

Smart Home for elderly adults

Parth Desai

Symbiosiscentre for Information Technology,
Pune, India

Hiromitsu Hattori

Assistant Professor
RitsumeikanUniversity, Shiga, Japan

Abstract—Population is rapidly aging worldwide so to aid them with latest cutting edge technology is new challenging area of research. In this paper, we describe a new idea of model “Smart Home - for assisting elderly adults” in which we focus on using cost effective sensors rather than costly sensors with rich features which can facilitate self-care and extend the self-reliance to the elderly adults. To provide smooth workflow between sensors, we have used Multi Agent System (MAS) technology, wherein sensors are only responsible for data gathering and basic processing, while computationally expensive processes are assigned to agents. The successful adoption of proposed smart home concept will provide elderly adults to stay in their own home longer with safety and independence and still connected with their loved ones. This will also give peace of mind to the loved ones living away because of various constraints.

Index terms -Internet of Things (IoT), Multi Agent System (MAS), smart home, smooth workflow.

I. INTRODUCTION

A home having lighting, heating, and electronic devices that can be controlled remotely thru’ smartphones and computer is called “Smart Home”. This paper focuses on developing smart home equipped with above mentioned functionality and especially designed features for elderly adults.

Elderly adults living alone in home faces many problems such as lack of proper food, fail to get medicine on time, fall and injuries, unable to respond in emergency situation etc. All the listed problems can be solved up to certain level.

Our aim is to provide a solution to the above cited problems Of Elderly Adults by using Internet of Things technology. It is proposed to elderly adults to wear a wrist band having 3D accelerometer and gyroscope and other sensors such as motion detector sensors will be placed in various places in home to track the different activities of them. Status of such activities will be sent to their loved ones time to time so that they can be updated about the elderly adults’ routine and health.

II. MOTIVATION

The world is witnessing unique process of demographic transition that will result in older populations everywhere. Improved health care facilities, decline in fertility rate are believed to be the main reason for this transition. The number of older persons is 841 million in 2013, which is four times higher than the 202 million that lived in 1950. The older population will almost triple by 2050, when it is expected to surpass the two billion mark. In most countries, the number of those over 80 is likely to quadruple to nearly 400 million by

then [1]. Increasing number and proportion of older adults requires a greater focus on policies and resources to meet their needs.

Due to urbanization, youth is heading to urban areas while the most of the elderly parent would prefer to stay in the community and also have a keen desire to live independently and comfortably in their own home. Such situation forces them to live alone or move to an old age homes. This dilemma of elderly adults often causes problems in their life.

Increased life expectancy is often associated with increased vulnerability to diseases and injuries. Furthermore, older adults are at high risk of chronic diseases such as cancer, diabetes, arthritis, heart disease and chronic obstructive pulmonary disease and also falls and injuries are common in them. Hence, Elderly adults require 24*7 care.

Therefore, we need a more viable and scalable solution to meet those demand through latest cutting edge Internet of Things (IoT) technology so those elderly adults can do their work with comfort at their own home instead of moving to an Old age home. This will also provide sense of relief and happiness to them. At the same time this model “Smart home” provides additional comfort and peace of mind to their loved ones living away from them because of various constraints.

III. TECHNICAL DESIGN

As discussed in motivation section proportion of elderly adults in total population is increasing rapidly, their problems should be addressed using technology. We are planning to use

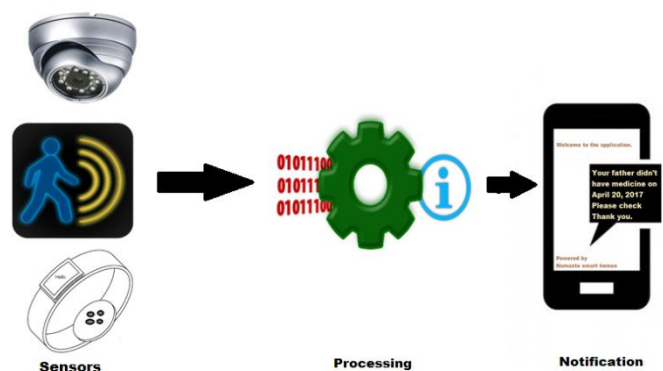


Figure 1 Data flow in system

Internet of Things (IoT) to develop a system which can facilitate elderly people. Multiple sensors will be placed to gather data regarding latest happening. Collected data will be processed as per the requirement. Once information is generated from raw data predefined rules will be applied to get final results. Notifications will be sent to respective parties.

