Discovering and Analyzing Internet of Things (IoT) Technologies and Applications for Aged Care

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Abstract. With the increasing aging of the population, the use of the Internet of Things (IoT) is increasing. This research aimed to review the existing IoT literature in aged care. We analyzed IoT using reports for aged care from online stores, so as to discover IoT technologies and applications in aged care. Current research shows that IoT technologies can help elderly people improve their quality of life and they can reduce the pressure on the healthcare system and minimize its operating costs. While previous studies have summarized IoT/wearable applications for geriatric purposes, it is still necessary to review the aged care field. This paper analyzed the IoT/wearable technologies, including a collection of the typical types of devices used in geriatric healthcare. Technology acceptance model (TAM) and familiarity and trust model1 (FTM1) were further conducted on these using reports to value why IoT technologies and applications are accepted. We found IoT applications are ready used in aged care. IoT applications were significant positive advantages for aging population monitoring.

1. Introduction
The aging population is often plagued by chronic disease management, senile dementia management, long-term bed care, emergency rescue, comprehensive psychological problems and other problems [1, 2]. If the aging population needs to maintain their own independent lifestyle, they are more dependent on medical resources [3]. The increase in the elderly population has brought huge challenges to the health care and health system, especially the increase in medical expenses and the health management of chronic diseases [1, 2]. Therefore, IoT technologies are being used for chronic disease management, emergency management, health monitoring, health promotion and health interventions for the aging population [1, 2].

IoT technologies have the potential to change elderly health management. They reduce the pressure on health care resources, improve the quality of care daily, reduce routine medical and health care expenditures, and increase the immediacy of emergency response [4-6]. Examples of such technologies are the IoT based wearable technologies, which can provide solutions to daily health management and emergencies in aged care [1-3]. IoT is also helpful in improving the life experience of the elderly, especially the elderly who want to maintain independence [1].

The IoT is still a vague concept, and it includes sensing and identification technologies such as GPS, RFID, NFC, Zigbee and other technologies [3, 6-8]. In general, the IoT is about providing sensing, networking and processing capabilities for connecting objects to interact and serve each other...
on the Internet to achieve useful purpose [2]. The Internet of Things is considered to have 6C characteristics: communication, integration, computing, connectivity, collection and content, and it enables people to connect with anyone, anything, anytime, and anywhere through any network and service [4]. The most important elements of being a member of the IoT include attributes such as expression, sensing, connectivity, intelligence, energy and security [3, 9]. The Internet of Things (IoT), which connects virtual objects and physical that allows data to be exchanged and combined, now offers a wide range of solutions to aged care environments.

Wearable devices based on IoT system, which allows seniors to monitor physical activity and physiological data [4, 10]. These devices have embedded sensors that can analyze, track, and guide users' behavior, movement, or physiological parameters [4, 7, 8]. The wearable device based on applications of IoT has been reviewed by different researchers before. However, most research focuses on the use of IoT applications to solve certain aged care problems [1, 3-5, 7, 8]. Therefore, there is a lack of comprehensive understanding of its use and application in aged care.

The pilot study aims to improve the IoT technology population aging measurement standards, and as part of a follow-up large-scale study. It uses the IT research method of evaluating IoT applications, and the content of the IoT application is the key to assessing the acceptance of the technology. The purpose of the trial is to understand and determine the measurement standards or IoT applications used by the evaluation team, and to check the consistency of these standards in the aged care process.

2. Methods

2.1. Data source

Firstly, we reviewed the published articles about the IoT/wearable technology and its application in the field of aged care. Then we randomly selected 100 valuable comments (between 1 January 2021 and 10 April 2021) from top 10 online shops’ using reports on the IoT devices as the basis of the data analysis. The keywords are ‘IoT’, and ‘aged care’, or ‘Elderly monitoring’.

2.2. Piloting text data mining method

Internet of Things (IoT) technology is text data, and we use qualitative content analysis to identify IoT application measurements. Technology acceptance model (TAM) and familiarity and trust model1 (FTM1) was further conducted on these using reports to value why IoT technologies and applications were ‘perceived ease of use’ or ‘perceived usefulness’ [11]. An automated programmer was developed to extract the contents of a partial IoT application for the report. A ‘keyword search’ and a ‘manual reading of content’ is then performed to the identified IoT applications (Figure 1).
We randomly selected ten IoT using reports, each of them comes from a different store. Each sentence in these reports is used to analyze and extract the IoT applications and the reasons for using the Internet of Things.

The 4th and 5th authors used qualitative content analysis methods to analyze sentences in the IoT application section in a report. They first read each sentence carefully to accurately understand the meaning. Sentences with multiple meanings will be divided into sub-sentence, and the sub-sentence include one meaning. The sub-sentence and sentence are consistent in structure.

