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AI in Laboratory, Health & Diagnostics

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Abstract

This paper sets its focus towards looking at the data used in diagnosis and how such data can play a key role towards diagnosis and facilitating healthcare needs. This research paper adopts exploratory techniques and qualitative/quantitative analysis to identify key opportunities and areas where they can impact laboratory tests and diagnosis/treatment. Data is the key element that enables towards understanding of the key trends. Various data sets come in from such diagnostic tests or from the medical system that help to build effective databases or knowledge. This knowledge can be fed into the artificial intelligence system to make it more capable of helping in making decisions towards the diagnosis or treatment of patients. This paper aims to understand the key trends in AI in healthcare and diagnosis and also looks at the impact of such data sets that aid in better diagnosis and decision-making capabilities which in turn paves the way for building intelligent system that helps the doctors or lab technicians to make better decisions.

Keywords: Artificial Intelligence, Diagnosis, Intelligent System, Machine Learning, Computer Vision, Natural Language processing, Surgical robots.

Background

Health plays an important role in one's life. Taking care of health and being self-aware of healthcare aspects in today's fast-growing world is very important. Health is a fundamental aspect of human well-being and this impacts the well-being of today's society. There has been significant awareness and information sharing among the public in these areas of healthcare and its key importance. Patient care and patient safety are gaining attention as it is revolving around the patients and the quality of health treatment offered by hospitals. Patient safety is crucial for protecting life, building trust, delivering high-quality care, minimizing costs, maintaining compliance, enhancing professional reputation, preventing adverse events thus ensuring public health preparedness and upholding ethical standards in healthcare.

The World Health Organization (WHO) states that new research indicates that social determinants of health may have a greater impact on health than either healthcare or lifestyle decisions. A state of whole mental, physical, as well as social well-being as opposed to only the

absence of disease is known as health. Each and every human being, regardless of race, political opinion, religion, social standing, or else economic status, has the fundamental right to the best possible standard of health.

Costs of healthcare are increasing. The expense of healthcare has expanded over the last thirty years at a far greater rate than other economic sectors. In the majority of developed nations today, healthcare is one of the biggest industries. At the same time, there aren't enough resources for healthcare. Many people lack equitable access to healthcare, and many governments are unable to provide adequate treatment for all of their people. The location as well as the point of provision of healthcare have a significant impact on its availability along with usage. The needs of the population served tend to be inversely correlated with availability.

Health service reforms have been triggered by these considerations in both developed as well as developing nations. Health authorities are required under the 1990 National Health Service Act to evaluate the health requirements of their communities as well as apply the results to set goals for enhancing the health of the local population. This provided health authorities with better opportunities to customize local services to their own populations.

Assessing a patient's health requirements includes beyond just listening to them and depending on individual experience. It is a methodical approach of recognizing unaddressed health as well as healthcare requirements within a population along with implementing modifications to fulfill these requirements. The strategy utilizes epidemiological & qualitative methods to set priorities, incorporating clinical as well as cost-effectiveness with patient opinions. This strategy must balance the ethical, clinical, as well as financial aspects of need, considering what can, should, and should not be undertaken. The 1980 "Black report" by Sir Douglas Black et al. focuses on identifying the level of health inequality in the UK and suggesting ways to address some of the underlying causes of health as well as making sure the NHS contributed to reducing health inequality.

The evaluation of sickness should not be the sole emphasis of health needs assessment, as this perspective assumes that the condition is treatable. The inclusion of the ability to advantage emphasizes the significance of the efficacy of health interventions and clarifies the specific benefits desired. According to economists, there will always be more people who can benefit than there are resources available, and health needs evaluations should take priority setting into account.[1] Moreover, they contend that many needs assessments are only attempts to divert focus away from the challenging choices connected to rationing.[2]

Health needs assessment offers individual practices as well as health professionals the possibility for:

- Characterizing the local population's disease patterns as well as how they differ from regional, district, or else national disease patterns;
- Acquiring deeper insights into the requirements as well as patients' priority along with the surrounding community;
- identifying the areas in which needs are not being met and providing a clear set of objectives to work toward to meet these needs;

- logically selecting the best distribution of resources to improve the community's health in the most practical along with effective way possible;

Assessing health requirements is not a simple, quick treatment. Different approaches will be needed for different topics. These might involve transferring as well as modifying what is already known or available, or combining qualitative as well as quantitative research approaches to gather original data.

