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A REVIEW ON COHABITATION OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Medical Science

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ABSTRACT

Digitization has consolidated Healthcare systems and generated large amount of data which can be tapped for valuable Insights. Similarly, lower costs of compute hardware, cloud computing and computer algorithms has made it possible to apply AI (Artificial Intelligence) & ML (Machine Learning) at a very cost effective manner. One of the areas which is being transformed with this is the Healthcare Industry. AI is gaining popularity in a variety of domains like Hospitals, Clinical research, Clinical laboratories, Insurance sector, Medical Coding and Billing etc. It is used to enhance the efficiency in delivery of Healthcare and to solve problems that are hard to deal with. Today algorithms are outperforming humans in predicting diagnosis, finding matching cohorts for clinical trials, automating insurance workflows and medical coding and billing processes.

In this review, we have summarized the latest developments of applications of AI in in hospitals, clinical trials, insurance processing and medical coding and billing. The aim of this review is to keep track of new scientific accomplishments, to understand the availability of technologies and to appreciate the tremendous potential of AI in Healthcare.

Here we have reviewed articles and journals to get in-depth of the current scenario of AI in healthcare with its implications and challenges. Most of the implementations of AI come with common challenge though - accountability, transparency and privacy. While this can be solved with governance and newer regulations, there has been not much done by the authorities at the present. One other challenge this transformation faces, is the growing concern among Healthcare workers about job loss to AI and automation systems. A model of cohabitation is needed where human skills and AI can deliver care in a scenario where human empathy is needed and which also lessens fear of losing jobs. The need of the hour is regulations that have standards to assess the AI systems safety and efficacy, better data exchange policies and regulations for data privacy.

KEYWORDS

Artificial Intelligence, Hospitals, Cohabitation, Digitization

INTRODUCTION

AI systems have been developed with a careful process of reverse-engineering human traits and capabilities into a machine, and using it's computational prowess to surpass what we are capable of. Among many AI techniques that exist today, below six core AI techniques are seen to have wide range of application in the Healthcare domain.

- Robotic Process Automation – Are primarily used for automating and mimicking user actions. These are primarily applied in automating huge amount of manual software and data intensive tasks.
- Computer Vision & Deep Learning – Have applicability in understanding Image and Video streams to identify patterns and provide correlation and insights
- Data Analytics – Helps in diving into large amount of data and deliver insights and help in predictions
- Natural Language Processing – Makes it easy for computers to understand human verbiage and accordingly provide automated responses and accurate resolutions through systems like chatbots etc.
- Voice Analytics- Ranging from sentiment analysis to tonal analysis, these AI algorithms can provide real-time insights to live call recordings and conversations
- Robotics- AI powers Robotic system to operate on precision activities with intelligence based on data from multiple sources, correlated and processed in real-time.

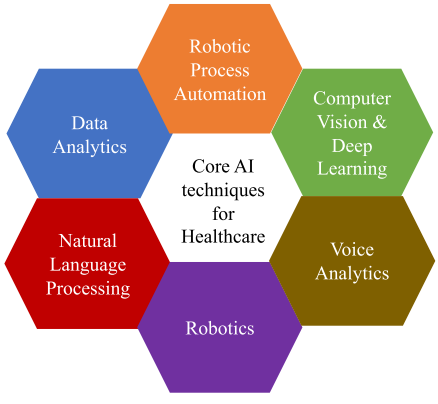

Figure 01: Core AI techniques for Healthcare

This paper takes you through the breadth and depth of implementation of these techniques in various areas of Healthcare domain and also provides details of how multiple of these techniques can be applied to the same problem.

LITERATURE REVIEW

Human physicians will not be replaced by machines in near future, but AI can assist physicians to make better clinical decisions or even replace human judgement in certain functional areas of healthcare[1]. Global artificial intelligence (AI) in healthcare market is expected to reach approximately USD 17.8 billion by 2025, at a CAGR of 43.8% between 2019 and 2025. Global spending on cognitive and AI systems is expected to reach $57.6 billion in 2021. The share of jobs requiring AI skills has grown 4.5 times since 2013. AI will boost profitability by 38 percent and generate $14 trillion of additional revenue by 2035[2].

