ARCHITECTURE OF SMART HEALTH CARE SYSTEM USING ARTIFICIAL INTELLIGENCE

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ABSTRACT

Artificial intelligence is becoming increasingly useful for doctors, nurses, radiologists, researchers, pharmacists, emergency medical service, and many other healthcare professionals. This paper proposes the creation of a smart healthcare system using artificial intelligence as a means of efficiently solving challenges in the healthcare industry and as a tool for optimizing patient care plans. The proposed AI-assisted system shows that it can support a patient who is admitted to the hospital through emergency medical services, easily process the patient's data, and offer early detection of serious diseases. It can automatically recognize the complicated patterns which have been obtained from radiologists, can analyze complete human molecular data and genetics in the clinic, and can support doctors by producing AI-generated radiologist reports, clinical laboratory reports, and many other decision-support tools. The proposed architecture can easily handle diverse and complicated healthcare problems and can be used by any modern hospital to save time and money. This work also shows the recent development of AI applications in healthcare, which could be used in the proposed architecture.

Index Terms— Artificial intelligence, smart healthcare, Machine learning, Deep learning.

1. INTRODUCTION

In the healthcare market, Artificial intelligence (AI) was valued at about $1441 million in 2016, and by 2023, it is estimated that it will reach approximately $22,700 million. AI plays a role in gathering information, then it processes that information and makes a perfect prediction by using algorithms that have been tested repeatedly to diminish the margin of error. The important AI technologies in this context include the natural processing of languages, physical robotic systems, and machine learning, along with deep learning and neural networks. The main aim of AI in healthcare is to analyze the important connections between patient outcomes and treatment methods for prevention [1-5].

Different AI algorithms have been created for different applications. [6] proposes using target recognition and image interpretation, [7] suggests using a remote sensing image retrieval algorithm based on an improved Sobel operator, [8] indicates large-scale, high-dimensional data processing for images of the human brain in order to establish a hierarchical model of hidden relational logic, detecting the criminals of future smart cities using AI is explained in [9], video stream based on object detection is proposed in [10], and [11] shows how to extract images of cultivated land using deep learning. [12] uses deep learning for diagnosis fault from images. A hash network algorithm based on deep neural networks is proposed in [13] to retrieve animal images from a massive network of images. [14] proposes a moving target tracking algorithm based on block information.

AI has also been applied in different fields of smart health services, such as robotic surgery, cardiology, cancer treatment, and neurology [16]. Drug development has been addressed, and so has patient monitoring and personalized medication, as well as helping doctors make perfect decisions [17], finding related medical data or information from different textbooks and journals [18], storing patient data on the Cloud for easy access, and so on.

The purpose of this paper is to provide an architecture for an AI-based smart healthcare system where patients will get complete support throughout the course of

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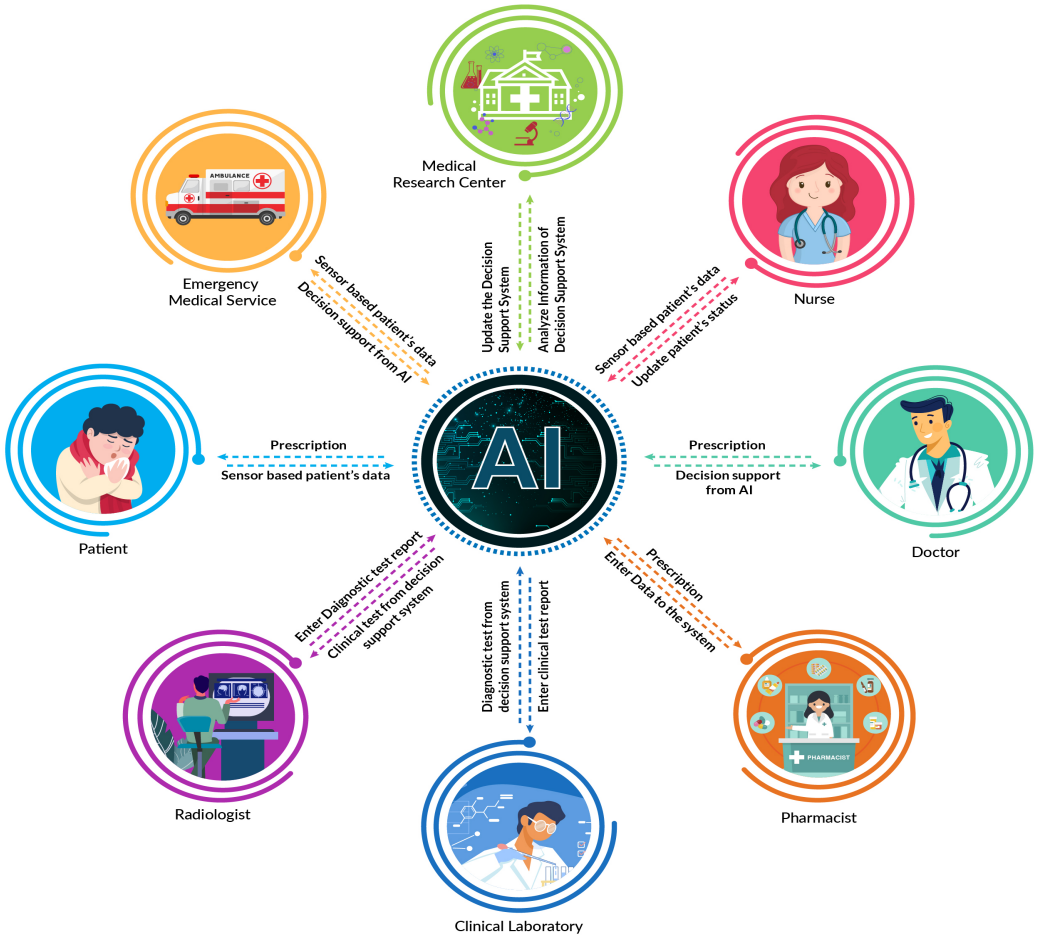

