Design of a New Personal Alarm System

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P.A.S

Personal Alarm System

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A word of thanks goes out to the following people :

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For giving me the opportunity to work in his project team on this proiect.

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Introduction

The number of elderly people is growing steadily each year[4-6].Many of these elderly still live independently and prefer to keep on doing so. Unfortunately this is not always possible due to their risk of falling. These elderly are often moved to a nursing home when this not really necessary based on their general physical and mental status. The problem is that when a person falls the risk of serious permanent damage increases by every minute he or she does not receive assistance[1-3].

At Philips they also recognize this problem and for the past 2 years they have been working on a system that can detect a fall automatically. It can send an alarm to an ERS (Emergency Response Service) whenever a fall occurs. While developing this system they realized that the market share for this device would be relatively small. People are not inclined to invest a lot of extra money when according to them a simple push button alarm would suffice.
A problem with these push-button systems is that false alarms are common due to the design and interaction of the device[3]. Daily activities sometimes result in an accidental push of the button. When this happens too often, the elderly does not want to wear the device and future falls go unnoticed.

This project was conducted at Philips Research Shanghai from July to December 2007(Fig 1a).

The following things were completed at the time of my arrival.

- Use of an acceleration sensor to determine falls
- Algorithm able to automatically distinguish between an alarm generated by a fall and an alarm generated by an everyday activity
- Acceleration sensor and algorithm were tested at five body positions to see which position could be used to gather fall data, these positions were neck, wrist, ankle, thigh and waist[7].
- Wearable prototype, waist-based to test the algorithm and position of the device
- Sensing network implemented in a nursing home. At several locations repeaters were placed. Whenever they detected a signal from the device a notification was send to one of the two base stations
- Two base stations using a simple interface which enabled the nurses to indicate to the system whether the detected alarm was real or false (important for the

testing of the algorithm)

Fig 1a
1. Start of project (2005) 2. Development of Algorhitm 3. Start of project (2007)
4. End of project (2008) 5. Further development 6. Product to market (2009)

I joined the project team because they wanted someone that could write and execute a test protocol and was able to develop the design and interaction of the device.
The team had already defined a basic list of criteria that I had to adhere to. These criteria were as followed:

- Device has to be waterproof
- Proper power source has to be defined
- The final design has to be a wearable device

Goals:

- Test the current prototype through a field trial.
- Develop an interaction and design that facilitates the automatic fall detection.
- Enhance the functionality of the product to make it more attractive for a larger target group.
- Reduce the amount of false alarms that take place through accidental activation. The interaction should facilitate this.

The first step was to determine what parts of the system I had to design. The entire system consists not only of the wearable device but also of the in-home base station that connects to the Emergency Response Service. I created an overview by means of a scheme. This scheme is show in (Fig. 1).

Most parts of the system such as the base station and link to the ERS had to be developed by the engineers in the team because it required programming. This is the reason that the rest of the report only focusses on the design and development of the wearable device.

To determine where and how our device could assist the elderly of today in their daily life I wrote a user profile based on information that was provied to me by Philips[2,3]. This profile should be read as a possible user scenario and does not describe the user in general.

For this profile see the next chapter.

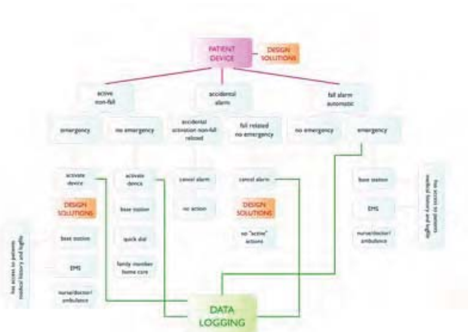


Fig 1 System overview For a larger version please see the Appendix page: 38

User profile

The target user for this project has been defined as an elderly person from 65 years onwards who is still in relatively good physical and mental condition enabling him/her to live independently. At the beginning of this project it was defined by Philips that our target user lives in Europe or the United States of America. This was done because of their existing market share in these regions[2,3].

