Connected Pouch: A wearable health monitoring system for patient

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Introduction

- **Wearable health monitoring systems** have been **under the spotlight recently**, especially among the **research community** and the **health industry**.

Pantelopoulos A, Bourbakis NG. (2010). *A survey on wearable sensor-based systems for health monitoring and prognosis.*

- **The market size of wearable healthcare** is estimated to be approximately **2 billion dollars** and is expected to reach 41 billion dollars by 2020.

Koenig P, Elsler L, Binder S (2014). *The wearable health revolution.*

- Around one in three adults over 65 who live at home will have at least one **fall** a year, and about half of these will have more frequent **falls**.

Falls. (n.d.). Retrieved November 20, 2015, from http://www.nhs.uk/conditions/Falls/Pages/Introduction.aspx

[Fictional entry.]

Introduction

In this paper,

- Summarizing my previously developed wearable device, **embedded in a wig**, which is
  focused on healthcare for patients.

- The device monitors patients' specific physical states (**falling**), as well as physiological data
  (**heart rate** and **body temperature**), and situational information (**current location**).

- Building **preliminary guidelines** for developing such a system by interviewing **healthcare experts.**

- Developing and evaluating a small pouch-shaped device that can be attached to either

Related Work (1)

- Smart Wig

  - Tobita and Kuzi introduced two key functions, navigation and presentation, as applications

    of the wig-formed wearable device. While their analysis identified two important functions

    and advantages of the smart wig, it did not focus on healthcare.

Tobita H, Kuzi T. (2012). *SmartWig: wig-based wearable computing device for communication and entertainment.*

- Fall

  - A fall refers to one's sudden change of position to the ground/floor or a lower position

    compared to a primary position.

Tinetti ME, Speechley M, Ginter SF. (1988). *Risk factors for falls among elderly persons living in the*

Related Work (2)

- Fall Detection System

  - Integrating two bi-axial accelerometers into a hearing aid housing. They used three trigger thresholds for acceleration and velocity to detect falls.

Lindemann U, Hock A, Stuber M, Keck W, Becker C. (2005). *Evaluation of a fall detector based on accelerometers: A pilot study.*

  - Developing a threshold-based fall-detection algorithm using a bi-axial gyroscope located in the sternum. They measured angular velocity, angular acceleration, and change in trunk angle to detect falls.

Bourke AK, Lyons GM. (2008). *A threshold-based fall-detection algorithm using a bi-axial gyroscope sensor.*

Design and Approach

- System Architecture

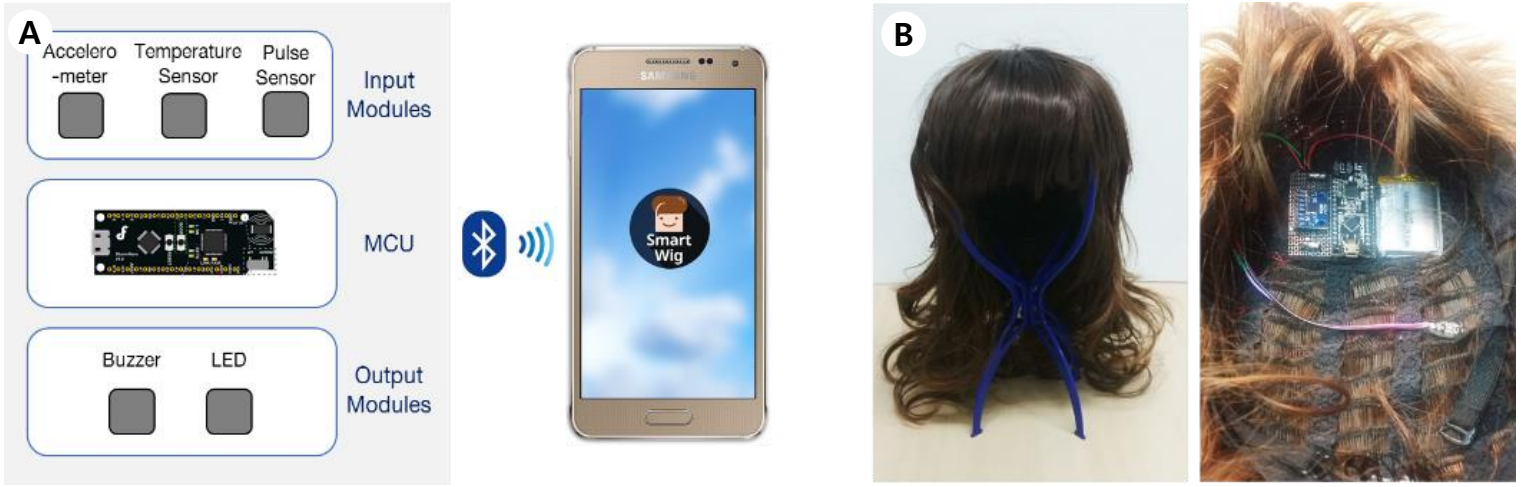


Figure 1. (A) System Architecture (B) Wig-formed wearable device prototype

– This system is to monitor patients' specific physical states, as well as physiological data,

and situational information. It has also capability of sending text messages to pre-

configured recipients.