Fig.1 Architecture of smart health system using artificial intelligence

their lives. This AI-based support will come from all departments, including Emergency Medical Service (EMS), nursing, doctors, radiologists, clinical laboratories, pharmacy, and so on. Researchers will also be able to use patients' data and AI-based decision-making for further development in the health care system. This proposed system will also explain how to deploy the recent developments in AI to automate the whole healthcare system, which is unprecedented in existing research.

2. ARCHITECTURE OF SMART HEALTH SYSTEM USING ARTIFICIAL INTELLIGENCE

Figure 1 shows the proposed architecture for AI-supported smart healthcare systems, where AI supports doctors, patients, nurses, Emergency Medical Service (EMS), pharmacists, radiologists, clinical laboratories, and researchers. The following sections explain how those actors are receiving that support:

2.1 Patient:

Hospitals that use this architecture for smart healthcare systems will provide a sensor-based wireless device to track each of its listed patients. That device, whether placed at home or in the hospital, will automatically update the patient's daily information in a centralized database system. AI will make decisions based on the patient's data, and Emergency Medical Service (EMS) will be provided if required.

The most important role AI will play for patients is that it provides all the pertinent patient data in a timely manner and properly screens the patients' affected part. AI advises the patient and guides the physician in giving proper treatment. These AI-based support systems are sometimes smarter than a physician and can give a proper diagnosis and can treat patients with serious conditions more effectively than a doctor. This AI-based decision support system is under a process of continuous improvement based on several factors such as new patient data, rate of cure, et cetera. The medical research center will always maintain the system, which will be explained later.

2.2 Emergency Medical Service (EMS):

Sensor-based devices that are always with the patients' hands can be useful for EMS. AI assists EMS in decision-making as well as providing emergency treatment for serious patients, like stroke patients. AI-based algorithmic computers ask for several inputs like temperature, blood pressure, and so on, to monitor the patients' status and provide fast aid for a short time. The AI plays a role in drawing blood from the patient, and also provides directions to nurses. Nurses update the patients' status with the help of AI. It also helps direct patients to the designated hospital for a particular disease.

2.3 Nurses

Nurses can easily handle massive amounts of patient data with the help of smart AI-based devices without having to enter the data manually. Nurses are always updated from the AI-based system, which receives the patients' data from their smart devices. AI also assists nurses in evaluating disease status and helps them to anticipate future interventions.

2.4 Doctors:

AI makes everything easier and faster by monitoring and screening the patient as well as providing support for making decisions quickly. AI can easily convert the unstructured data into the structured form, giving accurate results, and leading to the perfect diagnosis. Doctors get help from AI-generated radiologist reports, clinical laboratory reports, and many other decision-support tools. Doctors can utilize AI to analyze important discussion between nurses and patients as well as patient notes. It also helps doctors to pinpoint the effected parts which reduce patients' quality of life and target effect areas before they develop into chronic ailments.

2.5 Radiologists

Radiologists benefit from AI with regard to detecting and monitoring diseases. AI algorithms have shown exceptional progress with tasks related to image recognition. AI mainly provides assessments of radiological graphs, and automatically recognizes complicated patterns in the form of images. Recent AI applications detect the pediatric bone age known as RSNA, to show the effected part in greater detail than can be detected by the naked eye. As we know, lung cancer is the most common and harmful type of tumor which needs rapid detection and treatment. Screening for lung cancer is necessary to identify the pulmonary nodules. AI can automatically identify nodules, which are then categorized as malignant or benign.