The success of AI in healthcare can be attributed to the fast growing accessibility of healthcare data, thanks to EMR; combined with the quick development of analytic methods in big data. AI system has the Machine learning component to analyse structured data (genetic data, EP data, Images) and the Natural language processing component to mine unstructured texts. Using algorithms trained with healthcare data, the system can assist physicians with disease diagnosis and suggestions for treatment[3].

Somashekhar *et al* demonstrated that the IBM Watson for oncology would be a reliable AI system for assisting the diagnosis of cancer through a double-blinded validation study[4]. Bouton *et al* developed an AI system to restore the control of movement in patients with quadriplegia[5]. All three diseases are leading causes of death so early diagnoses are crucial to prevent morbidity and mortality. Moreover, early diagnoses can be potentially achieved through improving the analysis procedures on imaging, genetic, EP or EMR, which is the strength of the AI system.

Drug research and discovery is one of the more recent applications for AI in healthcare. According to the California Biomedical Research Association, it takes an average of 12 years for a drug to travel from the research lab to the patient. Only five in 5,000 of the drugs that begin preclinical testing ever make it to human testing and just one of these five is ever approved for human usage. On an average, it will cost a company US $359 million to develop a new drug from the research lab to the patient. AI can streamline the processes involved thus reducing

both the time to market for new drugs and their costs[6].

Artificial intelligence has predictive analytics and clinical decision support tools that clue providers about problems long before they recognize it. AI can provide earlier warnings for conditions like seizures or sepsis, which often require intensive analysis of highly complex dataset[7].

One of the challenges is that we do not have the regulations that have standards to assess the AI systems safety and efficacy. Secondly, for good results AI systems need continuous training with data from clinical studies which needs a continuous data supply. Thirdly, data privacy is another issue that needs to be addressed adequately. Important legislations that regulate patient data like the European Union's GPDR and the HIPAA in the US are very protective of patient privacy[3].

AI IN HOSPITALS

Robotic process automation of Hospital processes and documentation

Robotic process automation (RPA) is one technology that is capable of helping providers achieve overall cost reduction and efficiency ,which is financially beneficial for them[8].

RPA is used to automate time-consuming, repetitive, rules-based processes with maximum efficiency and accuracy. Healthcare environment is such an example that involves layers of administrative, managerial and customer service functions, marked by information intensive manual tasks. Classic examples include: claims processing and coding changes, provider data management, patient case management, billing, revenue management and more. Many of these tasks can be easily, effectively, and efficiently undertaken with RPA. Once deployed, they not only help in improving efficiencies and cutting costs, but also reducing negligence and ensuring patient safety[9].

Learning a new system through traditional learning methods may not always be cost effective, practical and efficient for healthcare professionals. Healthcare professionals can't always get away from their duties, patients, or businesses to participate in classroom time, or to complete lengthy e-learning sessions[9].

With attended RPA they can learn on the job with directed guidance or automate tasks directly from their desktops. Furthermore, these solutions can direct them to follow through the correct steps to prevent disastrous or costly errors by giving alerts to users within the application.This can in turn reduce training time and costs and helps organizations avoid errors, employee turnover and other common frustrations[9].

AI for Electronic Health Record management

While AI is being applied in EHR systems principally to improve data discovery and extraction and personalize treatment recommendations, it has great potential to make EHRs more user- friendly.

Application:

- Clinical documentation and data entry- "Capturing clinical notes with natural language processing allows clinicians to focus on their patients rather than keyboards and screens," the authors wrote. Healthcare solutions company Nuance offers AI-supported tools that integrate with commercial EHRs to support data collection and clinical note composition[10].
- Predictive algorithms- Google is teaming up with delivery networks to develop prediction models from big data to alert clinicians to potentially life-threatening conditions such as sepsis and heart failure[10]. In Google's research into Deep Learning powered predictive data models based off of EHR data, engineers built on top of the FHIR framework in order to support machine learning analysis of the stored medical data[11].
- Clinical decision support- Decision support was previously generic and rule-based. Now, Allscripts, IBM Watson are coming up with machine-learning solutions that learn from new data and enable more personalized care[10].

