POINT OF VIEW

Artificial Intelligence and Deep Learning: The Future of Medicine and Medical Practice

Madhusudana Girija Sanal[1], Kolin Paul[2], Senthil Kumar[3], Nirmal Kumar Ganguly[4]

Abstract

Artificial Intelligence (AI) and access to "Big Data" together with the evolving techniques in biotechnology will change the medical practice a big way. Many diseases such as type II diabetes will no longer be considered as a single disease. Many familiar cancers such as cancer of liver or pancreas will have hundreds of subtypes whose management will be very different. The way we think about diseases will change. It will no longer be possible for clinicians to make a diagnosis, remember the names of diseases, the names of drugs or management protocols without the help of computers. As computer intelligence becomes more important than human intelligence in deciding diagnosis and treatment there will be a paradigm in the role of doctors. Internet, computers and social media will become more important than individuals in decision making. As a result, medicine will go more and more egalitarian ("wiki") with increasing community participation in health decision making and management. A socialistic pattern will evolve over time globally as an adaptive reaction to the pressures put by artificial intelligence. This is because the individual differences in knowledge or intellect between human beings will become less apparent compared to the super powers of artificial intelligence. Qualities which are unique for humans such as compassion, empathy and emotional care will decide the professional success of future physicians even more than today. Today we are using artificial intelligence in diagnosis and prediction to help clinicians. Clinical algorithms and human experience cannot be replaced by machines. It will take many years to completely merge or replace humans with machines. However, we need to modify our medical education system in order to prepare the medical community and sensitize the society well in advance for a smooth transition.

"I Propose to Consider the Question, 'Can Machines Think'": Alan Turing

Artificial Intelligence (AI) as a philosophy and its practical application thereof, relates to a process wherein the operational aspects of the complex functions of the brain (biological neural network) are developed to varying levels of complexity and invested in a non-biological system. The origins of research into AI can be traced to the defence industry in the 1950's, but since, has been increasingly used in many fields of human endeavour. This includes navigation (ground, sea and air), geosciences, astronomy, education, finance, manufacturing and art. Healthcare is no exception.

Artificial Intelligence, and access to "Big Data"** together with the evolving techniques in biotechnology will change the medical practice in a big way. We are at the threshold of the era of precision medicine and AI is an integral part of it. AI will affect the various phases of patient care delivery – from risk prediction, to diagnosis, to tailored therapeutics, to monitoring. Although machines empowered by AI will be better, faster, and cheaper and perform without a break, the purpose of AI is not to replace physicians, but to assist them. With this perspective AI may be better expressed as 'Augmented intelligence' or Adjunctive intelligence'. AI has the potential to become a disruptive innovation which would make many of the current processes and protocols obsolete. Although every conceivable speciality in medicine will eventually be affected and changed by AI, the ones which depend heavily on pattern recognition, such as radiology, pathology, dermatology and neurology will probably benefit the most in the beginning of the AI revolution in medicine.

From White Light comes the Rainbow: With Precision Medicine Diseases will Split into Several Subtypes

As the resolution of the microscope increases we can see two points as separate. Similarly, as our understanding of the diseases at a molecular level and their associations increases, our diagnostic precision increases. Many diseases such as type II diabetes mellitus will no longer be considered as a single disease. Many familiar cancers such as cancer of liver or pancreas will have hundreds of molecular subtypes whose management will be different. It will no longer be possible for clinicians to remember the increasing numbers of diseases, drugs or management protocols. Even today, it is difficult for many of us to remember increasing list of 'biologicals' or the HCV drugs! Richard Smith (former Editor BMJ), predicted that there will be a paradigm shift in the role of doctors in future with the evolution of technology.[10] As computer intelligence becomes more powerful than human intelligence in deciding diagnosis and treatment