Sensors

Complete and correct knowledge of any situation is important to be able to respond to those circumstances. Sensors placed in different places of the home could even detect the slightest movement. Elderly adults has to wear a wrist band which will have basic sensors such as 3D accelerometer, gyroscope etc. Motion detector sensors will be placed in the entrance of the home and some other places as per the requirement. To be able to get pictures remotely system will be having camera in place.

Processing

After collecting data from sensors proper processing of data is a key task because raw data will be of no use until we get some meaningful information from it. Multi agent system will be used in processing sensor networks. Each sensor will have agent to do computational processing on there behalf. Hence, Agent will work as a proxy of a sensor.

A. Multi agent system

Proposed smart home will have variety of sensors/devices to get data from environment. These wide varieties of types of devices' (e.g. cameras, motion sensors) management and usage may differ. These sensors are usually specialized in specific applications, so they do not offer the same services. The combination of different types of sensors in a network and the use of its data requires a high-level of modularity and adaptability in the architecture. Sensor heterogeneity is a major challenge.

Multi agent system can solve the above mentioned problem. A multi-agent system is a loosely coupled network of software agents that interact to solve problems that are beyond the individual capacities or knowledge. Agents are computer programs that act on behalf of their users, across open and distributed environments, to solve complex problems.

Sensors will be considered as devices controlled by agents. They are only responsible of data gathering and basic processing, while computationally expensive processes are assigned to agents. This organization gives freedom of choice to put the execution of data processing either mainly in the sensors or in the controllers.

The system is composed of four interconnected agents (There can be more agents): linear motion agent, rotation agent, motion agent and supervisor agent. Linear motion agent is responsible for utilizing linear movement of the elderly adults. Rotational movement is extracted by the rotation agent. Motion agent classifies motion in a particular area of the smart home. These agents exchange information with the supervisor agent to provide collaborative service to end user. The skeleton of the multi agent system is illustrated in figure 2.

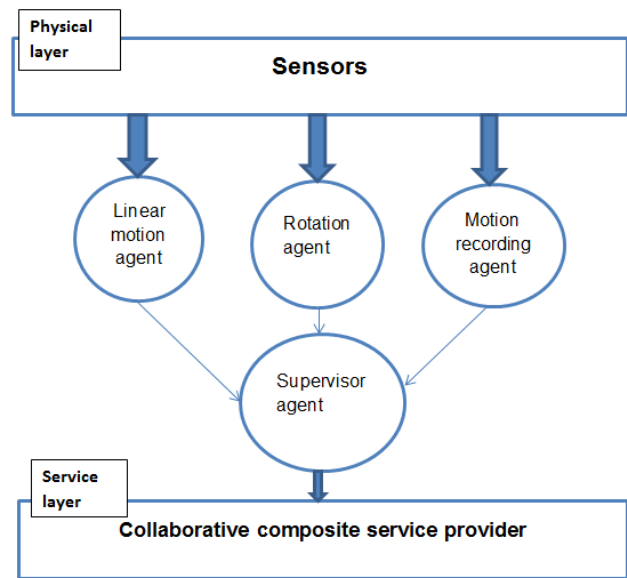


Figure 2 Multi Agent System Architecture

Advantages of Multi agent system

Using MAS in place of monolithic system will give many benefits to the system.

- **Robustness:** Robustness refers to the ability that if control and responsibilities are sufficiently shared among agents within MAS, the system can tolerate failures of one or more agents. If one of the sensors got damaged other sensors can work smoothly as each agents are independent to each other.
- **Modularity:** Rather than tackling the whole task with a centralized agent, programmers can identify subtasks and assign control of those subtasks to different agents. The difficult problem of splitting a single agent's time among different parts of a task solves itself. Thus, when the choice is between using a MAS or a single-agent system, MAS is often the simpler option.
- **Scalability:** Scalability of MAS originates from its modularity. It should be easier to add new agents to MAS than to add new capabilities to a monolithic system. This advantage gives us flexibility to later on enhance the system with an ease. We just have to add sensors and associated agents and entire system can remain as it is.
- **Parallelism:** Having multiple agents could speed up a system's operation by providing a method for parallel computation. For instance, a domain that is easily broken into components--several independent tasks that can be handled by separate agents--could benefit from MAS.

Notification

Family member who wants to be updated with the activities of elderly adults has to install and application in their smart phone or tablet.



Figure 3 Sample notification in band

At the time of deviation from the normal schedule firstly elderly adults will be notified. If deviation still persists their care taker or family members will be intimated via notification (Figure 3) so that they can be aware of the situation.

