A Comprehensive Review on Usage of Internet of Things (IoT) in Healthcare System

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Abstract: Prediction of Chronic Disorders in early stage is very vital. IoT facilitated remote health monitoring system has enormous benefits over customary health monitoring system. It is imperative to accumulate correct raw data in an efficient way; but more significant is to explore and mine the raw data to abstract more valued information such as correlations amongst things and services to afford web of things or Internet of services. In this Paper we have addressed the use of IoT in Healthcare system, challenges of IoT in Healthcare System and review on various works carried out on this research area with which a proposed methodology is been discussed.

Keywords: ***Chronic Disorders; IoT; Healthcare System.***

I. INTRODUCTION

Chronic disorders (examples: respiratory diseases cardiovascular diseases, mental health disorders, stroke diabetes, etc.,) are the foremost causes of death and infirmity in India. Most chronic diseases are equally prevalent in poor and rural inhabitants and often arise together. Though a wide variety of cost-effective primary and secondary prevention stratagems are available, their coverage is generally low, especially in poor and rural populations. Improved public health and primary health-care systems are indispensable for the implementation of cost-effective interventions. More than 5% kids in the Indian population suffer from the disorders called Attention Deficit Hyperactivity Disorder (ADHD) and Dyslexia [1]. Clinic research says that these disorders are very common and are categorized as "Medically Manageable" and "Treatment can help".

Since the birth of modern computing, scientists and doctors alike have always been captivated by the potential that AI methodologies might have in medicine and healthcare applications. Indeed, conventional AI methods such as machine learning, expert systems and knowledge representation techniques have been strongly exploited for designing and implementing medical applications belonging to the following areas: diagnosis, prognosis, medical training, and so on. Expert- or knowledge-based systems are the most common type of AI application in Healthcare. When there is not enough knowledge for designing Healthcare expert systems, machine learning approaches can be used for analyzing a collection of clinical cases producing a systematic description of that clinical knowledge that characterizes the clinical conditions of a give patient or a disease. These are only some samples of AI applied to healthcare domain but, in general, all of AI healthcare systems have to deal with manipulations and transformation of data and knowledge [2].

The Internet of Things (IoT) is a web of objects with inimitable identifiers that can converse with each other with or without the assistance of a computer or internet. The communication is aided through the sensors installed into the participating devices. Numerous technologies like wireless technologies, micro-electromechanical systems (MEMS) and the Internet have subsidized to the development of the IoT. Due to obtainability of low-cost sensor devices, market analysts estimate that there could be about 25 billion installed units by 2020 and the market scope to be around 2.1 trillion by 2025[3]. IoT applications will be cleverer than the applications we use currently in a way that they would be able to communicate with each other and facilitate decision-making giving them intelligence of their own.

IoT has been evolving as the newfangled area of research field. It is intended that billions of physical things or objects will be equipped with diverse kinds of sensors and actuators and allied to the Internet via diverse access networks assisted by technologies such as embedded sensing and actuating, wireless sensor networks, radio frequency identification (RFID), real-time and semantic web services, etc. IoT is essentially cyber-physical systems or a network of networks. With the enormous number of things/objects and sensors/actuators allied to the Internet, a massive and in some circumstances real-time data flow will be inevitably produced by connected things and sensors. It is significant to gather correct raw data in an effectual way; but more significant is to analyze and mine the raw data to abstract more valued information such as correspondences amongst things and services to provide web of things or Internet of services [4].

The Internet of Things (IoT) creates smart objects the eventual building blocks in the improvement of cyber-physical smart universal frameworks. The IoT has a diversity of application domains, including health care. The IoT revolution is restyling contemporary health care with promising technological, economic, and social prospects [5].

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A. IoT in Health Care

IoT aided remote health monitoring system has enormous advantages over traditional health monitoring system. Health sensing components have developed much squeezed and portable, allowing patients to wear them round the clock for monitoring. If these monitoring devices are fortified with inimitable identifiers like RFID, then those devices can be exclusively identified over the Internet. It deeds as an information retriever, retrieving information from the physical world to the digital world. An IoT aided health monitoring device connected to a patient can be considered as a virtual patient in the ordinal world. The simulated patient has the exact physiological conditions as the real patient. A doctor can observe a patient only a uncommon times a day but critical health issues can occur at any moment, 24/7 monitoring of health facts is crucial and it is necessary. As IoT assisted patients can be accessed over the Internet and by other machines, the health state of a patient can be supervised uninterruptedly, allowing critical illness to be detected at the right time so that applicable actions can be taken. Also, IoT can support to collect health records. Generating statistical information correlated to health condition, can be performed by machines. It is faster and voluminous and error free assortment of data that is conceivable manual methods could never achieve. Generating statistics, surveillance, risk drawing of diseases can be completed using remote health data [6].

