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Internet of Things Health Care

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Abstract: This paper is an overview of some of the implications of IoT on the healthcare field. Due to the increasing of IoT solutions, healthcare cannot be outside of this paradigm. The contribution of this paper is to introduce directions to achieve a global connectivity between the Internet of Things (IoT) and the medical environments. The need to integrate all in a global environment is a huge challenge to all (from electrical engineers to data engineers). This revolution is redesigning the way we see healthcare, from the smallest sensor to the big data collected.
Keywords: Internet of Things, healthcare, medical environments, sensors.

I. INTRODUCTION

The Internet of Things (IoT) is a concept that's reflects a "connected set of anyone, anything, anytime, anyplace, any service, and any network" This technology, named as Internet of Things (IoT), "provides an integration approach for all these physical objects that contain embedded technologies to be coherently connected and enables them to communicate and sense or interact with the physical world, and also among themselves". Healthcare is an essential part of life. Unfortunately, the steadily aging population and the related rise in chronic illness is placing significant strain on modern healthcare systems , and the demand for resources from hospital beds to doctors and nurses is extremely high. Evidently, a solution is required to reduce the pressure on healthcare systems whilst continuing to provide high-quality care to at-risk patients.

This paper further provides a comprehensive survey of the state-of-the-art technologies that fall within the proposed model. Focus is placed on sensors for monitoring various health parameters, short- and long-range communications standards, and cloud technologies. This paper distinguishes itself from the previous major survey contributions by considering every essential component of an IoT-based healthcare system both separately and as a system.

II. IOT

The term "Internet of Things" was disseminated by the research work of the Auto-ID Center at the Massachusetts Institute of Technology (MIT) in 1999 [17].IoT includes two concepts: "Internet" and "Thing", where "Internet" refers to "The world-wide network of interconnected computer networks", based on a standard communication protocol, while "Thing" refers to "an object not precisely identifiable" [6]. These concepts mean that every object can be addressable by an IP(Internet Protocol), and can act in a smart space, like a healthcare environment. Another definition of IoT is "a self-configured dynamic global network infrastructure with standards and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities, and are seamlessly integrated into the information infrastructure" [3]. Indeed, IoT is the resulting global network interconnecting smart objects by means of extended Internet technologies, the set of supporting technologies necessary to re alize such a vision (including e.g., RFIDs, sensor /actuators, machine-to-machine communication devices, etc.)

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III. HEALTH CARE

Healthcare is one of the main priorities for all governments, basically related to population growth, rural urbanization, declining birth rate, population aging ,economic growth and social unbalanced resource utilization, some social problems have become increasingly apparent in the healthcare field, some of these issues in healthcare that IoT may prevent, or can combat in a most effective way:

Health management level and the incapability of responding to emergency;

–serious shortage in medical staffs and institutional facilities especially in rural areas, lack of medical facilities, low level of treatment, inadequate healthcare system;

–Imperfect diseases prevention system cannot meet the national strategy requirements to safeguard the health of the citizen resulting in an heavy burden on economy, individuals, families and State;

–Inadequate disease prevention and early detection capability But there are some challenges, that IoT can help to solve:

–break geographic barriers, providing rapid clinical responses;

–medical consultation and communication links of medical images and videodata;

–a unique ontology for all things among IoT-based healthcare. There are a lot of applications in the healthcare field, including the possibility ofusing smartphone capabilities as a platform for monitoring of medical parameters that advise patients of medical issues.

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IV. IOT HEALTHCARE SERVICES AND APPLICATIONS

Regarding IoT Healthcare Services and Applications, the range of fields can include: management of private health and fitness, care for pediatric, supervision of chronic diseases, elderly patients, among others. For a better understanding of this topic, this paper categorizes the discussion in two aspects: services and applications.

Continuous glucose monitoring for insulin pens is the best example of this. All these devices can communicate with each other and take important actions that would provide timely help to save someone's life. After collecting the data, an IoT healthcare device would send this critical information to the cloud so that doctors can act upon it.From this, we can say that the potential application of IoT in healthcare can improve not only a patient's health but also the health care employee productivity and hospital workflows.