– This system consists of three parts (Input module, MCU, and Output module,

Design and Approach

- Application

– This is wirelessly connected to the hardware systems and has two functionalities:

monitoring the patient's state and emergency alarm.

– The application displays the pa

– Highlighting abnormal data in r
when undesirable situations oc
(Fig. 2 (B)) .

– When the undesirable situations
continue for more than 5 secon
a pop-up alarm appears (Fig. 2 (C)).

Figure 2. Android application

Focus Group Interview

- Interview with Healthcare Experts

  – 3 participants

  (head of cancer education division, a medical researcher, and a senior registered nurse)

  – This could identify several primary considerations for developing wearable healthcare

  devices such as form factor, wearing area, motivation, target, and additional functions.

  – The interview helped me create the following preliminary guidelines to build a healthcare

  wearable system for monitoring the states of patients.

  First, the wig-formed device is not recommended.

Improvement

- New Prototype
  - Developing a small pouch shaped device that can be attached to either head, arm or waist.

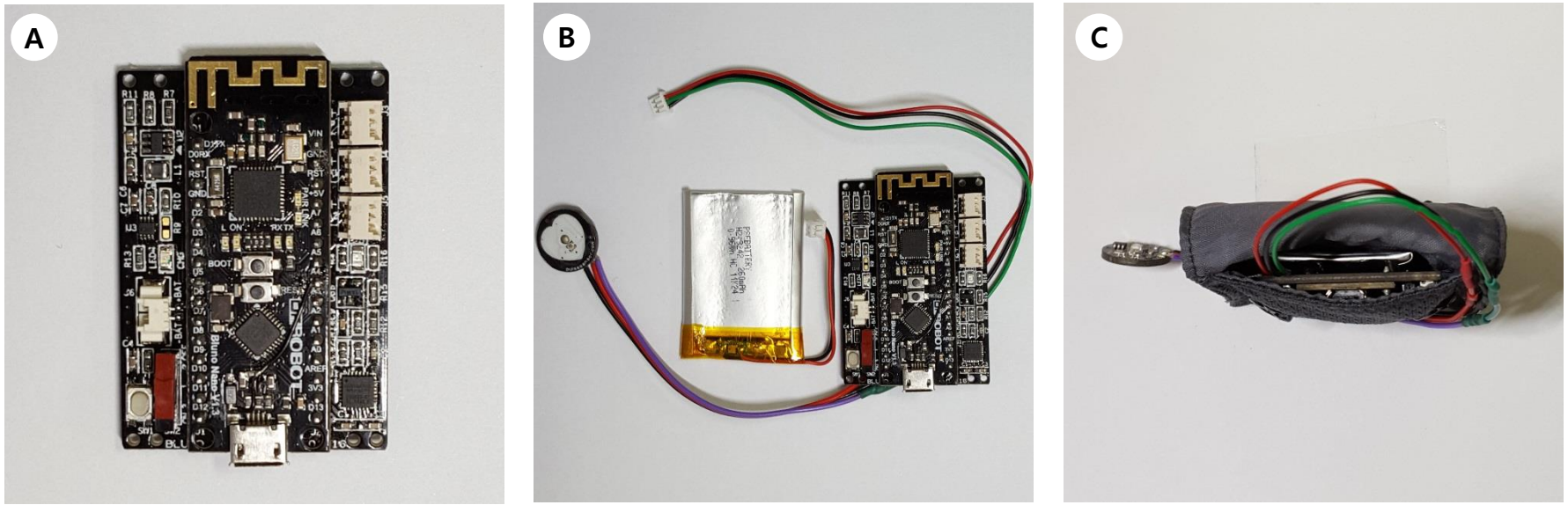


Figure 3. (A) An Integrated circuit board (B) A board with a pulse sensor and battery (C) A Connected pouch

Evaluation: Outline

- Evaluation List
  - Sensor data (e.g. Hit, Miss, False alarm, Correct rejection)
  - Questionnaire (e.g. Demographic data, Main question)
  - Interview