I was only supplied with a short list of criteria by Philips however in order for me to use these points for the design phase and to provide my team with a better understanding about who we are designing for I wrote the following user scenario :

Mary Jacobs

Mary is 82 years old and sadly lost her husband 4 years ago. She still lives in the same house where they have lived together for the last 35 years. She recognizes the fact that the chores she once was able to do, are becoming more difficult for her. She has a small garden in which she likes to totter around and feed the birds that visit her everyday.

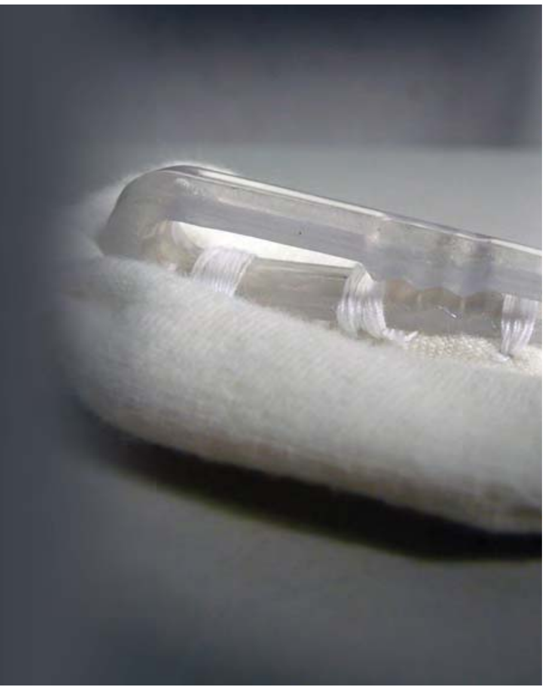
Mary has 2 children; Peter who is 54 and lives with his wife and children in a city 200 miles away, and Debby who is 52, single and lives near her mother and comes to check on her every once a week. Mary is still an active person and does most of her daily shopping herself, although sometimes she calls upon Debby for help. She used to go cycling and fishing however since her husband died she at first didn't want to do it anymore because they used to do it together and now she has sort of forgotten about it. Her husband always used to take the initiative.

In the last two years Mary has fallen down once or twice although not with any serious consequences. She attributes this to clumsiness. She does realize that she is getting older and therefore does not like to venture up to the attic anymore because the stairs are a bit dodgy. Because Debby only visits her once a week she sometimes worries about what would happen if she would trip or fall. She is wondering whether it would be safer for her to get more help, although she does not want to leave her house, especially because her friends still live in the neighborhood, and she is quite able to do all the normal chores.

As mentioned in the introduction it was my job to write the test protocol to evaluate the existing prototype.

In the next chapter I will briefly describe the field trial of the existing prototype and its outcome.

Field Trial



Before I joined the project the project team had already prepared a prototype that they wanted to test. The main goals for this trial were to test the algorithm's reliability (e.g. amount of false alarms generated) and the comfortableness of the waist-worn device.
The prototype consisted of a waist-worn (Fig. 3) box (Fig. 2) which had an acceleration sensor and a transmitting component inside.

Fig 3 Bags with rope and clip, to wear prototype around waist

Fig 2 Box with technical components

It was decided to evaluate the current prototype and it's position by means of a field trial conducted at a nursing home in Shanghai*. The trial consisted of two phases; a pretest and an evaluation. The pretest, which consisted of a questionnaire (see Appendix 2 pages 50-54), was mainly used to determine the current use of the personal alarm system available in the nursing home. The current system worked well. Because we did not explain the new sys-properly it was difficult for them to see the added value at that point. This meant that for the evaluation we had to change our approach. More results and conclusions can be found in the Appendix 1 pages 39-47

After the pretest we started with the evaluation. The evaluation lasted for a month and we had 11 participants divided over 3 rooms. The comfortableness was evaluated by means of an in-

**For the purpose of this report I have only focussed on the issues directly related to the design and wearability. Findings can be found in Appendix 1 39-47* terview. The most important findings are listed below. For more information on the method used and a overview of the questions asked I would like to refer to the Appendix 1 and 2 pages 39-53.

