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ARM BASED IMPLEMENTATION SUPPORT SYSTEM FOR MEDICAL STAFF AND HOME CARE PATIENTS USING SENSOR NETWORKS

B.CHANDRASHEKAR
MTECH (VLSI & ES), JNTUH

R.V.KRISHNAIAH
B.TECH, M.TECH (EIE, CSE) PH.D (ECE)

Abstract: In this paper we have developed a system using a combination of a multi-hop sensor network and 3G networks to support patients daily in home care. Each medication of a patient is represented by a sequence of close-open-close events of an off-the-shelf pill box, which are detected by a small Hall sensor. The system enables home visiting nurses to remotely monitor their patients here there is a bidirectional communication between medical staff and patients is there where we can save the patients immediately. A semi-automatic message generation system helps medical staff to send feedback without spending excessive time and effort. We have been examining this system for more than three months with three subjects and found that a simple open/close sensing of an off-the-shelf pill box can provide a valuable medication history. It has also shown that the feedback system improves the rate of failure medication from 5.3% to 0.0% in the best case. so ,this project is so helpful and can be more advantageous if it can be implemented.

I. INTRODUCTION

Home care is a form of medical treatment outside hospital. Medication management represents how a patient takes medicines in relation with the prescription from his or her doctor. Medication management is one of the biggest issues in home care as it is difficult for patients to control on their own. Generally, medicines are effective only if they are taken “modo praescripto”, i.e. in the manner prescribed. The degree of medication management can be represented by “medication compliance”. High medication compliance means a patient manages his or her medication well. In Japan, medication management is only permitted, by regulation, to the patient, the patient’s family and medical staff, i.e. home visiting nurses, pharmacists, and doctors. Home-care helpers, who are the largest contributors in home care in Japan, are not allowed to manage their patient’s medication. On the other hand, it is difficult for medical staff to take care of their patients’ medication in case of home care, simply because of time and labor constraints. As a result, medications are sometimes mistaken or forgotten by patients in home care. This is particularly problematic for single living, elderly and dementia patients. There are also many cases where patients are not allowed by medical staff to take home care

TABLE I
EXISTING FUNCTION PILL BOXES

type(example)	pros.	cons.
partition([1])	There are many off-the-shelf products.	No information share with medical staff. Patients need to control their medication.
reminder([2])	Embedded alarm urges medication at the right time. [2] can detect intaking motion.	No information share with medical staff. Restriction on size of medicine.
monitoring([3])	Automatic alarming. Data collection from remote place.	Heavy and bulky to be installed in most patients’ homes.

the methods to use pill boxes with additional functionalities and the systematic approach. Existing function pill boxes can be classified into three types according to their functionalities (Table I). The partition type is composed of compartments each for one dose. These boxes are common in home care, but patients need to manage medication by themselves in these cases. The reminder type pill box can notify the patient for the preset timings of taking pills. PivoTell [2] is equipped with acceleration sensors to detect the rotational motion of the box when a set of pills are taken out. The monitoring type pill box is similar to the reminder type but a back-end system can collect and store the history of the time when pills are taken. The history can be used to analyze the patient’s daily medication management. However, the cost and size of these boxes are too high and large to be brought into most patients’ homes.

In the systematic approach arena, Isomursu [4] proposed an RFID (NFC [9]: Near Field Communication: ISO 18092) enabled medicine package for the medication management by the vision impaired. The system involves two scenarios: one is an audio interface of medicine information using NFC; and the second is a combination with a background information system. Tattletale pill [5] is an innovative digestible antenna equipped pill case. The signals from the pill case in a patient’s body are received by an external receiver. Koutkias [6] proposes a framework in which sensors at the patient’s site are wirelessly connected to the medical center through a mobile base unit enabling a bidirectional communications between patients and medical staff. Establishing bidirectional communications seems essential and interesting. Both [4] and [6], however, have not conducted any experiment so that the effectiveness is not proven. Oliveira [7] proposes an interesting idea of improving medication compliance using a mobile social game. After six weeks of the experiment with 18 elders, it was found that the social game approach improves medication compliance. It also reports the caveat that cheating occurred even though the social game does not provide any monetary reward.

According to the experience of the first author as a home visiting nurse, the following requirements are essential for medication support systems in home care especially for seniors.

• Use of off-the-shelf pill box: Patient's choice of pill box shall be used as much as possible.

• Flexibility in the layout of equipment in the patient's home: System shall not change the patient's daily life.

