Editorial

Artificial Intelligence in Primary Healthcare: Listening, Learning and Talking Computers

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Computers and advanced computing technologies such as machine learning and artificial intelligence (AI) are predicted to revolutionise healthcare.[1,2] Computers have been evolving for the last eighty years when the first digital systems were developed (Figure 1).[3] The capabilities of AI systems have developed very rapidly from an embryonic beginning in the 1950's and in the last two decades have surpassed human capabilities in areas of handwriting recognition, speech recognition, image recognition, reading comprehension, and language understanding.[4] Some of these technologies are freely available-such as image recognition and speech transcription- in a cell phone. AI that generates language has entered our world in many ways over the past few years- emails get auto-completed, massive amounts of online text get translated, videos get automatically transcribed, reports get auto-generated, and media-outlets practice AI generated journalism.[3,4]

On the other hand, many of these technologies that have used standardized formats are performing much worse than humans in the real world. This is because all the AI systems rely on machine learning and need to be trained. *Training computation* is one of the three fundamental factors that drive capabilities of the system, the other two being *algorithms* and *input data* used for the training.[3] All these three components must be in synchrony to be useful in healthcare. Given the diversity in language and variations in expression of medical terms, especially in large middle and low-income countries, success of conventional AI in healthcare delivery is not yet visible.

Despite this caveat, many computer pundits continue to predict usefulness of AI in healthcare.[1] AI based systems have been used to improve health related bureaucratic systems such as financial management, demand and supply logistics, and a few non-clinical systems (drug delivery, drug dispensing, drug interactions, nursing, and clerical support). Components of hospital management systems have successfully incorporated computerization. Examples of more important successes have been usefulness in claims and billing, personal health records, performance, and patient satisfaction research, drug and treatment research, and population health with limited success in clinical outcomes.[4] Ten powerful examples of AI used in healthcare today have been collated and are listed in table 1.

Healthcare is directly related to patient outcomes and AI has yet to evolve into a super-intelligent system that performs routine medical tasks such as listening to history and utilize findings of clinical examination to arrive at a diagnosis or differential diagnoses, order appropriate and cost-effective investigations, arrive at a provisional or

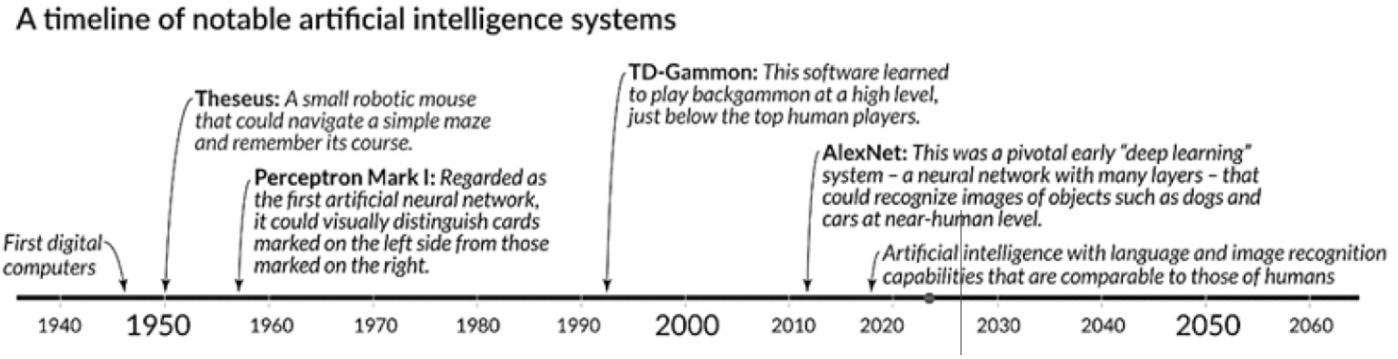

Figure 1: Timeline of evolution of digital technologies and artificial intelligence systems.

Table 1: Ten examples of artificial intelligence in current clinical use[5]

Examples
Robot doctors for dermatology, COVID-19, etc.
Robot dentists in dental care
Robot-assisted surgery
Virtual nursing assistants
AI assisted treatment centre Melanoma detection
Image analyses for radiological investigations
Improving medication adherence
Healthcare marketing
Automation of administrative tasks

Table 2: Challenges for adoption of AI in clinical care

Challenges
Focus on clinically important problems and information
Data sources and quality
Algorithmic bias
Lack of data standards and interoperability
Overfitting and problems with replication
Evidence base
Regulatory approvals
Data security and privacy
Interpretability and performance
Clinical integration

working diagnosis and recommend treatment.[1] Computers and AI-systems that think like a human brain may be a couple of decades away, although the such time-frame predictions keep on getting postponed repeatedly.[6] The present prediction is based on an optimistic scenario of development of highly advanced computer systems that would be able to communicate with the patient, investigate her and arrive at a diagnosis and suggest treatment. Terry et al[7] performed a qualitative study and reported that most primary care stakeholders in Canada are averse to using AI. There are multiple challenges for successful adoption of AI in clinical care (Table 2).[8] All these require context-specific mitigation strategies that would be different in our country.

