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Smart Healthcare System Using Artificial System, Computational Experiments, Parallel Execution and Blockchain Technology

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Abstract

To improve the accuracy of diagnosis, effectiveness of treatment and securing the personal healthcare data, a frame work of parallel healthcare systems (PHSs) based on artificial system, computational experiments and parallel execution approach is proposed in this paper, to secure the transaction of data as well as amount we will be using the blockchain technology, blockchain technology will also be used to create contract between patients and different healthcare research institutes and hospitals.

Keywords - parallel healthcare system, artificial system, computational experiment, parallel execution, blockchain.

1. INTRODUCTION

Smart healthcare is an idea everyone is looking for it in future and many of the healthcare organizations has started to work on this, many different and advance technologies (such as IOT, cloud computing, AI and big data) are used to achieve an effective smart healthcare system. DeepMind and Enlitic are a good example of medical imaging diagnostic system, this utilize computer vision for disease diagnosis. Beside this Watson use data mining and natural language processing to search treatment in a large number of unstructured literatures and patient records such as the patient's medical history, symptoms and laboratory tests to provide decision support for doctors.

Although smart healthcare system have made impressive progress in recent years, situation in practical applications are still far from ideal. There are some of the cross-border diseases which requires experts from different medical fields, thus it becomes necessary to have them work together using technological means. On the other hand due to the regional and individual differentiations among patients, the demands for precise medical care, personalized diagnosis, and treatment are increasing, which makes the accurate patient picturing ever more important than before.

To this hand we propose the framework of parallel health care system (PHS) based on artificial systems, computational experiments and parallel execution. First an artificial healthcare system (AHS) is constructed, to despite and model the patient's and doctor's static and dynamic features, which is called the "descriptive intelligence". Second, by adding different types of diseases scenarios in AHS, computational experiments are used to test and evaluate the applicability of various therapeutic regimens, thus to achieve the "predictive

intelligence". Third, the final regimen is chosen from a recommended list by an expert and parallel executed in both the AHS and the actual healthcare system, to realize "prescriptive intelligence".

In addition we used blockchain technology into the construction of PHS to contain the patients, hospital, health bureau, health communities and medical researchers is deployed, and blockchain powered smart contracts are used to enable electronic health records(EHRs) sharing, record review and care audit ability.

2. FRAMEWORK OF PARALLEL HEALTHCARE SYSTEM

Parallel healthcare is the application of a parallel theory implemented in medical theory. Parallel theory comes from artificial systems, computational experiments and parallel execution. Artificial system is built for modeling and representation, computational experiments are utilized for analysis and evaluation, and parallel executions are conducted for the control and management of complex systems.

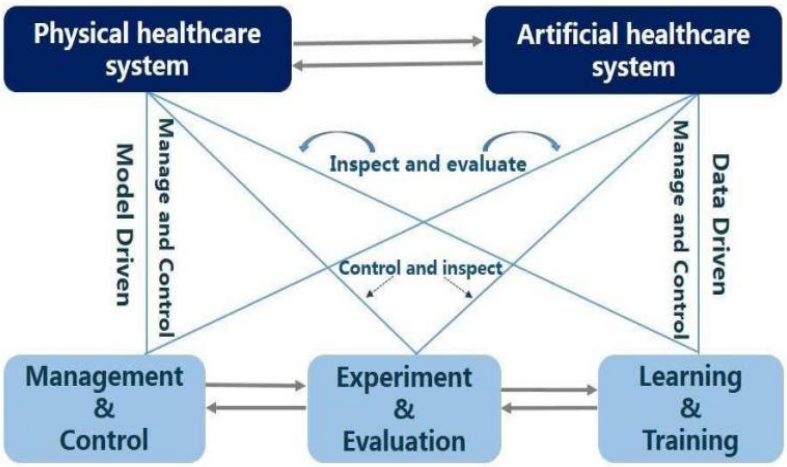

Fig. 1. Framework of PHS.

As shown in figure parallel healthcare consist of a physical healthcare system and AHS.

Physical healthcare is a medical scene in reality in this the real doctor will interact with the real patient diagnosis the disease and suggest treatment for the disease to the patient. In particular, the AHS is the core of the PHS, built according to physical healthcare system, it will be parallel to the physical healthcare system. There will be artificial doctors and patient in AHS. The AHS will participate in each step what the physical healthcare system performs and can transfer the incomputable disease diagnosis and treatment process into computable one.