In order to check the validity of the extracted statement, the authors compared the extracted statement and the original sentence one by one. If there are inconsistencies, the consensus method is used. To determine the reliability, the authors analyzed the remaining four reports in the same way.

In the end, 16 sentences were extracted, they were recorded in the table, and each sentence was assigned a unique ID. Finally, through the analysis of the research results, the authors reached a consensus of 72%. The difference of opinion lies in how many clauses the sentence should be divided into and how to break it. They discussed every sentence they disagreed with and reached a 100% agreement. In the end, we distinguished 43 sub-sentences from 16 sentences.

2.3. Coding the content

During the first-level code generation process, we shortened each sentence and retained their meaning. In the example of elderly residents given above, the clause is shortened to "Elderly residents indicate that their protection is appropriate. We continue to compare the first-level code and summarize it according to its meaning, and then the first-level code is split into the second-level code.

2.4. Constructing the measurements

These sub-sentences are constructed as four IoT measurement statements under four themes: nine protection items, 19 usable items, and 15 applications items. The 43 items in the process are related to the aging of 22 IoT applications on the IoT.

The previous 100 randomly selected reports were used in the mapping process (Figure 1). In order to systematically analyze the four main indicators, we have made a keyword search list. An automatic program is used to search for keywords in text documents or excel spreadsheets, extract information and export surrounding information.

For example, all sentences that identified the keyword ‘age care’ in the IoT applications section of these 100 case reports have been identified. The authors carefully read the selected content, and finally determine whether the selected sentence can be semantically mapped to the sentence. Finally, we recorded and analyzed the percentage of each sentence in order to check the consistency of the measurement statements.

3. RESULT

3.1. Extracted IOT applications statements

Four IoT applications for IoT aged care were identified and the three topics (surveillance, protection, and IoT useful applications) are divided into four categories: perception of usefulness, correct use, and perception of ease of use (Table 1).

The two IoT applications indicated that all of the using reports claimed 'perceived usefulness' (46 reports), 'perceived ease of use' (34 reports), 'perceived none usefulness' (7 reports), and 'perceived none ease of use' (8 reports). The remaining reports also mentioned IoT protection applications. They are 'using in the practice of employees to manage the use' (5 reports) and 'protected from surveillance' (4 reports).
TABLE I. IOT FOR AGING POPULATION.

| No | Knowledge of IoT                                      | Percentage |
|----|-------------------------------------------------------|------------|
| 1  | Perceived usefulness = true                           | 46%        |
| 2  | Perceived usefulness = false                          | 7%         |
| 3  | Perceived ease of use = true                          | 34%        |
| 4  | Perceived ease of use = false                         | 8%         |

3.2. Discovering knowledge of IoT applications

We found that effective protection, effective monitoring, and typically IoT applications are the main concerns of current aged care related IoT technologies (Figure 2). The first-level codes (22 sentences) covered: aged communication, chronic diseases care, Alzheimer’s care, emergency management, comprehensive psychological problems, health promotion, health intervention, health management, communication problem, physiological parameter monitoring, smart IoT using, smart care, healthy eating, falling, auxiliary for the disabled, rehabilitation treatment, medication management, bedsore management, home security, sleep monitoring, exercise monitoring, and electronic fence. Then we subdivide it into 43 sub-sentences in second-level codes with more details.

The study also found that many of the evaluations came from the family members of the elderly, rather than from the elderly themselves, which can be subjective. Knowledge mining shows that IoT technology can play a role in geriatric care as long as protection is qualified, effective regulation is effective, and appropriate use is made. Of course, the reliability and stability of the physical network technology is also an issue that has been mentioned many times in usage reports.

Figure 2. IoT for aging population.

4. Discussion

Our pilot research approach has yielded good results of identifying relevant aspects of IoT technologies. Our preliminary research found that the IoT case report has undergone a comprehensive assessment, which includes concurrency and coordination assessments of the process, structure, and IoT applications.

Only 43 sub-sentences focused on the evaluation process, four statements focused on the structure, and two statements aimed to evaluate IoT applications. Among the existing statements about the usefulness of IoT technologies, we only found that 46% of the reports stated their usefulness. These using cases also need to be reviewed by aged care professionals. However, the mapping results are not
comprehensive, and many reports do not mention the content of the measurement standards. Based on the public’s recommendations regarding the use and the inapplicability of elderly care IoT applications, the intensity of this measurement can be increased.