• Remote monitoring by medical staff: Medical staff shall be able to remotely monitor the medication status of the patient to take responsive action.

• Feedback system: Medical staff shall be able to provide a feedback to their patients to visualize their medication status and to motivate their medication.

This paper, therefore, focuses on a method for medical staff, a home visiting nurse in particular, to efficiently monitor his or her patient's medication in home care using a sensor network and wide area mobile network as well as to motivate patients by sending their medication status and a message from the home visiting nurse.

This paper is organized as follows. In Section II, we describe the system, which comprises a data collection subsystem and a feedback subsystem. In Section III, we report the result of three months of field experiment with three subjects.

2. SYSTEMDESCRIPTION

To meet the requirements listed in Section I, the following design was made.

• Off-the-shelf pill box: Battery driven small (1cmX2cm, 20g) ZigBee end device is attached to patient's pill box. The end device is equipped with a Hall-effect sensor to detect open/close of the pill box.

• Flexibility in device layout: The sensor data is relayed by ZigBee multi-hop network to reach its coordinator which is connected to a PC with 3G mobile network. This multi-hop network gives us flexibility to layout experimental devices in the patient's home. Usually a coordinator and its connecting PC are placed under a bed or in a storage resulting in low signal level from the Zigbee end-device with one hop network. If the communication signal is weak, we installed a router to relay the communication.

• Remote monitoring by medical staff: The open/close data is collected to a database and the data is processed and disclosed by a web application.

• Feedback system: We use a commercial digital photo frame as a feedback system in the patient's home because

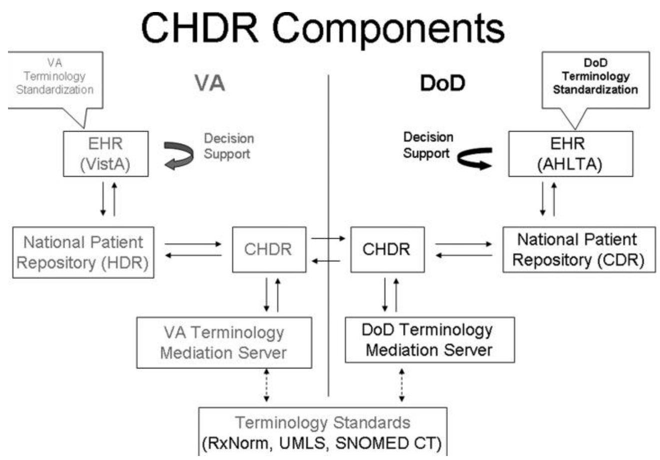

Figure. 1. System overview

Terminology standardization refers to the use of the same set of codes, preferably national standard codes, to encode patient data throughout a system.

Both VA and DOD have successfully standardized their terminology for vital signs, allergies, pharmacy, laboratory chemistry and hematology, and note titles with minimal impact to their operational clinical applications. [22] Patient data encoded with non-standard terms such as local compounds and study drugs cannot be exchanged in a codified way and thus cannot trigger decision support.

A. National Patient Data Repositories (HDR and CDR)

Today after standardization both VA and DOD patient data are collected from the different points of care and assembled into one enterprise health data repository for each agency. Each enterprise repository can then support viewing of the complete patient EHR, population queries, decision support, surveillance studies, and data exchange with external institutions.

At the present time the VA HDR is an HL7 message-based data store. The content includes vitals, allergies, and outpatient pharmacy and will soon include laboratory data and clinical document titles. DOD's CDR uses HL7 V3 RIM-based models for procedures, diagnoses, encounter notes, allergies, pharmacy, pathology, radiology, microbiology, and immunization data.

B. Terminology Mediation Servers

VA and DOD have each evolved a terminology maintenance environment based on standard terminologies like SNOMED CT, LOINC, and RxNorm. Although these standard code sets are represented in the terminology servers, they are not directly used by clinical applications but rather mapped to VA or DOD enterprise concepts. Each VA concept is assigned a VA Unique Identifier (VUID) and each DOD concept is assigned a Numeric Concept ID (NCID). Enterprise-specific terminology content is deployed to clinical applications along with specific services to access terms during runtime. For example, to support mediation, there are translation services that translate from an agency's internal terminology to the national standard terminologies (e.g., from VUID or NCID to RxNorm CUI). These services were developed conformant with the HL7 specifications for Common Terminology Services.