Mammography screening is a big challenge for most radiologists because of the long process. But AI can assist in interpreting the results, and easily characterizes calcium deposits in the breast of the affected person. The use of AI algorithms in this respect not only reduces the chronic disease's progression but also helps radiologists identify patients with serious conditions and treat them on a priority basis. AI also suggests which patients need to go to the radiologist's department. For example, the person whose leg is broken and who is unaware of this fact needs to go to Radiology immediately.

2.6 Clinical laboratories

The use of AI has increased tremendously in the daily operations and procedures of clinical laboratories.

Digital pathology enables capturing pathology information such as whole slide images (WSI) and uses machine learning to spot subtle patterns and provide the pathologist with detailed information. Use of AI in clinical microbiology laboratory settings supplements human ingenuity and is the gold standard in full-laboratory automation. The algorithms used make it possible to automatically read and interpret growth on plates, recognize colony morphology, and serve other essential functions. The AI-based clinical laboratories of this proposed system will test the diminutive volume of serum or blood from different samples in a single day and provide accurate answers to all the clinical questions which are difficult for human beings. For the detection of colon, lung, and breast cancer, the CAD system has been implemented progressively, which is one of the greatest applications of AI. Thus, CAD has become a common and popular AI application in clinical practice. AI has given a new approach for the analysis of complete human molecular data, as well as genetics. AI has the potential to fathom and solve numerous challenges related to clinical trials.

2.7 Pharmacy

In pharma, AI mainly refers to the use of automated algorithms to perform those tasks or activities which depend or rely on human intelligence. AI has a great impact on pharmacies and drug stores' operational efficiency. The proposed system will automatically provide notification about shortages of medicine, oversold or high/low demand of medicine, et cetera. AI has empowered pharmacists to move from just filling prescriptions to the management of the disease and of the patient's engagement. AI mainly identifies the relationship between different health problems and the types of medicines or drugs best suited to treat them. Hospitals that use the proposed system will provide AI-based mobile apps to monitor the patients' use of medications in real-time. These apps utilize a webcam to verify whether or not the patients are taking these drugs or medicines as prescribed. Researchers and scientists who are developing new medicines or drugs are also using these pharmaceutical data, which will be explained in the next section.

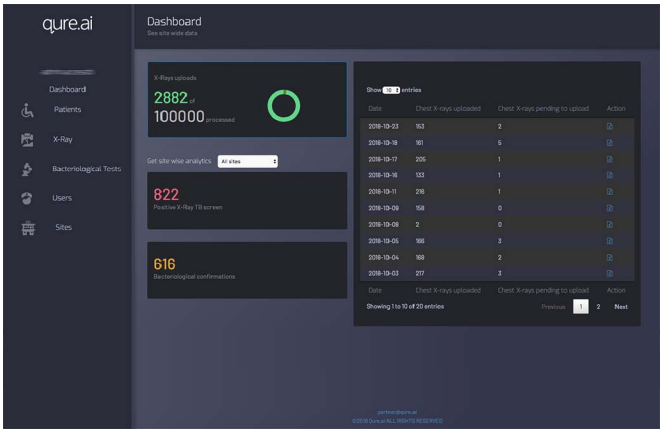

Fig. 2. Interface of qXR tool (www.qure.ai)

2.8 Researchers:

The proposed system helps researchers collect data more rapidly and obtain predictive analyses of new medicines or new diseases. AI can automatically write the stories provided by the doctors and nurses, and researchers can use formatted data for research purposes, obtaining a perfect and accurate report. This report helps researchers find the main cause of disease and gather the best evidence of its interactions with various biomedical entities, as well as optimizing the manufacturing process.

AI also permits researchers to verify the blend of biomarkers and recruit the patient, providing the opportunity for diagnosis. With the new indications, AI allows researchers to repurpose different drugs, as well as extricate the biological knowledge for discovering new ones. AI also plays an important role in testing different compounds against cells and identifying different compounds that need more analysis and time. AI speeds up the screening process

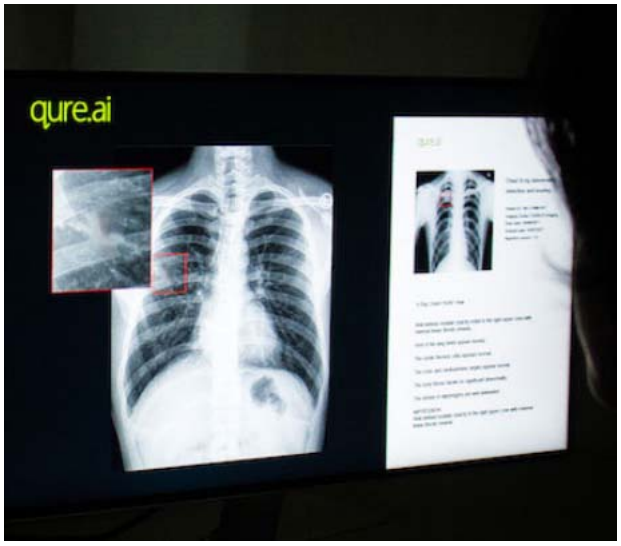

Fig. 3. Chest X-ray screening by qXR (www.qure.ai)

Fig. 4. Interface of qER (www.qure.ai)

and gives quicker results compared to the analysis done by human beings.

