Residents Aware Network for Intelligent Assistance

to

Enable Aging-in-Place

R. Reddy, S. Reddy

Lane Department of Computer Science & Electrical Engineering

West Virginia University

Morgantown, WV 26506, USA

***Abstract* — As society is aging it is imperative to find suitable technologies that can enable seniors to live in their own homes longer in order to minimize the social costs associated with institutional care. While there are many apps and gadgets to deal with individual situations such as *fall detection*, *smart medicine dispenser, remote doctor visit* etc. there are no comprehensive holistic solutions that can deal with all the challenges associated with aging. This is a complex task involving many disciplines. At West Virginia University (USA), we put together an interdisciplinary group including Electrical Engineers, Computer Scientists, Computer Engineers, Medical and Healthcare Professionals and Social Workers to create a realistic testbed to showcase integrated solutions that can be scaled-up by start-up companies using a wide variety of resources available at the University. This system known as RANIA (Residents Aware Network for Intelligent Assistance) is being developed by a group of nearly 100 students under the guidance of faculty from the College of Engineering, School of Health Sciences and the School of Social Work. In addition, we have also created a Collaboratory to enable participation from institutions around the world to create their own unique solutions suitable for specific environments. We believe this project can have profound impact on aging populations around the world by showcasing technologies that can enhance quality of living not only by delaying the need for institutional care but also reducing social costs associated with caring for seniors.**

***Keywords – Aging-in-Place, fall detection, smart medicine dispenser, social robot, virtual reality, remote doctor visit.***

1.Introduction

In the United States, it is expected that by 2020 there will be only three and half working people for every retiree. This is expected to fall further to two and half by 2060 [1]. Similar trends may hold true for most of the countries of the world. The social costs associated with providing institutional care (assisted for this population will stretch the budgets of most counties. In the US, the average cost of assisted living in an institution exceeds $10,000 per month, which is unaffordable to a vast majority of seniors. As technologists, we are challenged to address this important societal problem. Aging-in-Place has been advanced as the solution for addressing this social challenge. Recent developments in Artificial Intelligence, Natural Language Understanding, Internet of Things (IoT), Robotics, Virtual and Augmented Reality, and User Interfaces show promise that an economically viable technical solution can be found to directly address this issue. A house equipped with these technologies can mitigate many challenges faced by seniors with declining faculties such as forgetfulness, confusion, tendency to fall, and also reduce social isolation. At West Virginia University, an interdisciplinary team of engineers, computer scientists, healthcare professionals and social workers have set out to create a real-world testbed to demonstrate the feasibility of technology-assisted Aging-in-Place. We have also created a Google Group known as AiPTec (Aging-in-Place Technology Collaboratory) [2] to promote the exchange of technological advances from around the world. In this paper, we will provide a brief description of a number of sub-projects that are currently underway. These will be integrated and showcased in a 400 sq. ft. apartment known as RANIA HOUSE – a residence that is aware of the challenges faced by its inhabitants and will provide intelligent assistance as necessary. In the rest of the paper, we will briefly describe overall architecture of the RANIA System and some of its applications.

|  |
| --- |
|  |

1. Background and Related Research

Over the years, there have been many technological solutions for individual challenges faced by senior citizens. Reeder et al [4] collected evidence to show that a “health-smart” home can promote aging-in-place. Peek et al [5] studied factors that will influence acceptance of technologies by older people. Ahn et al [6] studied attitudes of people that determine the acceptance of technologies in the context of aging. Connely et al [7] and Demeris et al [8] studied approaches for understanding the impact of technologies. All these researches lead to the conclusion that homes equipped with technologies for assisting older adults age in place is a viable social imperative. The reality, however is that only piece-meal solutions focusing on a single aspect of aging have made it to market place. For example, fall detection and reporting is one of the most ubiquitous solutions [9]. Often it consists of nothing more than a button (worn as a pendent). The user, in the event of a fall, can press the button and the device reports that the user has fallen and reports the location registered to device – usually a room number or an address. But this is of little help if the user has fallen in another location, such as a surrounding garden. Also, this assumes the user is conscious and is able to push the button, which is often not the case. More recently wearable devices such as the Apple Watch can report the location and summon help even when the user is not conscious. However, this is quite an expensive solution. New research involving the use of radio waves to monitor a person without any wearable devices [9] is promising, but is at a very preliminary stage. The Telemedicine technology has matured but is a standalone solution, which requires technical expertise to setup. The technological complexities and limitations detailed above, therefore, present major obstacle for adoption by seniors. Medication dispensers currently available are no more than a box with compartments labeled for different days. In short, all of these *point* solutions necessitate varying degrees of technical sophistication or are highly limited in scope, preventing them from wide-scale adoption. As early as 2011, a sensor based network for assisted living was proposed [10, 11], but a practical system has not yet materialized. A recent European project known as MoveCare (<http://movecare-project.di.unimi.it/index.php/project/>) proposes a comprehensive approach using hierarchical sensors and remote human monitors. The project RANIA HOUSE, subject of this paper,, though similar in goals to the MoveCare project uses a non-hierarchical approach with an incremental deployment strategy. It addresses he usability challenge by using a natural language interface requiring minimal interaction with devices.

