Internet of Medical Things for Independent Living and Re-Learning

Ali Hassan Sodhro, Karin Ahlin, Awais Ahmad, Peter Mozelius
Computer and Systems Science
Mid Sweden University
Östersund, Sweden
Emails: {alihassan.sodhro, Karin.ahlin, Awais.ahmad, Peter.mozelius}@miun.se

***Abstract*— This position paper gives better insight about the role and importance of Internet of Medical Things (IoMT) for independent living and re-learning for older adults. Sensing Technologies are the paradigm shift for transforming conventional healthcare practices into the smart, and self-assisted activities, which are envisioned for today's medical world. Internet of Things (IoT) and IoMT are the inter-related technologies for promoting independent living and re-learning practices. In this paper, re-learning is defined as the process for adults to recover useful instrumental activities of daily living skills that have been lost after an impairment.**

Keywords: **Internet of Medical Things; Independent Living; Re-Learning; Smart Homes; Older Adults.**

I. INTRODUCTION

The aim of this positional paper is to show how the Internet of Medical things (IoMT) can be used for independent living and re-learning. In addition, the paper shows how healthcare is revolutionized with the help of the Internet of Things (IoT) and advanced sensing technology. This paper presents the role of IoMT in independent living of elderly people both in their own houses and in retirement homes, and the utility of embedding sensing technologies in everyday life objects. Thus, IoMT can reduce the expenses for healthcare due to the lower need for personal assistance, and provides a better Quality of Life (QoL) to the elderly users [1][2].

In the modern world, a better healthcare system is one of the main challenges of a growing world population. The IoMT is a collection of Wi-Fi-enabled medical devices intended to collect data on health parameters such as heart rate or blood pressure. Wireless sensor networks (WSNs) enable device-to-device (D2D) communication, necessary for the synthesis of multiple types of medical data. In addition, IoMT is the vision of providing a better healthcare system. The main requirements for WSNs are increased data rates, high speed and more bandwidth. Ongoing development of consumer technologies not only have enhanced the speed of Internet driven platforms, but also encouraged and promoted the markets of IoT devices such as smartphones, Personal Digital Assistants (PDAs), and many types of sensor-enabled wearables [3]. In addition, the technology company Ericsson claims advanced technologies that manage the massive data amounts, bandwidth, delay, and data rate will entirely transform and reshape the healthcare world. There are various advantages of the IoMT based smart and pervasive healthcare; for instance, better Quality of Service (QoS), adaptive and scalable features to other heterogeneous networks, high and cost-effective capacity, high reliability, lower delay, longer connectivity with intelligent data traffic management, and high energy-efficiency [4].

The IoMT is a collection of various sensor nodes, which collect data and transmit to a gateway (i.e., the platform or a medical office) for proper connection and communication with the help of the cloud and the Internet. The main task of the IoMT is to incorporate lightweight portable sensor technologies to support healthcare systems with impressive and integral capabilities for ongoing data collection and synthesis to support accurate monitoring and diagnosis of older adults. The physician can efficiently access and review patients' data and analyse which patient needs more attention. The IoMT is a promising technology for remote older patients monitoring where it improves medical care with the key focus on 'healthcare for anyone everywhere' [5].

The remaining of the position paper is organized as follows. Section II presents Internet of Things, Section III discusses Internet of Medical Things. Independent living is described in Section IV and Section V reveals the re-learning. Discussion, conclusion and future research are given in Sections VI and VII, respectively.

II. INTERNET OF THINGS

Longer lives and better healthcare facilities are cornerstones for an increasing aging society, and in several parts of the world healthcare is becoming challenging with high cost and poor economic status, which affects many generations. The recent trends in emerging Information Communication Technologies (ICTs) have reshaped the entire healthcare world by providing easy and effective data-collecting, diagnosis, and treatment facilities [1]. It is necessary to manage and preserve the patient's experience for efficient monitoring of the healthcare applications for instance, home health monitoring, and Personal Health Records (PHRs). Several IoT-based wearable devices for instance, smartwatches, smart rings, smart necklace, and Fitbits can be used with the human body (i.e., on/inside/implant) to collect vital-sign signals for effective diagnosis and cure. The service providers can access the data for accurate diagnosis and treatment to give convenient, cost-effective and timely treatment [2].