Discussion:

The comfortableness was hard to measure. Initially we thought that the inhabitants would remove the device, or ask the nurse to remove the device for them if it was uncomfortable. It turned out that most of the patients were "forced" to wear the device. This means that they could have decided against complaining too much because it was already determined that they would have to wear the device for a longer period of time. The patients that we were able to interview were appointed to us by the manager based on their capability to give reasonable answers to our questions.

It is striking to see that all the patients had fiddled around with the device and its position but that only two of them confessed to it being uncomfortable.

An important difference compared to the original target group was that these people do not live independently; they did not have to do household chores, grocery shopping, work in the garden, etc. This also makes their daily pattern completely different. It limits the number of locations and situations where falls could otherwise occur. Because they did not have to conduct these activities, their perception of wearability might be different. The target group might have extra requirements that we did not get from this field trial.

The number of people involved was too few to get a significant and representative result.

Extra study

In order to gather more data about what the target user expects of their personal alarm system I distributed a questionnaire (Appendix 2 pages 55-56) to a number of elderly people in the Netherlands. These elderly matched the description of our target user as stated in the previous chapter. Distributing this questionnaire allowed us to get a better idea about the preferred position out of the five mentioned in the introduction. It also gave us an idea about whether or not they wanted people to recognize the fact that they were wearing an alarm system. In the end 22 respondents completed the questionnaire. The main findings were that most respondents wanted the device to look like a piece of jewelry and that they would prefer to wear it on their neck or wrist.*

Based on the outcome of the trial, questionnaire and algorithm testing [7] it was decided by the team to focus on three positions, the head, neck and wrist. It was important to get an idea about the disadvantages and advantages associated which each position because this could later on help us to narrow down the number of positions to one, this list is presented in the next chapter.

For the purpose of this report I have only focussed on the issues directly related to the design and wearability. Findings can be found in the Appendix 1 39-47.

Positions

As mentioned in the previous chapter we had already narrowed down the number of positions to three. The following list has been created through group discussions with the team and consists of the advantages and disadvantages associated with each position. The discussions were based on the outcome of the field trial and questionnaire (chapter 3) and the reliability study executed earlier[7]. The most important points are highlighted in the following color.

The waist

Advantages:

- The waist position still remains interesting because that is the part of the body which moves the least during every day activities. It is relatively stationary at all times which can create a more reliable reading [7].
- It does not necessarily have to be a separate device but can be integrated with other devices such as mobile phone, PDA etc.
- If preferred by the user it is very easy to hide the device from sight by covering it with clothes

Disadvantages:

- The elderly user might not always wear pants with pockets or belts to which they can attach the system.
- The system can also be attached to the waistline of for example the pants or skirt but when the fabric used is relatively loose, such as is the case with stretch material, it is difficult to keep the device stable and you risk dropping it.
- It is difficult to connect the device directly to the body, as is the case with a necklace or bracelet, this means that the user always has to consciously remove and put on the device when he/she is changing his/her clothes. (Field trial Appendix 1 pages 39-47)
- Difficult to provide the user with visual information especially when a display is required for other functions

The wrist

Advantages:

- Wearing something around the wrist like a watch or bracelet is something that also elderly people are accustomed to. This means that they will be more inclined to accept such a solution.
- Offers possibilities to be combined with other applications such as time indication
- Does not (when made waterproof) have to be removed during daily activities such as shower or sleeping.
- Provides a good platform for giving feedback to the user if other

functions require a display
- Wrist is an easily accessible position on the body

Disadvantages:
- The main problem with the wrist solution is that the wrist is one of the most actively used body parts when doing daily activities[7]. The wrist is in motion a lot of the times which means that it is more difficult to get reliable data about the acceleration.**
- Might be difficult to create a widely accepted design especially because each and every person is used to wearing his own watch/bracelet suited to his/her own preference.
- Wearing something around the wrist means that you can only use one hand for the interaction as oppposed to two in for example the neck position.