AI in Robotic Surgeries

Artificial intelligence is being applied to surgical robotics where deep learning data is used to automate different scenarios. This deep machine learning data is collected from watching surgeons perform surgeries. AI can determine patterns within surgical procedures to improve best practices and to improve a surgical robots control accuracy to submillimetre precision. AI is also being used with machine vision to analyse scans and detect cancerous cases. Laparoscopic video analysis of surgeries, like sleeve gastrectomy procedures, helps to identify missing or unexpected steps in real time[12].

Application:

- Robots have a superhuman ability to repeat exact motions. This is extremely useful in hair transplant surgeries, for example[12]. This can be applied on areas with precision and tedious effort like harvesting hair follicles and then implants the follicular units into targeted areas on the scalp.
- Abdominal surgical robots can move by means of an eye-tracking camera control. Surgeons are able to move the camera simply by moving their eyes. The machine also provides haptic feedback so they can feel the forces that the robotics arms encounter[12].
- Surgeons need extremely steady hands when working in delicate areas, such as the eyes. Tests of a system to remove membranes from patients' eyes or blood underneath the retina due to age-related macular degeneration have been successful. And in some cases, the surgery via the robotic system was more effective than doing the procedures manually[12].
- Surgeons are using robotic surgery platforms that use micro-instrumentation, flexible robotics, and other technologies for bronchoscopy procedures. Robotics improve outcomes for patients by accessing and treating disease through the body's natural openings. The platforms integrate endoscopes, instruments, and navigation into a single platform, allowing physicians to better conduct endoscopic interventions[12].

Automated Medical Image Diagnosis with AI/ML

Medical image diagnosis is another AI use case in healthcare. One of the challenge faced by medical practitioners face is interpretation of the huge volume of information data from EHR and EMRs. This data also includes imaging data apart from procedure reports, pathology reports, downloaded data, etc. In the future, patients will send even more data through their remote portals(tele-medicine), including images of the wound site to check if there is a need for an in-person check-up after a healing period[13].

One of the most promising areas of health innovation is the application of artificial intelligence (AI) in medical imaging, including, but not limited to, image processing and interpretation [14].

Application:

- AI algorithms look at medical images to identify patterns after being trained using vast numbers of examinations and images. Those systems will be able to give information about the characterisation of abnormal findings, mostly in terms of conditional probabilities to be applied to Bayesian decision-making.AI systems look at specific labelled structures and also learn how to extract image features either visible or invisible to the human eye. This approach mimics human analytical cognition, allowing for better performance than that obtained with old CAD software[14].
- The recently developed Deep Learning networks have led to more robust models for radiomics, which is an emerging field that deals with extraction of peculiar features from radiological images. Indeed, data derived from radiomics investigation, such as intensity, shape, texture, wavelength, etc., can be extracted from medical images and extracted by data characterisation algorithms[14].

AI applications may enhance the reproducibility of technical protocols, improving image quality and decreasing radiation dose, decreasing MRI scanner time and optimising staffing and CT/MRI scanner utilisation, thereby reducing costs. These applications will simplify and improve radiology technicians' work[14].

AI to predict Pandemic & Cause of Diseases

AI initiatives are predominantly focused on developing algorithms that can predict a problem such as cancer in order to make diagnosis better, faster, and less expensive Rarely, are there organizations devoting resources to AI efforts aimed at understanding why diseases occur. To intervene as effectively as possible, both kinds of algorithms are crucial[15].

Application:

Predict Pandemic & the impact. AI regression models can predict the impact of diseases particularly through community spread. For example: a team from MIT has developed a machine learning model that leverages coronavirus data and a neural network to determine the effectiveness of quarantine measures and predict the spread of the virus. They are integrating machine learning and epidemiology in this model [16].

