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Smart Medical and Its Ethical Problems

Victor Chang[1], Rui Ying[2] and Qianwen Ariel Xu[1, 2]
[1] School of Computing, Engineering and Digital Technologies, Teesside University, UK
[2] International Business School of Suzhou, Xi'an Jiaotong-Liverpool University, Suzhou, China
ic.victor.chang@gmail.com, 541255071@qq.com and iamarielxu@163.com

Abstract. With the rapid development of smart devices, Big Data and the Internet of Things, the concept of 'smart city' has been raised and developed. Over the past decade, the concept of smart medical has received extensive attention. Currently, some simple, smart medical technologies have begun to be applied, such as online appointment registration, electronic medical records, etc. This report aims to introduce the vision of 'smart medical'. Based on the analytics of this study, some potential ethical problems are discovered, including privacy problems, data ownership problems, security and liability problems and unemployment problems.

Keywords: Smart Medical, ethics problems, Big Data, IoT, security problems, privacy problems, unemployment.

1. Introduction and background

In 2009, Samuel Palmisano, the CEO of IBM, put forward the vision of "smart city", which led to a smart city trend in a large number of countries and multinational corporations [1]. A smart city is an urban area that collects various data by applying sensors to offer information and services efficiently. The smart city concept includes smart power, smart medical, smart transportation, smart supply chain, and smart banking. This report will introduce the functions and explore the ethics problems of smart medical.

Generally, smart medical refers to the use of information technology such as the Internet of Things and cloud computing to connect physical, information, social and commercial infrastructure related to medical and health construction through perceptual, instrumented and intelligent ways. The goal of smart medical is to meet the requirement of the corresponding healthcare ecosystem intelligently. Smart medical is superior to ordinary digital medical services in terms of information system integration, information sharing and intelligent processing [2]. Smart medical is usually composed of smart hospitals, regional health, and family health. Section 2 will introduce smart hospital information and the application of Big Data and IoT in smart medicine. Section 3 will explore smart medical issues from privacy, data ownership, security, and labor disruption. Section 4 will conclude this report and section 5 will give some suggestions.

2. The vision of smart medical

2.1 Interaction in a future smart hospital

A smart hospital is a highly interactive, intelligent environment with a large number of computing devices and types of equipment, consisting of handheld computers which are able to generate and gain access to a limited amount of data, PCs that can be employed at fixed locations for long-term, and semi-public displays that are easy to locate, allowing users or patients to share and discuss information [3]. Smart hospital staff can use a specific set of services to interact with the environment, interpreting contextual information.

For a patient who enters the smart hospital for help, semi-public displays or even intelligent robot can give them corresponding guide services, including registration appointments, department selection guides, and map location queries. They can then register and login to the hospital system via their smartphone or other micro wearable devices, which has a guiding role in their further medical treatment.

Hospital members or staff have to be very familiar with the hospital environment and context to generate the data required for their work. As the environment and personnel of smart hospitals change frequently, this learning process is time-consuming and high-cost. The context-aware application is developed and integrated into smart hospitals to save the time of the staff by helping them to be informed about the location and status of medical

device, patients or other hospital staff, as well as applying a real-time digital map or lists of artifacts and people which is automatically updated [4].

In order to deliver germane data to hospital staff, smart hospitals will consider contextual information, including the user's basic information, the time of diagnosis and treatment, and the status of clinical information (e.g., availability of test outcomes). For instance, when a doctor arrives near the patient's bed, his tablet or another mobile device will display the patient's data and situation, reminding the doctor of some essential information that is of great importance to the whole process of medical treatment. The smart hospital also takes into account the user's personalized context. For instance, physical access to a public device or workstation only shows the physician's patient data, personnel scheduling, and recommendations, which are significant for him to integrate his further working project.

Stanford [5] stated that the developed technology makes a significant contribution to advancing the efficiency of medical staff collaboration, such as consulting with experts or requesting help in transferring patients. For instance, based on the video call technology, the teleconference can help the hospital in a remote area to find a better method to address their severe problems. Furthermore, the 3D simulation technology can be used by physicians in different regions to solve complex surgical case problems, reducing the time cost of solving complex problems.

2.2 Smart medical based on Big Data and the Internet of Things

With the technologies of big data and the Internet of Things becoming more advanced, their applications are becoming more widespread. Utilizing IoT, Big Data, cloud computing and other related information technologies, smart medical connects patients with medical staff, medical equipment, and medical institutions to promote a comprehensive information model and improve service efficiency.