The head/neck:

Advantages:
- A necklace is an easy accessible position as well as comfortable for the user.
- Offers many interaction possibilities
- Easy to integrate the device in a pendant so it will not look like a personal alarm system
- Does not have to be removed during daily activities

Disadvantages:
- Even though the necklace is easier to accept for women, men might have a problem with wearing a necklace because it can be considered to be feminine, especially when they are required to wear a pendant (Appendix 1 page 39-47)
- Difficult to provide the user with a lot of visual information especially when a display is required for other functions
- Should stay close to the body and sudden movements such as bending forward might trigger an alarm more easily

After this discussion we as a team did not yet want to narrow down the number of positions to one. The reason was that the interaction was also important. I first wanted to explore the various interaction possibilities, and combine these results with this position list to come to a conclusion. This exploration is described in the next chapter.

*** While I was there two members of my team, James Chen and Sheng Kim were already developing an intelligent algorithm that could distinguish a fall from a daily activity. This means that the wrist position becomes technically feasible in time.*

Interaction Exploration

In order to get an idea about what was possible in terms of interaction for the three positions mentioned in the previous chapter I started with an interaction exploration. I generated various ideas that dealt with the interaction. The most important thing was to determine which types of interaction a person can have with a product when he or she is wearing it[33,36]. To do so I started by drawing various interaction possibilities, and some of them are shown in the following pictures (Fig 4,5):

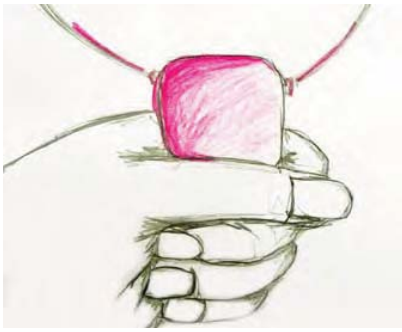


Fig 4 'Tear' interaction

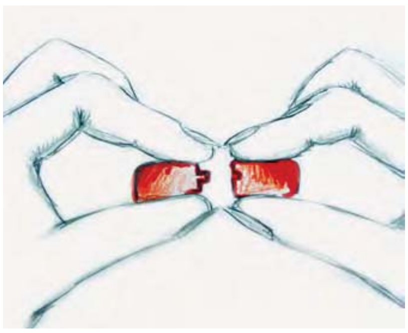


Fig 5 'Connect/Disconnect' interaction

To classify the drawings and to determine which interaction possibilities would be useful we needed a list of criteria. This list was created through group discussion and was based on common sense as well as the outcome of the field trial (chapter 3) and [3] and consisted of the following points:

Criteria:

- Device has to be easy to operate with one hand
- The activation should be simple to conduct and should be reachable within seconds
- The activation itself has to be done in a way that it is deliberate, meaning that the possibility of a false alarm will become less
- The activation should be intuitive, something that can be done in an emergency
- The action cannot be too complex to make sure that even when

the elderly person cannot think straight he or she is still able to activate the alarm
- The activation has to be feasible technically speaking. It should not imply that various extra components have to be added and that the algorithm has to become far more complicated to accommodate it.
- The device should indicate that the alarm has really been send. If the interaction already facilitates this link for the user this is an advantage (for example in case of breaking a pendant from the necklace it is clear that the connection is interrupted and that the action has been executed correctly. E.g. when the pendant is removed a signal can be sent).

Mock-ups (Fig 6,7,8,9) were created to test the wearability of the ideas. The main motivation for this decision is that you cannot measure wearability on paper, but only by experiencing it.