1. A Scenario

Let’s consider the following scenario. George, an 85-year old retiree, lives alone in the house where he has lived for over 40 years. Lately, he noticed that he sometimes forgets to take his various medicines or gets confused about the timing of which medicines to take and with what (water, food, etc.). His walking has become a bit unstable and is afraid that he may fall and hurt himself. Additionally, he feels that his family may not know what happened if he is unable to call or press a button on his pendant. George was also regular attendee of his church and now finds himself unable to attend the services because of mobility challenges. He misses the camaraderie he enjoyed with his fellow parishioners. He also misses dinner-time conversations at the table with his family. His loneliness is beginning to create psychological issues. George’s family has seriously considered moving him to an assisted living institution, but the high cost associated with that option has made it infeasible. The goal of the RANIA HOUSE project is to help people like George live in his own home assisted technologies to mitigate some the day-to-day challenges he faces.

1. The RANIA system

RANIA is an Intelligent System which understands natural language, "knows" what is happening around her (through a network of sensors in every room of the house), can deduce when something is abnormal and can determine what is the appropriate action, and monitors its own "health" to ensure the system is always available.

RANIA responds to commands, initiates dialog, takes action as warranted, and can realize when something is out of its scope, seeking assistance (calling the human “guardian angel” to intervene).

Here are some examples of interactions with RANIA:

1. RANIA, where are my glasses? Can you bring them to me?
2. RANIA, did I take my morning medicine?
3. RANIA, I am hungry! (RANIA can be a chef also!!!)
4. RANIA, can you order groceries from Kroger?
5. RANIA, I want to go for a walk? (RANIA follows to watch over the person).
6. RANIA, I want to see my grand-daughter.
7. RANIA, take me to the church.
8. RANIA, can you check around the house to see if everything is OK? (RANIA can report if she finds the roof is leaking in one of the rooms)
9. RANIA, I am going out, can you close the garage door and activate the security alarm? (or RANIA, can determine the situation and take the necessary actions).
10. RANIA, take me to the Doctor's Office.
11. RANIA, read Don Quixote to me, where you left off.

As you can imagine the list is endless and some of the interactions listed above are obviously futuristic. The key is to continuously improve and enhance RANIA's capabilities as technology evolves, keep it affordable and make it easy to use.

The RANIA system is based on the basic Sense-Think-Act paradigm of all intelligent systems. The house is equipped with a number of sensors such as RFIDs and cameras, in addition to sensors worn on the person of the resident. The RANIA system constantly polls the status of the sensors. When it detects a change in the status of any of the sensors, it invokes the relevant service to take the necessary action using the *Publish and Subscribe* model. For example, if the system detects the resident has fallen (based on the fall detection sensor worn on the person of the resident), it will invoke the fall detection service, which will take the necessary actions prescribed the in the fall detection protocol programmed into the service. Apart from reporting the fall to the remote carer, the system may dispatch the omniscient robot to the location, which may take pictures for sharing with the authorized people, as well as engage in an appropriate conversation (using the natural language service) to comfort the resident as well as inform him of what is happening externally (e.g., the ambulance is on the way). The top-level view of the RANIA system is shown in Figure 1. It is important to note that all computations are done locally with the exception of Natural Language Processing (NLP), which is done in the Cloud.

The system has two primary interfaces: the Resident and the remote Carer. The former is used by the resident to request local services such as asking the Companion Robot to read a book. The latter is used by a remote Carer, for example to program the medication dispenser based on the latest physician’s instructions. Security of data and privacy are fundamental for acceptance of this system and has been made a high priority item. In the following section, we will briefly describe the various services that are currently part of the RANIA House Project.