C. CHDR Patient Data Exchange Gateway

CHDR is the gateway service that enables computable patient data exchange between VA and DOD for shared patients. CHDR incorporates a push and pull model, meaning patient data can be sent automatically upon creation (push) or queried on demand (pull). VA CHDR extracts existing patient data from the HDR, automatically receives subsequent updates, structures data in a commonly agreed-upon HL7 message format, and sends the message to DoD CHDR, where it is unpacked and saved in the DoD CDR along with data created in DOD. Conversely, VA CHDR receives DOD patient data and stores it in the HDR. During these transfers, key clinical elements of the message (e.g., a medication name or an allergen name) are translated from/to the agency vocabulary to/from a commonly agreed-upon mediation terminology.

With this strategy, if a patient is an Active Dual Consumer (i.e., receives care from both VA and DOD), then that patient's allergies and outpatient pharmacy data are duplicated in both agencies' national data repositories. When a patient is first designated as an Active Dual Consumer, the data are extracted from one agency and added to the other agency's national data repository. Then, as new data are created for this patient at either agency's care sites, the data are immediately and automatically sent to the other agency.

D. Data collection subsystem

As a sensor, a switch combined with a ZigBee [8] end-device is used. ZigBee is a wireless sensor network platform based on IEEE802.15.4 standard with networking extensions. It features low cost and low power consumption. It consists of an end-node which implements the actual sensor, a router to relay the signals, and a coordinator-device which aggregates the data from end-nodes.

The sensor is attached to the pill box that a patient uses daily in order not to change their usual lifestyle. When the patient opens the pill box, the end-node wakes up from a sleep mode and sends the open/close information of the pill box to the coordinator via wireless communication with fixed time interval (5 seconds). The coordinator will then transfer the data via RS-232C to the data collecting PC. The PC will send the information to the central web server via 3G mobile network. In order to differentiate a system failure and no medicine intake, the connecting PC generates a heartbeat signal at every 30min. The data collection system alerts (send email to) operators in the event of not receiving the heartbeat over 30 minutes. To save battery, the end-device goes to sleep mode after detecting five-in-a-row close signals or an extensive open signal (currently 20 min.).

Medical staffs, including a home visiting nurse, are able to check their patient's medication status by accessing the web-server using any type of device capable of viewing the web. Typically, a home visiting nurse and engineers use smart phones. Figure 2 is a screen-shot of the web page which lists the medication status. The web page shows when and how long the box was opened along with a patient ID. The digested medication history is generated automatically mitigating medical staff time and effort to identify medication history. This mechanism enables a home visiting nurse to remotely and effectively monitor the medication status. If the system has not received open/close data for one day, a message

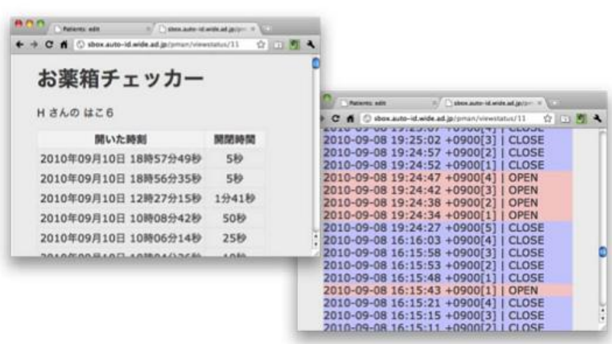

Figure. 2. Screen-shot of web site

Figure. 3. Contents of message

is sent to the medical staff. The message reads "There has been no medicine consumption after breakfast, lunch or dinner.". After a home visiting nurse gets the message, the nurse can call the patient or send the message to the patient.

B. Feedback subsystem

In order to provide feedback to the patient, a digital photo frame (DPF) called PHOTO PANEL 02[10] is used in this paper. This device is connected directly to a 3G mobile network and is capable of displaying images sent via the internet.

After the home visiting nurse checks the medication status via the web site typically once a day, he or she will give a feedback by sending an Email with an image containing the medication status and a message to the patient. In order to generate the image and send it to the corresponding DPF, a web-based application written by using RUBY is developed.
Figure 3 shows an example of the message, showing the medication status using icons and a message to motivate the patient's medication with the home visiting nurse picture.

When an Email containing the image is received by the DPF, an embedded LED flashes indicating a new message has been delivered. In order for the patient to view it, the patient must manually press a button. Pressing the button will send a message back to the nurse confirming that it has been viewed.

TABLE II
ERRORS EXPERIENCED DURING DEMONSTRATION PERIOD

Cause of error	number of errors
Battery ran out	8
ZigBee network not responding	5
Disconnection of 3G network	24
Other	1
Total	38

3. EVALUATION

In order to evaluate the effectiveness of the system, a demonstration experiment has been conducted with three subjects for more than three months in total.

