



IT applications in healthcare management: a survey

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Abstract Healthcare management is currently undergoing substantial changes, and reshaping our perception of the medical field. One spectrum is that of the considerable changes that we see in surgical machines and equipment, and the way the procedures are performed. Computing power, Internet and associated technologies are transforming surgical operations into model based procedures. The other spectrum is the management side of healthcare, which is equally critical to the medical profession. In particular, recent advances in the field of Information Technology (IT) is assisting in better management of health appointments and record management. With the proliferation of IT and management, data is now playing a vital role in diagnostics, drug administration and management of healthcare services. With the advancement in data processing, large amounts of medical data collected by medical centres and providers, can now be mined and analysed to assist in planning and making appropriate decisions. In this article, we shall provide an overview of the role of IT that have been reshaping the healthcare management, hospital, health profession and industry.

Keywords Healthcare · IT applications · Healthcare management · Ubiquitous · Robots · Internet of medical things · Big medical data analytics · HMIS

1 Introduction

Internet and Web 2.0 have been instrumental in evolving most of the Information Technology (IT) applications that we are now accustomed to. Barely 20 years ago, we had not imagined the technological advancements, which are now implemented into our lives. Technological advancement, riding on the wave of disruptive technologies of the last quarter of a century, is reshaping and redefining the world's social order and norms. The medical field is part and parcel of our lives and is perhaps one that we care the most about. In the recent times, this field has undergone vast changes. The medical profession today has evolved greatly since the beginning of this century. Not only the medical procedures, the medical data flow and management has also undergone considerable improvement. Advance data transfer and management techniques have made improvements in disease diagnostic and have been a critical role in national health planning and efficient record keeping. In particular, the medical profession has undergone substantial changes through the capabilities of database management, which has given rise to the Healthcare Information Systems (HIS). Medical data collected from different institutions can now be mined and analysed in time using Big Data Analytics tools.

This article shall provide an overview of the involvement, importance and benefits of IT and how data management is contributing to the medical science field. In particular, the following will be discussed:

1. Artificial intelligence and robotics in healthcare
2. Virtual, augmented and mixed reality in medical education and procedures
3. Centralized monitoring of hospital patients
4. Historical background of HRIS

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5. Patient and data management
6. Big medical data analytics
7. Privacy and security of healthcare data

2 Artificial intelligence and robotics in healthcare

Artificial Intelligence (AI) is a field of computer Science which has its roots in logic (mathematics), psychology, philosophy, linguistics, arts, science and management among others. Many AI-dominant tools and applications can be found in games, auto spare parts, heavy machinery and various medical instrumentations. According to [1], many programs are developed with the help of AI to perform specific tasks which make use of many activities including medical diagnostic, time sharing, interactive interpreters, graphical user interfaces and the computer mouse, rapid development environments, the linked list - data structure, automatic storage management, symbolic, functional, dynamic, and object-oriented programming. Here are some other examples.

Pharmaceutical developments involve extensive clinical trials in real environment and may take many years, sometimes more than a decade. This process requires a considerable amount of resources and can cost billions of dollars. In order to save lives and money, it is desirable to expedite this time consuming process to make healthcare cheaper. An urgency of this nature was witnessed during the Ebola crisis in some West African nations [2]. An urgency of this nature was witnessed during the Ebola crisis in some West African nations [2], where a program powered by AI was used to scan existing medicines that could be redesigned to fight the disease.

2.1 Digital consultation

Nowadays medical consultation, with the help of an online illness database, can take place without the direct interaction of a medical practitioner. An example of such a practice can be found in [2]. Advantages of such consultations lies in the fact that the symptoms presented online by the patients are matched with those of about ten thousand known diseases [3], whereas doctors can only match the symptoms against a fraction of the known diseases which they are familiar without the intervention of an IT database. Likewise virtual nursing to support patients online is also available from [4]. Yet another app [5] developed by Boston Children Hospital provides basic health information and advice for parents of ill children.

