Smart HealthCare: A boon for Disabled

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ABSTRACT

As the technology is branching out, it has rendered unimaginable capabilities to the domiciles of this mother Earth. Today, internet is no longer a system that connects computers and servers. Actually, it has become internet of things. The things which are intelligent enough to sense weather, temperature, time, human needs and demands, health issues, diseases and so on. The internet in today's world has artificial eyes, ears, and brains which is collectively known as 'Artificial intelligence' in the world of science. The bestowal of science and technology has modified the way to pursue healthy life. Health care technology is progressing from its nascent stage towards its maturity and it is developing with the development of various technologies namely cloud computing, internet of things, artificial intelligence, big data, deep learning and so forth. In this paper, the author has put forth the various strategies' which are beneficial for the

Keywords: Patient centric; remote patient monitoring; m-health and intelligent buildings.

INTRODUCTION

Technology is expanding its horizons, as it is expanding it is providing humans with supernatural powers. The contribution of technology in human health and fitness is one of the pivotal domains of study in recent times and is excessively sensitive in terms of designing and manufacturing health and fitness equipment. Smart health technology is a fusion of diverse form of technologies ranging from Cloud Computing, Internet of things, and Artificial Intelligence to Big data and deep learning. Furthermore, the approach to health care is no longer clinic-centric as it has become patient-centric. This approach to smart health keeps doctor more involved with the patient better than ever [1]. In this era, Artificial Intelligence has its panoptic influence which is not limited to the domiciles of earth, as it has wider scope which covers skies and the waters as well. The state-of-the-art IoT technology uses smart sensing devices, actuators and bio-sensors for remote patient monitoring by fetching real-time data of patients[2] [3] [4]. These technologies when collaborate can drop the cost of personalised and effective health in two ways which are elaborated in the upcoming paragraphs. This ubiquitous computing has countenanced people around-the-globe to self-monitor their health anytime and anywhere. Not only this, it's reliable, cost-efficient and timely nature has an influential impact on the self-sustained ecosystem of struggling health care in the medical world[5]. The time is no longer far away when smart hospitals with intelligent intensive care units, specialised units and primary units would be serving patients. Patients would be sensed every second using bio-sensors to render amenities than ever before. Section I of this book chapter explicates the technologies utilised in smart health. Moreover, technology has contributed in the health by gifting numerous wearables including intelligent fitness system, smart wheelchairs, online symptom-checker services, pavlok, H2Opal (Smart Water Bottle Hydration Tracker), Smart Thermometer etc. to the mankind. What's more, some body wearables are subservient in receiving vital information like ECG, heart-rate, blood pressure etc [3]. In addition to it, a health-care system namely ZUPS render numerous amenities to disabled persons which incorporates medical alarms, health monitoring, smart navigations and so on [3]. Notably, countless apps which can be installed on body wearables sense data from the wrist to monitor heart rate, blood pressure, diabetes mellitus, vascular disease, previous stroke, and hypertension and so on[3]. This m-health is significantly worthwhile that it succours the sufferer to receive personalised health care without forsaking the comfort of the couch of the living room[5] [6]. The primary purpose of such advanced measures taking place in health care industry is to mitigate the cost of travelling for patients and to render intelligent health services at hand. The study of each device mentioned above is performed in section II of this chapter. Smart health domain has enormous impact on the health of elderly, disabled, new born babies, and mothers. In the times of sickness, home acts as the best place for regeneration and if it is a smart home having intelligent and connected healthcare services it is not less than a paradise for the sufferer[7] [8]. Intelligent health care systems accentuate majorly on rendering comfort to the elderly and disabled persons by monitoring their daily living activities in order to prevent them from foreseen health problems. Another mind-boggling innovation of smart health is for mothers who have to feed new born babies while experiencing uneasiness. A smart breast pumps exempt mothers' overhead of feeding babies manually at work or during travel. Health care of elderly, disabled persons, babies and mothers is delineated in section III. The section IV portrays the mobility of the patient using smart transportation. Smart wheelchairs and smart ambulances aid in the mobility of the

