the global economy, this is projected to grow to $ 15 Trillion by the year 2030. As a comparison, the size of the US economy was 22 Trillion in 2021.

AI is synonymous with the 4th industrial revolution, encompasses a wide range of applications of data sciences into abroad scope of functionalities and data-driven predictions in our daily lives, including healthcare and education.

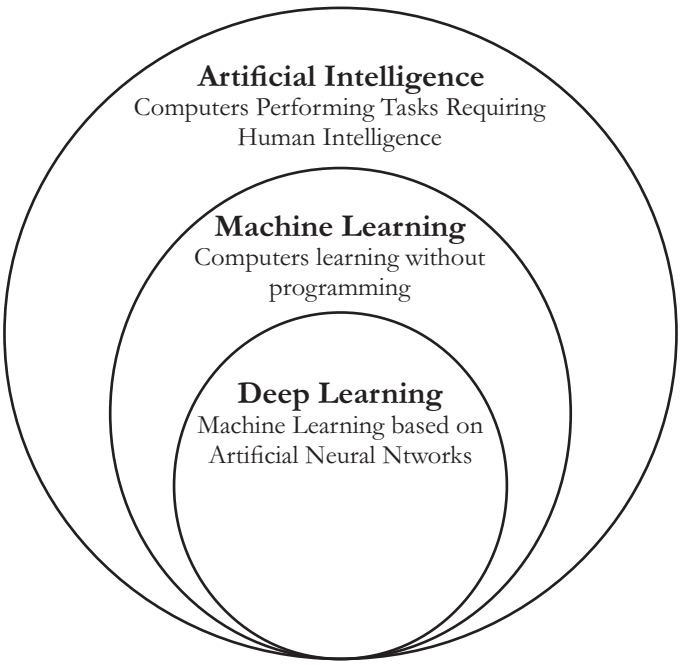

Figure 1: *Artificial Intelligence (AI) and branches: Machine Learning (ML), and Deep Learning (DL). The terms, AI and ML may be used synonymously.*

Traditional computers were unable to handle the

colossal data required for AI. But the AI enabled machines are powerful enough to perform this function. In the last 50 years the power has in increased astronomically. For example, even the iPhone 6 computes 120 million times faster than the best computers that guided the spacecraft Apollo 11 to the moon.

Machine Learning (ML), Deep Learning (DL) are the names given to the groups of AI process for data based and image based predictive analysis. Figure 2 shows the schema of computing in conventional versus AI-enabled computers.

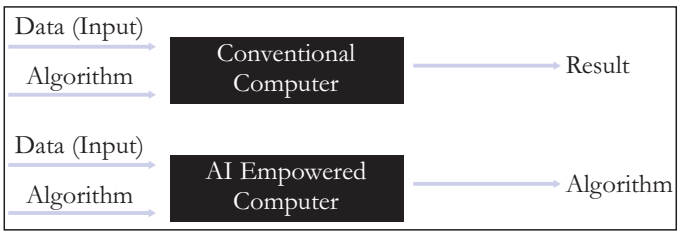

Figure 2: *Schema of conventional Computer versus AI Enabled Computer.*

Machine learning (ML) is the study of the processes by which computer algorithms can learn by repeated exposure to the problem specific training data. ML, also called predictive analytics, is a statistical method to automatically process large amount of data to uncover hidden patterns and trends. DL is primarily used for image and video recognition and analysis. DL is synonymous with Artificial Neural Network. ANN is inspired by the interconnections of the neurons in the human brain.

This short review summarizes some of the implications of AI in medical education. We will review how AI is improving delivery of medical education and discuss importance of developing AI curriculum for medical students to make them comfortable and efficient in working with AI as future doctors.

AI Applications in Medical Education:

Reducing Cognitive Load in medical education

New and innovative applications (apps) for smart devices are continuously entering the users' market in all AI fields. In healthcare these apps have been shown to increase productivity, efficiency and accuracy and improved access for the patients. As a result, there is reduction in hospital workload and the cost of care. Point of care instant access to medical literature, textbooks, institutional diagnostic and patient care protocols make it easier for learners to not have to memorize by rote such data-heavy information such as medication dosages, interactions with each other, weight based dosing and other standardized treatment protocols. These take the guessing or remembering out of the equation for improved compliance and reduced medical errors. Studies have found that the younger physicians access apps more frequently than their seniors. Many such applications are now built into Electronic Health Systems providing automated checks or decision support at the point of care. AI teaches medical students the potential benefits of technology in healthcare and education. The apps can take over many repetitive students related and clinical tasks during training and rotations[1].

Teachers Perspective: Machine Learning improves teachers' tasks and effectiveness.

Machine learning (ML) makes the educators more efficient by taking over repetitive tasks such as class and student scheduling, reminding teachers or students for follow up, provide editing and designing educational content, automating evaluation of assignments, and classroom management. Thus, teachers could devote more time to focus on student and their development.

ML based data analytics can reveal insights into individual student's performance and attitudes from which positive impact on teaching and learning processes can be derived. This provides much needed feedback to the teacher on effectiveness of delivered content and quality of delivery techniques.

Data Based prediction can be made about students at risk of dropping out due to academic failure, and even predict their scores on standardized testing and examinations based on their performance data. Early intervention can thus reduce failures and dropout rates.