Once the AHS is built, the computational experiment will be utilized for a medical process for making diseases diagnosis and determine treatment plan. Initially, the AHS will make diagnoses based on patient's symptoms according to medical knowledge from medical publications and doctors' clinical experiments. Later, the artificial system will evaluate all kinds of the therapeutic regimen in digging out the best solution against the patient medical condition. Eventually, the artificial system will monitor the patients for the treatment effectiveness through virtual–real interaction between the AHS and the physical healthcare system together with treatment results feedback. If the treatment effectiveness is not in line with what the system expected, it will adjust the treatment plan timely and continue to monitor. This procedure is named as parallel execution [1], [2].

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Now we will introduce the three main components of the PHS, namely, the AHS, the computational experiments, and the parallel execution in detail.

2.1. Artificial Healthcare System

PHS consists of physical healthcare system and the software-defined artificial disease diagnosis and treatment system. The physical healthcare system include the real doctor and patient, correspondingly the artificial system includes the software defined doctors and patients (virtual ones).

Regarding to real doctor, the artificial doctor is consisted of three different virtual ones, we call them descriptive doctor, predictive doctor, and prescriptive doctor.

A. Descriptive Doctor*:* This integrate medical knowledge and clinical experience from real doctors, it can be considered as an intelligent robot possessing adequate skills in making diagnoses and treatment schemes for the patients, and owning to the same characteristics of real doctors.

B. Predictive Doctor: It is an ideal doctor who possesses perfect medical skills and comprehensive medical knowledge, as it outperforms any single real-world doctor by its advantage in knowledge assembling and experience accumulation from various medical professionals. In our PHS, the predictive doctor is constructed by knowledge graph (a structured semantic knowledge base, in which the knowledge can be used for reasoning and computing). The predictive doctor makes diagnoses and treatment plans for the artificial patient (we will introduce it later), then performs a real time observation and evaluation of treatment effectiveness through computational experiments.

C. Prescriptive Doctor: It refers to a set of optimal artificial doctors obtained via experimental verification based on different therapeutic effective nesses.

The artificial patient is a patient model that is constructed by simulation of the real-world patient, and is consistent with the real patient. The artificial patient is built by recording the biological characteristics, social relations and environmental characteristics of the real patient. Similar to the artificial doctor and artificial patient consists of descriptive patient, predictive patient and prescriptive patient as follows.

A. Descriptive Patient*:* It is a data driven agent regarding the information of the real world patient, it include his/her basic information such as name, age, gender, address, marriage and occupation along with this it will also contain the patient medical history, medical records, allergies, genetic test report and so on.

B. Predictive Patient*:* In predictive patient the artificial doctor can conduct various kinds of diagnosis and treatment experiments thus can help find the most reasonable diagnosis and effective treatment scheme according to experimental results.

C. Prescriptive Patient*:* It is the patient which receives the optimal treatment and reaching the expected goal of treatment effectively before applying to an optimal scheme treatment to the real patient. Afterward the prescriptive patient will keep pace with the real patient to monitor the real patient and help the real patient to achieve the goal of the treatment scheme.

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2.2. Computational Experiments

Generally the computational experiments include diagnosis computational experiments and treatment computational experiments [3].

The diagnosis computational experiments will be carried out under the principle of an evidence-based medicine, which combine clinical evidence, personal experiences, and the real condition of patients. Our artificial doctor will learn certain diagnosis standards in medical publications for each existing disease, learn the empirical diagnosis knowledge from the large historical cases, and also learn the methods of different diagnoses and evidence-based medicines. To achieve the diagnosis process, the artificial doctor will be created based on the present symptoms, medical examination results, past medical history, family medical history, and other information from the descriptive patient. Later, artificial doctors use the corresponding diagnosis knowledge to infer and compute the probability of related diseases. In many times, a patient may suffer from many diseases, especially for the elderly, and there is a mutual relationship between various diseases. Thus, the artificial doctor will learn from the diseases, find the probable source of the diseases, and give the patient a precise diagnosis. Besides, if the information is insufficient to give a certain diagnosis, the descriptive patient will ask the real patient for more details until reaching a reasonable diagnosis.

The treatment computational experiments will be carried out after the real doctor adopted the diagnosis made by the artificial doctor. The treatment computational experiments are more complicated than the diagnosis process because a standard treatment scheme is not feasible in many cases, especially for a patient suffering from many diseases. In reality, doctors will give a treatment scheme by their experiences, since the treatment scheme from different doctors would be various for the same patient. Therefore, the task of treatment computational experiments is to derive many different treatment schemes according to the diseases the patient suffers as the different doctor will do. Then, the predictive doctor will apply different treatment schemes to various predictive patients that derived from the real patients, and simulate and compute the effectiveness of different treatment schemes. The treatment computational experiments are based on the real doctor's treatment principle, and adhere to the idea of treating different diseases with the same origin and treating multiple diseases with the same treatment, and apply pharmacodynamics and pharmacokinetics to simulate and compute the effectiveness of different treatment schemes [4]. Eventually, the predict doctor will recommend the best treatment scheme for the real doctor as the result of the treatment computational experiments.