patient in a more promising way. Smart wheelchairs use sensors to sense the obstacles in order to assist the disabled person to move from one place to another without any sort of dependence on other human beings [9]. Smart ambulance is equipped with necessary paraphernalia and software components which would perform on-fleet diagnosis. Therefore, the surgeons can acquire the knowledge about the severity of the case well in advance, so that they can get ready for the operation before the arrival of the patient at the hospital. Furthermore, section V explains the smart buildings inclusive of smart homes and smart hospitals. Besides all the features of smart infrastructure which is explained in detail in section V, intelligent buildings are enabled recently to help filtering the air pollution and thereby contributing towards greener environment and better public health[10]F. Moreover, internet of things in health care sectors take into account the hospitals which focus on ameliorating the care facilities of the patients while considering other factors like space, size and expenditure. Next, the chapter puts forward assisted living technologies like telecare and telehealth in smart homes to manage health conditions. Technologists and researchers by joining forces with health policy makers and civil society can engender healthier society by the use of smart health solutions. Besides all the blessings of technologies, one of the phases of technology is in smart public health. The WSN has opened the doors for smart public health by sensing the conditions of the environment and ameliorating the health of the community by playing a considerable part in smart sanitation. Smart public health sphere is elicited in section VI. Next, in section VII, the chapter puts forward the prevailing disease detection and prevention systems. The Cloud computing has aided the cerebral stroke detection system to analyse and store data which would predict weather the patient is suffering from cerebral stroke or not[11]. Additionally, smart prevention measures are explicated for certain types of cancers (skin or lung) in context with the smart communities. Further in section VIII, the contribution of technology in keeping medical records smartly from birth till death is discussed. The Smart health cards which are the potential carriers of portable medical record, health report, insurance details, doctor visits and so forth[12]. This technology has drastically changed the lives of the patients by replacing traditional paper-reports and facilitating lifetime health monitoring and recognizing specific patterns of illness[12]. Further, in this chapter IoT layers linked with smart health care are discussed. Last but not least, myriad digital health care and elderly health care start-ups are actually contributing a major part in rendering smart health care to its patients which is elaborated including numerous mobile applications such as EyeNetra, uCheck, DementiAssist and so on[6].

BACKGROUND

Tech-savvy people are mixing technology with health as it is helping round-the-clock busy individuals to take a care of the health in an automated fashion. Varieties of technologies are used to reap the benefits out of the health and fitness equipment which would mimic as if the patient is physically interacting with the doctor to get the whole body examined meticulously.

Smart health commenced with the advent of virtualization [15]. The concept of virtual health is not novel; actually, the first virtual diagnosis was done in 1879 just after three years after the invention of telephone by one of the most revered innovator of nineteenth century known by the name ‘Alexander Graham Bell’ [15]. Subsequent to the invention of mystical telephone, there took place an unabated growth in the development and use of mobile telecommunications and internet access [15]. This development has not ceased even in recent times[15]. Virtualization is brought into picture by the revolutionary equipments, not limited to wearable gadgets and smartphones which are helping the populace to monitor health and diagnose diseases [16]. In order to sap the barriers in the route of medical care, virtualization played a major role by making healthcare more accessible and continuous [16].

Industry 4.0 came with the functionality to store and process data remotely which evolves cloud computing. It is cost-effective, energy saving, secure and flexible as compared to offline methods of processing and storing data [13]. Cloud computing is an umbrella term which comprises data centres, virtual machines, hosts, and other indispensable resources [13]. It is an unconventional way of delivering health care services with efficacy [17]. Cloud computing offers the populace with pioneering medical services which includes Microsoft HealthVault and Google Health Platform [17]. Many medical errors took place due to the inadequate access to the patients’ records. Cloud computing came with the purpose of sapping errors by engendering ubiquitous computing for efficient healthcare [17]. When cloud computing model is deployed for smart healthcare services, it renders the patients and the doctors with revamped quality of services (QoS) [18]. Besides upgrading the quality of services, cloud technology also aids the nexus of different healthcare centres [18].

'Medical IoT' is a new term which illustrates use of IoT in the domain of health and fitness [19]. This term expanded itself by integrating with Wireless Sensor Network (WSN) and Radio Frequency Identification (RFID), further it made progress by collaborating with more advanced form of technologies encompassing cloud computing, cyber-physical systems, internet services and so forth [4]. This approach is used to accumulate data from patients using a variety of resources [13]. MIoT is central to a numbers of applications in the domain of disease diagnosis, monitoring and prevention [20]. Numerous applications took birth from the womb of this technology ranging from self-health-monitoring devices to remote patient monitoring services and intelligent ICUs [20]. MIoT is a buzzword which exhibits enlightened ambience which comprises heterogeneous components leveraging revamped healthcare to the society [21].