V. HEALTHCARE SERVICES

Ambient Assisted Living Ambient Assisted Living systems have a potential to meet the personal healthcare challenges and involve citizens in their healthcare. The AAL systems provide an ecosystem of medical sensors, computers, wireless networks and software applications for healthcare monitoring, a service that can be provided by IoT. That is, a separate IoT service is mandatory.

m-Health Things (m-IoT) The m-IoT is "defined as a new concept that matches the functionalities of m-health and IoT for a new and innovative future(4G health) applications" [12]. As shown in [15], m-health is mobile computing, medical sensors, and communications technologies for healthcare services. In theory, "m-IoT familiarizes a novel healthcare connectivity model that connects the 6LoWPAN with evolving 4G networks for future internet-based m-health services. Although m-IoT characteristically represents the IoT for healthcare services, it is worth mentioning that there exist some specific features intrinsic to the global mobility of participating entities" [15] [16].

A. Adverse Drug Reaction

An adverse drug reaction is an injury from taking a medication, either a single dose of a drug or its prolonged administration or as a consequence of a combination of two or more drugs [9] [2]. Solutions to this issue can be found in the previous references.

B. Community Healthcare

A service that may be provided by IoT is a network covering an area around a local community, a municipal hospital, a residential area, or a rural community, being a cooperative network structure. A cooperative.IoT platform for rural healthcare monitoring has been proposed and found to be energy-eficient [20].

C. Indirect Emergency Healthcare

There are some indirect emergency situa-tions where healthcare issues are involved, including: adverse weather conditions, transport (aviation, ship, train, and vehicle) accidents, earthen sites collapse among others. Therefore, a service called indirect emergency health care (IEH)can be offer a bundle of solutions such as information availability [16] [7].

D. Early Intervention/Prevention

Monitoring of human activities and well-being, like monitoring everyday activity and report it to hospital or familymembers. IoT may provide the way to monitoring all that activities with device embedded.

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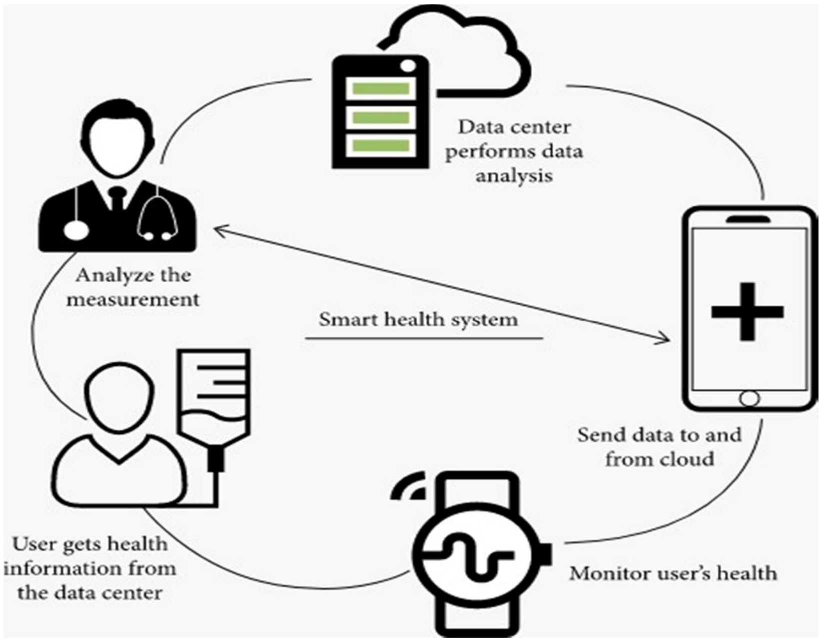
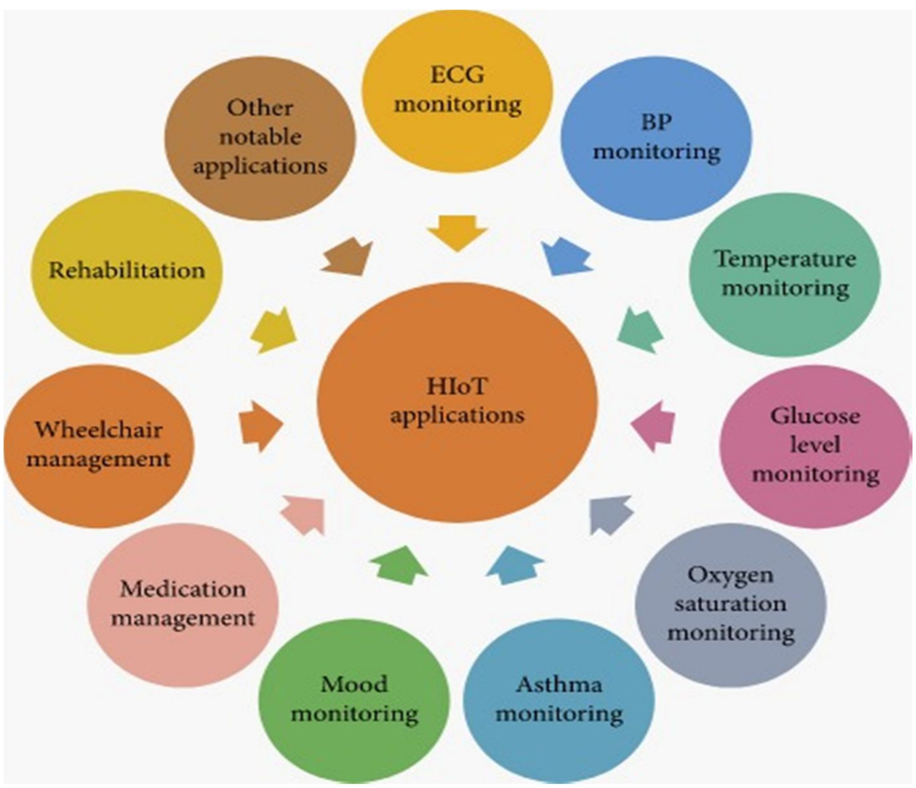
VI. HEALTH APPLICATION