B. Challenges of IoT in Health Care

Traditional applications and IoT applications (e.g., native or web based applications) are significantly different in many ways. It will convey enormous opportunities and even bigger challenges such as:

- Processing enormous volumes of data published at a high rapidity needs a matching infrastructure.
- Meaningful, Effective, and cost effective mining and analysis of the input events prerequisite a robust analytics platform.
- Since the quantity of connected devices might escalation drastically, the architecture prerequisite to be scalable applications has to have incorporation competences with diverse varieties of devices and systems.
- High network bandwidth is essential to read all the raw data generated by millions of associated devices.
- No uniform standards for data generated from devices which may result in data generated and can prevent widespread adoption.
- There could be potential security implications since the connected devices can be at risk to hacking and hence requisite a secure uniqueness management and authentication to be implemented.
- Defining the data archival, purging and retention could be a perplexing task for the massive amount of data that get engendered from devices.

II. LITERATURE REVIEW

Number of researchers have addressed various issues of chronic diseases, Artificial Intelligence in Healthcare, IoT in Health care and contributed research works. This section focuses on literature review in these areas.

Shima Okada, Naruhiro Shioza et al.[7] mainly attentive on the body movements during sleep because body movements are most directly related to the sleep-wake cycle. They have proposed a system for measuring body movements during sleep using difference image processing. In edict to substantiate the validity of the proposed system, body movement data calculated by difference image processing were compared with the sleep stages measured by PSG and they used video monitoring to characterize the differences in body movement during sleep in normal children and those with ADHD.

Darius Adam Rohani, Helge B.D et al. [8] presented a novel brain-computer interface (BCI) system aiming at the rehabilitation of attention deficit hyperactive disorder in children. It uses the P300 potential in a series of feedback games to improve the subjects' attention. They have applied a support vector machine (SVM) using temporal and template-based features to detect the disorder.

Tracy S. Barger, Donald E et al. [9] developed a Smart-House venture which customs a system of basic sensors to monitor a person's in-home movement; a prototype of the system is being tested within a subject's home. They have examined whether the system could be castoff to detect behavioral patterns and discussed the results in their work.

Tao Liu and Dongxin Lu [10] summarize the concepts of IoT (the internet of things), introduced the different comprehensions, history of IoT, illustrated the key technologies of IoT, and applications of IoT.

Dong-Hwan Park and Hyo-Chan Bang[11] focused on how technologies contribute to improve interoperability between IoT devices, and making easily use of IoT devices. The anticipated platform technology affords semantic-based IoT information services, and semantic interoperability of IoT devices. This service platform is applicable to a lot of semantic IoT services: collecting invisible information in tangible environs by smart devices, providing smart life services by sharing, participating, distributing open sensing information.

Chayan Sarkar and Akshay Uttama Nambi [12] presented a unified semantic knowledge base for IoT which uses ontology as the building blocks. Most of the current ontology for IoT focus on resources, services and location information. They built upon the current state-of-the-art ontology to provide contextual information and set of policies to execute services. Knowledge base consists of several ontology *viz,* resource, location, context & domain, policy and service ontology.

Sai Kiran P, Rajalakshmi et al. [13] proposed a remote health care monitoring system, the composed medical data from bio-medical sensors conveyed to the adjacent gateway for auxiliary processing. Transmission of data subsidizes to a substantial amount of power depletion by the transmitter and upsurge in the network traffic. The metrics castoff for performance analysis are the extent of power saving and reduction in network traffic. The proposed rule engine contributes a substantial reduction in energy consumption and network traffic generated.

Iuliana Chiuchisan, Hariton-Nicolae et al. [14] framed a general architecture for a health care system to monitor patients at threat in smart Intensive Care Units. The system counsels and alerts in real time the doctors/medical assistants about the mutable of vigorous constraints or the movement of the patients and also about important changes in environmental parameters, in order to take preventive measures.