As the data is proliferating, the transition took place from bits and bytes to zettabytes and yottabytes. Innumerable data is generated everyday due to which big data has taken the form of a phenomenon in biomedical domain [1] [22]. Although big data has some implications related to confidentiality, complexity, privacy and security of the data acquired by health monitoring devices in casual mode, via internet or biosensors [23]. From national to global level, professionals now consider the veracity of the statement 'big data will metamorphose the way to public health'[23]. In recent times, big data is being utilised to give a new way patients are prescribed medicines [14] [1]. That novel approach is none other than the precision medicine which renders the patients with customised and personalised healthcare [1].

Machine learning is a rudimentary structure to produce output by processing input data[24]. ML algorithms are categorized into three sections (based on disparate learning mechanisms): Supervised, Semi-supervised, and unsupervised machine learning algorithms[25]. Supervised learning entails labelled and known outcomes[25]. The example algorithms for SL are Neural Networks, Bayesian Networks, decision tree, and support vector machine[25]. Unsupervised learning is implemented when the data is unlabelled and the USL algorithm is coerced to unearth structure data and relationships between data variables[25]. The example USL algorithms are: K-means clustering, hierarchical clustering, and principal component analysis[25]. Semi-Supervised learning is an integration of supervised and unsupervised learning techniques[25]. This learning scheme is implemented when part of the data in the dataset is labelled and the remaining data is unlabelled[25]. Example algorithms for this learning mechanism are- Expectation-maximization, support vector machine, and Markov decision processes[25].

Neural network is the computational anatomy comprising neurons and synapses; these neurons are inter-connected where each connection has certain weight. It is a machine learning process which is inspired by the biological neural networks[26]. ANN are utilized to analyse medical records of patients [26]. Numerous observations and historical patterns of consumers' demands are taken into consideration for future predictions [26]. The ANNs have the core capability to learn from the previous inputs and thus contribute towards effective management of e-business systems [26]. Few decades ago, the neural networks were employed in diagnosing sleep disorders [27].

Deep Learning was inaugurated by Hinton and Salakhutdinov in 2006 [28]. It is defined as a learning network escorted by numerous layers of neurons [18] [28].To acquire the most out of Big Data Analytics, deep learning algorithms are utilized to take out useful information out of Big Data [29]. Apple's iPhone assistant 'Siri' deploy functionality using deep learning mechanism. Moreover, Google's translator, image and video searching, and android's voice recognition makes use of deep learning for its operation [29]. Deep Learning has multitudinous applications in the field of Health care, medicine, human behaviour, and so forth[29].

CONTRIBUTION IN THE WORLD OF HEALTH

Context-aware systems use raw data (e.g. behavioural, physiological and environmental) obtained from various sensors and devices, process it to acquire the information which is ultimately helpful in analysing patient's physiological and behavioural patterns [7]. The context aware systems record and recognise patients' daily activities, for instance, higher washroom activity may indicate the risk of diabetes and sleep disorders insinuate hepatitis C [7].

Health Smart Homes provide extensive care to the individuals with disparate diseases and disorders [30]. Telehealth is a method which makes use of telecommunication and information technologies to provide quality care to patients despite geographical disparity [30]. Virtual connections via digital, wireless and multimedia devices are formed to monitor and transmit patients' health related information [30]. The fundamental components of smart medical home are sensory devices, conversational systems, multimedia devices, virtual reality, wireless networking, haptic interface and health monitoring devices[31]. In addition to it, there are numerous conditions when people engrossed in daily activities forget to take medicines. Home based healthcare systems have put forth the medicine reminder systems for secure heath [32]. The system consists of sensors and alarm system to enable remote health monitoring and medicine reminder calls [32]. A pill container equipped with sensors is a smart medicine cabinet in which RFID sensors are embedded whose function is to notice the number of times the pill container is opened for use. Finally, it has in-built

operation to send notifications over the smart phone to attain improvement in the health of the sufferer [33]. Additionally, smart homes are equipped with three very common sensors namely ultrasonic sensors, infrared and pressure sensors (installed within the surface of the floor) to monitor the activities of the subjects. But the stumbling block in making use of these basic sensors is that these cannot distinguish the subject whose motion is to be watched [34]. Therefore, another approach to keep subjects under proper surveillance is 'multi-sensor monitoring systems' which make use of an electronic patch (accelerometer, a microcontroller and a 802.15.4 wireless transceiver), radio beacons, motion sensor networks and analysis algorithms to diagnose aberrant activities of the physically impaired persons and alert the caregivers in real-time [34]. Smart phone and tablet PCs render advantage of communicating and presenting the information to the users in smart healthcare infrastructure [34]. Numerous health smart home projects are in the development phase like 'Smart Medical Advisor' which is an initiative of AgeLab at MIT for ageing population to support independent living with the use of medical advisors and adaptive devices [31]. Another similar approach is being carried out by the Medical Automation Research Centre at Virginia University for smart in-home health monitoring including sleep monitoring under the name "SmartHouse Technologies" [31].