The HIoT services/concepts are used for the development of different IoT-based applications. Researchers working in the said fields have proposed different concepts to the service of mankind. In simple words, concepts are more developer-centric, whereas applications are user-centric. The rapid development in the IoT-technology has led to the development of more affordable and user-friendly wearable sensors, portable gadgets, and medical devices. These systems can be used to collect patient's information, diagnose diseases, monitor the health of the patients, and generate alerts in case of a medical emergency (Figure). In the following section, some of the most recent commercially available devices have been discussed. Further, various HIoT-based applications have been addressed including both single condition and multiple conditions.





A. ECG Monitoring

Electrocardiogram (ECG) represents the electrical activity of the heart due to the depolarization and repolarization of atria and ventricles. An ECG provides information about the basic rhythms of the heart muscles and acts as an indicator for various cardiac abnormalities. These abnormalities include arrhythmia, prolonged QT interval, myocardial ischemia, etc. The use of IoT technology has found potential application in the early detection of heart abnormalities through ECG monitoring. Numerous studies in the past have employed IoT in ECG monitoring [67–72]. The study reported in [72] has proposed an IoT-based ECG monitoring system that is composed of a wireless data acquisition system and a receiving processor. It employed a search automation method that was used to detect cardiac abnormality in real time. In [73], a small wearable low-power ECG monitoring system was proposed that was integrated with a t-shirt. It used a biopotential chip to collect good quality ECG data. The recorded data were then transmitted to the end-users through Bluetooth. The recorded ECG data could be visualized using a mobile app. The proposed system could be operated with a minimal power of 5.2 mW. Real-time monitoring in an IoT system can be possible after integrating it with big data analytics to manage higher data storage. Bansals and Gandhi have proposed an ECG monitoring system that can handle long-term and continuous monitoring by integrating the concept of nanoelectronics, big data, and IoT [74]. It is worthy to note that in [75], the authors have tried to resolve the issue of power consumption associated with a wearable ECG monitoring system. They have proposed a unique method called compressive sensing that can optimize power consumption and provide optimal performance in ECG monitoring. IoT-based fall detection and ECG monitoring system has also been reported in [76] that uses a cloud-based server and a mobile application. This system was designed to provide real-time monitoring to elderly patients by continuously checking their ECG and accelerometer data.

B. Glucose Level Monitoring

Diabetes is the condition in which the blood glucose level in the body remains high for a prolonged period. It is one of the most common diseases in humans. Three major types of diabetes are generally found, namely, type-I diabetes, type-2 diabetes, and gestational diabetes. The disease and its types can be identified following three tests, namely, random plasma glucose test, fasting plasma glucose test, and oral glucose tolerance test. However, the most widely used diagnostic method for the detection of diabetes is “fingerpicking” followed by the measurement of blood glucose level. The recent development in IoT technologies has been used in designing various wearable gadgets for blood glucose monitoring that is noninvasive, comfortable, convenient, and safe [77–80]. In [81], m-IoT-based noninvasive glucometer has been proposed for real-time monitoring of blood glucose levels. Herein, the wearable sensors and the healthcare providers were linked through IPv6 connectivity. Alarcón-Paredes et al. have designed a glove for the measurement of blood glucose level that is integrated with a Raspberry Pi camera and a visible laser beam. A set of pictures taken from the fingertip was used for detecting the diabetic condition of the patients [82]. In another study [83], an algorithm based on a double moving average was employed in the IoT architecture for the measurement of the glucose level. It is worth specifying that optical sensors such as infrared LED and near-infrared photodiode have also been used for glucose level measurement. Herein, the light signal reflected from the human body is used to compute the glucose level in the human body [84].

