Special Article

Artificial Intelligence in Medicine Avatar — A Promise for Healthcare

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Artificial Intelligence (AI) is an integration of computer science, data analytics, and pure mathematics, which enable computer systems to mimic human cognitive skills to simulate intelligent behavior and critical thinking comparable to a human being[1]. Today it is blended with our daily living and revolutionizes every part of our life in the form of navigation, computer gaming, the personal voice assistant in smartphones for hands-free mobile usage, facial recognition biometric technology, precise weather forecasting, pop up of recommendations of our interest in Netflix, YouTube, Flipkart, and Amazon-like websites, etc.

The emergence of AI-powered apps in smartphones, wearables (smart electronic devices) like smartwatches, smart wrist bands, epidermal electronics like continuous glucose monitoring devices, and biosensors has revolutionized medicine for better health care for the patients. We are at the beginning of a new era in medicine, where AI-powered medical technologies are widely used in all medical fields to improve the different aspects of clinical practice. This paper aims to discuss the evolution of AI, common AI algorithms used in healthcare and its use in various fields of medicine, and the limitations of AI in clinical practice.

Evolution of AI[2]

In 1950, the English mathematician **Alan Turing** was one of the founders of Modern Computers, and Artificial Intelligence described a test known as the "Turing test" to determine whether computers were capable of human intelligence. Later in 1956, American computer scientist **John McCarthy** coined the term "*Artificial Intelligence*" and described it as *"the science and engineering of making intelligent machines, especially intelligent computer programs".* Over the past 70 years, computing power has evolved dramatically in both hardware and software technologies and AI technology evolved as a powerful tool and led to the fourth industrial revolution in the 21st century (Fig 1). It is on its way to shaping our present generation as well as the future generation.

Based on the level of intelligence revealed by the machine, AI is broadly divided into 3 stages[3]

First stage: Artificial Narrow Intelligence (ANI)

ANI also called weak AI that has focused on single or specific narrow range task

eg, Machines with speech recognition- Google Maps

Second stage: Artificial General Intelligence (AGI)

AGI is also called strong AI, the intelligence of a machine that mimics human intelligence, which has the power to create its programs

eg, Robotic technology.

Third stage: Artificial Super Intelligence (ASI)

In the future, the intelligence of machines will surpass the human intelligence.

Types of AI used in Healthcare[2]

Like specialties in medicine, there are different modalities in AI but the following three are widely used in healthcare

Machine Learning (ML)

ML uses mathematical algorithms to compile data and makes inferences based on preset criteria. It is used in managing medical data, helping in the diagnosis and early detection of diseases, personalized medicine, and analysis of errors in prescriptions.

Deep Learning (DL)

DL is a subfield of ML that requires less human supervision. It is an upgraded version of ML that can solve the problem which is unsolvable by ML. It is used in medical imaging, analyzing a large amount of data, and predicting adverse outcomes.

Natural Language Processing (NLP)

NLP is another sub-discipline of AI and ML. It is related to text and speech recognition and makes decisions based on that information. It improves clinical

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documentation, helps the healthcare provider to review massive quantities of unstructured data, identifies candidates for the clinical trial, and facilitates root cause analysis.

Common AI Algorithms used in Healthcare[4]

Algorithms are a set of rules that a machine can follow to learn how to do a task. AI enlists an endless number of algorithms. Some of the algorithms used in the medical field are

- Artificial Neural Networks
- Logistic Regression
- Support Vector Machines
- Random Forests
- Naive Bayes Classifier

Reasons for the Rising of AI in Healthcare

- Increasing demand for healthcare services and facilities
- Shortage of healthcare providers, especially specialty physicians
- High expectations from patients in terms of service and outcomes
- Availability of AI to perform at par or even better than humans in terms of analysis of medical images, correlating biomarkers, etc.