Frequently, the accessibility of fresh funds for the advancement of health services or a person's personal interest serves as a stimulus for these assessments. The importance of the health issue (in terms of impact, cost, or else frequency), manifestation of critical incidents (for example, the passing of a patient who had been refused admission to ICU), proof of the efficacy of an intervention, or release of novel investigation discoveries regarding the burden of an illness should also serve as triggers for assessments.

Health and Healthcare Technologies

Healthcare as well as healthcare technologies are continuously evolving, driven by innovation, research and the need to address emerging healthcare challenges. Tele-medicine and remote care, healthcare internet of things, block chain technology, remote patient monitoring, precision medicine as well as genomics, artificial intelligence (AI), machine learning (ML), virtual reality & augmented reality, robotics along with automation are some of the technology trends shaping the healthcare industry.

Virtual as well as augmented reality technologies are still developing. There are already certain applications of AR in the medical field. In 2020, neurosurgeons from Johns Hopkins University carried out the first spinal fusion procedure with AR assistance. In order to facilitate additional interactions beyond what is feasible with augmented reality, mixed reality gives the virtual elements an additional layer of depth as well as perspective. The utilization of MR has predominantly persisted within the confines of diverse businesses via devices like the Microsoft Hololens. In this instance, Dr. Bertalan Mesko and colleagues emphasized that clinicians utilized the MR headset to engage in hands-free discussions with colleagues and patients while examining medical records and X-rays for clinical decision-making.

Healthcare data management is a key area which poses various challenges in terms of tracking and managing patient records including electronic health records (EHR). This section improves clinical decision making, streamlines workflows, as well as helps with documentation accuracy. For instance, Epic EHR, a top provider of electronic health record software, utilized Microsoft Azure OpenAI service to include AI in its software. This integration aids physicians in formulating tailored treatment regimens, hence enhancing patient participation and facilitating improved health outcomes.

The popularity of telemedicine has driven several ways for critical medical specialties including mental care and pediatrics. For people who need assistance of a doctor or hospital staff, telemedicine helps to provide immediate care for patients to take proactive measures towards

their health. People in remote areas, villages and old age people use telemedicine to a larger extent.

IOT and wearables are also getting used now a days to a very large extent in the field of healthcare. The wearables are fitted onto the patients which enables patients to track their health and also provide details regarding heart rate, pulse to the nearest hospital or doctors for further monitoring. AI can enhance the noise isolation capabilities of hearing aids. Furthermore, non-invasive WDs (Wearable Devices) data may be utilized to estimate BGL using AI-based approaches, which could streamline diabetics' management as well as monitoring.

Artificial Intelligence in Healthcare

In order to simulate human cognition when analyzing complicated medical data, AI in healthcare utilizes sophisticated algorithms and software. It possesses the capacity to revolutionize the industry by enhancing diagnosis, treatment choices, personalized medicine, drug development, as well as patient outcomes. AI technologies like natural language processing, computer vision, as well as ML are being employed to process big data, interpret medical images, predict patient outcomes, and assist in various clinical tasks. Despite its promising improvements, challenges regarding privacy, ethics, as well as regulatory compliance must be rigorously addressed for successful integration into healthcare systems.

With digitalization and automation, there is a wide focus on moving into the digital era. Similarly, there is a lot of research in the areas of medical field and healthcare in moving towards digitalization. Medical data records are not going in the digital format. The usage of these electronic health records is increasing every day, hence paving the path for new medical imaging techniques including analysis of such data or records.

Without explicit programming, machine learning approaches improve the ability to automatically learn from experience. Several machine learning techniques are applied in several fields, that includes image processing, data mining, predictive analytics, classification, regression, clustering, as well as dimensionality reduction. ML is commonly utilized in the field of medical imaging investigations.

Through the latest technologies and trends, there is a focus towards new imaging techniques and diagnosis. However, information and diagnosis results need to be precise as it has an impact on the patient based on the analysis done. Inaccurate diagnoses and delays might be harmful to the patient's health, hence it is equally important that there is precise way of handling to ensure accuracy and effectiveness in the diagnosis results. There is a lot of work going on to train such models or algorithms to provide effective results. Deep learning(DL) automation is one such technique that provides accuracy and efficiency.

To extract information from the images given to the DL model, many models are employed in deep learning. DL is currently being utilized extensively in the medical industry to identify and diagnose diseases, as well as to categorize them into specific illness categories. The convolutional neural network is a frequently utilized model for medical image processing. In addition to providing information on clinical applications in the medical field, DL uses deep

networks to identify diseases by recovering or extracting information from the images supplied to the network.