The major advantage of this study is that it provides a method and approach to quickly discover useful IoT equipment for the elderly, and provides rapid IoT solutions in a scientific and reasonable way.

The limitation of the research at this stage is the lack of IoT and nursing experts review the research results. Future research will expand the scale of data to verify the research results. The purpose of this research is to test the research method, so the selected sample size is insufficient, and the research results obtained have certain limitations.

5. Conclusion
This pilot study aims to understand the measurement of IoT technologies for aged care. We analyzed 100 of IoT using reports published by the top ten online stores from January 1, 2021 to April 10, 2021. We have determined that the transmission path is the main area of IoT technology. The most commonly reported measurements in the IoT using report include protection and/or use of IoT applications, and regular reviews of care needs and systems to ensure that aged care recipients use the correct way to handle IoT applications.

We recommend that IoT technologies should also use objective evaluations of IoT applications, rather than only using elderly residents who claim to be evaluated for IoT applications. This preliminary study confirms that with the help of semi-automatic data analysis methods, qualitative data analysis of officially released IoT using reports can improve the measurement of IoT, thereby avoiding the use of IoT applications in context.

The method of discovering knowledge needs to be improved to match the semantics between the IoT using report and the measurement statements. Further research will use this method to extract the measurement results of health education.

Acknowledgment
Fund Project: Guangxi Bagui Scholars; Reasonable use of existing resources combined with anti-epidemic work to further enhance teachers' online teaching capabilities (ZZSHJKYXY20001); The Risk Management System for Aged care Services in Guilin (2021KY0501); ‘Big data driven management and decision-making research’, a major NSFC project (91646205); Health Education and Health Promotion (No. 3, 2016), the fourth major public health program in Shanghai; Shanghai Integrated Traditional Chinese and Western Medicine Community Medicine and Health Management Research Project (SQ2)2019. The corresponding author is Tao Jiang.

References
[1] S. Wang et al., "Technology to Support Aging in Place: Older Adults' Perspectives," (in eng), Healthcare (Basel), vol. 7, no. 2, Apr 10 2019.
[2] E. Borelli et al., "HABITAT: An IoT Solution for Independent Elderly," (in eng), Sensors (Basel), vol. 19, no. 5, Mar 27 2019.
[3] S. Y. Y. Tun, S. Madanian, and F. Mirza, "Internet of things (IoT) applications for elderly care: a reflective review," (in eng), Aging Clin Exp Res, Apr 10 2020.
[4] T. G. Stavropoulos, A. Papastergiou, L. Mpaladzoros, S. Nikolopoulos, and I. Kompatsiaris, "IoT Wearable Sensors and Devices in Elderly Care: A Literature Review," (in eng), Sensors (Basel), vol. 20, no. 10, May 16 2020.
[5] N. Mora et al., "IoT-Based Home Monitoring: Supporting Practitioners' Assessment by Behavioral Analysis," (in eng), Sensors (Basel), vol. 19, no. 14, Jul 23 2019.
[6] J. Cahill, R. Portales, S. McLoughlin, N. Nagan, B. Henrichs, and S. Wetherall, "IoT/Sensor-Based Infrastructures Promoting a Sense of Home, Independent Living, Comfort and Wellness," (in eng), Sensors (Basel), vol. 19, no. 3, Jan 24 2019.
[7] T. Loncar-Turukalo, E. Zdravevski, J. Machado da Silva, I. Chouvarda, and V. Trajkovik, "Literature on Wearable Technology for Connected Health: Scoping Review of Research Trends, Advances, and Barriers," (in eng), *Journal of medical Internet research*, vol. 21, no. 9, pp. e14017-e14017, 2019.

[8] B. W. An *et al.*, "Smart Sensor Systems for Wearable Electronic Devices," (in eng), *Polymers*, vol. 9, no. 8, p. 303, 2017.

[9] P. Malhotra, Y. Singh, P. Anand, D. K. Bangotra, P. K. Singh, and W.-C. Hong, "Internet of Things: Evolution, Concerns and Security Challenges," (in eng), *Sensors (Basel, Switzerland)*, vol. 21, no. 5, p. 1809, 2021.

[10] Y.-S. Kao, K. Nawata, and C.-Y. Huang, "An Exploration and Confirmation of the Factors Influencing Adoption of IoT-Based Wearable Fitness Trackers," (in eng), *International journal of environmental research and public health*, vol. 16, no. 18, p. 3227, 2019.

[11] B. Rahimi, H. Nadri, H. Lotfnezhad Afshar, and T. Timpka, "A Systematic Review of the Technology Acceptance Model in Health Informatics," (in eng), *Applied clinical informatics*, vol. 9, no. 3, pp. 604-634, 2018.