[1]Assistant Professor, Department of Molecular and Cellular Medicine, Institute of Liver and Biliary Sciences, New Delhi; [2]Professor, Department of Computer Science and Engineering, Indian Institute of Technology Delhi, New Delhi; [3]Additional Professor (Liver Transplantation), Institute of Liver and Biliary Sciences, New Delhi; [4]Formerly Director General of ICMR, Director, PGIMER and President of JIPMER, Translational Health Science and Technology Institute, NCR Biotech Science Cluster, Faridabad, Haryana
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the difference between 'doctors' and common man decreases. This is because the individual differences in knowledge or intellect between human beings will become less apparent compared to the super powers of artificial intelligence. Internet, computers and social media will become more important than individuals in decision making. As a result, medicine will go more and more egalitarian ("wikification") with increasing community participation in health decision making and management. A socialistic pattern will evolve over time globally as an adaptive reaction to the pressures put by artificial intelligence. Although AI will outperform humans in the volume, velocity and veracity of data processing, the qualities which are unique for humans such as compassion, empathy and emotional care will decide the professional success of future physicians even more than today.

"Big- Data" and Sophisticated Sensors will Bring Machines Closer to Man

Last decade witnessed several breakthroughs in the fields of physics, computer science, material science, biotechnology, genomics and proteomics. These silent but disruptive technologies are revolutionizing the practice of medicine in an unprecedented manner. Artificial intelligence equipped with 'Deep Learning'* algorithms, biotechnological innovations such as precision genome editing, genomics, metabolomics and proteomics and "the Big Data" will change the concept of diseases, their definitions and patient management.[1,2] This "Big Data" will make medical practice more "holistic" because the artificial intelligence would be able to consider several variables ranging from your genomics, real time metagenomics (status of one's gut microbiome) to your social interactions from social media and wearables without breaching your privacy (as long as privacy means our personal data not seen by another human). This is important from the perspective of personalised medicine as well as public health because of its 'predictive and preventive' capabilities through extreme modelling and simulation.

Deep Learning is a group of computational methods that allow a program to modify and adapt itself from 'experience' by learning from a large set of examples that demonstrate the desired outcome or behaviour.[3] Even today we do not completely know how human mind works and the same may be true for "Deep Learning" algorithms because we still do not know the exact protocols which are developed in the "mind" of a Deep Learning machine-it is a "black box of dynamic algorithms and networks".

Currently, in certain specialities such as radiology, dermatology and pathology "computer-aided detection" is becoming popular. For example in radiology AI algorithms recognise the patterns and highlights suspicious areas, and helps the radiologists not to miss a finding. The software follows certain algorithms and identifies a suspicious lesion. These programs typically do not learn anything from a case. A machine that has "evaluated" a million MRI images or mammographs is no better than one that was exposed to a couple of images. There is nothing called experience. However, the new technology "Deep Learning" algorithms can actually learn and gain 'experience'-they can teach themselves. At this point a machine which has seen a million images will be several fold better than a machine which has seen a few. Remember that the most experienced radiologists cannot learn from a million images in his life time! Even at this point machines are limited by their senses and inputs. It do not have an idea about the patient's posture, texture, warm and smell of his skin, gait, facial expression, social and employment history, patient's family, friends or lifestyle. However, these machines (read networked machines) can come closer to human capabilities if they can receive inputs from sensors (for various frequencies of sound, light (infrared to UV), voltage, pressure, pH, chemicals (dissolved and gaseous)) and "Big-Data" from genomics, proteomic (OMICS) databases as well as from hospital database, social media and personal/wearable devices.

Historically, medical profession is a highly memory dependent profession. Experience of a doctor is often counted and respected. Experience is nothing but seeing more cases. The more one sees the more one learns. Experience means (but not limited to) identifying same thing in different contexts or identifying different things in same context. An eighty year old doctor might have seen 200,000 patients in his entire career.[4] On the other hand a modern computer capable of "deep learning" is 'competent' to analyse, learn, assimilate and generate new knowledge. An average medical student learns from less than 50,000 cases during his training period but a computer can learn from millions of archived cases. An 'intelligent machine' can learn and assimilate the content of 150 years of British periodicals in limited time.[5] However, the computer can currently learn only with reference to some specific "features" as machine learning techniques still are very poor at discovering new features.