As per knowledge graph, the knowledge based reasoning provides an effective way to carry out the computational experiments. The knowledge based reasoning mainly contains generative reasoning, symbolic logic reasoning, and statistical reasoning. Generative reasoning can realize the rule-based and data-driven knowledge reasoning. The symbolic logic reasoning and statistical reasoning can achieve the knowledge of self-learning [5].

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2.3. Parallel Execution

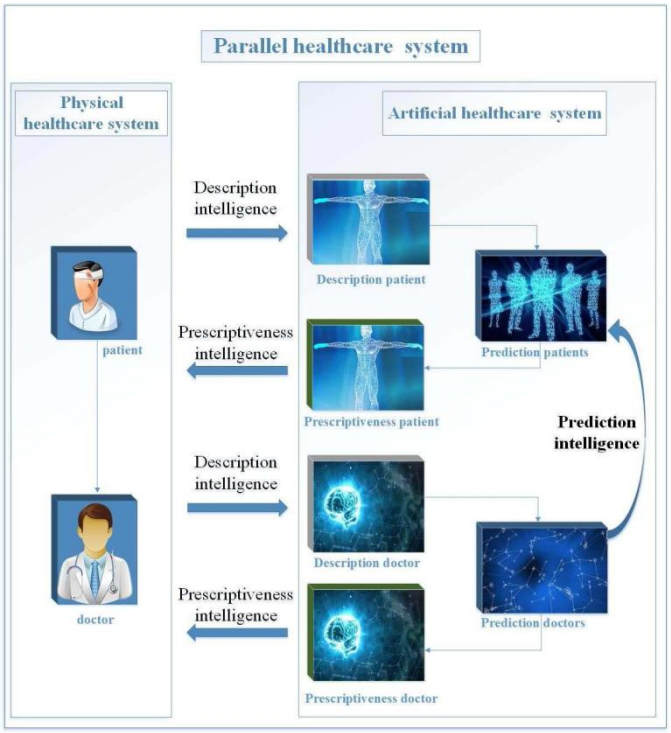

Fig.2. Parallel healthcare: new paradigm shift.

Parallel execution is the interaction of AHS and the actual healthcare system. It has two aspects as follows.

First aspect is the parallel execution between the real doctors and the artificial doctors. On one hand when the artificial doctor conduct diagnosis computational experiment then the real doctor will confirm the diagnosis by making an interaction with the artificial doctor. On the other hand, when the artificial doctor will choose a treatment the real doctor will give his opinion about the treatment and give the eventual treatment to the real patient. However when the diagnose or the treatment scheme of artificial doctor are inconsistent with what the real doctor offer, there will be probably two reasons, one is that the artificial doctor made a mistake, the other is that real doctor made a mistake. For former the artificial doctor will improve by learning from that case and the feedback from the doctor and become more intelligent. For the later, the artificial doctors will provide reasoning basis thus a misdiagnosis or mistreatment will be avoided next time. At the same time, the real doctor can learn from the case and become more professional.

The second aspect is the parallel execution between the prescriptive patient and real patient [6]. The prescriptive patient will continuously monitor the changes of all the biological indicators of the real patient. Besides, the prescriptive patient will also guide real patients to receive the treatment based on the optimal therapeutic regimen calculated previously. The prescriptive patient will provide long-term disease control and chronic disease management in regarding to real time information feedback. If there is a huge deviation of the therapeutic effect between the real patients and the predictive patients, the prescriptive patients will notify the

deviation reasons to the artificial doctor with requesting a recalculation of the treatment scheme and adjust it timely.

In brief, the PHS based on the artificial system, computational experiments and parallel execution approach provides a new paradigm to transform a classical medical process into a computable one and provides a precise medical service for both the doctors and patients. Through the interaction with artificial doctors, the parallel medical system would help real doctors to improve their medical skills and to avoid misdiagnosis or mistreatment. Meanwhile, through the interaction with real doctors, the AHS's performance will be improved as well. The parallel medical system can also provide the personalized guidance for each patient with "all weather" medical suggestion about their treatment scheme, diet, exercise, rehabilitation, and so on, which can help patients to recover quickly, as shown in Fig. 2.