C. Blood Pressure Monitoring

One of the compulsory procedures in any diagnostic process is the measurement of blood pressure (BP). The most accustomed method of measurement of blood pressure requires at least one person to do the recording. However, the integration of IoT and other sensing technology has transformed the way BP was previously monitored. For example, in [88], a wearable cuffless gadget has been proposed that can measure both systolic and diastolic pressure. The recorded information can be stored in the cloud. Further, the efficiency of this device was tested on 60 persons and the accuracy was validated. Guntha has implemented cloud computing and fog computing in the IoT-based BP measurement system [89]. This prepared the system for long-term real-time monitoring. The device could also store the recorded data for future references. In a similar study [90], a deep learning-based CNN model with time-domain characteristics was used for the evaluation of systolic and diastolic blood pressure. The measurement of BP using the ECG signal and photoplethysmogram (PPG), recorded from the fingertip, has been proposed in [91]. Herein, the BP was computed using the attached microcontroller module and then the recorded data were sent to the cloud storage.

D. Oxygen Saturation Monitoring

Pulse oximetry is the noninvasive measurement of oxygen saturation and can be used as a vital parameter in healthcare analysis. The noninvasive method eliminates the issues related to the conventional approach and provides real-time monitoring. The advancement in the pulse oximetry that comes from the integration of IoT-based technology has shown potential application in the healthcare industry. In [92], a noninvasive tissue oximeter was proposed that could measure the blood oxygen saturation level, along with heart rate, and pulse parameters. Further, the recorded information could be transmitted to the server using various communication technologies such as Zigbee or Wi-Fi. Based on the recorded data, a medical intervention decision was made. In another study [93], an alarm system that can alert the patients when the oxygen saturation reaches a critical level was reported. The system was integrated with a pulse oximeter and WLAN router that were connected using the Blynk server. Moreover, Von Chong et al. have proposed a multispectral sensor that reduces the adverse effect of a single LED [94]. A low-power and cost-effective remote patient monitoring system has been proposed in [95]. The device can be effectively used for real-time monitoring.

E. Asthma Monitoring

Asthma is a chronic illness that can affect the airways and may cause difficulty in breathing. In asthma, the airways shrink due to the swelling of the air passage. This follows many health issues such as wheezing, coughing, chest pain, and shortness of breath. There is no suitable time for an asthma attack to come, and an inhaler or nebulizer is the only lifesaver at that moment. Hence, there is a potential need for real-time monitoring of this condition. Numerous IoT-based systems for asthma monitoring have been proposed in recent years [96–98]. In [99], a smart HIoT solution for asthma patients was proposed that was used to record respiratory rate using a smart sensor. The health information was stored in a cloud server that gives access to caregivers for diagnostic and monitoring purposes.

F. Mood Monitoring

Mood tracking provides vital information regarding a person’s emotional state and is used to maintain a healthy mental state. It also assists healthcare professionals while dealing with various mental diseases such as depression, stress, bipolar disorder, and so on. Self-monitoring of the emotional state enhances a person’s understanding of their mental condition**.** In [105], a mood mining approach was reported that uses a CNN network to evaluate and categorize a person’s mood in 6 categories: happy, excited, sad, calm, distressed, and angry.

VII.CONCLUSION

The Internet of Things changed the healthcare industry, increasing efficiency, lowering costs and putting the focus back on better patient care. Meanwhile, the IoT is growing from building blocks of automation and machine-to-machine communication to the smallest sensors. We consider also how IoT can be used to increase healthcare and how IoT helps people and governments to improve daily activities in personal and public level. Although there are security issues in giving location information, we can give some permission to people in order to allow mechanisms to prevent people from abusing. Additionally, this paper provides information about the current healthcare services where the IoT-based technologies have been explored. By employing these concepts, the IoT-technology has helped healthcare professionals to monitor and diagnose several health issues, measure many health parameters, and provide diagnostic facilities at remote locations. This has transformed the healthcare industry from a hospital-centric to a more patient-centric system. We have also discussed various applications of the HIoT system and their recent trends. Further, the challenges and issues associated with the design, manufacturing, and use of the HIoT system have been provided. These challenges will form a base for future advancement and research focus in the upcoming years. Moreover, a comprehensive up-to-date knowledge on the HIoT devices has been provided for the readers who are not only willing to initiate their research but also make advancements in the said field works to be done in order to make the best use of this IoT technology. We need to grow the applications in the future until the desired level of health comes in society.