2.2 Medic robots

Since the introduction in 1960s, robots have been used in many scientific and social fields. Their use in fields like nuclear arsenal, production of automobiles, and manipulations in space has been widespread. In comparison, the medical science field has somewhat been gradual to take advantage of this technology. Nevertheless, robots are now days being utilised to assist in or perform many complex medical procedures, which has given rise to the term Robotic Surgery. A comprehensive discussion of robotic surgery is available in [6]. Indeed there are many advantages of using robots in healthcare management. For example, developing pharmaceuticals through clinical trials can take many years and cost may rise to billions of dollars. Making this process faster and more affordable could change the world. Robots can play a critical role in such trials. Robots are also very effective in medico training where simulations are achieved.

Use of Robots in abdominal surgery [7] is innovative in comparison to the conventional laparoscopy procedures, and has the potential to eliminate the existing shortcomings and drawbacks. According to [8], the most promising procedures are those in which the robot enables a laparoscopic approach where open surgery is usually required. Likewise robotic surgery for Gynaecology related ailments [9] can also be very effective. The conventional laparoscopy, the surgeon would have limited degree of freedom with a 2D vision, whereas the robotic system would provide a 3D view with intuitive motion and enable additional degrees of freedom. Prostatic surgery, being complex in the way of the degree of freedom, is another area where robots are very effective [10].

Nosocomial infections pose a major problem hospitals and clinics around the world. This becomes worst in case of large and intense gatherings of people like in Hajj [11]. To keep the environment free of these viruses and bacteria, the environments needs to be cleaned efficiently and regularly. However some viruses like Ebola [2] and MERs Coronavirus [12] are highly contagious and cannot be cleaned by humans without having protective gear, which can be costly and may or may not be effective. Cleaning the hospital with chlorine is an effective way. However, there are many drawbacks of this method including a high risk for cleaners to be infected themselves. A sophisticated approach was implemented in US hospitals by using robots [13] to purify the space. However, some of the robots used are not motorized and may require a human to place them in the infected room or area, posing the risk of infection to humans. It is not known as to which substance or matter can effectively eliminate deadly viruses like Ebola and MERs Coronavirus. However, according to [14], beta-Coronaviruses, which is one of the four strands of MERs

Coronavirus, can be effectively eliminated by UV light. For such a deadly and highly contagious virus clearing, a robot that can be remote controlled is needed, which can move forward, backward and sideways, and is able to clean itself.

2.3 Virtual, augmented and mixed reality simulations

Concept and related technology of Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR), which originate from image processing and make extensive use of AI, have been in use for decades in games and movies. For some time now, the VR, AR and MR tools and technology are assisting the medical field in a significant way. Virtual reality has been used in robotic surgery to develop simulators to train surgeons in a stress free environment using realistic models and surgical simulation, without adversely affecting operating time or patient safety [15]. An account of AR and VR technologies, including the advantages and disadvantages can be found in [16]. The AR and VR technology can be very useful in medical and healthcare education, an account of which can be found in [17]. Applications of VR, AR and MR can also be very helpful in Urology [18].

3 Historical background of health management information systems

Healthcare Management Information Systems (HMIS) is the generic name for many kinds of information systems used in healthcare industry. The use of HMIS is widespread in various units of hospitals, clinics, and insurance companies. A doctor records patient data (habits, complaints, prescriptions, vital signs, etc.) in one such system they use. A number of hospital/clinic units like Radiology, Pathology, and Pharmacy store patient data in these systems for later retrieval and usage by different stakeholders as shown in Fig. 1. Appointment System itself can also be part of a HMIS or a standalone system. Modern healthcare without HMIS cannot be comprehended.

An information system or electronic system dealing includes a database system, sometimes known as the backend of the main system. A database is a collection of data, tailored to the information needs of an organisation for a specific purpose. It can grow bigger or shrink to a smaller size depending on the needs of different times. A database in itself would be of no use unless it was coupled with a software system known as the Database Management System (DBMS), which facilitates various functions and processes like Data Entry and Storage, Retrieval, and Update, Data Redundancy, Data Sharing, Data

Consistency, Data Integrity, Concurrency, and Data Privacy & Security. More information about database systems can be found in [19].