AI-based Algorithms used in Medical Disciplines[1,2,5,6]

Over the last 10 years, several AI-based algorithms have been approved by the Food and Drug Administration (FDA). It has wide clinical adoption for early detection, disease diagnosis, its management, medical data management, and drug development. Some of the AI-based algorithms used in medical disciplines are (Table 1).

Table 1 — *AI-based algorithms used in medical disciplines*

Discipline	Application of AI (with some examples)
Cardiology	The Kardia app in smartphones or tablets is designed to monitor ECG and helps in the detection of arrhythmias. The Apple Watch Series 4 to Series 7 has an electrical heart rate sensors that detect atrial fibrillation
Pulmonology	AI-based software provides a more accurate interpretation of pulmonary function tests to diagnose respiratory diseases
Diabetology	• Wearable real-time Continuous Glucose Monitoring (rt CGM) measures interstitial glucose by small transcutaneous electrodes placed under the skin of the abdomen or the arm and tracks glucose levels. This device alerts the patient by vibratory or auditory mode if reaches the preset hypoglycemia and hyperglycemia thresholds. • AI-enhanced "Noninvasive" glucose monitoring is successful by a skin patch that transmits readings to a smartphone, wristband with a build-in biosensor, and wearable wristwatch by using optical sensors • Smart insulin pens which have a tiny screen display to view the last dose, when connected with the app, help to track insulin dosing and timing. • Many mobile apps for diabetes address caloric counter, carb counting, exercise tracker, calculating calories burned, tracking blood glucose, insulin calculator, medication reminder, monitoring sleep habits and log-book.
Artificial Pancreas / Automated Insulin Delivery	New generation Insulin pumps automatically adjust the dose of both basal and bolus insulin according to measured glucose concentration and achieves better diabetes control.
Hypertension	AI-enhanced Blood Pressure (BP) monitoring devices like Smart wireless BP devices, and cuffless wireless wearable devices measure BP easily. When connected with the app, it helps to track BP history.
Ophthalmology	Diabetic retinopathy screening in adults is done by AI programed IDx-DR software system which analyzes the retinal images taken with a fully automated digital fundal camera. It helps to detect diabetic retinopathy within minutes and leads to a reduction in diabetes-related ophthalmic complications.

Discipline	Application of AI (with some examples)
Nephrology	AI programmed software and algorithms help to predict the decline of estimated glomerular filtration rate based on serum creatinine concentration in patients with kidney disease and predict acute kidney injuries. Image analysis by computer-aided diagnosis helps in categorizing kidney tumors as cancerous and non-cancerous lesions.
Gastroenterology	Convolutional neural networks are widely used in medical image analysis. By colonoscopy, image analysis detects abnormal structures such as colonic polyps. Endoscopy and ultrasound image analysis is been used to diagnose various gastrointestinal diseases like gastritis, gastroesophageal reflux disease, esophageal cancer, inflammatory bowel disease, and metastasis in colorectal cancer.
Neurology	An AI-enabled wearable smartwatch detects seizures and sends an alert to caregivers and information about the patient location. Also, proven useful to quantitatively assess gait, posture, tremor, sleep, and medication reminders in patients with neurological diseases like Parkinson disease, Parkinsonism, and Huntington disease. AI-based automated seizure detection algorithms help in speedy and accurate interpretation of electroencephalography (EEG).
Pathology	Digitalized Whole Slide Image Technology is capable of diagnosing cancer with great accuracy, allowing the pathologist to focus on important slides as well as speed up the reporting time.
Radiology	Deep learning software revolutionizing all imaging modalities including X-ray, ultrasound, CT scans, MRI scans, and PET scans to diagnose various diseases.
Newer Drugs and Vaccines	AI-based sophisticated algorithms create new opportunities to speed up the drug discovery and vaccines and shorten the longest steps in the discovery process.
Surgery	The Da Vinci Surgical Navigation System- a Robotic surgical system assisting in minimally invasive surgical approach for many surgical procedures.
Medical Virtual Reality	Virtual reality and three dimensional (3D) aid in teaching and training of medical school curriculum. Virtual reality headsets use during surgical procedures or during labor pain make the patient feel more relaxed with less anxiety.
Healthcare Administration	Clinical documentation, health record management, billing, and insurance claiming process can be done by Robotic process automation. Natural Language Processing based application can understand and respond to text or voice and make simple transactions like refilling prescriptions and for appointments. Ambient Clinical Intelligence-based application analyzes the interview and automatically fills the patient's electronic health records.
Electronic Medical Record (EMR) / Electronic Health Record (EHR)	Both EMR and EHR digitalize the patient's health details including demographics, history of illness, lab and imaging reports, and medications. Unlike EMR, EHR records can be shared with all treating physicians wherever the patient goes, thereby facilitating healthcare outcomes more efficiently and less costly.
Adherence to Therapy	A mobile phone-based AI application reminder system improves drug adherence and acts as a tool for patient empowerment, which leads to better clinical outcomes and enhances the quality of life.