A large number of medical archive information resources generated in real-time and at high speed are the basis of smart medical care. In the context of big data, Chen [6] stated that various types of medical treatment systems related to medical diagnosis and treatment generate a large amount of electronic data almost every moment. Due to the diversity and rapid growth of medical data, traditional analytical techniques and storage relationship methods are difficult to cope with, making it more challenging to meet the needs of clinical applications. Fortunately, the technology of cloud computing can deal with this problem. With further breakthroughs in this technology, big data can be universally used in smart medical in the near future.

For medical institutions, smart healthcare means the rational allocation of medical resources. In China, large hospitals are often full of patients. Many of them are only infected with common diseases that primary health care institutions can solve, and primary healthcare institutions are often idle resources. Through big data and cloud computing, smart medical systems can reasonably distribute patient traffic, suggesting that patients infected with common diseases go to nearby primary hospitals for treatment. Simultaneously, smart medical can guarantee the safety and high quality of medical services in primary hospitals. Doctors can access patients' health records from databases and quickly retrieve relevant information such as their medical history and medication status. Utilize this auxiliary information, doctors make more accurate judgments and avoid medical accidents such as repeated medications and drug allergies [7]. Through big data, smart medical care can break the independent state of traditional hospitals, realize information sharing for patients, and rationally utilize medical resources, thereby improving work efficiency and service quality.

Artificial intelligence, based on big data analysis and cloud computing, can significantly help doctors diagnose and treat patients. For example, if there is a patient with a rare disease that the doctor cannot diagnose, without artificial intelligence, the patients can only try a better hospital. In this case, artificial intelligence can use artificial neural networks to identify and sift diseases similar to or related to the disease from a database with huge data volumes. Then, search for past solutions and the latest research results, and summarize this information to give the best solution based on their algorithms. Moreover, big data analysis can provide data support for diagnosis and treatment decision making. Currently, the majority of doctors or surgeons only refer to their past experience when developing a medical plan. In some cases, for lack of a large sample of data, they have to try solutions that may be effective, causing great pain to patients. With data support of previous medical experience from Big Data, they can access an efficient solution. To be specific, for instance, if a doctor wants to diagnose whether a patient has lung cancer, most of the current methods are based on the doctor's experience and consultations to reach a corresponding conclusion. When machine learning and data mining technologies can be applied more maturely in the medical industry, researchers can use the classification and cluster analysis methods to train the corresponding models based on historical data. These models show that case data that meet some characteristics have a higher probability of getting lung cancer. These characteristics can include several aspects of a person's situation, such as smoking, eating habits, location pollution, income status, genetic history, etc. This model provides a more reliable data reference when doctors diagnose patients. Simultaneously, this technology of artificial intelligence can also play a

more significant role in improving efficiency and saving labor costs.

Fig.1. Diagnose rare diseases

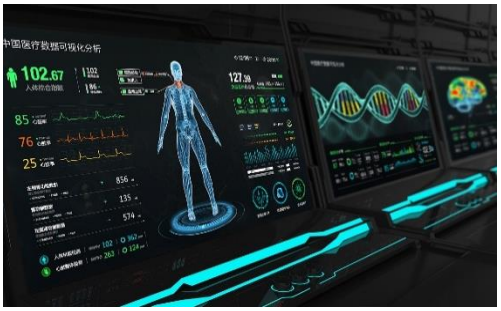

Fig.2. Data reference for medical decision

Shang [8] shows that data mining and data analysis of massive medical data through big data analysis systems can improve the scientific decision-making support of health-related departments. Smart data based on big data often means that medical departments can make more timely emergency measures. Through establishing an intelligent emergency response system, medical departments are linked to systems such as medical institution disease control centers, enabling timely and effective supervision and control. In the face of sudden public health incidents, they can also respond rapidly to improve the flexibility and timely response of the regulatory authorities in handling incidents.

In section 2.1, some functional implementations in the smart hospital employ the technology of IoT. Specifically, established on the IoT, the structure of a smart hospital is often separated into three parts: perception layer, network layer and application layer [9]. As is shown in Fig.3, the perception layer contains the data acquisition layer and access layer. The data collection layer is used to sense and acquire relevant data from hospitals and around the hospital. The access layer is used to convey data obtained from the data acquisition layer and input it into the global object connection network. The network layer includes a network transmission platform and an application platform [10]. The former ensures that the data obtained by the perception layer is transmitted in real-time and efficiently. The latter is the integration of various data so that third parties can develop a variety of applications on this platform for the relevant personnel. The application layer is mainly used in the hospital's informatization and advanced applications in management and decision-making.