 ISBN: 978-1-61208-892-1

It is also essential for the healthcare system to assure the availability of accurate and error-free critical information to intended users (physicians and patients). The mobility of IoT devices and pervasive features of integrated technologies adopt different healthcare applications with wide coverage and sustainable connectivity. Thus, it is important to effectively monitor the lives of elderly people while exchanging the data through IoT-based portable devices [6].

III. INTERNET OF MEDICAL THINGS

The rapid increase in the number of elderly people at present gives clear insight for future population record and healthcare status that about 15.7% population shall be in the age range of 65 or older by 2030 [7]. The flexible and scalable features of IoMT easily integrate the wearable medical devices with existing and advanced technologies for independent living, sustainable, reliable and better connectivity with improved efficiency, accuracy and economy [8]. The services offered by IoMT require less cost, are simple, accurate and have an effective mechanism with sustainable battery capacity at fast speed and with reliable connectivity. The IoMT system must be well-equipped with advanced network and continuous connectivity of devices. For scanning and connectivity with doctors, patients must have a valid identity. The rapid growth in smart cellular technologies have revolutionized the notion of healthcare with the support of IoMT [9].

The collected patient's data must be preserved privately for better analysis and diagnosis. Because of its sensitive nature, it is necessary to properly monitor and draw the reports. There is a big impact of IoMT in our daily life and its role increases as life goes on. It also provides solutions to chronic diseases as well as those patients who suffer a lot from constant and long-term pain [10]. The medical data of patients like electrocardiography (ECG), heart rate, and electroencephalogram (EEG) signals can be monitored within e-health applications through recent wearable IoT devices. An important issue in these IoT devices with the transmission of signals is power consumption and the devices need battery resources; there are serious limitations for the continuous observation of signals. To extend the battery lifetime, lossy signal compression is used to reduce the size of collected bio-signals data and, in return, increase the battery lifetime of wearable devices for continuous and long-term monitoring. One-dimensional bio-signals like EEG, ECG and respiratory data are usually available in commercial IoT devices. [11] gives the review of some existing medical data compression algorithms.

IV. INDEPENDENT LIVING

The emerging notion of independent living or ambient assisted living is realized due to the vast and revolutionary role of the Internet of Things (IoT). Due to the lightweight nature and cost-effective features of sensors, it is easy to provide quality of life to elderly patients even at remote locations. Thus, IoT can be considered as promising and vital for various fields such as smart healthcare, smart transportation, and smart cities [12]. The rapid progress and advancement in smart technologies have not only facilitated the lives of every age group, but also reduced the costs of healthcare to reasonable rates. Hence, longer and better life expectancy is the result of emerging and user-friendly IoT-based wearable devices [13].

Over the past two decades, the population of older adults has been rapidly increasing all over the world [14]. Due to these changing demographics, healthcare providers are facing an increasingly massive workload; as time goes on, the need to alleviate their workload becomes more critical [15][17]. On the other hand, despite age-related physical and cognitive problems, older adults like to live independently in their home environment [18]. Several studies highlighted that patients not only recover more quickly in their home environment, but their quality of life is also improved [15][19]. The Internet of-Medical Things (IoMT), which includes technologies and devices such as sensors for windows, doors, temperature, humidity, luminosity, and smart audio and video cameras, might be used to achieve a better QoL and independent living [20].

Several researchers emphasize IoMT as a foundation for independent living, called ambient assisted living; sometimes, the integration of IoMT throughout a house is referred to as a smart home [21]. Researchers focus on requirements for the technology and smart home applications and explain that devices and applications should be flexible, adaptive and changeable over time [21]. The authors of [22] focus on the middleware, which serves as a collection point on the one hand, and as a processing and distribution centre, on the other hand. The data is collected via tailor-made parameter monitoring devices and home sensor-technology and further distributed to care givers. The authors in [20] address problems with IoMT for independent living in terms of user interfaces, easy-to-use features, size, weight, and obtrusiveness. Besides these problems, [23] addresses lack of interoperability causing problems while connecting to caregivers or relatives.

The IoMT implementations for older adults focus on preventing falls and supporting Activity of Daily Life (ADL) [22][24]. Starting with falls, [25] express fall prevention as important for older adults. They built a prototype using an accelerator and sensors. In this case, the accelerometer detects if a fall has occurred and if it does happen, the server will automatically notify the caregivers or relatives. There are several examples focusing on supporting ADL, where one is to add awareness of older adults' decreased physiological resilience and weakened response to stressors [24]. The authors frame their study by collecting data from the participants' activity when moving around the city. The data from older adults is linked with data collected from smart city implementations, such as geographical positions. Another example is predicting upcoming or ongoing disease attacks for noncommunicable diseases and cognitive assessment [20]. They base their system on correlations between physiological and cognitive data and frame it as predictive analysis.