Boyi Xu, Li Da Xu et al. [15] proposed a semantic data model to store and interprets IoT data. Then a resource-based Ubiquitous Data accessing method is designed and developed to acquire and practice IoT data universally to improve the accessibility to IoT data resources. Finally, they presented an IoT-based system for emergency medical services and demonstrated how to collect, integrate, and interoperate IoT data.

Nuno Vasco Lopes, Filipe Pintoz et al. [16] presented IoT architecture for disabled people which is anticipates to describe, identify the furthermost appropriate IoT technologies and international criterions for the stack of the proposed architecture. In particular, they discuss the empowering IoT technologies and its feasibility for people with disabilities. At the end, they considered two use cases that are formerly being deployed for this population.

III. OBJECTIVE OF IOT IN HEALTHCARE

- Due to the availability of Internet for a decent price and the ease of access to Internet, wearable IoT devices have been a huge hit in the market. Because end users, clients and customers in healthcare network are humans (patients or health-conscious individuals), developing of ambient intelligence is crucial.
- To provide Ambient intelligence for the continuous learning about patient's data executes any required action triggered by a recognized event. The Integration of autonomous control and human computer interaction (HCI) technologies into ambient intelligence can further enhance the capability of IoT-aided healthcare services.
- To gain the information about human in real time through IoT wearable device.
- Preprocessing of data acquisitioned about human (if necessary).
- Analyzing and Prediction of chronic disorders in early stage through the data mining techniques which provides the methodology useful for decision making.
- To bring IoT-based healthcare solutions anytime, anywhere.

IV. PROPOSED METHODOLOGY

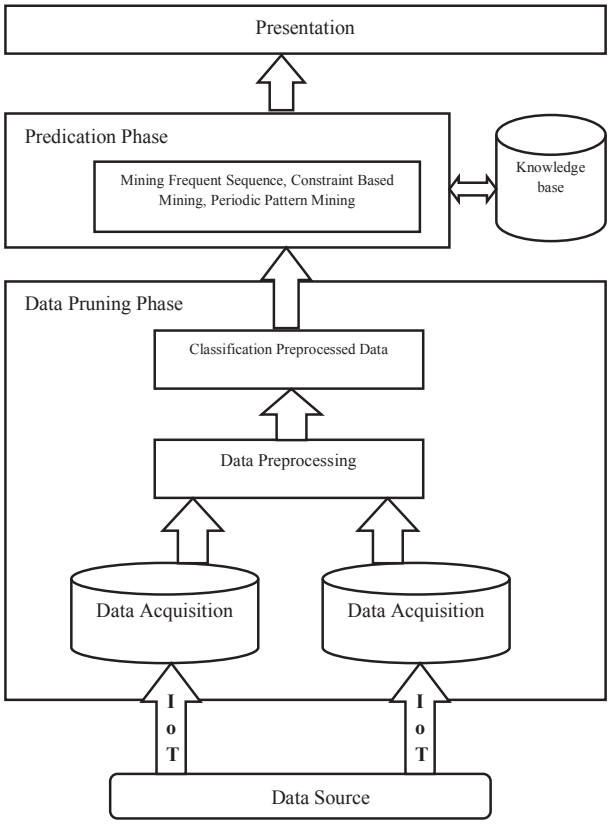

Figure 1: Inferring Information and Knowledge from Health Care Data

The above figure 1 depicted how to infer the Information and knowledge for the prediction of chronic disorders from the wearable Health Care devices. In tier-1 raw and unrefined data acquired from IoT healthcare devices/systems monitoring wearable device which has many sensors including EEG sensor, galvanic skin response sensor, ECG Sensor, accelerometer and a skin temperature sensor etc. In tier-2 information is inferred from the data by filtering, processing categorizing, condensing and contextualizing data if there is much irrelevant and redundant information existing or noisy and unreliable data. In tier-3 the analysis/predication phase, we need to design algorithms for prediction purpose of Chronic diseases (eg, cardiovascular diseases, mental health disorders, diabetes, stroke etc.) by the means of various mining techniques like Constraint based mining, periodic pattern mining with the data that we have gathered and come to some valid conclusions in decision making which results in catalogue the results into the following categories – Ideal, Normal, With Symptoms, Condition exists in real time. Knowledge is inferred from information by organizing and

structuring information and is put into action to achieve specified objective.