3. APPLICATION OF BLOCKCHAIN TECHNOLOGY IN SMART HEALTHCARE

In this section we give a brief overview of blockchain technology and smart contracts, and then list some typical application of the blockchain technology in smart healthcare system.

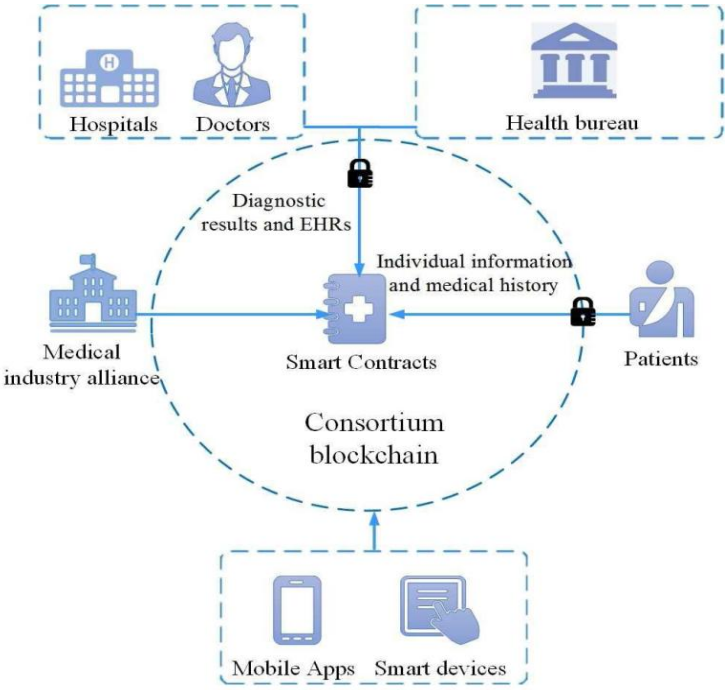

Fig.3. Consortium healthcare blockchain.

3.1. Overview of blockchain technology

Blockchain is a buzz word in current time, most of the people know about the Bitcoin and Ethereum which runs on blockchain technologies. The blockchain is a continuously growing list of records, called blocks which are linked and secured using cryptography. The blockchain can be regarded as an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way. The consensus mechanism ensures a common, unambiguous ordering of transactions and blocks, and guarantees the integrity

and consistency of the blockchain across geographically distributed nodes. The development of the blockchain technology has enabled a customizable programming logic to be stored in a decentralized way. This has revived the notion and facilitated the creation of smart contracts. Smart contracts are software programs that self execute complex instructions on blockchains. The smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for central authorities, legal systems, or external enforcement mechanisms.

3.2. Application of Blockchain Powered Smart Healthcare

There are three typical applications in the healthcare field namely, fast healthcare interoperability resources, user oriented medical research and counterfeit drug prevention and detection.

A. Fast Healthcare Interoperability Resources: At present time the patients don't have the control on their medical records and don't know the value of these data. With the help of blockchain technology, healthcare payers and providers can manage medical records and clinical trials data while maintaining regulatory compliance. They can keep record of their data and can also keep a record of the healthcare institute who has their data, they can also charge some crypto currency in exchange of the data with healthcare research institutes.

B. User-Oriented Medical Research: Health researchers often require broad and comprehensive data sets in order to advance the understanding of diseases accelerate biomedical discovery, and design customized individual treatment scheme based on patient's genetics, lifecycle, and external environment. The blockchain can effectively speed up the development process. A framework called ModelChain [7] is proposed to improve the security and robustness of distributed healthcare predictive modeling using the private blockchain; Gems, a blockchain air position indicator provider, announced a partnership with Philips to build an Ethereum blockchain for use in the development of an enterprise healthcare application.

C. Counterfeit Drug Prevention and Detection: Counterfeit drug poses a serious threat to the people's health. The interoperability, data security, and authenticity of the blockchain allow the healthcare and life science industries to indelibly record the medicinal data that will effectively combat counterfeit pharmaceutical property and protect intellectual property. We can use blockchain technology to track the drug positioning from manufacturer to the patients, this will increase security and accountability in the prescription drug industry.

4. CONCLUSION

In this paper, we present the PHS framework with blockchain technology based on artificial system, computational experiments and parallel execution approach. The PHS uses artificial system modeling to stimulate and represent the actual healthcare scenarios; then, the training and evaluation of various diseases diagnosis and treatment schemes are performed through computational experiments; through parallel execution between the actual and AHS, the accurate forecasting and guidance of the disease diagnoses and treatments are

realized. Next we introduce the blockchain technology in healthcare, by providing security to the data and keeping all the records of transactions of data as well as counterfeit drug prevention and detection.

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