- Evaluation order
  1. Introducing evaluation tasks
  2. Collecting demographic data
  3. Experiment (Trial 1 – Trial 3)
  4. Questionnaire
  5. In-depth interview

Evaluation: Experiment

- Material
  - Gym mats(120cm X 240cm X 15cm), Knee guards, Elbow guards, Wrist guards
  - Arm band, Waist band, Hat
- Condition
  - 24 subjects (18 male and 6 female, 1 Group for 6 participants)
  - Normal case (Sit on the chair, Bend over to pick up sth, Going up the stairs)
  - Fall case (Fall forward, Fall backward, Fall sideward)

User / Area	Head	Waist	Arm
Group 1	1	2	3
Group 2	1	3	2
Group 3	2	1	3
Group 4	2	3	1
Group 5	3	1	2
Group 6	3	2	1

Table1. Trial orders of each group

Evaluation: Experiment Result

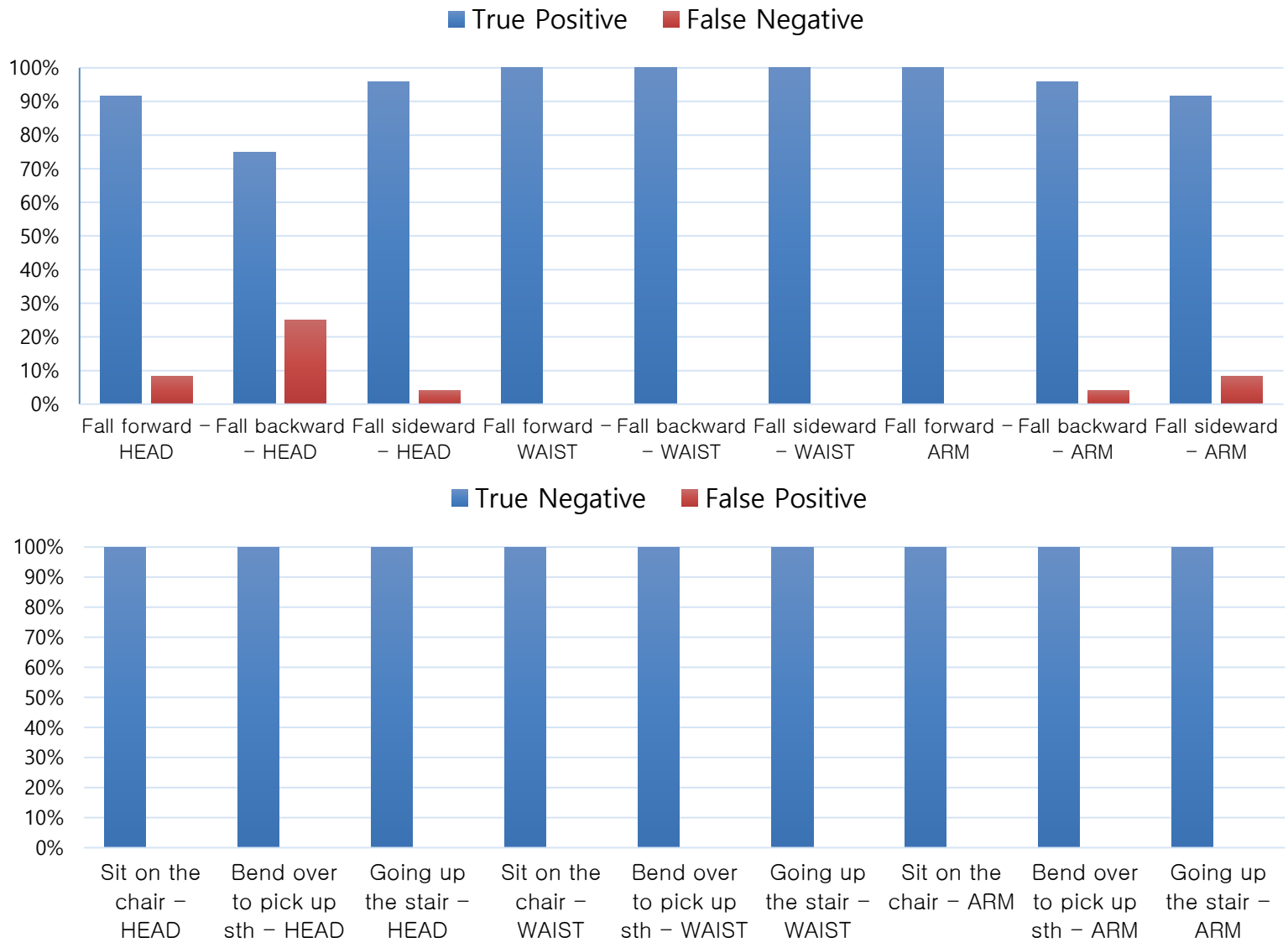


Figure 4. (A) False negative performance (sensitivity) (B) False positive performance (specificity)