In addition to that periodic customized report also will be sent to family members. Notification will be sent to family members and they can access it via application.

IV. FEATURES OF THE PROPOSED SYSTEM

As population is rapidly ageing world-wide, there is increasing interest in “smart homes for elderly adults” that can provide a safe, sound and secure living environment for the elderly adults. Automating lighting, heating, and electronic devices can definitely help resident of the home, but time has come to provide more personalize assistance.

Thus, we are proposing smart home having features which can help elderly adults and also keep them connected with their loved ones living away from them. The elderly adults can take advantages of “Smart home” having rich features such as routine tracker of elderly adults, medicine tracker, smart fall detection, periodic health report, medicine stock maintenance, emergency contact dialer etc.

A. Routine tracker

It allows us to track all daily activities of any individual which will help us to predict the serious changes in their routine health. It will also prove advantageous to their loved ones to take precautionary measures so that they can get back things to normal before it get worst.



Figure 4 Sample notification in application

Sometimes it becomes difficult for loved one to get specific details about elderly adults so they failed couldn't to help in such situation. Our system focuses on this simple yet so important issues such as whether they had proper sleep in night, whether elderly adult get up as per his/her normal schedule, how much time elderly adult has spent in his/her favorite place in home, whether they had food on time (breakfast, lunch, dinner). Minor change in such behavior may cause serious trouble in elderly adults' life. Hence, we focus to develop a system which alerts elderly adults about the deviation happens and if deviations keeps on repeating, system will send message to their loved ones so that the help can be provided immediately, if necessary.

With advent of wearable technology, we are proposed to wear a wristband tracker having various sensors to determine uncharacteristic behavior of a monitored subject which are as under:

[1] **Sleeping and Waking Pattern:** Sleep patterns tend to change with aging. Many elderly adults often get less sleep than the required which can lead to a nos. of problems such as depressed mood, memory loss, disturbed metal happiness, serious heart problems, high blood pressure, diabetes and many more. Hence, it is important to monitor the sleep and waking pattern for elderly adult's physical as well emotional well-being. This approach will be implemented by providing sleep counter in the proposed wristband. Such system will also send the details about elderly parent's sleep quality and wake up time to their loved ones time to time. So that proper measures can be delivered and impact can be mitigated at the initial stage.

[2] **Motion tracker:** Such segment will help to identify the movement of the elderly adults within the home and also to monitor the activity of the elderly adults. For example, time spent at his/her favorite place, physical activeness etc. Human activity detection within the home is also one of the advisable bases to access the elderly adult's health fitness. First, we propose to identify the specific movement of the elderly adults and then it will be monitored thru' GPS sensor provided in the proposed wristband. This will help to predict the elderly adult's state of mind more precisely.

[3] **Food Intake Schedule:** Such module will provide the detailed information pertaining to elderly adult's food intake. It will keep track if elderly adult skip their breakfast, lunch or dinner. Insufficient food intake can cause many diseases resistance to illness. Our purpose is to track the wrist movement to get the accurate details pertaining to elderly adult's eating activity. As per the figure 1, hand movement and wrist rotation are similar while having food irrespective of utensil used such as chop stick, spoon, fork, or hand. Furthermore hand movement and wrist rotation do not depend on the type of food subject is having [2]. Algorithm should be developed considering these points so effective and efficient food intake schedule can be developed.

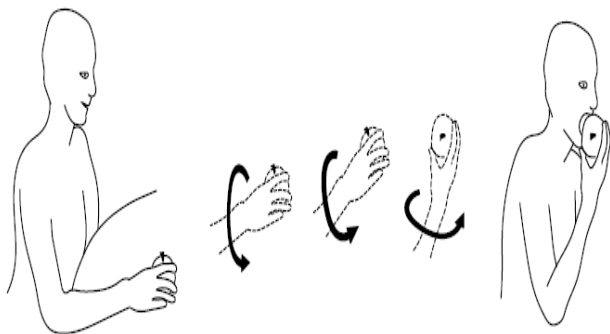


Figure 6 Wrist movement of an individual having food

The details gathered from all the above mentioned system will be shared through mobile application with their loved ones staying away in predefined periodic intervals and also when an unforeseen abnormal condition occurs. So that mitigation measures can be executed at the early stage itself.