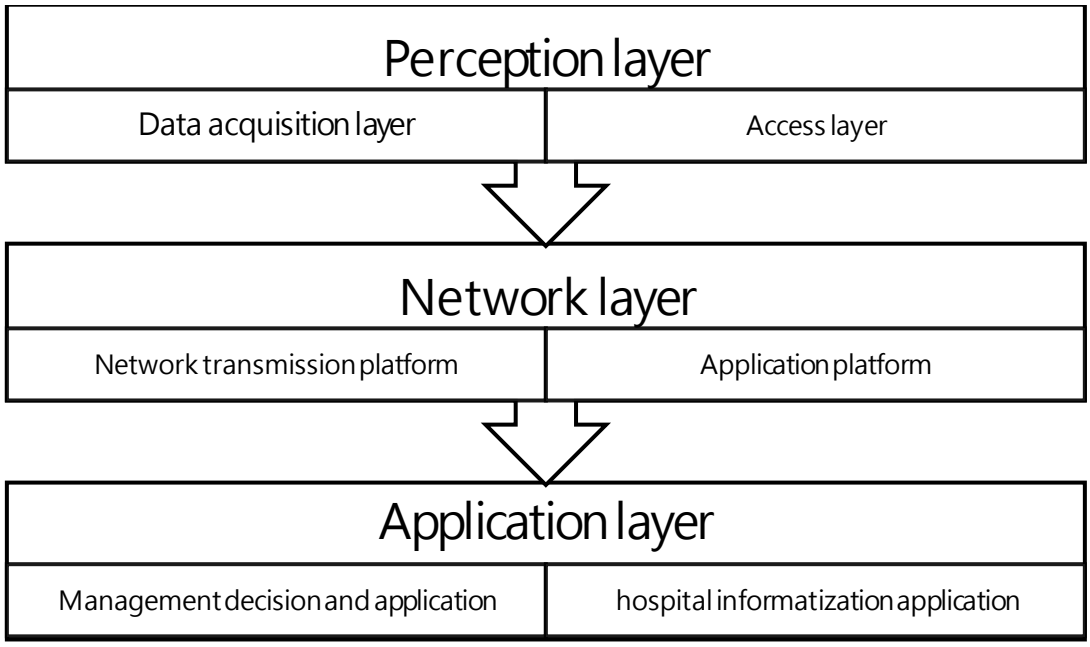

Fig.3. The architecture of the smart hospital

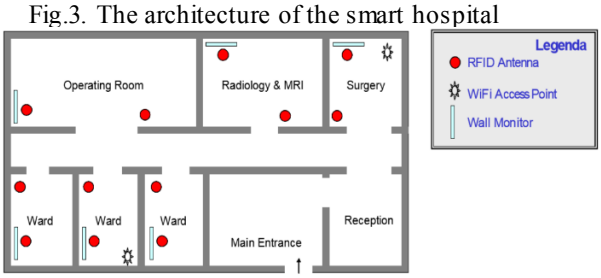

Fig.4. Hospital layout [11]

Fig.5. Smart wearable device [12]

Outside the hospital, the Internet of Things will also have a wide range of smart medical applications. In terms of residents' health management, utilizing IoT technology, relevant medical institutions can conduct physical examinations, preventive reminders, and knowledge popularization. It is essential to use artificial intelligence technology to quantify the patient's health trajectory to customize unique health guidance for different patient individuals, thereby improving residents' health and disease prevention awareness. Additionally, intelligent wearable devices based on the Internet of Things technology, such as Apple Watch, can monitor the user's physical indicators in real-time. The user is alerted when it is determined that the user is at risk of illness. In a critical moment, this device can even automatically call for help [2]. This will significantly increase the probability of surviving users in the event of an emergency.

Nowadays, medical resources are very tight, and hospital wards are often not enough for patients who need to be hospitalized. Using IoT technology, it provides remote consultation for patients in critical situations and enables continuous monitoring. Utilizing IoT technology, advanced medical technology is no longer limited by time and space, and can greatly alleviate medical problems in backward areas.