Students Perspective: Adoptive learning for improved engagement. ML based adoptive learning is a teacher-based learning management for students that addresses the difficulty of the delivered content, including formative assessments, to the current grade or capacity of the student. This improves engagement by keeping the students appropriately challenged by reducing g the num-

ber of boring repetitive tasks through automation and by tailoring to the level of learning difficulty for each student. This helps the students at both ends of performance spectrum. At the bottom end, the learning management program provides timely remediation of struggling students and at the top, appropriately challenges the gifted ones. The ML based system analyzes each student's performance and aptitude to allow customization of teaching material and method, based on weaknesses and strengths revealed by the data.

ML based student-centered form of personalized learning is an educational model where students can direct their own education. In some cases, students can learn what interests them the most, and at their own pace. On the other hand, the teachers adopt from the curriculum and according to the students' study needs. ML apps have been shown to grading students' assignments and grade tests more accurately than humans do. However, the process is not fully automated and does require human input. A combination of machine and human has a higher efficiency, validity and reliability.

Deep Learning for future education roadmap: The impact of Deep Learning (DL) in the practice of quantitative medicine is becoming established. Medical and paramedical students will encounter practical implementation of DL in their education, it is important that their curriculum include lessons on the potentials of how DL augments decision support and work flow. Post-graduate trainees in specialties that deal with medical images such as anatomical pathology, dermatology, ophthalmology and radiology will encounter advanced applications of DL in daily practice. Their training needs to include lessons on image based qualitative and quantitative diagnostics. Most other clinicians are unlikely to need expertise in the methodology of DL, but they should probably understand the fundamentals of how DL works, in order to appreciate opportunities for its use and expect its limitations. Experts believe that DL applications are still in their infancy, indicating great research potential[2].

Chatbots in education:

Chatbot is an AI powered program by which a computer can hold a conversation with human users, usually over the internet. Some examples of higher education chatbots are Mongoose Harmony by Enrollify Inc. (Los Angeles, California, USA), QnABot by Amazon (Seattle, Washington, USA) and IMB Watson (Armonk, New York, USA). These have been developed with teachers, students and administration in mind.

For instance, during admissions process, the surge of enquiries can be accurately handled by chatbots. Immediate and accurate answers can be provided 24/7 to enquiries about admission process, class size, students' accommodation and fees etc. via messenger or text message using a chatbot.

Another type of chatbot, the teacherbot, is an AI program that can deliver basic repetitive lectures, render advice for improved learning experience, students' engagement and retention. Enhanced communication between physician teachers, students and patients for enhances compliance for better educational and health outcome at a lower cost. Where necessary, anonymity for open feedback between student, teacher and third party can be assured. A teacherbot can be a lifelong learning companion. Powered by AI it can accompany and support students through their studies and beyond completion. These programs allow teachers to also focus on individual student's emotional needs, interests and learning pace during live sessions[3].

Learning outside the class room can continue by instant messaging between students and teachers that allows an exchange of questions and answers. Discussions among students, teachers and even international experts can be conducted on Chatbots at regional, national or international levels for understanding of complex topics.

AI in Medical Curriculum:

It is time for the medical and paramedical educators to include introduction to AI and its common applications as part of the medical curriculum. The students, residents, fellows and paramedical trainees should acquire basic concepts of ML and data science. Theoretical understanding allows students and trainees is to be able to make intelligent enquiries into clinical question, analyze AI applications, and learn to use various AI created biomedical databases[4].

The field of AI is complex and virtually limitless. The AI curriculum should be carefully chosen so as not to overwhelm the learners, staying within the scope of relevant future applications, acknowledging the evolu-

tion in healthcare. Appropriate curricular time needs to be set aside, replacing outdated contents. In medical colleges and universities, the complexity of AI curricular contents should aim to impart AI literacy rather than proficiency, ability to leverage technology for the benefit of the teachers, students and the patients.

Clinical curriculum, in addition to teaching the basics such as browsing the electronic health record (EHR), should teach predictive statistics applicable to epidemiology and population health. This aspect of AI knowledge can impact on staying ahead of the risk of the spread epidemics and communicable disease, its control and treatment. Students and teachers should learn to use the resources in the medical records, patients' databases and other internet resources. Medical students should be taught about the overall impact of AI on healthcare system by understanding the power of data science, natural language processing and image processing.

For the students, interested in administration, business and entrepreneurship students, AI electives should be offered to secure the future of the healthcare system. These students may also develop some basic coding skills enabling them to lead the efforts of future software development teams. Large libraries of learning programing resources are currently available free of cost on open-source websites. These skills would allow interested students to branch out into future leaders of medical informatics.

Conclusion:

AI is rapidly evolving with new applications emerging every day, but it is not a silver bullet for healthcare. Attention to ethics, security and privacy issues is far lagging behind the more profitable AI applications. Racial bias has been alleged in judiciary and banking AI programs. Serious risk of AI enabled attacks on public utilities and installation of national security continue to exist.

Adoption of AI is likely to be influenced by the knowledge, perception, and the attitude of the learner. Many surveys on AI literacy have found that limited AI knowledge was associated with fear or complexity. Many physicians feel AI belongs to information technology and is outside the scope of Medical practice and education. Even in the USA a 2020 survey of 1472 American College of Radiology (ACR) members, only about one-third were using AI in their practice. Most of those not using AI "saw no benefit" in it. Similar simple surveys at institutional level can help to heighten awareness and convert many to seek AI knowledge.

A question commonly asked, "will AI replace doctors in the future". The answer would have to be, "the doctors who are AI educated will replace in those who are not", especially those who are seeking work in the advanced counties for higher education. The role of AI should be considered assistive and supportive. Complexity and professional legality, and ethics will probably prevent AI from substantially taking over human functions for some times to come.

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