Scope / Research Methodology

This research discusses different aspects of healthcare technologies prevailing today including focus towards trends in AI, ML as well as other DL topics. Several articles including research papers were reviewed, analyzed and facts have been formulated that aid in disease detection and diagnosis techniques. This research brings its focus towards laboratory diagnosis, the areas of focus and usage of medical chatbots that help patients or clinicians to better understand and make decisions.

Over 30 articles were examined, and 20 were selected for further consideration. The review had been conducted through a literature search in PubMed, Elsevier, Kaggle, the Medical Biochemistry Journal, Google Scholar, & the National Library of Medicine.

Laboratory Diagnosis

In a laboratory, usually, some of the basic tests are performed that involve minor medical procedures. For a few laboratory tests, the medical procedures can be complex too. Laboratory diagnosis is a medical practice that entails the analysis of blood, urine, or other bodily substances. These tests can assist in establishing a diagnosis, formulating a treatment plan, or validating the efficacy of the treatment by monitoring specific diseases over time.

In healthcare, AI has become a potential instrument in numerous aspects of medical imaging, laboratory medicine, laboratory report automation, managing patient records information, medical diagnosis including identification of particular treatments or diseases using medical chatbots. AI has displayed a strong promise and effective solution in the healthcare field including accuracy of laboratory tests. In laboratory testing, AI and its capabilities have a clear potential to improve the accuracy of diagnostic procedures producing accurate results thus impacting better diagnosis and patient care. Healthcare systems and healthcare providers can focus towards leveraging AI algorithms for image analysis and data interpretation, thereby optimizing the diagnosis procedure as well as limiting the danger of human error. AI-driven predictive modelling tools can help identify patterns and trends in laboratory data, facilitating the early identification of diseases as well as individualized treatment approaches.

The results of molecular biology research, the extensive usage of EHR (electronic health records), and the expanding power as well as computer capability have drawn focus to "big data." Given the current Covid-19 pandemic that humanity is fighting, it is evident once more how critical it is to interpret large data in the fight against the illness as well as in the development of vaccinations or else medications [3]. Utilizing a variety of computational techniques and tools is necessary to process and derive meaningful conclusions from extensive yet complex data sets, as the Covid-19 pandemic has shown.

Lab testing and medical visits can be significantly reduced with the big data strategy. Access to data is essential, even though it can be worth its weight in gold [4]. Superior data will lead to

superior output as well. It's estimated that the use of big data may save global health expenses by more than $300 billion annually, not to mention protecting people's wellbeing [5]. "Harnessing the power of data" is a term commonly employed in discussions of big data. In the industry of healthcare, "big data" refers to a diversity of complex as well as varied data sets that are too challenging to handle and analyze with traditional software or technology [6, 7]. These comprise significant data sets gathered from public health, clinical, diagnostic, & demographic records that serve as a basis for choices regarding patient care, diagnosis, distribution of resources, as well as epidemiological trends.

Davenport's ([8], p. 44) characterization of AI as “analytics on steroids” is notably vivid, indicating that AI does not make decisions but rather enhances the quality of our (human) decision-making. This is achieved by utilizing DL with deep neural networks. Big data plays an significant role in achieving decision making systems that are particularly dependent on image and speech-processing technology.

A primary application of AI in laboratory testing is the analysis of medical images. Radiologists can identify abnormalities as well as diagnose patients more quickly and accurately by employing AI algorithms that have been trained to interpret pictures from MRIs, CT scans, as well as X-rays. This may result in early identification of diseases like cancer, enabling prompt treatment along with better patient results [9]. AI might also be utilized to analyze laboratory test results, such as blood tests and tissue samples. Through the utilization of AI algorithms, healthcare providers can find patterns and trends that human analysis might overlook by feeding vast amounts of data into them. This may aid in the disease’s early diagnosis, monitoring of disease progression, personalized treatment plans for patients. Predictive analytics is a significant additional utilization of AI in lab testing. AI algorithms can forecast the chance of specific diseases or ailments occurring in the future by examining patient data and medical history. This can help healthcare providers to proactively manage patient care and intervene before serious health issues arise.

Promising advances in AI have recently created new opportunities to drastically change how cancer is identified as well as classified [10]. AI tool integration into pathology practice's diagnostic workflow has advanced in a number of ways. Among the examples are precise, objective evaluation of immunohistochemical biomarkers for example PD-L1 and Ki67, cells quantification, assessment of cell arrangement in space, as well as examination of expression, density, and distribution pattern [11, 12]. AI can also be utilized to rapidly boost the sensitivity of detection by finding separate tumor cells in lymph nodes that may be metastatic carcinoma suspects.