Fig.6. Drug storage environment monitoring

Fig.7. Integration of telemedicine

In terms of drug management, by providing RFID tags for each drug, both medical personnel and patients can quickly learn about drug information. Dong, Wang and Zou [2] underlined that environmental factors such as temperature and humidity could be collected using IoT equipment. Once the environment is found to be unsuitable for the storage of certain types of drugs, a warning message can be given in time to prompt the management personnel to adjust the storage environment or replace the storage location, thereby effectively managing drugs. Poor management of medical waste can cause great damage to environmental safety. IoT technology can effectively detect whether the disposal location and method of waste are reasonable. When unreasonable conditions occur, it can quickly issue an alarm, which helps achieve reasonable supervision of medical waste.

3. Potential ethics problems

Based on analytics of the application of smart medical technologies, this study has identified a few potential ethical issues, including privacy problems, data ownership problems, security and liability problems, and risk of unemployment.

3.1 Privacy problems

Privacy refers to personal information that the parties do not want others to know or are inconvenient to know. By applying big data and IoT in the area of smart healthcare, privacy protection will become a huge problem. If the privacy data is leaked, it will cause considerable damage to patients and doctors. The majority of privacy problems are caused by poor data management, cyber-attacks, and patient's weaker privacy awareness.

For medical research, the data are usually anonymous or de-identified to obtain the consent of the data subject and to comply with data protection regulations, which is essential for data management [13]. However, for some databases of the medical institution, the data anonymization is not insufficient. The reason for the poor insufficient anonymization lies in the fact that some medical workers understand the deviation of privacy information. Ou and Lan [14] discovered that about 46.9% of medical staff believe that certain medical information of patients is not in the scope of privacy protection. Based on this understanding, they naturally do not pay attention to the security of such knowledge of patients. Moreover, healthcare workers know very little about the technical characteristics and operational methods of smart medical care, causing poor data management. According to the survey of Ou and Lan [14], only 31% of healthcare workers understand the smart health system, which means that 69% of medical workers do not understand the technical characteristics and operation of smart healthcare. In this situation, even if all healthcare workers have an awareness of patients' privacy, they still cannot protect patients' privacy when they use and manage medical data.

The patient's lack of privacy awareness is also one of the causes of data leakage. The survey found that many

people do not realize that their medical information is in the privacy category. For example, when asked if they are worried about others seeing their medical information, which may affect their job opportunities and professional status, 11% of respondents expressed great concern, and 45% of them expressed some concern. In other words, from the patient's perspective, 44% of respondents are not aware of protecting their medical information [14]. Besides, some people, such as the elderly and children, cannot understand the importance of medical data privacy. They are also potential victims of data breaches.

The data leakage caused by cyber-attacks is really dangerous because hackers may utilize the data for fraud or other criminal activities. In the era of smart medical care, social media, mobile APP, telemedicine and other medical applications are widely used between doctors and patients, which may lead to that patients' diagnoses, habits and other private data are likely to leave traces on the Internet. This increases the risk of personal data leakage. Since the current privacy protection techniques are primarily established on static data sets and big medical data has a dynamic characteristic, it may increase the risk of private medical data leakage [15]. Referring to the statistics from the United States Department's Health Civil Rights Office, in the first quarter of 2015 alone, 87 data breaches were incurred in the US, involving over 500 medical facilities and a total of 92.23 million private data leakage [16]. The secondary use of big medical data is able to create priceless value. However, once it is leaked, the harm is usually unpredictable. According to a Ponemon Institute study [17], the average expense of every global medical information breach caused by loss or theft is $380, which is a substantial economic loss.

3.2 Data ownership problems

In the era of big data, the data should be owned by whom it is always a problem. This is the issue of interest coordination among data users, collectors, and producers [18]. After comprehending the scope, manner and consequences of data utilization, the data subject should have the right to make decisions on how to utilize private data. However, many research institutions collect and develop their private data without achieving explicit consent from the data subjects, contrary to business ethics. In 2013, Snowden's exposure to the "PEISM" event caused great concern. In this incident, the National Security Agency collected a large amount of user privacy data from multiple Internet companies and communication companies for political purposes, reflecting the ethical issues of data abuse. Therefore, it is essential for the data subject to have the right to know who owns the data and decide how to use the data.

3.3 Security and liability problems

In section 2.2, it is mentioned that big data analysis has a reference function for medical decision-making. However, when a physician's experience is contrary to the big data analysis results or the artificial intelligence algorithm and its recommendations, which one should be chosen?