Data in an information system can be organised in several different ways. Classical representation of data [20] is tabular. Most tables can be regarded as mathematical relations, for this reason, a DBMS with tabular data organisation is known as relational. Relational databases have by far been dominant in the business organisations until recently. In the eighties and nineties of the last century, object-oriented and semantic data models were also introduced. In particular, object-oriented databases [20] became very popular for managing audio-visual data. Semantic database technology [21], although very efficient for search queries, did not reach its expected peak, perhaps because of its complex data model dealing with ontologies. A comparative study of relational, object oriented and semantic database systems is carried out in [21].

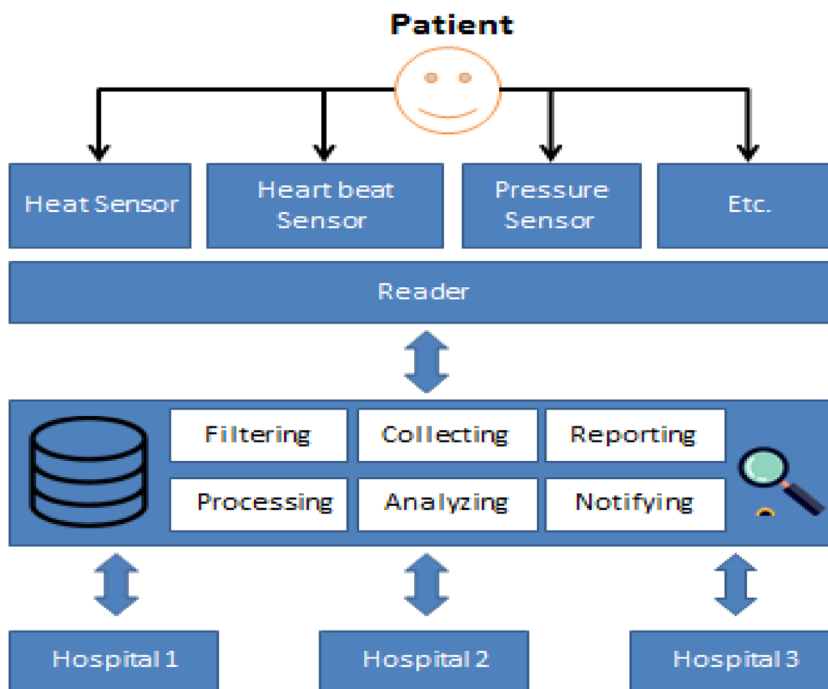
3.1 Evolution of healthcare systems

Although the evolution of Information technologies began much earlier, however, its implementation by businesses and corporations occurred in the second half of the last century. The healthcare industry a bit slow to take the advantage of the technology. Earlier, medical records and systems were paper based. Thus the first phase of the usage of information technology and systems in hospital and healthcare management was to transform paper based records to database systems. Not only did it change paper based systems to electronic ones but also allowed data manipulation. As a result, more data could be processed in a very short time, which was critical in making timely decisions. A discussion of early stages of this transformation can be found in [22]. Consolidation of this technology resulted in Healthcare Management Information Systems (HMIS). Timely decision is critical in all walks of life but it assumes a much greater urgency in some healthcare cases. HMIS is capable to transferring data from one location or application to another within split of a second, as opposed to days without the help of electronic systems. This allows users to access, use and manipulate data instantly and concurrently. As the technology continues to evolve and refine, the performance of information systems operations, in particular those of HMIS, is bound to improve.

3.2 Ubiquitous healthcare system

Ubiquitous health system is meant to provide healthcare services remotely. According to [23], Ubiquitous Healthcare system means the environment that users can receive the medical treatment regardless of the location and time. Essentially, a Ubiquitous healthcare system would monitor

Fig. 1 Data flow of patient consultation



daily or periodic activities of patients and alert the patients or health workers of problems, if any. A discussion of national healthcare systems in Korea, including the concept of u-Hospitals, is discussed in [24]. A rich picture of a Ubiquitous Healthcare System is shown in Fig. 2.

4 Internet of medical of things and big data analytics

Internet of Things (IoT) is an emerging technology. Data in organisations, including hospitals, clinics, and insurance companies, is increasing every day. To process this large

data, advanced data processing techniques are combined into what is now known as the Big Data Analytics.