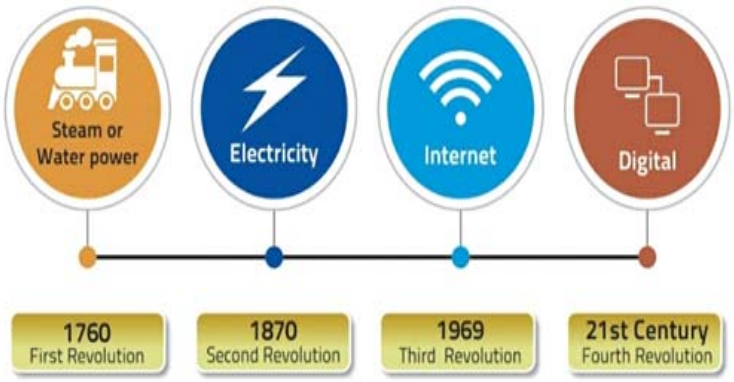

Fig. 1 - FOUR INDUSTRIAL REVOLUTIONS

Limitations of AI in Clinical Practice[5,7]

Technical Aspects :

- Challenges of the application
- Validation of the algorithms
- High cost for updating on the latest hardware and software
- Need frequent up-gradation of software
- For digital experience, proper training and knowledge are needed in computational sciences, coding, algorithmic, and mechatronic engineering
- Lack of clarity for some AI algorithms
- Lack of medical curriculum based teachings
- Electronic waste or e-waste, the harmful materials like lead, beryllium, and cadmium in electronic items are a hazard to the environment and human health

Psychological aspects :

- Fear of slow replacement of job opportunities of physicians and other health staff
- Empathy, trust, and moral support for treating patients would be compromised by using AI
- Negative impact on vulnerable age group
- Reduction of human contact and negative impact on health due to AI dependence and addiction

Ethical and Security issues :

- Lack of personal data privacy and misuse of personal information
- Risk for criminal and malicious use
- Lack of transparency
- Lack of informed consent

Though AI has limitations in various aspects like technology, ethical issues, security issues, and psychological which should be addressed by further studies, proper regulations, and a legal framework, AI technologies certainly improve physician performance by reducing the burden of clerical work and allowing them to spend more time with patients and the healthcare team.

Conclusion :

"Necessity is the mother of all innovations"

The European Union High-Level Expert Group on AI (2019) clearly states that *"AI is not an end in itself, but rather a promising means to increase human flourishing, thereby enhancing individual and societal well-being and the common good, as well as bringing progress and innovation.[7]"* Today high-quality medical care requires strong clinical skills along with appropriate tests and technology like AI. At the beginning of a new era in medicine, the integration of digital medicine is an essential part of the growth and development of medicine, which was accepted as complementary to physicians. AI is a Stethoscope of the 21st century that cannot replace physicians but rather helps physicians to create a paradigm shift toward precision diagnosis, risk prediction, prognosis, and management.

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