The proposed system will also support Contract Research Organizations (CRO) for research. The CRO is a firm that helps support medical industries, pharmacies, and biotechnology companies, but on a contract basis. They are mainly introduced to minimize the costs of those companies who are developing new drugs or medicines for healthcare markets. CROs have a wide range of experience working with scientists, researchers, and clinicians to define particular questions that are beneficial for all.

3. RECENT DEVELOPMENT IN HEALTH SERVICE USING ARTIFICIAL INTELLIGENCE

AI has amazed the world with its recent technologies, and everyone in the medical professions is trying to adopt it. A few of the recent developments, such as qXR for TB screening, qER tool for Head CT scans, qScout-EMR, InMotion ARM, Google AI for breast cancer detection, which will be used in the proposed system are listed below:

3.1 qXR for TB screening:

qXR is a tool for scanning chest X-rays that detects signs of pulmonary, hilar, and pleural tuberculosis. qXR uses an AI algorithm that can detect both classic primary pulmonary TB and its atypical manifestations [19]. In addition to its applications with regard to tuberculosis, it has the ability to screen for conditions such lung malignancies in high-risk populations, COPD, and some cardiac disorders simultaneously.

3.2 qER tool for Head CT scans

This is a tool detects, localizes, and determines the extent a multiple types of brain pathologies, such as all types of intra-cerebral bleeds, midline shift, mass effect, infarcts, and cranial fractures, as shown in figure 4. The accuracy is given in table 1.

Table 1. The accuracy of each algorithm (www.qure.ai)

Abnormal finding	AUC (Confidence interval)	Specificity	Sensitivity
Intraparenchymal haemorrhage	0.95	0.86	0.9
Extradural hemorrhage	0.97	0.87	0.95
Intracranial haemorrhage	0.95	0.89	0.9
Subarachnoid hemorrhage	0.95	0.89	0.9
Subdural hemorrhage	0.96	0.89	0.9
Intraventricular haemorrhage	0.98	0.91	0.95
Cranial Fracture	0.96	0.9	0.9
Infarct	0.94	0.87	0.87
Midline Shift	0.97	0.93	0.93
Mass Effect	0.93	0.88	0.88
Atrophy	0.92	0.84	0.84

3.3 qScout-EMR for contact registration and tracing

This tool can be accessed from any mobile device or laptop. It is mainly designed for COVID-19, for registration and contacting. However, we will collaborate with the company to modify this app for all patients, for monitoring daily symptoms. Figure 5 shows the interface for this tool.

3.4 InMotion ARM

InMotion robots are used as neurorehabilitation tools in the United States and over 20 other countries. Extensive research has shown InMotion robots are effective for treatment of a number of motor impairments, including spinal cord injury, cerebral palsy, hemiplegic shoulder pain, multiple sclerosis, Parkinson's disease, stroke, and muscle spasticity.

Fig. 5. Interface of qScout (www.qure.ai)

Fig. 6. InMotion ARM (www.bioniklabs.com)

3. CONCLUSION

The proposed architecture shows that any healthcare organization can implement this AI-based approach to as a means of reducing costs and managing all stakeholders efficiently and accurately. The proposed AI-assisted system supports a patient starting from the time of their admission into the hospital using emergency medical services, processes the patient's long data, detects serious diseases, automatically recognizes complicated patterns, and can analyze the complete human molecular data and patient genetics in a clinic setting. It minimizes potential human error on the part of the doctors by generating AI-generated radiologist reports, clinical laboratory reports, and providing many other decision-support tools, easing the decision making process with regard to the early detection and diagnosis of diseases. It not only processes the patient's raw data, but also generates reports very quickly, which helps researchers, doctors, nurses, and other stakeholders get the support they need in an efficient manner. This work also shows the recent developments which relate to the role of AI in healthcare and which could be used in this proposed architecture, such as detection of cancers in the early stages, finding the genetic code linkages, developing new drugs, et cetera. In other words, the proposed system will enhance the capacity of healthcare professionals to understand their patients' basic needs, allowing them to more easily guide and support their patients effectively, making optimal use of the staff's time and reducing costs. AI-based healthcare offers a wealth of improvements to the healthcare industry,

and healthcare professionals and hospitals around the globe need to move towards AI-based systems.

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