Fig 6 Mock-up 1

Fig 7 Mock-up 2

Fig 8 Mock-up 3

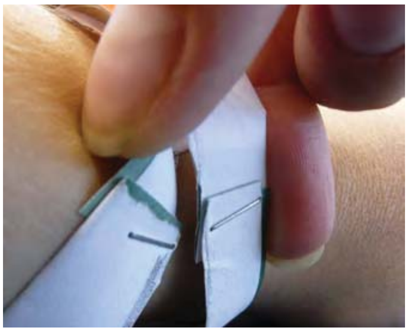


Fig 9 Mock-up 4

The criteria and mock-ups made a first selection of ideas possible. Points were given if an idea would fulfill a certain criteria. Some criteria were rated higher than others (based on importance) and as a result some ideas had more points than others. For example the criteria: “Has to be easy to use” and “Action has to be deliberate” were considered important because these two help to define the likelihood of a false alarm. The idea categories that were selected were :
- Twist/Turn (Fig 9)
- Connect/Disconnect(Fig 5)
- Grasp (Fig 6)

The final decision was not yet made because it is necessary and helpful to first get an idea about what was on the market at this time.
For inspiration I looked at several fields related to this project.

Exploration

In the previous chapter I have briefly introduced the interaction exploration that was conducted for the project. An interaction is not finished without a shell to fit around it. To determine what is already out there I started my exploration by looking at personal alarm systems available on the market today.

Existing devices (Fig 10):

Fig 10
a : example of base station (Linear LLC)
b : wrist worn personal alarm (Philips)
c : personal alarm pendant (Linear LLC)
d : pendant/watch (Condigi/Televagt)

What I noticed is that most of the devices look really similar. They are made of a specific type of plastic and often white, probably to give it a more "sterile/clean" look. Most existing devices use the necklace and/or wristband as main position for button placement. The design is without any exception very simple which enables the user to locate the button easily and use the device in an emergency [32].
Fortunately there is a growing number of designers that realizes that these devices require some extra attention in terms of design. This is visible in fig 10(b+d) .
Unfortunately for most products that I came across this is still not the case. The elderly makes a clear statement when wearing it and it is probably a statement that they do not want to make. Most people would immediately recognize it as a personal alarm system even if they are not familiar with the product itself. Wearing such a device often implies to others that :

- The person has already fallen a number of times and therefore needs the device
- Or he/she is afraid to fall and therefore uses it as a precaution
- Or he/she is not regularly visited by other people and fears that an accident might go unnoticed, meaning that they are left to their own devices for too long.

These points are based on the discussions that followed from the extra study as mentioned in chapter 3.
It is one of my aims to develop a product that at first sight does not directly give a clue about its intentions and that the person will wear with pride.

To see what types of interaction methods are used for emergency devices I conducted another exploration.

Devices used in emergency situations (Fig 11):

All devices have to be operated with one hand, which was also one of the criteria I had stated in chapter. Most activations require an interaction method that uses the whole hand for pushing or pulling something in a certain direction. This can be explained by the fact that if a person has to conduct a certain sequence it would be too difficult and most importantly take too long.

Fig 11 Current emergency systems

By not making it one-finger specific the risk is reduced that a person might not be able to use all his fingers properly either due to shaking or local stiffness caused by for example arthritis. Another criterion that followed from this was that it would be advisable to design an interaction that does not require a very small movement, for example where they would have to turn something while almost having to press their finger tips together.

Jewelry (Fig 12)

A point that has to be considered is of course that the elderly population might have a slightly different taste than the "younger" generation. They often prefer the more traditional pieces of jewelry, for example a combination of gold/silver and/or various types of stones or gems.

An interesting point is that in terms of cultural differences people in China have a different approach to jewelry than for example the Dutch people have. (This is not confirmed by a statistical analysis, but more from observations and conversations with locals). It is very uncommon for Chinese people for example to wear rings, unless they are married.

Fig 12 Jewelry

To broaden my perspective I did not just look at existing personal alarms systems but I also included other wearable devices.

Wearable devices (Fig 13)

There has been plenty of exploration done in the field of wearable devices, some of them also proposing medical benefits. These devices aim to monitor the wearer and either warn him (for example with a heart rate monitor or blood pressure watch or coach him towards a healthier life such as the Sense wear from Bodymedia [8]. Most of these devices require regular charging however and are still quite bulky due to the amount of sensors that they have tried to embed. One of the biggest differences between those wearable devices and our solution is that those devices are not meant for 24/7 wear [33].

