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The contours of a human individual model based empathetic u-pillbox system for humanistic geriatric healthcare

Runhe Huang *, Xin Zhao, Jianhua Ma

Faculty of Computer and Information Sciences, Hosei University, 3-7-2 kajino-cho, Koganei-shi, Tokyo 184-8584, Japan

HIGHLIGHTS

- We propose an empathetic u-pillbox system.
- We design a holistic elderly healthcare framework.
- This research emphasizes on understanding of the elderly and provision of humanistic care.
- This system provides personalized healthcare based on Cyber-I, digital clone of Real-I.
- Data mining technology is the key to the wisdom discovery from data.

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ABSTRACT

A wide range of specific health issues affects the elderly, but one particularly significant issue in geriatric healthcare is non-adherence to medication regimens, particularly among elderly patients living alone. To address this problem, a range of electronic pillbox devices has been developed. Although these may offer a partial solution to this problem by ameliorating the issue of failing memory, it is important to have a full picture of medication adherence that includes other aspects besides forgetfulness.

This article proposes an empathetic u-pillbox system that aims to overcome the shortcomings of existing systems in ensuring adherence to a medication regime and makes an effort to design a holistic elderly healthcare framework by supporting additional functionalities like providing personalized services to the elderly based on an awareness of their individual situations by placing emphases on understanding of the elderly and provision of humanistic care. This system consists of three main processes: data acquisition of the elderly situation and medicine taking state; data analysis and elderly model enhancement; and provision of empathetic services to the elderly, in which cyber-I, human model, data cycle for the spiral quality of model enhancement, knowledge fusion towards wisdom for providing smart services are our critical concepts and techniques. This article will describe the system by going through three scenarios concerning the elderly using and interacting with the proposed u-pillbox system.

Although this system is designated for geriatric healthcare, it has a potential extension to general health monitoring and care at home. Moreover, there are many potential applications in clinic or hospital medication care systems. We believe the proposed framework to be a promising approach to one of the great social challenges facing societies in the 21st century.

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1. Motivation

Healthcare is an increasingly important aspect of 21st century life, widely considered a basic human right in economically advanced countries and as an essential concomitant of economic development in less economically developed countries. As a consequence, issues centered around the funding and provision of healthcare are deeply emotive political issues in all advanced polities.

There is considerable variance in healthcare systems, but in all advanced economies the proportion of the economy devoted to healthcare is significant. According to an Organization for Economic Co-operation and Development (OECD) report on healthcare, in 2012, almost 10% of GDP in Japan and the United Kingdom was spent on healthcare. In the major western European economies this figure was slightly higher, and in the United States 17.6% of GDP was spent on healthcare [1].

In all the countries above, a significant proportion of healthcare expenditure, and one which is increasing at a rate greater than the GDPs of these countries, is that of providing healthcare to the elderly. The fiscal burden on the economically active is expected to become a crucial political question in the coming years, if levels of care currently considered acceptable are to continue.

* Corresponding author. Tel.: +81 42 387 4541; fax: +81 42 387 6028.
E-mail addresses: rhuang@hosei.ac.jp, runhe.huang@gmail.com (R. Huang).

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The pressing problems caused by the provision of efficient and quality healthcare to the elderly and the ongoing continuous nature of their healthcare needs cannot be ignored as health care expenditure directed at the population 65 years and older has been rising year on year. According to an OECD Economic Department report of 2010 [2], the percentage of health care expenditure on the elderly to GDP reached 3.98% in Japan, 3.73% in Germany, and 6.48% in USA. Moreover, the demographic problem of a graying population creates another big problem in the form of a shortage of nursing staff and caregivers. The Japanese Health Ministry has stated that the number of nurses, midwives and other medical staff needed to fulfill its needs reached about 1.4 million in 2011, but according to one current investigation, there will be a shortfall of nearly 56,000 people. This problem is particularly acute in geriatric healthcare.

One answer to spiraling costs and staff shortages, and also to the proliferation of paper-based patient health records, is e-healthcare systems [3,4]. These apply advanced Information and Communications Technology (ICT) to the sharing of patient data among healthcare professionals and even envisage network-based health consultation and medication provision. Whilst these developments may provide overall improvements in healthcare system efficiency [5], they have a limited impact on the quality of care experienced by patients as this would require a more detailed and timely picture of patients' health situations. These deficiencies in combating the healthcare situation described above have led to the appearance of proposed u-healthcare systems for the elderly.