We suggest an alternative for development of AI technology for primary care (Figure 2). This would shift focus from creating non-contextual computer systems to the context-specific patient-physician encounter for clinical diagnosis and individual level patient management. This could be transformative for countries such as India that are poised to massively expand the primary healthcare network in the next few decades with a focus on high quality healthcare.[9]

Listening and learning computers:

Language understanding and processing have evolved rapidly in the past 20 years and most of the computer systems can be trained to understand language. Medical dialogue is, however, very complex.[1] India has 22 official languages and hundreds of regional sub-languages and dialects. Every patient has different words for most medical symptoms, for example symptoms of pain, dyspnoea, fatigue, weakness, dyspepsia, seizures, joint pain, etc. can be variably expressed. To create AI-based software that can interpret such a variety and put it into understandable language will need highly advanced supercomputers, and even with massive computing power it is likely to be available to a select few. Even within a single language, the usual physician patient communication involves use of multiple vernaculars that need to be integrated into an AI system (Figure 2). Patients are also not happy sitting in front of the computer and clicking their symptoms.[7] This method also fails to interpret body language (soft signs) that is utilised by seasoned clinicians to reach a diagnosis.[10] Addition of physical findings to the patient AI-based record is a relatively simple task. There are multiple algorithms available that can provide suggestions for investigations and shall also be a relatively simple task for an intelligent computer.

Learning computer systems involve interpretation of symptoms and their assimilation (Figure 2). Many times, most of the patients' history is jargon and unreliable. To separate wheat from chaff involves a highly skilled

Listening Computer Systems

- Basic demographic data on every patient.
- Transcription of patient history into software. Coherent understanding of the patient communication.
- Accurate transcription involves translation of the local dialect and traditional medical slangs into usable language (English or major Indian languages).
- Simultaneously transcribe physician communication/s into software.
- Write down salient and relevant clinical findings according to physician- and nurse-led physical examination.
- Suggestions regarding further investigations.

Learning Computer Systems

- Understanding medical language and translate into simple and understandable language for better understanding by all concerned.
- Clinical findings to be recorded. Separate seeds from chaff.
- Investigations to be compared with previous tests using previous data.
- Real-time integration of history, physical findings and laboratory investigations.
- Understand disease epidemiology.
- Formulate a working diagnosis based on history, physical examination and investigations.
- If no definite diagnosis emerges, develop differential diagnosis using clinical algorithms and guidelines.

Talking Computer Systems

- Suggest differential diagnoses and a working diagnosis.
- In individuals with multi-morbidity serialise the diagnoses according to patient needs.
- Suggest patient-specific lifestyle management. Focus on dietary components and patterns, exercise-prescription, etc. Smoking and tobacco cessation and alcohol moderation must be emphasized.
- Medical treatment according to established local, regional and national guidelines.
- Flag any drug-drug interactions in case of polypharmacy.
- Suggest follow-up management protocol.
- Track compliance and adherence to lifestyle and pharmacological interventions.

Figure 2: Artificial intelligence in primary care: Listening, learning and talking computers.

clinician and although AI can provide such a scenario, we believe it may not be possible in the near future. Application of AI in healthcare has been prophesied for many years,[1] but the timelines keep on getting delayed (Figure 1) and recent prediction is the year 2050.[6] Assimilation of patient history, physical examination, current laboratory investigations and assimilation of previous data including genetic data involves complex AI-task.[1,8,11,12] Moreover, this may not be cost-effective to be widely implemented in clinical practice especially for lower-middle income countries such as India:[13] computers are expensive, software are expensive, and multiple high-level investigations including genetic investigations are beyond reach of a common individual.[14]

Interpretative (talking) computers:

The final barrier for AI is to cost-effectively diagnose various medical conditions, especially in primary care. Initial efforts of computer based diagnostic systems failed and till now no AI systems exist that can safely diagnose patients' disease.[1] Examples of single disease detection are many and AI has been validated for diagnosis in dermatology, pathology and radiology using a retrospective study design.[1,2] However, in a recent randomised controlled trial, AI was found to be inferior to radiologists' interpretation of routine radiographs and the AI candidate was able to pass 2 of 10 mock examinations (required pass rate is 90%).[15] We would expect AI shall be able to suggest working diagnosis, serialize the clinical problems based on clinical importance of multiple morbidities, guide the physician and patients regarding personalised lifestyle management, suggest therapeutic management, flag the drug allergies and any drug-drug interaction and suggest management protocol according to established national and international guidelines (Figure 2). The AI-based system should also be able to teach the patient for compliance to prescribed medications and promote adherence using technological interventions. Randomised trials shall be required before widespread implementation of AI in the clinic. A tall task indeed that demands Churchillian aphorism of blood, sweat, toil and tears!!

CONCLUSION

Computers and AI have changed our world immensely, but we are still at the early stages of development. This technology feels familiar so it is easy to forget that all these are very recent innovations, and that most profound changes are yet to come.[6] There are no signs that these trends are hitting any limits anytime soon and over the course of last decade, the fundamental trends have accelerated: investments in AI technology have rapidly increased, and the doubling time of training computation has shortened to just six months. All major technological innovations lead to a range of positive and negative consequences. This is true for AI. As this technology becomes more and more powerful, we should expect its impact to become greater still. A technological development as powerful as this should be at the centre of our attention.[3] Healthcare could be the final frontier for AI and progress that has occurred in the last decades is miniscule. However, little might be as important as big for the future of our world and future of our lives.

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