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A Survey on Internet of Things
for
Smart Health Technologies

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Extended Abstract

Nowadays, accompanying with prolonged life expectancy, there is an increase of chronic diseases which include obesity, diabetes, cardiovascular diseases, cancer, osteoporosis and dental diseases at the global level. As a result, the task of supporting, enhancing and improving upon the existing healthcare services poses a wide range of challenges. Accordingly, the utilization of sophisticated technologies in the healthcare field, which is called smart health, is not an optional value, but a requirement. It is accepted that the Internet of Things (IoT) is the core technology of smart health. The adoption of advanced technology, particularly Internet of Things (IoT), in the field of medicine and healthcare, benefits patients with better medical assistance, reduce a treatment time, lower medical costs and more satisfying healthcare services.

Many efforts have been made and a large body of research regarding the potential and implementation of IoT in healthcare already existed. The main problem, however, is the need for a comprehensive literature review which states the extensive overview of the field and advances in IoT-based healthcare technologies in the aspect of system architecture. This study aims to state the comprehensive overview of the field and advances in IoT-based healthcare technologies in the aspect of system architecture. The research survey investigates and summarizes the existing knowledge, state-of-the-art technologies of each aspect in the field. Further, this research provides an exhaustive understanding of the successful case studies on the IoT in the healthcare context which is expected to be useful for further research. Following the structure of standard IoT-based healthcare system architecture, the summary of our project paper is given as follows.

First of all, we identify physiological information, the environmental aspects, as well as indoor location information. They are the necessary data that needs to be collected in order to ensure the quality of life, safety, and well-being. Vital signs, which primary are temperature, pulse rate (heart rate), respiration rate (breathing rate) and blood pressure, are essentially physiological signs to indicate the status of the body. Besides, several extra medical signs for example muscle activity level, blood glucose level, gaseous carbon dioxide levels (CO_2), electrical activity in the brain are all essential to track down the healthcare status. Since an abnormal change of indoor environment may cause dangerous situations and result in undesired consequences of directly or indirectly harming occupants,

environmental aspect is another relevant information. Moreover, based on the advantages of the information, the demand for indoor localization especially in healthcare area is increased recently. The specific normal range, effectiveness, and typical application of each type of data are sufficiently discussed.

Secondly, we discuss and investigate between recent advances in sensor technology, microelectronics, and telecommunication which applied to collect and monitor healthcare data. The environmental sensors can be used to capture environmental parameters. For instance, accelerometer and compass sensors are applied in location monitoring application while the biomedical sensors such as electrocardiogram (ECG) and photoplethysmography (PPG) sensors can be used to monitor the health figure of the human. The collected data can be analyzed and sent to the server through communication technologies. Wildly known technologies in smart health field are RFID, NFC, Wifi, 6LowPAN, Bluetooth, ZigBee. Advantages of in sensor technology and common sensor devices are defined. The flexibility, communication efficiency and cost-effective of using Body Area Networks Architecture in healthcare are also presented. Furthermore, we compare among IEEE 802.15.1 (Bluetooth), 802.15.4 (the basis for Zigbee) and 802.15 (standard for wireless personal area network - WPAN), these are the most commonly employed wireless communication standards in BANs.

In the healthcare field, especially in healthcare monitoring system, the reliability of input data is extremely important. Accurate healthcare decisions can only be obtained with accurate input data. However, it is possible to have noise and outliers in sensor data. It is caused by (1) low quality sensors or errors of the sensors and (2) occurrence of noise or motion artifacts in all sensor networks. Consequently, these might lead to faults in reading and giving alarm for patient and healthcare provider deliveries. In other to control data quality, the collected data need to go through preprocessing steps before being analyzed by algorithms. We employ several criteria including usage, referable, possibility, popularity, standardization and intelligence to evaluate the impact of algorithms. The most critical data preprocessing algorithms in the healthcare system can be classified into two categories: imperfect data and imbalanced data preprocessing methods. The chart is used to demonstrate the evolution of academic publications concerning the data preprocessing algorithms from 1990 to 2016 while constructing tables thoroughly reviews the detailed figure of them from 2010 to 2016. Publication statistics are acquired from Google Scholar; the search query is defined as the subfield name of algorithms and at least one term of medical or health appearing, for example, "'support vector machine' AND medical OR health".

IoT-based healthcare systems can be utilized to a diverse array of fields, including care for pediatric and elderly patients, the supervision of chronic diseases, and the management of private health and fitness, among others. Starting from the most successful support vector machine algorithm, we identify plausible architectures in the healthcare domain. The research trends in algorithms applied for healthcare decision support systems as well as the number of publication referring to several algorithms are analyzed. Among abundant IoT-based

healthcare applications, we can classify them into two main categories: pervasive monitoring and medical informatics applications. In order to provide the overview, we summarize the feature IoT-based healthcare applications.

Sensor data issues, the accuracy of indoor location monitoring system and system design are emerging as the principal challenges and limitations in the IoT-based healthcare area. We briefly clarify these issues and through the final discussions, further areas that would benefit from the introduction of IoT technologies will be identified.

As a second study, based on the general system architecture we conduct the implementation of the smart healthcare system. The system applied modern technologies to solve the current problem in smart healthcare. Besides, the implemented system is expected to be useful for further research.

Regarding future works, we propose an Integrated Home-Based Healthcare Monitoring System ensuring wellness for each individual lives in the house. In this system, the data collected by health sensors, environment sensors, and location sensors will be pre-processed and sent to the Smart Health Platform through the IoT gateway. The Smart Health Platform not only stores the data but also controls the connectivity of devices and provides the APIs for the third-party application. The Smart Health Applications can provide several safety applications such as fall detection and emergency assistance.

Through the survey, researchers can get enough understanding, save their time in searching articles and reduce repetitious work for supporting the task of designing and developing the smart healthcare system. Besides, stakeholders, healthcare manufacturers, family members and especially patients will get benefit from our research.

Keywords. Internet of things, healthcare, technologies, smart health, applications, networks, sensors