V. RE-LEARNING

In the e-health area, re-learning has been described as the process for an adult to recover useful instrumental activities of daily living skills that have been lost after an impairment

 ISBN: 978-1-61208-892-1

[26][27]. This is a process with the aim of improving the quality of life and well-being of patients, to increase their potential for an independent living. Often, re-learning consists of an unstructured process that has been referred to as the Trial-and-Error method, with skills acquisition by guessing correct responses and learning from errors. However, more structured methods have been tested and the study by [28] found an advantage for errorless re-learning when compared to errorful re-learning among memory-impaired patients.

Errorless learning refers to the use of feed forward activities to prevent learners from making mistakes. Therapists present the different steps in a re-learning activity with detailed instructions and visual cues. Another structured re-learning method is the spaced retrieval approach, a technique that requires a patient to memorise and reproduce task sequences. These methods have been tested and found successful for patients with memory impairment [26][27][29]. In addition to older adults' need for cognitive re-learning, there are also needs for motoric re-learning and speech re-learning [15]. For all these three branches of re-learning, it is essential to adapt the more general instructional design for the older adult target group. A frequently applied approach is to extend pedagogy with the principles of adult learning [30][31].

Cognitive and motoric re-learning are today, to a high degree, technology enhanced, but speech re-learning could also possibly be technology enhanced. However, the condition is to tailor software and hardware solutions to the actual target group [32]. This should also be a condition for instructional design and pedagogy, where the important adult learning principle 'learning to learn' [33] is not exclusively for older adults. For e-health in general and for IoT solutions in particular, there is also a need for upskilling the staff [34]. Finally, for re-learning in the growing number of older adults, it seems worth to consider an extension of the pedagogy–andragogy–heutagogy continuum [35], in the direction towards geragogy, with the idea of facilitating their e-health media literacy [36].

VI. DISCUSSION

A. Smart healthcare

Rapid progress in IoT-based wearable devices has revolutionized the entire traditional healthcare perspective into a smart and pervasive fashion. IoMT is the cornerstone to achieve the required and standard needs of the elderly patients. Intelligent features of the IoT-based IoMT devices not only provide ease and comfort to the patients, but also lead to cost-effective and smart healthcare anywhere and for anyone. Thus, it can be claimed that sensors within IoT and IoMT based wearable technologies, are the vital entities for promoting smart and ubiquitous healthcare.

B. IoMT and older adults independent living

For older adults to live happily and independently, IoT seems to be a cornerstone and it is widespread in its functionality. This claim is built on transforming the traditional homes of the elderly into smart homes using sensing technologies for sending information to caregivers. IoMT allows the possibility to prevent common falls among older adults as well as predict various diseases. Besides, in smart homes, IoMT can be useful for geographical monitoring, combining smart city approaches with older adults' data while conducting physical activities. Still, IoMT for independent living of older adults seems to be in its infancy, and the development potential is not fully utilized.

C. IoMT and Re-learning

Amongst many other things related to e-health and independent living, re-learning can benefit from IoMT enhancement in several aspects. One aspect is the possibility of measuring the progression in the various branches of re-learning. For cognitive and motoric re-learning, there is also the opportunity of monitoring re-learning, both for assessment of exercises and for avoiding accidents. Furthermore, the general technology enhancement can realise the idea of re-learning anytime and anywhere and support the andragogy-heutagogy concept of self-directed learning.

D. Usability and technology acceptance of IoMT for older adults

Although the IoMT based devices have several potential benefits for older adults, the usability of and technology acceptance for these devices has been a matter of concern. Particularly, the older generation who have not used the technology frequently in their entire life might have problems with adapting and using these devices. Age-related impairments and chronic diseases also limit the use of technology in older adults. Therefore, it is of great importance to design and develop IoMT based devices and services according to the special needs of older adults. A User-Centred Design (UCD) approach should be adopted where the users are involved throughout the design and implementation process.

