LinkWell: A Wearable Sensor for Categorized Fall Detection

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# Abstract

Falls are a major health issue which risking elderly people’s lives. Many researchers are working on study and design fall detection technologies and systems to improve the elderly people’s living qualities. Therefore, many fall detection products are designed to support and alert users when falls happen. However, many seniors don’t like to let others know their non-fatal falls, and ignore the consequences of these falls. The accumulation of minor falls could also risk elder people’s lives. In response to this, in this paper, we introduce LinkWell – a multi-functional wearable sensor with meticulous fall detection which categorize falls into two: emergency fall and minor fall, enabling specific alert and support towards different falls. Besides, LinkWell connects users directly with their caregivers when falls happen, and provides unobtrusive health monitoring and instructions for elderly people.

# Author Keywords

Elderly people; wearable sensors; fall prevention; fall detection; fall notification; fall categorization.

# ACM Classification Keywords

H.1.2. User/Machine Systems: Human factors; H.3.4. Systems and Software: User profiles and alert services; H.5.2. User Interfaces: Evaluation/methodology, Graphical user interfaces (GUI), Interaction styles, Screen design, User-centered design; H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; See<http://acm.org/about/class/1998>

# Introduction

Fall as a major hazard to elderly people’s health (Steven, 2003) always draws people’s attentions. It not only causing injuries for elderly people which generates extra costs, but threaten old people’s safety and independence. reports that the unintentional fall death rate for adults aging over 65 years old is increasing since 2005, and it is over 60% in 2014. (CDC, 2016) Based on the data in WISQUARS (Web-based Injury Statistics Query and Reporting System) of the Centers for Disease Control and Prevention (CDC) in United States, 2.8 million elderly people are treated in emergency departments for fall injuries **(WIS)** People with fall injuries suffer from physical injuries (e.g. head injuries and hip fractures) and their consequences like psychological traumas and traumatic brain injuries, which could limit their activities causing further physical decline and depression. These falls not only threaten elderly people’s lives, but generate lots of extra costs. Based on CDC’s report, the medical costs of fatal and non-fatal injuries are about $32 billion in 2015 (**Elizabeth**).

Sometimes, fall injuries could become fatal if medical support is not given in time. For example, elderly people might become unconscious right after fall and have no chance to call for medical help. Many fall detectors with different technologies have come out to help reduce the issues mentioned above by providing automatic emergency contacts after users fall. However, about half of the elderly people who fall don’t talk about it, because they fear it will reduce their independences. (Stevens KA). Since automatic fall detectors would report their falls automatically, many senior adults wouldn’t like to use these devices.

In this paper, we designed LinkWell: a categorized fall detector, which could categorize falls into two: emergency fall and minor fall. Emergency fall is defined as

# Related Work

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Activity tracking and emergency alert system for elderly do not lack in number on market. Each feature different functionality. In general, these products can be categorized into three types. One type is emergency response system that relies on the elderly to press a button on the wearable to reach out for assistance. Once the button is pressed, the elderly is connected to an emergency station where professional staff will evaluate the situation and decide the next step action. There is usually a monthly service fee, and this has been the most widely used product in the past thirty years. Representative products include Life Alert, Philips Lifeline, Amulyte. Another type of product is home monitoring system like Alarm.com Wellness. It is usually thorough in terms of activity tracking.

Yet multiple sensors need to be installed at home which drastically increase the cost, and can be intrusive for the elderly. A third type of products do not emerge until recently. Such products have features such as automated fall down detection, medication alert, CUI. These wearables, like allen band, unali watch, are developed by startups or even individuals. Though more human-centered in both appearance and emergency fall detection functionality, it does not address the problem of lack of attention and knowledge on non-emergency falls. Though documented in-home fall down statistics are alarming, it falls short of real number as many falls are unreported and unrecognized by family members and elderly themselves. In non-emergency falls, elderly can get up on their own, or with the help of their families or caregivers. These non-emergency fall may have illness indication, or significant impact on elderly’s health.

# Research Methods and Analysis

Before doing the design, we attempted to conduct 8 semi-structured interviews with an expert and elderly adults as well as their caregivers (mainly their children).

## Expert Interview

We conducted one interview with an expert Rebecca, who was the manager of a senior care center located in Bloomington of Indiana State. From this interview, we found that seniors feel embarrassing and reluctant to talk about their falls, which support the previous result well that elderly people don’t like to talk about fall to others (Stevens JA, 2012). Besides, she also demonstrated her own demands about senior caring: “I couldn’t be around the seniors all the time, it would be very helpful if I can see further information about their falls. If I know they fall a lot during a certain period, or in certain places, I’ll call and ask what happened and see if some indoor settings need to be changed.”

## Semi-structured Interview

After expert interview, we tried another 7 semi-structured interviews with the participants we found in a public library in Bloomington. Specifically, 5 participants were people aging over 60s. 2 participants were the children of elderly people, namely the caregivers. However, further support the previous research results, all the 5 senior participants stopped our interviews when heard our topic was about fall.