- **Treatment optimization.** One of the most exciting field of applications of causal AI is providing decision support to care providers[15].
- **Discovering mechanisms of disease.** Healthcare systems want to improve the rate of survival by understanding the underlying disease mechanism. AI models with data from a clinical trial with multiple patients who were being treated with different drugs had helped identify both molecular and clinical causal drivers that can serve as biomarkers for survival, so doctors can better target the right treatment to the right patient[15].
- **Social Determinants of Health.** Health care professionals globally are struggling to understand how social factors surrounding a patient can impact health[15]. AI models built on social metrics can produce good insight to the direct impact of these factors surrounding a patient, thereby helping the doctors to classify the patients into corresponding risk zones.

Telemedicine & Healthcare monitoring

People today need medical assistance in the comfort of their homes, for as long as they can. For the first preliminary overview of any symptom, personal health companions have become popular amongst people all around the world. Babylon Health is a UK-based start-up that has developed a chatbot for the early prevention and diagnosis of diseases. When the application receives a symptom explanation from a user, it compares the same to its database and recommends an appropriate course of action based on the history of the patient, his circumstances, and the symptoms he reports.

Similarly, these personal health companions use AI and ML to track the patient's health and provides insights and understanding to the patient for any changes in their health.

Application:

- Application of AI in telehealth could assist with the issue of uneven demand versus supply of healthcare services by developing algorithms to match the care providers available with skills required to the need for such skillsets in the immediate locality.
- The operational issues of telehealth such as when the telecommunication link fails or the remote care physician is not available can be mitigated by AI . It can provide mechanisms for human or virtual interactions to occur, and thereby address difficulties in timing and availability of clinicians (such as the time taken to understand the patient's problem or taking a history[17].
- History taking - Analysing the history of presenting complaint in any case is important in the diagnosis of the disease. AI can prompt by asking the right next set of questions based on the answer saving the clinician time. For example, a person suffering long-term with chronic, dull aching pain in the upper abdomen without interference with sleep is likely suffering from gastritis. Aligning a series of such questions by AI delivered as part of a telehealth application can be useful and may be implemented efficiently using mobile ICT.
- Another area for tele-diagnosis is tele-dermatology. Currently, diagnostic accuracy for melanoma is dependent on the experience and training of the treating doctor. A recent study has shown that a computer algorithm using convolutional neural networks outperformed the majority of 58 dermatologists tested in accurately diagnosing melanoma, with a median area under the receiver operating characteristic curve of 0.86 compared with 0.79, $P < 0$[18].
- Conversational Agents and Virtual Assistants- Speech-text conversion utilities and chatbots capable of audio or typed inputs and outputs are examples of such technologies .These automated conversational interactions can enhance and in some cases replace human carer tasks. These may include reminders and motivational messages e.g., for medication, nutrition, and exercise; routine condition checks and health maintenance, based on personal monitoring data; answering of health queries and provision of targeted health information and education; providing a personalised means to address social isolation and community involvement; acting as an intermediary entity between multiple carers or service agencies.
- Remote Patient Monitoring and Management- Tele-monitoring has been evaluated for the distant surveillance of patients with chronic disease, such as chronic heart failure[19], chronic obstructive pulmonary disease (COPD)[20], and diabetes mellites.. By using Classification and Regression Tree (CART) patients at high risk of an imminent exacerbation has been validated using telehealth measurement data recorded from patients with moderate/severe COPD living at home. Similar approaches could be used for foreseeing exacerbation in a number of chronic conditions[20].

In these ways AI-enabled telehealth contributes in the form of quality improvement and betterment of existing practice, as well as to suggest new models of care.

AI in Clinical Trials

Randomized controlled trials has long been used as a clinical trial for testing mass-market drugs and has changed little in recent decade. But they lack the analytical power, flexibility and speed required to develop complex new therapies that target smaller and often heterogeneous patient populations. In addition, suboptimal patient selection, recruitment and retention, together with difficulties managing and monitoring patients effectively, are contributing to high trial failure rates and raising the costs of research and development.

Recently, Biopharma companies have been able to access RWD(real world data) which is the extensive amount of scientific and research data from a variety of sources[21]. Unfortunately, there is a deficit of skills and technologies to enable them to utilise this data effectively. Predictive AI models and analytics tools has the potential to unlock this data and help accelerate the understanding of diseases, identify suitable patients and key investigators to inform site selection, and support new clinical study designs.