VII. CONCLUSION AND FUTURE RESEARCH

Independent living and re-learning are main activities to be practiced effectively by the older adults on a daily basis to keep themselves happy and healthy. This can be possible through the emerging sensing technology, IoT and IoMT driven wearable devices. Besides, smart and pervasive healthcare is based on the fundamental characteristics of these unobtrusive portable and lightweight devices. Due to its highly intelligent sensing and processing capabilities, IoMT easily provides the 'smart and cost-effective healthcare for older adults'. Finally, the implementation of IoMT to support re-learning and independent living share the same concerns as other e-health technologies: trust, security, personal integrity, user acceptance, and accessibility of ICT.

 ISBN: 978-1-61208-892-1

REFERENCES

[1] E. Borelli et al., "HABITAT: An IoT solution for independent elderly", Sensors. vol. 19, no.5, p. 1258, 2019.

[2] L. Mainetti et al., "An IoT-aware AAL system for elderly people. 2016 IEEE International Multidisciplinary Conference on Computer and Energy Science (SpliTech), 2016, p. 1-6.

[3] M. Hooshmand et al., "Boosting the battery life of wearables for health monitoring through the compression of biosignals", IEEE Internet of Things Journal, vol. 4, no. 5, p. 1647-1662, 2017.

[4] A. H. Sodhro et al., "Towards wearable sensing enabled healthcare framework for elderly patients", IEEE International Conference on Communications (ICC), Dublin, Ireland, 2020, p. 1-5.

[5] D. Rosewater et al., "Battery energy storage state-of-charge forecasting: models, optimization, and accuracy", IEEE Transactions on Smart Grid, vol. 10, no. 3, p. 2453-2462, 2018.

[6] S. M. M. Fattah et al., "Building IoT services for aging in place using standard-based IoT platforms and heterogeneous IoT products", Sensors, vol. 17, no. 10, p. 2311, 2017.

[7] H. Magsi et al., "A Novel Adaptive Battery-Aware Algorithm for Data Transmission in IoT-Based Healthcare Applications", Electronics, vol. 10, no. 4, p. 367, 2021.

[8] T. Zhang et al., "A joint deep learning and Internet of Medical Things driven framework for elderly patients", IEEE Access, vol. 8, no. 2020, p. 75822-75832, 2020.

[9] A. Rashed et al., "Integrated IoT medical platform for remote healthcare and assisted living", 2017 IEEE Japan-Africa Conference on Electronics, Communications and Computers (JAC-ECC), 2017, 1-7.

[10] H. Arora et al., "Experimental validation of the recovery effect in batteries for wearable sensors and healthcare devices discovering the existence of hidden time constants", The Journal of Engineering, vol. 2017, no. 10, p. 548-556, 2017.

[11] H. Kaur, "An Energy Efficient Wireless Body Area Network Using Genetic Algorithm", International Journal of Advanced Research in Computer Science, vol. 8, no. 8, p. 98-106, 2017.

[12] R. Maskeliūnas, R. Damaševičius, and S. Segal, "A review of internet of things technologies for ambient assisted living environments," Future Internet, vol. 11, no. 12, p. 259, 2019

[13] A. H. Sodhro et al., " Power Management Strategies for Medical Information Transmission in Wireless Body Sensor Networks", IEEE Consumer Electronics Magazine, vol. 9, no. 2, p. 47-51, 2020.

[14] P. Mozelius, K. Ahlin, and A. Ahmad, "A game-based approach for motoric stroke rehabilitation: defining the requirements", ECGBL 2019, 13th European Conference on Games Based Learning, Odense, Denmark, 2019, p. 1-7.

[15] A. Ahmad, P. Mozelius, and K. Ahlin, "Testbed requirements for technology enhanced stroke rehabilitation to support independent living", ICT4AWE 2019-5th International Conference on Information and Communication Technologies for Ageing Well and e-Health, Heraklion, Greece, 2019, p. 1-8, INSTICC Press.

[16] A. H. Sodhro et al., "Towards Convergence of AI and IoT for Energy Efficient Communication in Smart Homes", IEEE Internet of Things Journal, vol. 8, no. 12, p. 9664-9671, 2021.

[17] Y. K. Choi and H. J. Thompson, "Use of an Internet-of-things smart home system for healthy aging in older adults in residential settings: Pilot feasibility study", JMIR aging, vol. 3, no. 2, p. 21964, 2020.

[18] S. Peek et al., "Older adults' reasons for using technology while aging in place", Gerontology, vol. 62, no. 2, p. 226-237, 2016.