A. Evaluation Overview

We have three subject patients "Mrs.H", "Mr.T", "Mr.I" in the experiment and use the system. Mrs.H, Mr.T and Mr.I are a 102 year old female, a 83 year old male and a 88 year old male, respectively. They all live alone during the daytime at their homes. All of them must take medicine three times a day after breakfast, lunch and dinner. This experiment is implemented in two stages. The first stage is to grasp and analyze the patients' medication status before implementing the feedback system and accuracy check. The second stage is to evaluate the effectiveness of the feedback system toward medication compliance. Mrs.H is the first patient in this experiment. The experiment has taken place from July 28th to until the time of this writing. For the first 39 days we did not try the feedback system in order to obtain base data which includes time distribution of medication, missing medication rate and to evaluate reliability of the system. Then, we installed a digital photo frame (DPF) in Mrs.H's home and continued the observation by providing a message once a day to evaluate the effect of the feedback system. The remaining patients' experiment, Mr.T and Mr.I have started each from October 19th and October 21st to until the time of this writing. They
are now on the first stage in the experiment.

B. Reliability of the system

Table II shows the system errors while using this system in the demonstration experiment lasting three months. Typical system failures were the running out of button

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batteries, the ZigBee Node could not join to the PAN (Personal Area Net-work) and 3G mobile network shut down. Those are all hard-ware related errors. Network applications have been updated to solve those problems and batteries changed frequently. These erroneous data are removed from the subsequent discussions.

C. The analysis of medication time distribution

The following graphs show the distribution of each medication time for each subject. Figures 4, 5 and 6 show the medication statistics of subjects, Mrs.H, Mr.T and Mr.I after breakfast, after lunch and after dinner, respectively.

Each pattern has a peak value. For example, Mrs.H, her medication after breakfast is mostly taken between 7:00 and 8:00 am. Furthermore, the medication interval of Mrs.H

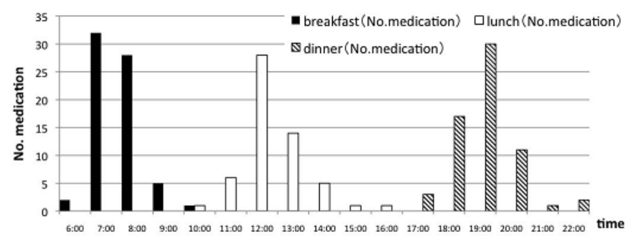

Figure. 4. Mrs.H's time distribution for each medication

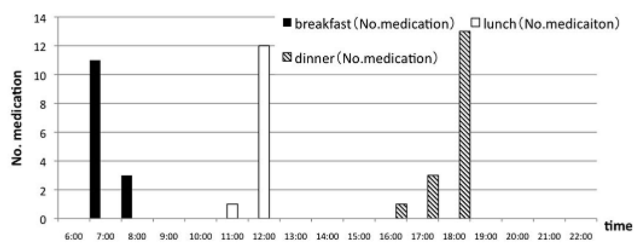

Figure. 5. Mr.T's time distribution for each medication

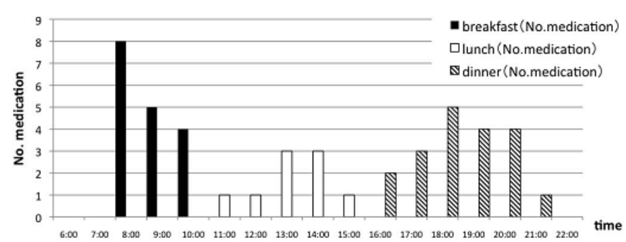

Figure. 6. Mr.I's time distribution for each medication

TABLE III
MISSED MEDICATION RATE OF MRS.H, MR.I ANDMR.T AFTER EACH MEAL

	After breakfast	After lunch	After dinner
Mrs.H	3.1 %	17.1 %	9.4%
Mr.I	15.0 %	25.0 %	0.0%
Mr.T	0.0 %	0.0 %	0.0%

and Mr.I are relatively inconsistent, especially medication after lunch are wide spread throughout the time. On the other hand that of Mr.T is consistent. This result proves that a simple open/close sensing of a pill box can record such medication time distribution. From the medical staff's point of view, this data is valuable because such data has not been easily available in the home care. Table III shows the rate of Mrs.H, Mr.I and Mr.T missed medication after meal time. The result shows that Mrs.H and Mr.I often missed the medication after lunch. It is quite interesting and essential that the two subjects, Mrs.H and Mr.I, used to say that they have never forgotten medication.