Application:

- Internet of things has expanded the vast patient base for research studies and clinical trials. Researchers and medical professionals can select more ideally-suited individuals for their studies by AI-powered screening tools[22]. AI supports clinical trials by stratifying patients and matching patients with doctors and studies. For example, Belong.life which is a social network for managing and navigating treatments powered by machine learning and AI provides a series of personalized benefits for cancer patients. It matches potential patients with clinical trials along with offering patients personalized content and updates. It also helps patients chat with skilled health care professionals and connect with a network of peers who are on the same path. Similarly, TrialJectory and MassiveBio, also matches cancer patients with potential clinical trials, using self-reported medical data. Tools like these make the clinical trial process more effective and efficient, help patients receive the right care, and create more specialized, high-quality datasets that can initiate further research. Software developed by Deep 6 AI, an AI-based trials recruitment company in Pasadena, California, was used by researchers at Cedars-Sinai Smidt Heart Institute in Los Angeles, California, to find 16 suitable participants for a trial in one hour. A conventional approach had turned up only two people in six months.
- Natural language processing (NLP) when applied to medicine, allows algorithms to search doctors' notes and pathology reports for people who would be eligible to participate in a given clinical trial[23].
- Every clinical trial follows a protocol that describes exactly how the study will be run. Designing better protocol is crucial as it helps run the trial smoothly.Trials.ai, a start-up company in San Diego, California, uses AI in designing better trials protocols. It collects and analyse publicly available data such as journal papers and drug labels, as well as private data owned by the drug or medical-device companies by using NLP and other AI techniques. From those data, the company's software can help determine how different aspects such as the strictness of its eligibility criteria, might affect outcomes such as cost, length or participant retention. If a customer wants to test a drug for diabetes, criteria required for people to participate i.e. the amount of glycated haemoglobin, could lead to different trial outcomes. When the eligibility threshold is too low, improvements due to the drug can be harder to

detect. But when the threshold is too high, the participants in the trial may be low. By searching the literature, Trials.ai's algorithm can quickly find population-wide diabetes statistics to help the protocol writer to identify a level that balances both.

- Reliability of participants is yet another challenge faced in clinical trials. AiCure, a data-analysis company in New York City enables people to use their smartphones to record videos of themselves taking medication. By analysing those images using computer-vision algorithms, AiCure's software can identify the person and the pill, and confirm whether it was taken. A study in people with schizophrenia showed that around 90% of people who used the AiCure platform took their medication as prescribed, compared with about 72% of those who were periodically monitored by a person when taking medication. The company says that its software can even measure people's facial expressions to track how they respond to treatment, which could guide the development of therapies.

AI in Insurance Processing

Insurance is a data-driven industry, with enormous amount of data and repetitive manual processes. Automation is the answer for insurers looking profitability in an environment of low interest rates, market overcapacity, intensified competition and growing regulations. Intelligent process automation (IPA) enhances software bots with cognitive technologies that mimic human perception and judgment[24]. These include artificial intelligence (AI), machine learning (ML, a more advanced type of AI in which a computer improves its performance without being explicitly programmed to do so) and automated case management. These solutions can automate a wider range of activities and result in greater cost reductions. IPA also benefits by improving efficiency, quality, compliance and customer experience.

Application:

- Insurance advice- To improve customer experience insurers are making wider use of chatbots on messaging apps to resolve claims queries and answer simple questions.
- Agent-facing chatbots can identify the customer before the agent even answers the call, process queries in natural language and make suggestions based on the customer's profile and guides them to the next steps. For example, U.K.-based start-up SPIXII is a virtual insurance manager that chats with customers to understand their insurance needs and recommend the best coverage for them. The chatbot can converse in six languages[25].
- Fraud prevention- Advanced image analysis and predictive analytics tools can provide instant damage estimates and helps processing of claims based on uploaded accident photos, reducing time and costs. For example, U.K.-based software company Tractable has an AI review program that checks thousands of repair estimates every minute, flagging unnecessary repairs. Using image recognition analysis apps like Mitchell helps insurance companies improve repair estimates by using computers to analyse photos of damaged vehicles.
- Risk management- RPA is now applied in the assessment of loss runs, which forms the basis for underwriting and pricing of products. Automated reporting of several years of claims history of customers with the help of RPA can reveal hidden information related to previous losses. For example, LexisNexis' Data Prefill ,with just a few customer data points, pre-populate applications and claims for insurance carriers and other organizations in the insurance ecosystem
- Claims processing- Insurers are using machine learning to improve operational efficiency, from claims registration to claims settlement. Leading vendors such as UiPath and Blue Prism created software bots for performing repetitive structured tasks like data. In total, over 200 insurance organizations have already launched RPA projects.