B. Medicine tracker

Most of the elderly adults suffer from such diseases which require special care and daily medication. Memory loss and related disorders, is common complaint among the elderly adults which often results into missing a dosage or taking a double dose that leads to more complication. Hence, we are focusing to provide system which gives on time reminder to elderly adult about the medicines. In addition to that system will also intimate about the quantity and type of medicine. System will notify family member or caretaker if elderly adults don't check in that they took medicines, so they can remind elderly adults to take drugs if needed.

This feature can be made more intelligent by providing wearable camera to elderly adults. By doing so elderly adult don't have to check in that they took drugs and system will automatically figure out whether they took medicines or not from image processing. Once elderly adult is notify to take medicines wearable camera will start taking picture and these pictures are matched with the preinstalled images of medicines in the system just to check which drugs have been consumed. Pictures should be immediately trashed after processing by keeping storage capacity in mind. This hypothetical approach needs to be implemented by considering above mentioned idea.

C. Smart fall detection

The elderly adults are exposed to falls owing to the deterioration of their physical functions. When an elder person falls and becomes unconscious or is unable to move his/her body, he/she may succumb to the injuries that caused the fall [3]. Thus, system that can automatically detect falls in the elderly adults will be useful feature so their family members or care taker can take immediate actions to help them.

The identified fall-detection systems can be classified primarily into two categories: context-aware systems and wearable devices. Context-aware systems use devices such as cameras, floor sensors, infrared sensors, microphones, pyro electric infrared (PIR) sensors, and pressure sensors, deployed in the environment, to detect falls. Wearable devices use various sensors such as accelerometer, gyroscope, mounted on wrist, to detect fall.

Context-aware systems

Motion detecting sensors can be placed in certain area of the house. If motion is detected in those area and then stop being detected for a selected amount of time, system can send notification to their loved ones or care taker. As an example, if someone goes to the bathroom in the middle of the night, and then there was no motion detected 30 minutes later, you'd probably want to make sure that they are okay. Problem of this context-aware system is cost-efficiency.

Wearable devices

A wearable fall-detection device can be used by having 3- axis acceleration [3]. After detecting fall through wearable we can send notification to loved once or care taker to make them aware of the situation. Problem with the wearable device is that elderly adults have to wear this device all the time.

Both the type of smart fall detection techniques is been discussed. Both have their pros and cons. System can have any of these depending on requirement and budget.

D. Periodic health report

Keep an eye on health of elderly adult is very important for the wellbeing of them. If loved one or care taker can know about any lapse in health of elderly adult early they can avoid future complications. We focus to measure blood pressure, body temperature, and heartbeat of elderly adults. As health report

is PII (Personally Identifiable Information) of an individual prior consent of elderly adult is needed. After getting consent of elderly adults system can monitor their health on a daily basis and if it crosses predefined threshold system will send notification to loved ones or care taker.

We can measure blood pressure, heart beat and temperature through wearable having sensors. To have information about health wearable should have optical heartbeat monitor, temperature sensor, and blood pressure sensors. These sensors are still not that mature so it may give false positive results sometimes but at least it can give rough idea of their health. These sensors may add up the cost of the system.

Periodic health feature can mull out the possibility of elderly adults being ignorant about their health. This is the major concerns among family members living away from elderly adults. In a result it will give peace of mind to loved ones as they are aware of health of elderly adults and they can assist them at the time of problem.

E. Medicine stock keeper

This feature would focus on keeping medicine stocks available as and when it is needed. Often care taker or family members are responsible for keeping medicines available for elderly adults. Responsible person just has to enter information about the amount of dose in a week and number medicines bought. Then system will count the number of days this stock would run and it will give notification to care taker or family members once medicine stock reach below the safety stock.

To implement this feature we are planning to build a mobile application with a simple user interface which take input from care taker or family member of elderly adults and remind them to buy new medicines through a notification once stock reaches to safety stock.

F. Emergency dialer

Many times elderly adults require instant help in critical situation. So we are planning to have a button on the wearable which can send emergency signal to a number or a group of numbers. Elderly adults need not want to find their number on phone and call them separately and by just pressing a button for two times they can send their message to them.

G. Location tracker

Entrance tracker will keep check on who is coming to home. Camera will be placed in the entrance to take images of the guests. If guest came to home in undesirable time to home photos will be clicked. Photo will be send to care taker or loved ones to make sure that the person is authorized.

In addition to it we are planning to keep track on the position of the elderly adults. System will intimate loved ones if elderly adults leave home in undesirable time such as middle of the night or very early in the morning etc. Through this feature loved one can be updated about elderly adults' real time location even after staying away from them.