[19] A. H. Sodhro et al., "Power Control Algorithms for Media Transmission in Remote Healthcare Systems", IEEE Access, vol. 6, no. 2018, p. 42384-42394, 2018.

[20] C. Vizitiu et al., "Exhaustive Description of the System Architecture and Prototype Implementation of an IoT-Based eHealth Biometric Monitoring System for Elders in Independent Living", Sensors, vol. 21, no. 5, p. 1837, 2021.

[21] S. Helal and C. N. Bull, "From smart homes to smart-ready homes and communities", Dementia and geriatric cognitive disorders, vol. 47, no. 3, p. 157-163, 2019.

[22] J. Plattner et al., "Using IoT middleware solutions in interdisciplinary research projects in the context of AAL", Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments; Corfu, Greece: Association for Computing Machinery, 2020, p. 51.

[23] M. M. Baig et al., "A Systematic Review of Wearable Sensors and IoT-Based Monitoring Applications for Older Adults – a Focus on Ageing Population and Independent Living", Journal of Medical Systems, vol. 43, no. 8, p. 233, 2019.

[24] P. Abril-Jiménez et al., "Ageing-friendly cities for assessing older adults' decline: IoT-based system for continuous monitoring of frailty risks using smart city infrastructure", Aging clinical and experimental research, vol. 32, no. 4, p. 663-671, 2020.

[25] L. Sumi, I. Longchar, and S. Dey, "IoT-based Fall Prevention and Detection for Senior Citizens, Physically and Intellectually Disabled", 2019 IEEE International Conference on Information Technology (ICIT), Bhubaneswar, India, 2019, p.190-195.

[26] J. Bourgeois et al., "Re-learning of activities of daily living: a comparison of the effectiveness of three learning methods in patients with dementia of the Alzheimer type", The journal of nutrition, health & aging, vol. 20, no. 1, p. 48-55, 2016.

[27] O. R. Oyeleke, "A situation-driven framework for Re-learning of activities of daily living in smart home environments", Lowa State University, 2020, p.114, Graduate Theses and Dissertations. 18197, https://lib.dr.iastate.edu/etd/18197.

[28] M. Muzammal et al., "A Multi-sensor Data Fusion Enabled Ensemble Approach for Medical Data from Body Sensor Networks", Information Fusion, Elsevier, vol. 53, no. 2020, p. 155-164, 2020.

[29] H. Payne and S. Brooks, "Different strokes for different folks: the bodymind approach as a learning tool for patients with medically unexplained symptoms to self-manage", Frontiers in Psychology, vol.9, no. 2018, p.2222, 2019.

[30] A. H. Sodhro, Y. Li, and M. A. Shah, "Energy-efficient Adaptive Transmission Power Control in Wireless Body Area Networks", IET Communications, vol.10, no.1, pp.81-90, 2016

[31] N. M. Salbach et al., " The role of theory to develop and evaluate a toolkit to increase clinical measurement and interpretation of walking speed and distance in adults post-stroke", Disability and Rehabilitation, p.1-17, 2020, DOI: 10.1080/09638288.2020.1867653.

[32] A. Ahmad and P. Mozelius, "On the Importance of Tailor-made Speech Re-learning Software for Stroke Rehabilitation", ICT4AWE 2020:SciTePress, 2020, p.1-8.

[33] N. Zahid et al., "An Adaptive Energy Optimization Mechanism for Decentralized Smart Healthcare Applications", 93rd IEEE Vehicular Technology Conference (VTC) 2021-Spring, 25-28 April, Helsinki, Finland, 2021, p. 1-5.

[34] D. Hu et al., "Decomposing Atrial Activity Signal by Combining ICA and WABS", 35th IEEE Annual International Conference of the Engineering in Medicine and Biology (EMBC), Osaka Japan, 2013, p.1-5.

[35] L. M. Blaschke, "The pedagogy–andragogy–heutagogy continuum and technology-supported personal learning environments", In: Jung I. (eds) Open and Distance Education Theory Revisited. Springer Briefs in Education. Springer, Singapore. https://doi.org/10.1007/978-981-13-7740-2_9, p. 75-84, 2019.

[36] P. Rasi, H. Vuojärvi, and H. Ruokamo, "Media literacy education for all ages", Journal of Media Literacy Education, vol. 11, no. 2, p. 1-19, 2019.

 ISBN: 978-1-61208-892-1