Evaluation: Questionnaire

- Subjects : 24
- Questionnaire type : 5 points Likert scale
- Measurement : Reliability, Safety, Satisfaction
- Procedure : After experiments, all subjects surveyed questionnaire of 6 items

	Sex
Male	18
Female	6

Age avg.	26.75

	Fall experience
Yes	18
No	6

Table 2. Demographic data

Evaluation: Questionnaire Result

Q.1	Do you usually use the wearable devices (e.g. smart band) ?	1 (Never use) – 5 (Always use)
Q.2	I agree with accuracy of this device.	1 (Strongly disagree) – 5 (Strongly agree)
Q.3	I agree with safety of this device.	
Q.4-1	I feel comfortable (head) with wearing this device.	
Q.4-2	I feel comfortable (arm) with wearing this device.	
Q.4-3	I feel comfortable (waist) with wearing this device.	

Table 3. Questionnaire list

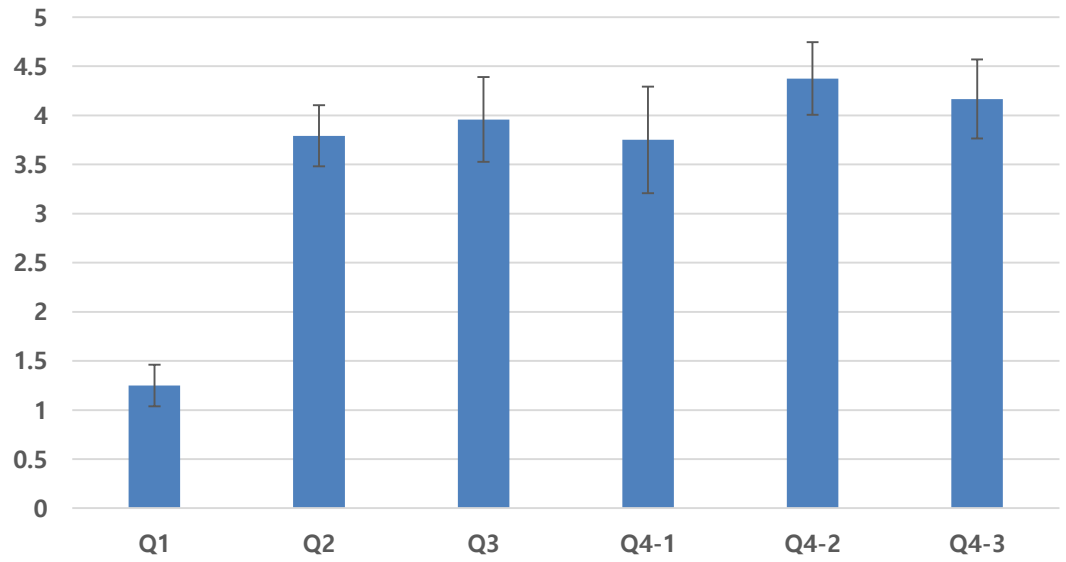


Figure 5. Questionnaire result

Evaluation: Interview

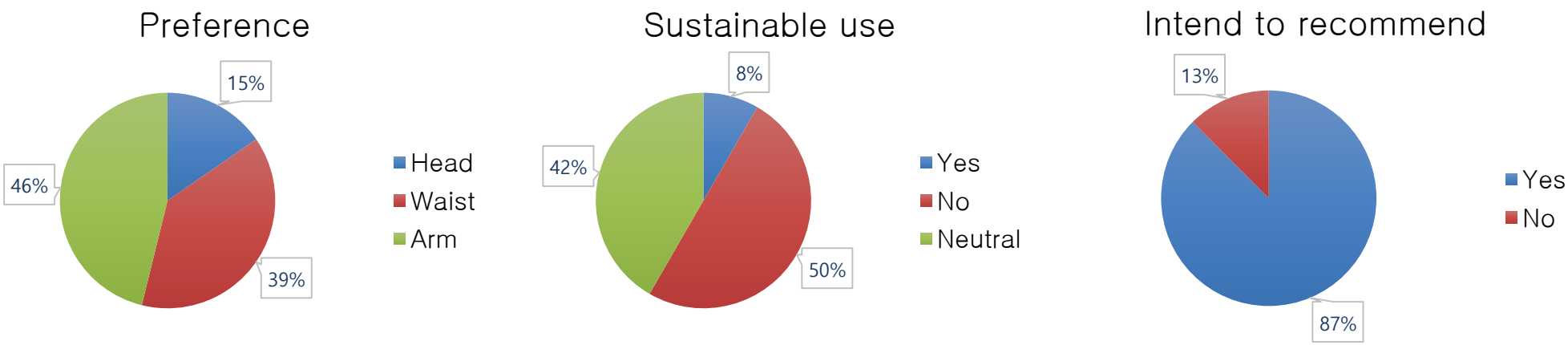
- Subjects : 24
- Interview type : semi-structured interview
- Measurement : Subject's opinion about the system(on the Connected Pouch)
- Procedure : after subjects finished their questionnaire, all of them took an interview.