V. IoT HEALTHCARE STATUS AND VISIONS OF SOME WELL-KNOWN TECHNOLOGY FIRMS

This section gives the scope of the usage of IoT in industry side and government sector:

Google and Microsoft: Google has opened its code for an open source physical web standard for IoT, which can be considered an attempt to arrange an easier approach to communicate with connected medical devices [17] and Microsoft has focused on using an intelligent system to uncover the potential of IoT-based health care solutions. Intelligent systems provide the backbone of technologies that allow for capture of health data from devices to ensure required connectivity [18].

Intel and IBM: Intel emphasizes real-time synchronous communication systems and health data streaming, which can help reduce the cycle time and improve the first-time quality of many existing medical workflow environments. Intel's vision is to bring about IoT-based healthcare solutions anytime, anywhere [19] and IBM redefines value and success in health care through the notion of smarter health care. IBM has develop a set of IoT devices through partnerships of other renowned firms across the world. It focuses on a series of healthcare solutions such as connected home health, data governance for health care, and health analytics for healthcare providers [20].

Apple: Apple has publicly claimed the IoT as an ultimate technology. The apple watch can be considered a smart watch, a fitness tracker, or heart monitor. The Memorial Hermann healthcare system relies a completely on Apple's Solutions to provide efficient and connected healthcare services focusing on secure access, physician gains, and better care [21].

CISCO and Qualcomm: CISCO is ready to provide converged systems based on unrelated networks and can introduce effective algorithm for handling cumulative traffic loads originating from massively deployed IoT healthcare devices with advanced data analytics. CISCO is working with leading healthcare organizations to develop medical-grade network architecture [22] and the 2net Platform of Qualcomm Life offers a set of wireless health solutions that can capture and deliver health device data to integrated portals and databases from almost all wireless medical devices of users. Qualcomm is demanding to advance intelligent, intuitive, and innovate IoT healthcare solutions [23].

Government Sector: Moreover the Indian government took lot of initiatives to encourage the IoT in healthcare. These efforts are predictable to boost the use of IoT in India's Healthcare sector. Most of the country likes U.S, Japan, Germany, Korea, china, France, Australia taking initiatives to drive the use of IoT in the healthcare sector.

VI. CONCLUSION

Early identification of any disorder or medical condition can help a person in overcoming it at the earliest. From the above literature it is clear that the primary research goal has to be greatly enhanced the quality and efficiency of Health care and to respond to widespread public health emergencies through the acquisition, management, and use of information in health data using IoT.

REFERENCES

[1] Vikram Patel, Somnath Chatterji, et.al "India: Towards Universal Health Coverage- Chronic diseases and injuries in India", Vol. 377, pp 413-428, January 29, 2011.

[2] Giovanni Acampora, Diane J. Cook, Parisa Rashidi and Athanasios V. Vasilakos, "A Survey on Ambient Intelligence in Healthcare", Proceedings of the IEEE , Vol. 101, No. 12, pp 2470- 2494, , December 2013.

[3] Ramakrishnan Iyer and Radharaman Mishra, "Building Intelligent Internet of Things Applications using Microsoft Stream lnsight", IGATE Global Solution, pp 1-7, April 2014.

[4] Chonggang Wang and Mahmoud Daneshmand, "Guest Editorial Special Issue on Internet of Things (IoT): Architecture, Protocols and Services", IEEE Sensors Journal, Vol. 13, No. 10, pp 3505-3510, October 2013.

[5] S. M. Riazul Islam, Daehan Kwak and Kyung-Sup Kwak, "The Internet of Things for Health Care: A Comprehensive Survey", Volume 3, IEEE, pp 678-708, 2015.

[6] Sourav Kumar Dhar, Suman Sankar Bhunia and Nandini Mukherjee , "Interference Aware Scheduling of Sensors in IoT Enabled Health-care Monitoring System", Fourth International Conference of Emerging Applications of Information Technology,IEEE, pp 152-157, 2014.