Innumerable health and fitness issues in elderly and dependable people have made necessary the inclusion of smart health monitoring systems as a part of smart home. Besides sapping the expenses of doctor visits these health monitoring devices are also conducive in rendering timely e-healthcare services to the people who are in the dire need of punctilious supervision.

A variety of smart watches, heart rate monitors and other fitness trackers are available in the market to benefit the society in a smarter way[35]. IoT with artificial intelligence and web-technologies contribute collaboratively in developing different intelligent fitness systems. Firstly, a system designed to guide an individual to perform fitness exercise accurately.

The wounds become chronic when the affected tissues are not regenerated within the stipulated time of three months [36]. In such a situation, paper-based smart bandages are advantageous in monitoring wound status wirelessly [36]. This is an automated approach which would also diagnose the generation of pressure ulcers besides monitoring wounds in an automated fashion [36]. The automated, omniphobic, single-use, inexpensive, lightweight, easy-to-use and biodegradable bandages use potentiostat which wirelessly report the user or the medical personnel about the conditions of the chronic wounds and eventually facilitating its successful treatment and cure [36]. It helps in maintaining the long-term data statistics of the damaged tissues wirelessly to guide treatment decisions [36]. It is noteworthy that these bandages take care of the health of the patient using sensor which is fabricated on its flexible surface to mitigate the stress and suffering incorporated by the overhead of changing the dressings [36].

Smart wearable devices are auspicious in bringing fortunes towards people's health. Miscellaneous wearable gadgets which are linked with smartphones through disparate mobile applications are utilised to cognize health status [4]. Health conscious patients can collect data about various health parameters inclusive of heartbeat rate, blood pressure, glucose level and so forth [4]. This hand-held monitoring would help the patient to recognise in advance the symptoms of forthcoming threats to one's own health [4]. In such a way, one can predetermine the genesis of certain ailments and can prevent or cure before they become fierce and complicated [4].

Smart wheelchair is sophisticated mobility equipment which succours dependable and physically disable person to move across with-in a building or even outdoor using automated technology [9]. Smart wheelchairs are equipped with sensors, tracking systems and smart algorithms to control the electrically powered wheelchair to perform necessitated tasks [9]. Moreover, two-dimensional laser range finder is employed for indoor localization whereas outdoor localisation is accomplished by Global navigation satellite system (GNSS) [9]. Notably, GNSS alone is not sufficient to carry out outdoor localisation because smart wheelchairs operate more often on pedestrian paths which are not documented precisely on the google maps [9]. So, the miscalculations in GNSS are conquered by integrating GNSS with odometry and *OpenStreetMap(OSM)* data [9].

IoT-driven smart cities can render more efficient healthcare with the introduction of smart transportation for the patients suffering from serious diseases. Such people can be brought to the hospitals in smart ambulances. Smart ambulances come with variety of features like on-fleet diagnosis so that the caregivers including nurses and surgeons can keep ready the necessitated devices and tools before the arrival of the patient. This scenario is possible with the integration of IoT in which the surgeon knows the condition of the patient beforehand.

Smarter equipment and communication systems engender enhanced administration, exclusive patient-care, efficient operations and surpassing profitability [34]. The technology has become smart enough to sense the polluted air; thereby scientists have developed a novel system 'SmartAir' to filter the particulate matter from the air, hence, purifying it for the benefit of the patients suffering from asthma, other respiratory or cardiovascular troubles.

CONCLUSION

Technology is like you touched the mobile application and, hey presto, your diabetes are checked! The wearable gadgets and sensors are excessively user-friendly. Even in health smart homes (HSH), variety of devices are employed to monitor health on regular basis, possibly all the devices could be operated by the caregivers at home with their eyes shut. In this world of smart health, people can diagnose various disorders and ailments like cancer, diabetes, blood pressure, sleep disorders and so forth while sitting on the comfy couch. Physical and mental health is becoming effortless, nowadays, with the advent of different technologies. The fluctuations in the health are diagnosed very easily and thereby requisite measures are taken to cure them afterwards. Technologies in particular IoT, Artificial Intelligence, Big data and Machine Learning are applauded every minute which are rendering the individuals of the modern world to manage their heath periodically. Last but not least, this cost-effective approach mitigates the doctor visits; moreover, telemedicine and telehealth are other contributions of smart health which would predetermine the symptoms and prevent an individual to pay big bucks for the treatment of the disease which is diagnosed later in life.

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