The application of big medical data attempts to use data to present all human activities, including vital signs, disease information, living environment, education level, eating habits, etc. Nevertheless, the application of big medical information brings a problem: in the interaction between people and numbers, data often exists away from the subject, and the subject is replaced by data [19]. This phenomenon may have a negative impact on both doctors and patients. On the one hand, if medical workers rely too much on data to diagnose and treat diseases, they are likely to limit their thinking ability and lose their traditional clinical experience, which will make it difficult for doctors to form a complete impression on patients. On the other hand, for the patient, as they are labeled with different kinds of data and become digital symbols without thinking abilities, consciousness and emotion, their pain becomes a bunch of numbers and images, and then their human subjectivity is lost [6]. At the same time, the patients will be confused and have a feeling that they are not truly listened and understood, which may undermine the contact and human care between doctors and patients, thereby reducing the effect of treatment [16].

In the future, artificial intelligence will be more universally used in smart healthcare, which may generate medical liability issues. If a doctor utilizes the data analysis results or AI recommendations, rather than believe his own experience. Still, he fails to heal the sick, who will be responsible for the medical accident? The AI, the doctor, or the data model researcher? Therefore, doctors' over-reliance on data analysis and AI may generate responsibility problems, which is one of the ethical issues that need to be solved in smart medical.

3.4 Risk of unemployment

In 2016, the AI robot AlphaGo defeated the Go game world champion, which means that the robot will surpass humanity in more and more fields. Since the invention of steam engines, machine replacement of human labor had always been a serious ethical issue. As mentioned in section 2.2, the application of AI contributes to improving

efficiency and saving labor costs. With the gradual popularization of smart healthcare, AI and mechanical automation may replace some medical workers' work. First of all, the work tasks of some positions are relatively simple, such as the production and packaging of drugs. These mechanical and physical work are easily replaced by artificial intelligence, which leads to the unemployment of workers. Furthermore, doctors who are mostly engaged in mental work will also be affected. For example, AI can help doctors improve their efficiency when they perform diagnostic and therapeutic work, which means that more medical problems can be solved in less time. The workload of workers will be significantly reduced [20]. In this case, the hospital may dismiss some employees to save costs.

It is worth mentioning that artificial intelligence is a conditional alternative to human labor. First of all, the primary condition for its replacement of human labor is that AI can accomplish higher-quality tasks than laborers. Typically, machines cannot automate the entire job. They can only automate part of specific tasks in the job [21]. Moreover, AI systems need to be superior to human labor in terms of cost.

4. Recommendations

According to the analytics of problems and conclusions in this study, we have some recommendations for each identified issue.

For privacy problems, the authorities of countries worldwide are supposed to improve the corresponding regulations to protect data subjects' privacy. Medical workers must improve their understanding of smart medical to protect data subjects' privacy better as well. Meanwhile, data subjects need to pay attention to the importance of data protection. Additionally, more advanced databases and firewall technologies will significantly contribute to resisting network attacks in the future.

In terms of data ownership problems, the institution or company that can make the best use of it deserves to own data. Specifically, a party that can protect data and uses data to benefit all sides can own the data. However, if the institution wants to use the data, it must ask for the consent and tell the data subject how the data will be used [22].

From my perspective, the data analysis is just a tool or a reference and the final judgments have to be made by doctors. Therefore, doctors still have to bear the primary responsibility of a medical accident.

Piero Scaruffi [23] believes that future AI society will create new jobs that we cannot even imagine today for the unemployment problems. Although the application of artificial intelligence will replace part of the work, it will also create numerous jobs. Medical workers are supposed to improve their knowledge structure and actively understand AI applications, which may help them utilize AI technology to assist their work. Additionally, developers should realize that AI is designed to do things that people can't do, rather than replacing them.

5. Conclusion

In conclusion, based on big data, IoT and artificial intelligence technologies, smart medical is going to change the means of interaction between patients and doctors. Especially under circumstances like the COVID-19 pandemic, people must go through a quarantine period and the approach of face-to-face counseling cannot be used. This is not convenient for the people with health requirements, the patients who need regular consultation in particular. In such a case, the existence of smart medical care, such as teleconsultation, will help solve this kind of problem [24][25]. However, although smart healthcare will improve the patient's treatment experience and the doctor's efficiency, it will also bring many ethical issues, including privacy problems, data ownership problems, security and liability problems, and the risk of unemployment. In the future, governments, medical institutions, medical workers and patients are supposed to pay attention to these issues and try to avoid them.

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