1) The effect of feedback system: Table IV shows the missed medication rate before and after implementing the feedback system. This number is changed between Table IV

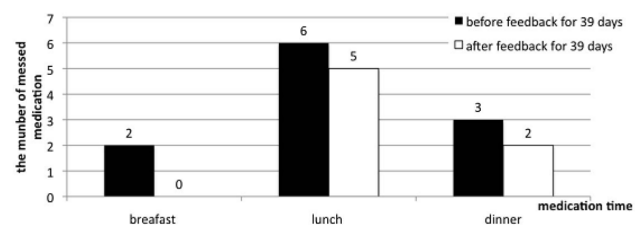

Figure. 7. Missed medication number before and after feedback

TABLE IV
MRS.H'S MISSED MEDICATION RATE BEFORE AND AFTER FEEDBACK

	After breakfast	After lunch	After dinner
before feedback	5.3 %	15.8 %	10.7%
after feedback	0.0 %	13.1 %	7.1 %

and Table III. Because the rate of Table III is the total of Mrs.H's missed medication number.

And Figure 7 shows the missed medication number before and after implementing the feedback system. It reveals that, after Mrs.H has started to use feedback system, Mrs.H did not forget medicine after breakfast. Although the number of subjects is only one, the feedback system seems promising to improve medication compliance.

2) Questionnaires result: We have conducted a questionnaire of patients, their family and medical staff about the bidirectional medication support system. We asked how they felt about the pill box, web monitoring system, and feedback system. The questionnaires have been analyzed with a view to pros and cons

• Pros.

– The three patients and their family do not mind of the sensor devices in their pill box.

– Patients feel comfortable to being cared for by medical staff.

– Patients are looking forward to seeing the feedback message.

– The message reminds the patients of their missed medications.

– Medical staff can know the patient's medication and that they are alive.

– The nurse has less need to visit the patient's home.

– This system motivates the nurse because the patients are waiting for the feedback message.

• Cons.

– The patients sometimes feel that they are being watched.

– A nurse reported that setting the system and the sensor is difficult.

– This system incurs an additional workload for nurses.

– A nurse thinks that it is time consuming to make the contents of the message.

4. CONCLUSION

Medication management is one of the keys to the success of home care. Since medication management is a medical treatment, we have developed a bidirectional medication support system for medical staff and home care patients. In this system, each medication of a patient is represented by a sequence of close-open-close events of an off-the-shell pill box, which are detected by a small Hall sensor. The medication data are collected by a multi-hop sensor network in the patient's home to be stored in a central database and can be monitored by medication staff through web interface. This way, medical staff can easily access their patient's medication status through a mobile phone, for example. Simple open/close detection of an off-the-shelf pill box provides valuable information of patients' medication status, which have never been available to medical staff. We can identify the missed medication rate by observing such data. The bidirectional system also features a feedback from medical staff to patient. Daily

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Shiori Suzuki, Takehiro Yokoishi, Hisakazu Hada, Jin Mitsugi, Osamu Nakamura and Jun Murai, "Bidirectional medication support system for medical staff and home care patients", 978-1-4244-9445-3/11/$26.00 ©2011 IEEE.

[4] Isomursu, M.,Ervasti, M., Tormanen, V.,"Medication management sup-port for vision impaired elderly: Scenarios and technological possibilities".

.

[5] Tattletale pills, bottles remind you to take your meds.

[6] Koutkias, V.G., Chouvarda, I., Triantafyllidis, A., Malousi, A., Giaglis, G.D., Maglaveras, N.,"A Personalized Framework for Medication Treatment Management in Chronic Care".

[7] Oliveira, R.,Cherubini,M., Oliver,N., "MoviPill: improving medication compliance for elders using a mobile persuasive social game".

AUTHORS:

B.Chandra shekar is student of DRK college of engineering ,hyderabad, ap, india. He has received B.Tech Degree Electronics communications and Engineering, M.Tech Degree in Electronics communications and Engineering. His main research interest includes Embedded systems.

Dr.R.V.Krishnaiah (Ph.D) is working as Principal at DRK INSTITUTE OF SCINCE & TECHNOLOGY, Hyderabad, AP, INDIA. He has received M.Tech Degree EIE and CSE. His main research interest includes Data Mining, Software Engineering