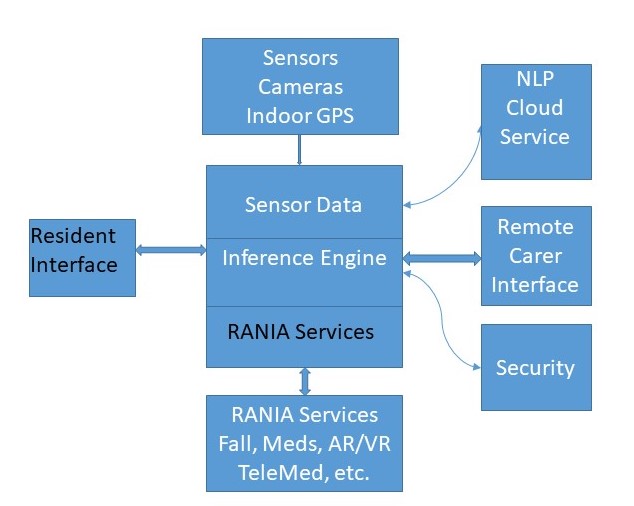


Figure 1. RANIA System Architecture

1. RANIA HOUSE Services

This is an ongoing project, which is in its initial stage. We expect the first integrated prototype of the RANIA House to be available by the end of 2019. Because of this, we will only describe the functions provided by each service. Technical details are deferred to later papers.

* 1. Smart Medication Dispenser

Ensuring a patient takes his/her medicines correctly and regularly is an important concern of health care professionals [12]. We are designing a Smart Medication Dispenser (SMD) to ensure that the Resident takes all medications at the prescribed times and using the appropriate protocol (e.g., take two pills with water). To address the challenge, the SMD will be designed to consist of a number of compartments to hold medications which can then can be programmed remotely by a Carer (a family member or a nurse). For example, if the attending physician changes the protocol, it will be incorporated into the SMD. When the time for administration of a certain medicine arrives, an LED will light-up at the appropriate compartment, the instructions will appear on the screen on top of the SMD and the companion robot will “tell” the resident what to do. A camera mounted near the SMD will also document that the medications have been administered correctly in addition to logging the event. This can be replayed by the remote Carer to ensure integrity of the system.

* 1. Fall Detection and Reporting

Falling is one of the most common vulnerabilities faced by aging seniors. While fall mitigation will be the most desirable, we do not yet have technologies that can do this. The next best thing will be detection and rapid intervention by summoning help. Most residents of nursing homes are provided a pendant that can be activated on fall, however, it has serious limitations. If the fall results in unconsciousness, the pendant will be of no help. Moreover, the pendent simply reports the assigned location such as the apartment number – even if the fall took place elsewhere.

The Fall Detection Service (FDS) in the RANIA House will detect the exact location within an accuracy of a few inches (by triangulation). The Robot Companion (RC) will be dispatched to the location promptly. In the event of a fall, the RC can assess the situation and determine if external help is necessary. If needed, the RC can stream a video to the remote location so that the remote Carer can assess the situation and take necessary actions. The RC can also engage in conversation to comfort the fallen resident.

* 1. Tele-Visit to Doctor’s Office

In conversations with residents of the Village at Heritage Point (in Morgantown, West Virginia USA), an assisted living center for seniors, the logistical difficulties of making a trip to the doctor for routine visits to the physician was prominent concern. Because Telemedicine technologies have advanced significantly over the last few years, incorporating these technologies into the RANIA House will be relatively simple. The focus of this service in the RANIA house is in streamlining and simplifying the user interface so that this can be as easy as making a phone call.

* 1. Virtual and Augmented Reality to overcome Social Isolation

Many seniors find themselves isolated because of their reduced mobility and inability to travel. In this service, we are developing a remotely navigable robot equipped with a 360- degree camera. Using this, and an Augmented Reality (AR) device, George can experience conversation at the family table or immerse himself into a service at his parish church. These technologies are highly evolved and the focus of this service in the RANIA project is on integration and simplification of the interface.

* 1. Robot as a Companion

The concept of the Robot as a Companion was envisioned by futurists a long time ago. With the advances in Natural Language Processing and robot navigation, this has become closer to reality. Psychologists have also theorized that a robot can become almost like a family member, once given a name and referred to by that name. On a lighter note, the authors have a vacuuming robot named Rosie (named after the robot maid Rosie in the futuristic cartoon from the Sixties, “The Jetsons”) and refer to Rosie the robot by name when her vacuuming services are required.