For the 3 participants, the interviews were conducted in about 30 minutes that mainly consisted 3 aspects: 1) demographics about the senior adults, 2) descriptions of falls happened on senior adults and 3) needs for preventing seniors fall. Questions like “Does your father/mother live alone or with companions?” were asked to collect senior adults’ socioldemographics, and questions like “Have your parents experienced fall in the past?” “xxxx”were asked to understand the. “”

# Design Process

## Ad-Hoc Personas

Norman found that people could build effective Personas which could strengthen the design points by mining their extensive experiences. **(Book)** Personas allow us to understand user needs and prioritize each of their different needs. Therefore, to make our design more effective, we created two personas for our design. Since the target users of our design are elderly people and caregivers, we identified two different cases: one is the elderly, and the other is the caregiver. Then we invented one Persona for each case:

* Case one (Elderly): David retired from a high school teacher 16 years ago. After retirement, he spent a lot of time reading and writing at home. He has been proud to live an independent and meaningful retiring life. David has chronic arthritis, and he is aware that he is not as mobile as he used to. Still, he does not want his family to worry too much about him, and he would use a crutch to support himself. However, fear for falls has made him restrict from moving around at home.
* Case two (caregiver): Nancy works as a manager in a mid-sized company. She has a fixed working schedule, yet she would still take time to visit her father who has been living alone after retirement. She realized that recently her father has become less agile when she visited. Her father is very positive, and would insist on taking care of himself. However, she worried about her Dad's safety, but she also knows that her Dad would not be happy to receive calls and being asked about daily schedules often.

The personas suggest that our design should connect caregivers and the elderly in an non-intrusive way. It should give sense of security to elderly, and at the same time, help to reduce their embarrassment of falling down as well. Also, since elderly is a user group that is not familiar with technology, the design should meet their needs and allow them to use it without provided instructions.

# LinkWell Design

|  | **First** |  | **Second** |
| --- | --- | --- | --- |
| child | 22 |  | 44 |
| adult | 22 |  | 16 |
| Gene | 22 |  | 11 |
| Cliff | 34 |  | 22 |

Table : A narrow table in the margin

Design Pics **here** (with title).

In this section, we present the design of our fall detection sensor which is called LinkWell. We show the system design followed by product design and interaction design.

## System Design

## Product Design

Fall down tracking and alert products can be viewed as a type of product that falls under the category of assistive technology product. Assistive technology (AT) is defined as devices ranging from low-tech and high-tech that can help individuals with disabilities, aging problems or rehabilitative difficulties after surgery. (**Gitlin, Laura N. "Why older people accept or reject assistive technology." Generations 19.1 (1995): 41-46.)** However, its use, particularly among elderly population, is often associated with social stigma, thus resulting in reluctant use of the target group. Many studies also show that use of AT would change elderly’s self-perception, resulting in low self-esteem of themselves. (**Hersh, M. A. (2010). The design and evaluation of assistive technology products and devices Part 1: Design. International Encyclopedia of rehabilitation.**) Our design address this problem by making the wearable product in resemblance of an actual watch, so that our target user, the elderly can use it without embarrassment.

The product is also designed in a way that the elderly can use it without any instruction. The wearable itself does not have a multifunctional interface. The tangible interface only displays time, with a build-in microphone placed underneath to allow the elderly to listen to automatic reminders from the system or voice messages from caregivers. Through listening to voice messages, the elderly is able to receive timely attention of their health conditions, and still keep their life independent.

From research, we know that most elderly have multiple health problems that might affect the flexibility of body movement, their ability of hearing and seeing. button to maximize the pressable area. Our design also provides enough affordance for the elderly. When the elderly got voice messages, the wearable will provide haptic feedbacks via vibrations and visual feedbacks via glowing to remind the elderly to press the button and listen to it. Material of the band is waterproof, allowing the elderly to wear it during bath time.

## Interaction Design

On caregivers’ side, they can see fall down histories and get notifications when multiple minor falls happen within a certain amount of time. The app allows them to take actions based on the data. The fall down history is presented in both visualized chart and log.

Analytics Chart

Provide visual analytics data to the user so that he/she can monitor fall down history.

Fall Down Log

Present details about each fall, including fall down data, time, fall down severity types and warnings.

Being able to see when and where the fall down happen allows caregivers to take actions to prevent fall downs in the future. In emergency fall downs, caregivers are notified immediately once the wearable connects 911 and allows caregivers talk to the elderly after the 911 call is finished.

# Conclusion

LinkWell is a multi-functional wearable sensor with categorized fall detections which enabling appropriate connections between seniors and their caregivers when falls happen. Categorized fall detection could give senior adults immediate medical support when fatal falls happen, and could provide enough independences for senior adults unless frequently minor falls happen.

# Acknowledgements

We thank all the volunteers for participating in our design research. We also thank Dr. Jeffery Bardzell for giving us great advices and suggestions.

# References format

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