AI in medical coding & billing

Medical coding and billing is one of the fastest growing jobs in the healthcare field, with a predicted 15% job growth expected between 2014 and 2024[26]. The medical billing outsourcing market alone is projected to reach $16.9 billion by 2021. The coding and billing process translates patient record information into standard codes which are used for billing patients and third-party payers such as a Medicare and insurance companies. The transition from ICD-9 to ICD-10 resulted in an increase from 3,824 to 71,924 for medical procedures. Similarly, the codes for medical diagnoses increased from 14,025 to 69,823.Thus automation can help reduce risk for medical institutions and allow medical personnel to spend more time focusing on patient care and more complex coding scenarios[27].

Application

- It can identify duplicate coding, trends of upcoding, and common errors that medical coding professionals make. A computer assisted coding system (CACS) is software that analyses healthcare documents and produces appropriate medical codes for specific phrases and terms within the document. Companies are using machine learning and Natural Language Processing (NLP) to automatically recognize and extract data from medical documents for proper coding and billing. These helped to minimize false positives and to maximize detection accuracy to an enormous extent, henceforth reducing company's manual time consumption in the whole medical billing process.
- Payment Productivity- "Care transition analysis "is a long term data mining method that helps insurers take decision about which organizations to partner with. This information can help them identify suspicious billing patterns, separate hospitals with a high rate of rehabilitative success from those with extreme readmission rates, and even develop prepayment solutions for quicker transactions.
- Record reconciliation- AI can easily sort through past files and documentation to determine which information are out of date, what may need to be added to patient files, and what files are no longer relevant at all. This reconciliation work can also make patient files much more manageable for doctors and coders.

RESULT OF THE RESEARCH

Applications of AI in Healthcare has broadened to every possible area. Using large amount of data around in cognitive decision making is enhancing the efficiency of the Healthcare workers. While AI delivers required insights, it cannot replace human empathy and communication needed in dealing with patients. So a model of co-habitation is needed where AI and human elements together deliver effective Healthcare. One of the challenges is lack of sufficient regulations and standards to assess the AI system's safety and efficacy. Secondly, for good results AI systems need continuous training with data from clinical studies which needs a continuous data supply. So obstacles in data exchange is another challenge. Thirdly, data privacy is another issue that needs to be addressed adequately. Important legislations that regulate patient data like the European Union's GPDR and the HIPAA in the US are very protective of patient privacy.

CONCLUSIONS

Enormous amount of data that is generated by the digital systems around gives a huge potential for automated and cognitive decision making. With the advancement of AI & ML along with easy and cheaper availability of compute & storage, cognitive decision making is driving fast digital transformation of the Healthcare sector. AI techniques ranging from regular Data analytics, to Deep Learning based Image recognition, Natural Language Processing, Robotic Process Automation and AI based Robotics are driving multiple use-cases in different areas of Healthcare system. Implementation and adoption of these techniques have gone multi-fold in the last few years.

RECOMMENDATIONS

A model of cohabitation can help where human skills and AI can deliver care in a scenario where human empathy is needed and which also lessens fear of losing jobs. The need of the hour is regulations that have standards to assess the AI systems safety and efficacy, better data exchange policies and regulations for data privacy. While there is no doubt in the value AI brings and the wide range of applications it delivers, isn't it high time to bring in governance and regulations to deal with typical issues of accountability, transparency and privacy in using these systems.

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