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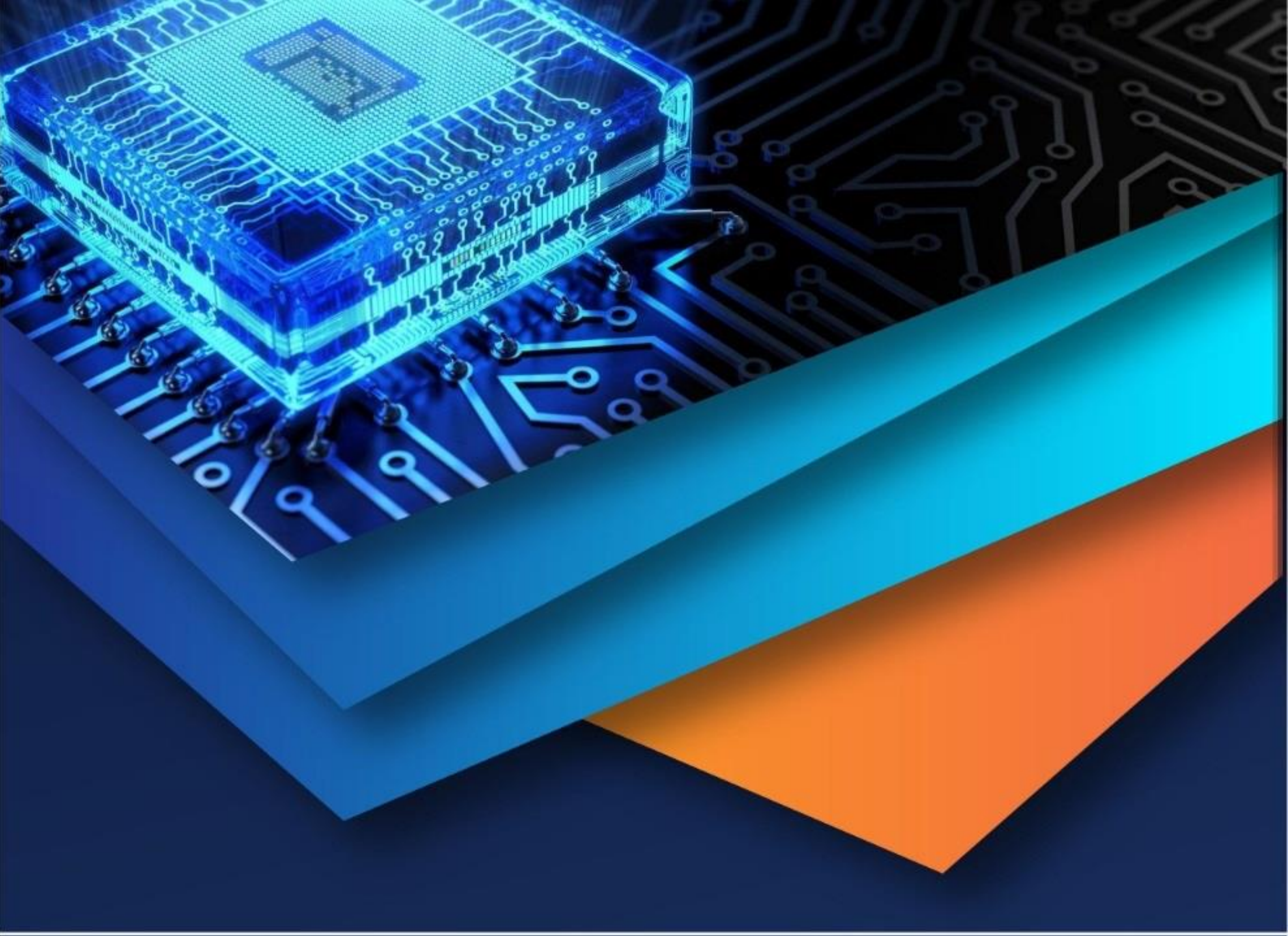

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