

Research on the Fusion Model Reference Architecture of Sensed Information of Human Body for Medical and Healthcare IoT

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Abstract—The body sensing object information fusion model is the application basis of medical and healthcare big data, so it is necessary to make a unified modeling of medical and healthcare big data. Based on IoT concept mode, this paper proposes an information fusion reference architecture of body sensing object under the healthcare IoT environment, specifies 5 levels of information fusion processing, which was analyzed by a case study of sleep quality monitoring service. At the same time, it provides 6 functional domains of healthcare operation and describes the intra-domain information fusion function. It is expected to provide impact estimates and decision support for healthcare services and provide reference for standard development in medical and healthcare IoT.

Keywords—IoT six-domain mode; Body sensing information; Reference architecture;

I. INTRODUCTION

New technologies such as the IoT, mobile communications, cloud computing and artificial intelligence are quickly integrated into the medical and healthcare field. Medical data has shown an explosive growth[1]. As an important basic strategic resource for China, the medical and healthcare data will play an important role in facilitating the people, deepening medical reforms, and promoting economic development[2]. To fully achieve the value of medical data, the information fusion between Health Data, Health Service Requirements and Information Technology must be fully realized[3]. Multi-level processing of multi-source information is necessary to obtain accurate impact estimates, provide timely, comprehensive and personalized diagnosis and treatment services for healthcare service targets, and promote the development of medical and healthcare industry[4,5].

The national standard that IoT Reference Architecture provides a scientific and reasonable IoT reference architecture that can guide the development of information fusion models[6]. The information fusion model centering on human sensing objects is the basis for the application of medical and healthcare big data, and it is also a useful supplement to existing resident health record data. Modeling medical health big data can realize the integration and exchange of information collected by sensing devices and traditional health service information,

forming a new type of medical healthcare service based on diagnosis rules and requirements.

II. IOT SIX-DOMAIN MODEL

The six-domain model of IoT is a highly abstract and modeled representation of various IoT applications. It can provide effective, reliable, and extensible framework design guidance for IoT application system reference architecture design in different industries[7]. The six-domain model consists of six parts: user domain, target object domain, sensing control domain, service provision domain, operation and maintenance management domain, and resource exchange domain, as shown in Figure 1.

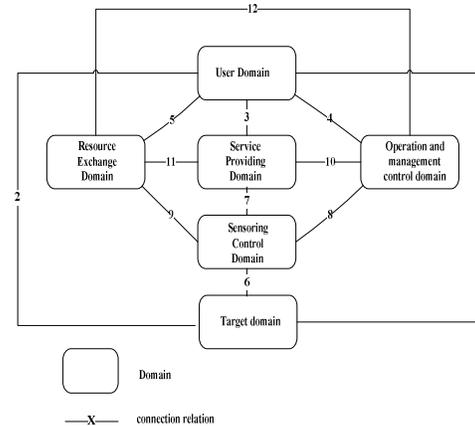


Figure 1. IoT six-domain model

Based on the IoT six-domain model, this paper combines the features of the medical and healthcare industry to fuse human sensing and traditional health activities. Refining the owners and entities in the reference architecture of medical and health environment, as well as the interfaces and associations between the entities, to form a human sensing information fusion reference architecture that can guide the development of standards and applications in the medical and healthcare IoT field.

The human body object attribute information obtained in the perceptual control domain of the model is the core of the healthcare IoT industry service, and is also the basis of medical information fusion and application.

The perceptual control domain obtains attribute information of the human perception object through the interface 6, including identity, location, vital signs, behavior, and environment, etc. At the same time, the interface 6 controls the behavior of perception object, so as to improve the accuracy of equipment acquisition data c, for example, to regulate the use of surveillance equipment such as high blood pressure in human body wear mode, can improve the effectiveness of intelligent apparel equipment acquisition data, provide better decision support for doctors. The Perceptual Control Domain specifies correct mapping between physical entities and virtual objects through the interface 6, and provides users with local collaborative information processing and remote management services, thereby truly transforming traditional medical service models that rely on face-to-face medical treatment.

III. ARCHITECTURE DESIGN FOR HUMAN BODY SENSED INFORMATION REFERENCE

A. Architecture diagram of human body sensed information reference

The reference architecture diagram for sensed information of human body abstracts the information fusion process that adapts to the characteristics of the medical healthcare IoT, as shown in Figure 2. The figure uses the six-domain model architecture to associate 5 fusion levels and entities that support fusion processing. There are relationships like information fusion and functional support between different levels.