Diagnostic algorithms can be used as autonomous reporting algorithms, diagnosis-assistance tools, or automated quantifiers of particular aspects in digital pathology workflows. Without the pathologists' input, autonomous reporting algorithms are capable of producing automated reports and diagnoses. Biopsies may be employed to identify normal tissue, for example, the colon, gastric, breast, etc., utilizing screening algorithms. It is imperative to take into account the diverse range of normal tissue while developing an algorithm, in order to prevent the omission of infrequent microlesions (like benign mimics of cancer) or else focal lesions, that are rare cancer

variations. Algorithms employed in diagnosis-aided tools evaluate several histological parameters, such as tumor grade, kind, as well as extent. Correct pathological diagnosis requires the skilled human eye to evaluate and combine a number of features. These AI algorithms' usefulness is judged by how simple it is to integrate them into the diagnostic process and how much value they contribute to the pathologists' diagnosis. This can be evaluated according to the features evaluated, the amount of time needed to produce findings, and the correctness of the results. In contrast to the inter-observer variability observed in clinical practice, breast cancer grading systems, for instance, may offer the advantages of inter-reader reliability, objectivity, as well as prognostic clarity.[13]

At present, CNNs (convolutional neural networks) are the most frequently utilized DL techniques in pathology applications. CNN is a kind of deep feedforward network that is made up of several sequential layers, or convolutional sheets, that work together to deconstruct an image into low-level cues in order to compute an output from an input. The synthesis of basic cues, that include edges, curves, or else forms, results in the establishment of a complex structure for feature recognition [14, 15, 16, 17, 18, 19, 20, 21]. Araujo et al. employed CNN to classify WSI of breast tumors as in-situ, benign, invasive, or else malignant. CNN exhibited performance similar to dermatopathologists in distinguishing benign lesions, for example from keratinocyte carcinoma, seborrheic keratosis, as well as benign nevi from malignant melanoma [22]. Tschandl et al. discovered that CNN demonstrated diagnostic accuracy akin to that of humans in the accurate classification of pigmented skin lesions utilizing digital dermatoscopic pictures. These discoveries, among others, have defined the role of AI-driven technology in diagnostic practice [23].

New advancements in medical technologies have given rise to the emergence of a novel medical area-augmented medicine. Additional digital instruments, for example, surgical navigation systems for computer-assisted surgery as well as virtual reality continuum tools for surgical procedures, pain management, as well as psychotic disorders, are facilitating augmented medicine. AccuVein serves as a notable example. Employing laser-based technology, the handheld gadget can "see" through your skin and into your veins. Finding a vein to take blood or insert an IV device is meant to be simpler for medical professionals such as nurses and doctors. Employing a headset that included a display that the doctors could see through to the patient, the augmented reality technology was employed. It made it possible for them to view both at once by projecting images from, say, CT (computed tomography) scans or X-rays onto the body. Provided the images are perfectly aligned, it appears as though surgeons possess X-ray vision. [24]

Medical chatbots

Usage of chatbots in medical field is increasing day by day. With scope for automation in several areas in the healthcare field, there have been several advancements in the software areas and software applications. One such application is the chatbot application or chatbot software. Chatbot is a software program that interacts with the user on the basis of inputs supplied by the user. The behaviour of this application depends on how we train the model designed to perform certain functions. For example, the application can be trained to provide inputs to the user based

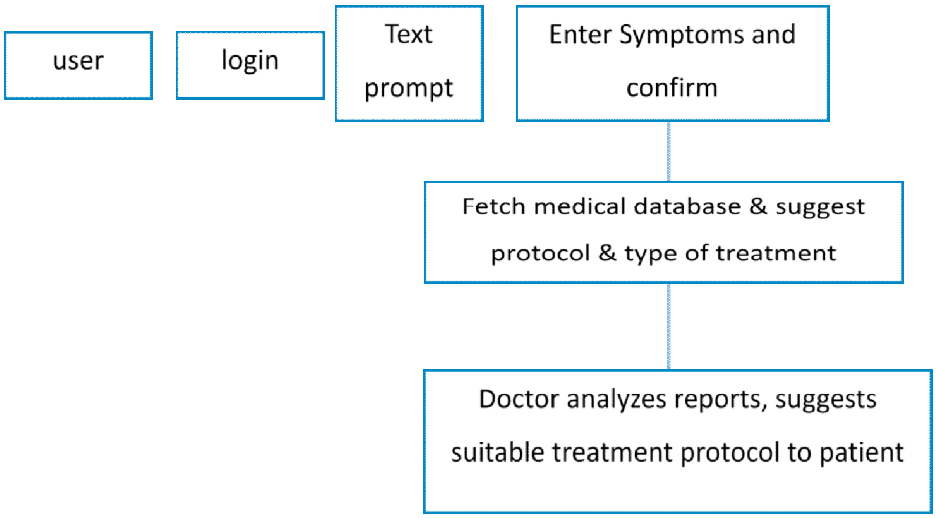
on the questions asked by the user. If we feed data or user manual to the application, the application can be trained further to respond to the query. The application uses Natural language processing to pick the content from the user manual and provide the information to the user.