"Change Alone is Eternal, Perpetual and Immortal" - Arthur Schopenhauer

Machines are becoming more and more sensitive at detecting and analysing/ diagnosing the many subtle indications that our bodies are misbehaving and even more importantly they are on the path of excelling humans in systematically investigating and diagnosing diseases. In evaluation of retinal fundus photographs from adults with diabetes, an algorithm based on deep machine learning had high sensitivity and specificity comparable to that of trained ophthalmologists for detecting referable diabetic retinopathy.[3] An automated screening based on electronic auscultation at clinic level was successful and could be of great benefit in rural practice where there is an acute shortage of experienced clinicians.[11] The sensitivity of a computer aided diagnosis system using artificial intelligence for malignant thyroid nodules was as good as that of the experienced radiologist.[12] The performance of convolutional neural networks was not significantly different from the best classical methods and human doctors for classifying mediastinal lymph node metastasis of Non-small cell lung cancer from PET/CT images.[13] Machine learning algorithms were comparable to trained clinicians in detecting cancer from mammograms, neural disorders, fractures and other orthopaedic conditions, evaluating echocardiograms, dermatological conditions, and detection of polyps from endoscopic images.[14-20] Currently most of the machine learning is

limited to pattern recognition from limited input types (such as images) and therefore inferior to humans who go beyond pattern recognition by analysing inputs from multiple senses. However, 'pattern recognizing' machine may have an edge over human doctors who do not use their skills beyond pattern recognition. This is important considering the fact that our defective education system selects "memorizers" over thinkers.

Slowly as the technology improves they can be put to more general use and resulting in decreased medical spending. The evolving technology will enable machines to handle large amounts of patient data from multiple sources and correlating them. Currently, machines may be limited by their inputs but sooner technology will enable them to acquire inputs from multiple levels-genomic data, chemical sensors (Mass Spec, NMR, Raman etc.) which will surpass human chemical senses (such as smell, taste), physical senses (ultrasound, Doppler, elastometry data which will surpass human palpation and auscultation), social context data (input from social media, wearables), and the 'big data' from genomics, proteomics, metabolomics. Machines can process this data more effectively than humans leading to decide faster, precision diagnosis and personalised patient management.

Learning algorithms are evolving fast- the speed and quality of learning as well as the creative aspects of machine learning such as conceptualisation, hypothesis generation and even imagination would eventually excel humans. However, the current artificial intelligence systems are nothing more than a tool to help the clinician in improving the diagnosis and prediction. Today, a clinician's experience cannot be replaced by any computer and it will take many years to completely merge or replace human skills and perceptions with output from machines.

The AI technique which is currently powering social media, self-driving cars, super-human image recognition will soon be saving many lives. It is inevitable that AI will infiltrate most areas of healthcare. The pace at which this happens will only accelerate. It is for the medical community to adapt to and embrace this change.

Footnotes

*Deep Learning: Deep learning (also known as deep structured learning or hierarchical learning) is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. Learning can be supervised, partially supervised or unsupervised (Ref. Bengio, Yoshua; LeCun, Yann; Hinton, Geoffrey (2015). "Deep Learning". Nature. 521: 436–444.)

**Big Data refers to the use of very large data sets (which are large or complex and beyond the handling capacity of traditional data processing application soft wares) used for predictive analytics, user behaviour analytics, or other advanced data analytics methods.

About

The practice of medicine will be disrupted by artificial Intelligence and its access to Big Data' from "OMICS", wearable real time monitors, historical patient and genealogical databases, social media and internet databases. The way we think about diseases will change because many diseases such as type II diabetes, non-alcoholic liver disease, hepatocellular carcinoma, pancreatic cancer will no longer be considered as a single disease. They will split into hundreds of subtypes or altogether distinct diseases whose diagnostic criteria, prognosis and treatment would be significantly different. Therefore, it will become, humanly, more and more difficult, to make a diagnosis and remember the management protocols unaided by computers. As computer intelligence gain more importance in medical practice, it will diminish the importance of human intellect and the current role of doctors will change. Medicine will go more and more egalitarian with increasing community participation ("*wikification*") in health decision making and management. Medical education and training should be adapted to accommodate this foreseeable future. For future medical practitioners, human qualities such as compassion, empathy and emotional care will be increasingly more vital determinants of professional success.

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