All interview is recorded after getting agreement.

Then, I conducted 'context analysis' during watching the recorded video

Evaluation: Interview Result

- Usability and utility of connected pouch.



▶ Preference of wearing position is strongly influenced by the usual accessories to wear.

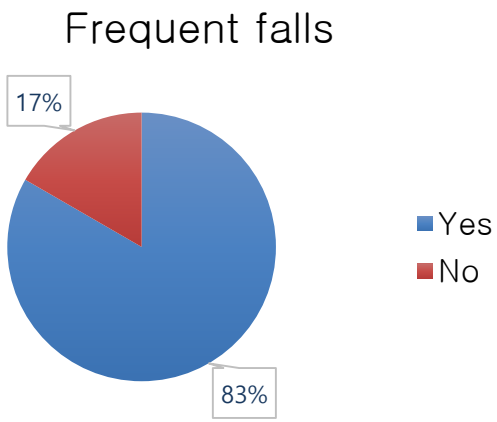
Male prefer the waist position than female because they frequently wear a belt.

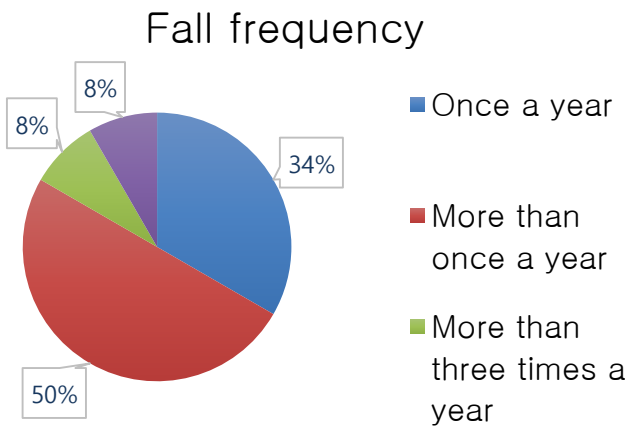
Many of interviewee said the device is difficult to use sustainably. Because they think they

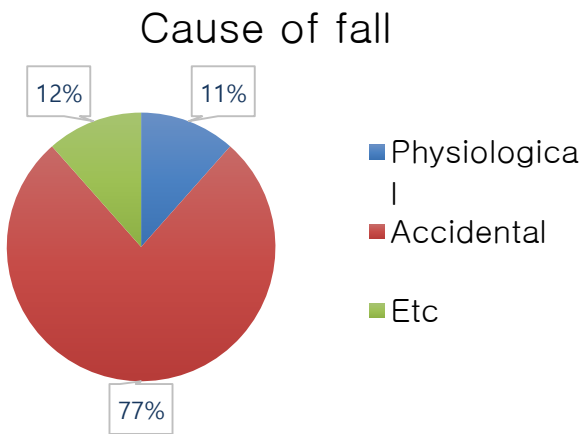
are very young for using the healthcare device. But, most of the subjects were

Evaluation: Interview Result

- About fall







▶ Many of interviewee had a experience of fall. In case of female subjects, they had a

experience of fall due to physiological reasons. In general they often have a experience of

fall by the physical cause.

Conclusion

- Discussion
  - This research is certification research of the idea : Connected Pouch: A wearable health monitoring system (possible to wear anywhere) for patient
  - At the experiment, the fall detection accuracy was 97.2% (σ=7.86). If I improve the accuracy of fall backward case (head), it would be able to actually use.
  - At the interview, Many of interviewee said the device is difficult to use sustainably. But, they were willing to recommend the devices to acquaintances especially elderly person.

- Limitation
  - Total number of subjects is too small to certified the system.

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Thank you!

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