In the RANIA House, we expect the system to be able to engage in natural language conversations (a la Amazon’s Alexa and Apple’s Siri), read a book, summarize the day’s news and stock market events and deal with issues like what to do if George falls – as described in an earlier section.

* 1. Item Locator

One of the most common occurrences associated with aging is forgetfulness. Most, seniors spend considerable time looking for their reading glasses and keys. In the RANIA House, such items will be tagged with RFIDs and tracked as they are moved from location to location. For things that cannot be tagged, we will use an approach to detect patterns of usage and infer likely locations for the item being searched.

* 1. Remote Carer Interface

The Remote Carer Interface (RCI) is one of the key enablers for Aging-in-Place. In an ideal scenario a family member may live with the aging parent or relative to mitigate the many challenges faced by the aging senior. Using the RCI, a relative living at a distance or a remote nurse can keep track of everything that is happening and intervene quickly. Security and ease of use are the key drivers in the design of this service.

1. Future Work and Conclusions

In this paper, we have briefly outlined the concept of the RANIA House and a few of the envisioned services. Of course, there are many more useful services and each will be pursued in due course. In addition, we hope that others around the world can contribute to this through the Aging-in-Place Technologies Collaboratory (AiPTec). People interested in participating can contact Ramana Reddy (Ramana.Reddy “at” Mail.wvu.edu).

1. Acknowledgement

We are indebted to Patricia Moore, the world famous gerontologist for her suggestions and encouragement during a meeting at Rochester Institute of Technology in May 2018. We are also grateful to our colleagues: Brian Woerner, Powsiri Klinkhachorn, Gina Baugh, Amy summers and many other West Virginia University (WVU) colleagues. Finally, we would like thank the more than 80 students in the Capstone Program, who have been working in small groups for over a year to make the RANIA Testbed a reality.

1. References

[1]Normie L. (2017) Wireless Sensor Networks for Aging-in-Place: Theory and Practice. In: van Hoof J., Demiris G., Wouters E. (eds) Handbook of Smart Homes, Health Care and Well-Being. Springer.

[2] https://groups.google.com/forum/#!forum/aiptec

[3] Shomir Chaudhuri, Hilaire Thompson, George Demeris **Fall Detection Devices and Their Use with Older Adults: A Systematic Review,** Journal of Geriatric Physical Therapy. 37(4):178–196, OCT 2014

[4] Reeder B, Meyer E, Lazar A, Chaudhuri S, Thompson HJ, Demiris G: Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention for independent aging: a systematic review. Int J Med Inform 2013; 82:565-579.

[5] Peek STM, Wouters EJM, van Hoof J, Luijkx KG, Boeije HR, Vrijhoef HJM: Factors influencing acceptance of technology for aging in place: a systematic review. Int J Med Inform 2014; 83:235-248.

[6] Ahn M, Beamish JO, Goss RC: Understanding older adults' attitudes and adoption of residential technologies. Fam Consum Sci Res J 2008; 36:243-260.

[7] Connelly K, ur Rehman Laghari K, Mokhtari M, Falk TH: Approaches to understanding the impact of technologies for aging in place: a mini-review. Gerontology 2014; 60:282-288.

[8] Demiris G, Rantz M, Aud M, Marek K, Tyrer H, Skubic M, et al: Older adults' attitudes towards and perceptions of ‘smart home' technologies: a pilot study. Med Inform Internet Med 2004; 29:87-94.

[9] Deepak Vasisht, Anubhav Jain, Chen-Yu Hsu, Zachary Kabelac, Dina Katabi, Duet: Estimating User Position and Identity in Smart Homes using Intermittent and Incomplete RF-Data. ACM UbiComp / IMWUT, 2018

[10] Villacorta JJ, Jiménez MI, Del Val L, Izquierdo A. A configurable sensor network applied to ambient assisted living. Sensors (Basel) 2011;11(11):10724–10737. [[PMC free article](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3274310/)] [[PubMed](https://www.ncbi.nlm.nih.gov/pubmed/22346668)]

[11] Cheek, Penny BSN, RN; Nikpour, Linda BSN, RN; Nowlin, Heather D. BSN, RN, Aging Well With Smart Technology Nursing Administration Quarterly: [October-December 2005 - Volume 29 - Issue 4 - p 329–338](https://journals.lww.com/naqjournal/toc/2005/10000)

[12] Takacs, B., & Hanak, D. (2008). A prototype home robot with an ambient facial interface to improve drug compliance. Journal of Telemedicine and Telecare, 14(7), 393–395