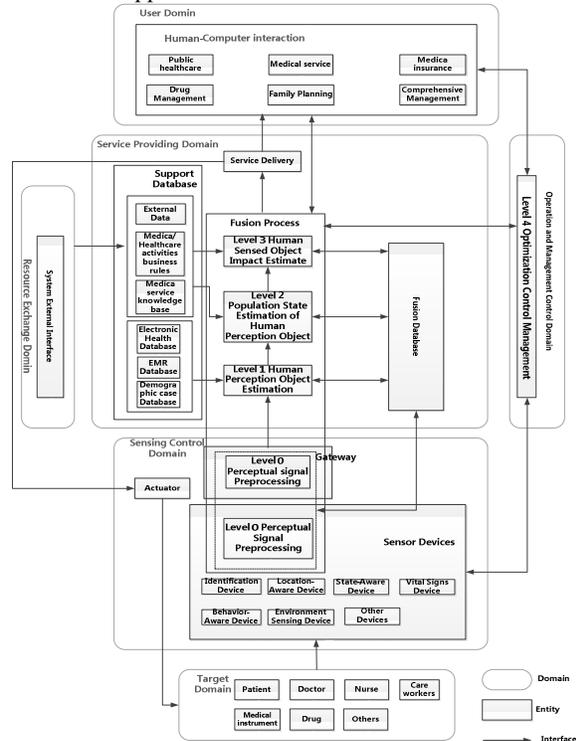


Figure 2. Reference architecture diagram for sensed information of human body

B. Functional description of intra-domain information fusion

The reference architecture diagram for sensed information of human body is oriented toward the healthcare industry and provides 6 major service functional domains from different operational perspectives. The intra-domain information fusion functions are described in Table 1.

TABLE I. INTRA-DOMAIN INFORMATION FUSION FUNCTIONS

Domain	Information Fusion Functional Description
User Domain	Provide human-computer interaction interface, presenting all levels of fusion products, and realize user's intervention control of fusion processing.
Sensing Control Domain	Sensing information sources that involved in information fusion are provided, and level 0 fusion (level 0 perceptual signal preprocessing) is completed. Level 0 fusion is primarily implemented in gateways or Intellisense devices.
Service Providing Domain	The core processes: Level 1 fusion (Human Perception Object Estimation), Level 2 fusion (population state estimation of human perception objects) and Level 3 fusion(Human perception object impact estimation). In the basic services, support databases and fusion databases are required for integration at all levels are provided, and level 1, 2, and 3 integration are realized in operational services.
Operation and Management Control Domain	Monitoring, managing, and optimizing various types of sensing devices and gateways during operation, according to the system needs for medical and healthcare information fusion. At the same time, it also monitors, configures, and optimizes information such as fusion algorithms, operating parameters, and estimation results in the 0-3 level fusion process.
Resource Exchange Domain	Provides access to external data in the database.
Target Domain	Provide information fusion target objects. The target objects in this paper are human perception objects.

C. Case analysis for sensed information of human body

Taking the sleep quality monitoring service as an example to analyze the 5-level processing of medical and healthcare data fusion. Sensing devices used in this case include smart mattresses, environmental labels, etc.

- Level 0 fusion--Perceptual Signal Preprocessing: Sensing devices such as smart mattresses and environmental labels process the collected raw data and output standardized data according to each type of parameters (heart rate, respiratory rate, pressure value, temperature, humidity, and brightness).
- Level 1 fusion--Human Perception Object Estimation: The spatiotemporal registration, data association and other operations are performed on the output data of Level 0 fusion. At the same time, medical monitoring information such as personal case database, electronic healthcare record database, and electronic medical records database of the monitoring object is associated to form linked data indexed. The user's sleep quality monitoring and quantitative analysis report can be obtained through information fusion.
- Level 2 fusion--Population State Estimation of Human Perception Objects: By integrating the

Level 1 fusion output of monitoring service groups and combining the professional knowledge of sleep analysis, we can obtain the situational distribution of sleep quality of service groups, such as the dimensions of age, sex, health, temperature, region, etc. In addition, an association analysis between objects and external environment can also be obtained, giving quantitative indicators of sleep quality and the factors affecting sleep quality.

- Level 3 fusion--Human Sensed Object Impact Estimation: According to the situational distribution data of level 2 fusion output, and the information of a sensed object, one's healthcare prediction will be provided. And if there is an abnormal risk, an alarm message could be output.
- Level 4 fusion--Optimized Control Management: Monitoring, managing, and optimizing the operational status of devices such as sensing devices and gateways. At the same time, it also monitors, configures, and optimizes information about algorithms and operating parameters in the 0-3 level fusion process.

IV. SUMMARY

This paper proposes a reference architecture for sensed information of human body, gives a 5-level process of medical and healthcare data fusion. The main functional entities in the information fusion system are defined, and the entire fusion process is analyzed and verified, by using the sleep quality monitoring service as an example. It innovatively integrates medical healthcare sensing data with traditional medical data such as electronic medical records, healthcare records, and public health information. Information fusion transformation is achieved, from centering on sensing devices to health service objects. It can provide impact estimation and decision support for medical and healthcare industry services, and provide reference for the development of standards in the field of medical and healthcare IoT.

There is an extensive development space for medical and healthcare big data in China, as an important basic

strategic resource. However, it also faces huge challenges, mainly because of the lack of standards and severe information isolated island. It is particularly important to formulate scientific and rational standards that meet the current development needs. Therefore, in the future we can base ourselves on the reference architecture what we put forward in this paper, in-depth development of medical and healthcare IoT information standards development. We hope to provide system decomposition and top-level planning reference for medical workers to better achieve clinical decision-making. This will promote the great development of the medical and healthcare industry, and realize the health and well-being of the entire people.

ACKNOWLEDGMENT

This work is financially supported by Scientific Research Project of Jiangsu Provincial Commission of Health and Family Planning (No.LGY2017014).

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