GPS sensor can be placed in a wrist wearable though which we can have location information. We propose to activate GPS

sensor once elderly adult left home because it consume lot of power so rather than keeping it on all the time activate it when it matters. When elderly adults are at home GPS sensors will be dormant.

H. Daily photos

There are lot of instant messaging applications is available in market. But some elderly adults are not that techno savvy to be able to use it properly. It can bother loved ones living away from them. We are planning to send a daily picture of elderly adults.

V. CONCLUSION

We describe the smart home assisting elderly adults. Motivation behind taking this niche field is discussed. Furthermore, different features that a smart home can have for helping elderly adults were listed. Features described in a paper can be implemented with the efficient use of internet of things technology. We also include short approach in all the features so while implementing it would help. As we are using large number of sensors in smart home collaboration between these sensors is important. To ensure smooth workflow we have used multi agent system for sensor networks.

Building a truly generalizable system for elderly adults represents a significant challenge. We believe such a system could provide the foundation for a new class of practical applications, benefiting elderly adults and their loved ones. Despite limitations and opportunities for improvement, we believe this work provides compelling evidence that a practical solution of elderly adults' problems is possible.

REFERENCES

- [1]. Economic and social affairs of United Nations, World population aging 2013
- [2]. Dong, Y., Scisco, J., Wilson, M., Muth, E., and Hoover, A. Detecting periods of eating during free living by tracking wrist motion. *IEEE Journal of Biomedical Health Informatics* (Sept. 2013).
- [3]. Dongha Lim, Chulho Park, Nam Ho Kim, Sang-Hoon Kim, and Yun Seop Yu, Fall-Detection Algorithm Using 3-Axis Acceleration: Combination with Simple Threshold and Hidden Markov Model. *Hindawi Publishing Corporation Journal of Applied Mathematics Volume 2014*
- [4]. Arab, L., Estrin, D., Kim, D. H., Burke, J., and Goldman, J. Feasibility testing of an automated image-capture method to aid dietary recall. *European Journal of Clinical Nutrition* 65, 10 (May 2011), 1156–1162.
- [5]. Edison Thomaz, Irfan Essa, Gregory D. Abowd, A Practical Approach for Recognizing Eating Moments with Wrist-Mounted Inertial Sensing.

- [6]. S. Theodoridis and K. Koutroumbas. Pattern Recognition, Fourth Edition. Elsevier, 2009.
- [7]. M. Ring, U. Jensen, P. Kugler, and B. M. Esko_er. Software-based Performance and Complexity Analysis for the Design of Embedded Classification Systems. In Proc. of the 21st International Conference on Pattern Recognition (ICPR 2012), pages 2266{2269, Tsukuba, Japan, 2012.
- [8]. Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU). ActivityNet Benchmark Datasets: BaSA – Basic Step Activities. <http://www5.cs.fau.de/activitynet/benchmark-datasets/basa-basic-step-activities/>, 2014. [Online; accessed 30-Juli-2014].
- [9]. N. MohdNordin, P. S. Chee, M. MohdAddi, and F. K. Che Harun. EZ430-Chronos Watch as a Wireless Health Monitoring Device. In Proc. of the International Conference on Biomedical Engineering (BIOMED 2011), pages 305-307, Kuala Lumpur, Malaysia, 2011.
- [10]. C. V. Bouten, K. T. Koekkoek, M. Verduin, R. Kodde, and J. D. Janssen. A Triaxial Accelerometer and Portable Data Processing Unit for the Assessment of Daily Physical Activity. IEEE Trans Biomed Eng, 44(3):136{147, 1997.
- [11]. A. Zijlstra, M. Mancini, L. Chiari, and W. Zijlstra. Biofeedback for Training Balance and Mobility Tasks in Older Populations: A Systematic Review. J NeuroengRehabil, 7(1):Article 58, 2010.
- [12]. O. D. Lara and M. A. Labrador. A Survey on Human Activity Recognition using Wearable Sensors. Commun Surveys Tuts, 15(3):1192{1209, 2013.



Hiromitsu Hattori is with College of Information Science and Engineering, Ritsumeikan University Kusatsu, Japan. (e-mail: hato@fc.ritsumei.ac.jp)

Authors Profile



Parth J Desai is a student in Symbiosis Centre for Information Technology, Symbiosis International University. He is currently doing his Masters of Business Administration in Information Technology with Information Security as a major. His research interests are Information security, Product design,

Business Process Management, Internet of Things etc. (E-mail: desai.parthj@gmail.com)