[7] Shima Okada, Naruhiro Shioza W A and Masaaki Makika W A, "Body Movement in Children with ADHD Calculated Using Video Images", Proceedings of the IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI 2012)Hong Kong and Shenzhen, China, pp 60-61, Jan 2012.

[8] Darius Adam Rohani, Helge B.D. Sorensen and Sadasivan Puthusserypady, "Brain-Computer Interface using P300 and Virtual Reality: A Gaming Approach for Treating ADHD",IEEE, pp 3606-3609,2014.

[9] Tracy S. Barger, Donald E. Brown and Majd Alwan, "Health-Status Monitoring Through Analysis of Behavioral Patterns", IEEE Transactions on Systems, MAN And Cybernetics—Part A: Systems And Humans, Vol. 35, No. 1, pp 22-27, Jan 2015.

[10] Tao Liu and Dongxin Lu, "The Application and Development of IOT", International Symposium on Information Technology in Medicine And Education ,IEEE, pp 991-994, 2012.

[11] Dong-Hwan Park and Hyo-Chan Bang, "Semantic Open IoT Service Platform Technology", World Forum on Internet of Things (WF-IoT, IEEE. pp 85-88), 2014.

[12] Chayan Sarkar and Akshay Uttama Nambi S. N, "A Scalable Distributed Architecture towards Unifying IoT Applications", World Forum on Internet of Things (WF-IoT),IEEE, pp 508-513, 2014.

[13] M. P. R. Sai Kiran, P. Rajalakshmi, Krishna Bharadwaj and Amit Acharyya, "Adaptive Rule Engine Based IoT Enabled Remote Health Care Data Acquisition and Smart Transmission System", World Forum on Internet of Things (WF-IoT), IEEE, pp 253-258, 2014.

[14] Iuliana Chiuchisan, Hariton-Nicolae Costin and Oana Geman, "Adopting the Internet of Things Technologies in Health Care Systems", International Conference and Exposition on Electrical and Power Engineering (EPE 2014) IEEE, pp 532-535, 2014.

[15] Boyi Xu, Li Da Xu, Hongming Cai, Cheng Xie, Jingyuan Hu and Fenglin Bu, "Ubiquitous Data Accessing Method in IoT-Based Information System for Emergency Medical Services", IEEE Transactions on Industrial Informatics, Vol. 10, No. 2, pp 1578-1586, May 2014.

[16] Nuno Vasco Lopes, Filipe Pintoz, Pedro Furtado and Jorge Silva, "IoT Architecture Proposal for Disabled People", Third International Workshop on Internet of Things (IoT) Communications and Technologies IEEE, pp 152-158, 2014.

[17] Physical Web: Walk Up and Use Anything. [Online].Available: http://google.github.io/Physical-web, accessed June 15, 2015.

[18]Health Solutions From Microsoft. [Online]. Available:http://www.microsoft.com/windows/embedded/en-us/healthcare.aspx,accessed June 15, 2015.

[19]Intel Across Healthcare. [Online]. Available: http://www.intel.com/content/ www/us/en/healthcare-it/intel-across-healthcaredishman-video.html, accessed June 15, 2015.

[20] Smarter Healthcare: Rede ning Value and Success in Healthcare. [Online].Available:http://www.ibm.com/smarterplanet/us/en/healthcare_solutions/nextsteps, accessed June 15, 2015.

[21]Memorial Hermann Healthcare System. [Online]. Available:http://www.apple.com/iphone/business/proles/memorial-hermann, accessed June 15, 2015.

[22]Cisco Services for Connected Health: Intelligent Network,SmartMedicine.[Online].Available:http://www.cisco.com/web/strategy/healthcare/connectedhealth/index.html, accessed June 15,2015.

[23]Introducing the Award Winning 2net Platform.[Online].Available:http://www.qualcommlife.com/ wireless-health, accessed June 15, 2015.

[24] Hui Yang and Erhun Kundakcioglu, "Healthcare Intelligence: Turning Data into Knowledge", IEEE Computer Society, IEEE, pp 54-68, 2014.

[25] Jacek Lewandowski, Raouf N. G. Naguib and KuoMing Chao, "Logic-Centered Architecture for Ubiquitous Health Monitoring", IEEE Journal of Biomedical And Health Informatics, Vol. 18, No. 5, pp 1525- 1532, September 2014.