4.1 Internet of medical things

Internet of Things (IoT) is a general paradigm. When dealing with medical environment, it is known as Internet of Medical of things (IoMT), which is same as the Medical Internet of Things. A discussion of IoMT can be found in [25]. The fundamental objective of IOT is to provide ubiquitous access to numerous devices and machines on service providers (SPs) [26], covering many areas such as location based services (LBS), smart home, smart city,

Fig. 2 Ubiquitous health system



E-Health [27, 28]. These tools, devices and machines cover service providers in many areas of location based services. A few other could be smart home, street or city, elements of ubiquitous health systems, tools for electronic learning and electronic business, the number which is increasing day by day and it may reach fifty billions in 2020 [29, 30]. We have conceptualised this in Fig. 3. The IoT applications invariably use cloud storage coupled with fog computing [31].

4.2 Big medical data analytics

Data in organisations is growing at a rapid rate. Some organisations have collected huge pile from their operations. Organisational data needs to be mined and analysed on a regular basis to uncover hidden patterns, unknown correlations, market trends, customers, patients and treatment records to help organizations to plan and make more informed decisions. Mining and analysis of big data captures the immense wealth of intelligence hidden in organisational data, makes information transparent and usable at much higher frequency, and enhance performance. All of these contribute to providing higher value in efficient decision making. When data grows, it cannot be handled manually, often big data organisations use robotic arm to perform data loading and unloading operations.

Medical data is also growing at a rapid rate in many hospitals, clinics and insurance companies. Mining and analysis of healthcare data is even more critical as it relates to the wellbeing of the society. Data centric research is highly desirable to find answers to questions on many chronic diseases, and to plan and manage national and

international health programs. Potential benefits of big data analytics in healthcare are discussed in [32]. In particular, authors have provided five strategies for success with big data. These are (1) implementing big data governance, (2) developing an information sharing culture, (3) training key personnel to use big data analytics, (4) incorporating cloud computing into the organization's big data analytics, and (5) generating new business ideas from big data analytics. A survey of big data analytics in healthcare and government is conducted in [33], where the need for the analytics is linked to the provision and improvement of patient centric services, detection of diseases before they spread, monitoring the quality of services in hospitals, improving methods of treatment, and provision of quality medical education. Authors in [34] identify medical signals as a major source of big data, discuss analytical techniques of such data. Some of the well known tools used for big data analytics are

Apache™ Hadoop® is highly scalable storage platform. It provides cost-effective storage solution for large data volumes. It doesn't require any particular format.

Apache Spark is an open source, in-memory processing machine. Its performance is much faster than that of Hadoop.

MapReduce is used for iterative algorithms or interactive data mining.

There are many other big data analytics tools, a list of them can be found at <http://bigdata-madesimple.com/top-30-big-data-tools-data-analysis/>.

Fig. 3 Internet of medical things



5 Data centric issues in healthcare

There are always security and privacy concerns associated with data. Protection of privacy and security is a responsibility of data holding organisations. With medical data these concerns assumes higher pronounce and priority. Medical data can be very sensitive, and may be linked to life and death of the patients. Often socio political issues are linked with medical data. It is well known that India was divided into two countries giving rise to Pakistan in 1947. Mohammad Ali Jinnah, very clever and shrewd, was the leader of Pakistan campaign, Larry Collins and Dominique Lapierre [35] argue that the partition of India could have been avoided if “the most closely guarded secret in India” had become known. Jinnah was suffering from tuberculosis which was slowly but surely killing him. In [28, 36, 37], privacy issues of data are discussed.

6 Conclusions

Healthcare procedures and management are now greatly relying on IT applications, which are providing realtime access to data and utilities. Without these applications, healthcare will be limited, compromised and prone to major problems. Many of the medical equipments, which are used in procedures, are highly dependent on technology. AI, Robots, VR, AR, MR, IoMT, ubiquitous medical services, and big data analytics are all directly or indirectly related to IT. HMIS is critical for efficient management of records, appointment systems, diagnostics and their needs of medical centres. As the technology advances, the healthcare is likely to further improve.

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