A u-healthcare system, u-health meaning ubiquitous healthcare, is envisaged as overcoming the deficiencies of e-healthcare systems. Stemming from the vision of Mark Weiser [6], the concept of u-healthcare refers to the application of ubiquitous technology with ICT to gather continuous pertinent and timely information about a patient's situation to provide comprehensive non-intrusive healthcare. Among the ubiquitous technologies that could realize this vision are miniaturized smart devices, wireless sensor networks, and seamless interfaces. These would acquire data on a patient and their environment. Developments in ubiquitous intelligence computing, in particular AI, machine learning, large scale data mining and other related technologies would enable a u-healthcare system to process and analyze the data acquired, and in tandem with the expertise of health professionals, ensure healthcare of the highest quality. Moreover, a u-health system would empower patients to take a more active role in their personal health management and illness prevention.

A number of u-healthcare systems have been proposed for supporting efficient and effective quality health care for the elderly; our previous research into reminding the elderly to take their medicine, making the elderly feel happier at home, and the cyclic data circulation system in W2T (Wisdom Web of Things) as an appropriate u-healthcare platform [7–9].

Since non-adherence to prescribed medication regimes for the treatment of chronic conditions is one of the most common problems in healthcare for the elderly, some studies have concerned medication management systems for geriatric patients who live alone at home. As an approach to meeting the special needs of the elderly and a response to the urgent need for smart u-health systems, the smart u-pillbox system is one of the most promising representative ubiquitous systems appropriate for geriatric healthcare.

2. Existing pillbox systems

There have been earlier studies into employing technology based on pillbox systems aimed at the problem of non-adherence to medication regimes among the elderly. An estimated one third to one half of all patients in the US do not take their medications as prescribed by their doctors [10], a phenomenon potentially dangerous to health. In 1998, Doughty et al. designed a pillbox device (TEMPEST) which comprised of up to 6 containers programmed with prescription information by the pharmacist for dispensing a number of pills or tablets at the correct time [11]. A MIT research team designed an electronic pillbox device (called uBox) in 2008 [12] that dispenses pills, alerts the patient that it is time to take the medication, records the time the pill was taken and prevents double-dosing. However, after two weeks, a health care worker has to reload the box and digitally record and transmit the information stored in it. These earlier pillbox devices were essentially containers with timer and alarm functions. Although in recent years a few more systems such as My Electronic Pillbox [13], Epill [14], Med-Q [15], and MedFolio Pillbox [16], have appeared, these basically function by tracking medication adherence but do not provide social interactions and empathetic responses.

There are also a number of smart pillbox products presently on the market. Most are simply alarm medication-taking products such as timer pillboxes or medical alert watches, smart pill caps which fit on standard prescription bottles and use light and sound reminders to alert patients to take medications on time. These can be followed up by a phone call or text message so patients do not miss a dose like InforMedix's Med-eMonitor [17], which can store and track up to 25 different medications, and uses musical chimes to remind patients to take their medications at the right time. Patients can receive their health information and reports on medication dosing, administration, and health status via Smartphone. Wireless connected networks play an important role in pillbox systems like AT&T's wirelessly connected Vitality GlowCaps [18], which are pill caps designed to alert patients to take medications on time. Each time the pill bottle is opened; adherence data is recorded and securely relayed to Vitality over the AT&T wireless network. This daily adherence information is used to compile periodic progress reports that are sent to patients, caregivers, doctors, and family members. There are other products such as MedSmart PLUS Monitored Automatic Medication Pill Dispenser (e-pill MedSmart MD2) [19] and CompuMed Automatic Pill Dispenser MD3 (e-pill CompuMed MD3) [20]. A summary of existing pillbox systems/products is given in Table 1.

Table 1 shows that the existing smart pillbox products focus on providing a timely medicine-taking reminder service to the users using flashlights, beeps, calls, text messages and email. They have fixed and limited medicine store capabilities, most provide 1 week of medicine and divide the medicine-taking time into three or four time slots: morning, noon, evening and bedtime. Only the last three products in the table connect to a network and provide an automated data upload service; the others do not have this function and data needs to be uploaded manually. Most products have a refill reminder function, which sends a text message and email to users when the medicine storage is empty or nearly empty. Only a few products provide a medication-taking report service and only one product (MedFolio Pillbox) provides a medicine information service. None of the products can consider the situation of users, which means no interaction with them and no smart/active service.

Briefly speaking, all the pillbox devices mentioned are attempts to deal with the problem of adherence to a medication regime. However, all these systems could cause a break in the regime since pillbox storage capacity is limited, perhaps leading to a patient's miss to pick up a refill prescription. The patient may hear the timely alarm, understand it is time to take their medication, but some elderly may not like to be reminded since they do not need this or they prefer personalized alarm styles which could meet their individual needs. There is still a high possibility that the patient will become distracted before actually ingesting any pills and some considerations to handle this problem may be necessary. Moreover, the existing systems have hardly any functionality for facilitating interactions with the elderly so as to understand them and provide empathetic services to them.

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