Chatbots are designed to engage with clients utilizing Natural Language Processing through text or else text-to-speech formats. This existed in the entertainment industry only initially. This has been creating greater opportunities in healthcare field as timely medical care access and medical information is the need of the hour. Chatbots are cost effective solutions that help people with immediate or faster access to information. In the medical field, the key necessity is faster access to information. This solution is provided in the form of medical chatbots that are evolving faster.

For treatment types, treatment methods and protocols for specific types of treatment, medical chatbots provide guidance to doctors as well as to patients to diagnose and provide guidance. On the basis of information supplied by the user in terms of patient information, their medical background and basic details, the medical chatbot can guide in providing the details of treatment and the diagnosis involved in the treatment. This chatbot can also provide information about the type of antibiotics to be given including the medicine details based on patient's health background. NLTK (Natural Language Toolkit) is a Python module that facilitates symbolic as well as statistical Natural Language Processing for English text. It is utilized to evaluate spoken input and provide human-like answers.

Natural Language Processing entails the creation of computing methods for the automated analysis as well as representation of human language. Automatic speech recognition denotes a machine's or computer's capacity to discern the content of words as well as phrases in a certain language & transmute them into a machine-readable format. Automatic speaker recognition is the process of identifying an unfamiliar speaker by analyzing the information included in their speech signal through machine algorithms. [25].

Simon Hoermann [26] examines the existing research about the viability and efficacy of online individual mental health interventions utilizing text-based synchronous chat. Synchronous written dialogues, sometimes referred to as "chats," are gaining popularity as web-based mental health interventions. According to an assessment of specific synchronous Web-based chat systems, this review has been established.



The above functional block diagram provides the details for chatbot usage in the case of cancer diagnosis and treatment. Once the reports are seen by the doctor, usually in the oncology department, a careful evaluation of the patient's reports needs to be done and a suitable protocol for the treatment plan needs to be defined. Many a times, the chief doctor discusses with other doctors and defines the required protocol depending on the patient type, age, patient condition including any other complications possessed by the patient. These analysis steps are automated now with the medical chatbots that can have their data present on the database and can be used by medical specialists at any point in time.

In this example above, once the doctor analyzes the patient reports for cancer diagnosis, they use this medical chatbot to further find the right treatment protocol for their continued treatment. Usually in the cases of oncology patients, the treatment decision and suggested plan requires careful evaluation and assessment. The doctor keys in the required patient information into the chatbot and provides the symptoms related details. The chatbot uses DL techniques as well as neural network algorithms to generate the best possible outputs. Data is gathered from the datasets and the artificial intelligence techniques to determine the input message's class. The neural network that trains the chatbot receives this input. After this step, the chatbot along with predictive modelling techniques predicts the specific class and returns a response to the user by providing the correct protocol to be used for this treatment.

Conclusion

This research paper reflects on the significance of AI in healthcare, particularly in laboratory diagnosis and usage of medical chatbots with DL methodology. From various research done by fellow colleagues, certain aspects have been presented here in this paper that provide opportunities in the healthcare field to ensure laboratory diagnostics with high accuracy details. The key highlight is also regarding analyzing patient data and medical history, wherein AI algorithms can predict the likelihood of certain diseases or conditions developing in the future. Especially, in the analysis of medical images, AI algorithms can be trained to accurately interpret images for example MRIs, X-rays, as well as CT scans, helping radiologists to identify abnormalities as well as make diagnoses more quickly along with accurately. Artificial intelligence can be utilized to detect isolated tumor cells in lymph nodes, which are suggestive of metastatic carcinoma, hence improving detection sensitivity efficiently.

The big data shows promising trends for the analysis of such data that will help in medicinal research and laboratory medicine. The technology is very promising, however, there are various ethical concerns including a focus towards data and privacy. Patient safety and quality is the key aspect that must be very well taken into consideration in all phases of research.

Chatbot's approach in medical industry paves way for new medical chatbots that aid both doctors as well as patients in obtaining medical and treatment suggestions. This paper highlights the key importance of decision making systems which are built from the experience of various doctors that aid doctors or clinical specialists in planning better protocols for patient treatment especially in the field of oncology.

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