Fig 13
a : BP monitor(Hammacher/Schlemmer)
b : Sensewear (Bodymedia)
c : pendant concept (Nokia)
d : clip watch(Vessel)

They often monitor the user at a certain point of the day, requiring the user to actively turn it on. This means that most of the devices adhere to different criteria and requirements. This holds especially true with regards to the power usage, because these devices often have to be synchronized with some sort of terminal, enabling the device to recharge. It makes more functionality possible because the battery is not required to work for a very long period of time. Therefore the battery is not the limiting factor the functionality by its mere size and capacity.

I mentioned in chapter 4 that we first wanted to explore the various possibilities before narrowing down the number of positions to one. Through group discussion and by taking all factors into account we chose the wrist position. This choice of position was based on the outcome of the extra study (e.g wrist and neck were preferred positions), the interaction concepts, the exploration, the technical feasibility determined by the engineers [7] and the advantages and disadvantages stated in chapter 4 (e.g it was very important that the person could wear the device 24/7 without problems and that it would be a product suitable for either man or woman).

Using the various fields of inspiration I started by exploring the design possibilities through sketches and 3D Renderings. The renderings below were used to explain the interaction possibilities to the team by means of short animations. (Fig 14).

Fig 14, Stills from the animations

These possibilities followed from the interaction exploration conducted in chapter 5. To be able to continue with the design it was also important to focus on one specific interaction method. This process will be explained in the next chapter.

Interaction

In this project the interaction was more important than the design. I wanted the design to follow the interaction principle instead of dictating it. A basic shape (flat bracelet) was chosen and from there I started by defining the precise interaction method before continuing with the final design.

By selecting one position I was able to focus the interaction on the wrist and the possibilities associated with it. Looking at the previously mentioned criteria ad ideas (chapter 5) as well as the ergonomic factors associated with design for the elderly [29](e.g. decreased motor functions and stiffness in hands & fingers) we selected one interaction method. The criteria that were most important in this decision were : Device has to be easy to operate with one hand, and the activation itself has to be done in a way that it is deliberate, meaning that the possibility of a false alarm will become less.

The chosen mode of interaction revolves around the principle that the user merely has to gently touch the device with one hand. The user can place his/her hand on the surface as he/she sees fit. The only condition is that the hand touches upon two parts of the device. This means that either a combination of top and sides or bottom and sides or bottom and top will suffice (Fig 15,16). By implementing this condition any false alarms triggered by accidentally hitting the surface of the device can be avoided*.

By eliminating the use of complex movements, specific grips or finger positions we can ensure that the elderly user is able to use the device even if he or she has limited control of the hand.

To detect if the device is being touched or the user is wearing the device I suggest a solution that will only require the use of one type of sensor. The sensor proposed is a FSR or pressure (touch) sensitive sensor. (Fig 18). The basic idea behind the FSR is that a decrease in resistance occurs when an increase in the force is applied to the active surface[9]. This means that you can determine if a surface is touched and how much force has been applied. For the interaction with the device itself the amount of force is not really important, however it could supply the caregiver with more information about the situation.

**This method was later on also tested by means of a functional prototype (Fig 19,20).*

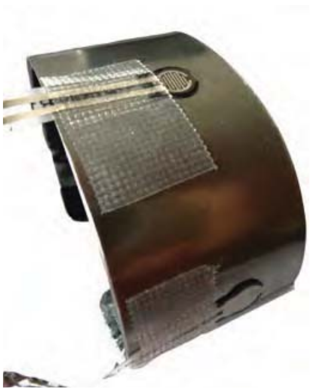
Fig 16,17 Demonstration of interaction method

Fig 18 FSR-sensors

One of the reasons the FSR is chosen as preferred sensor is the following: the FSR is fairly sensitive so only a small amount of force is needed, merely touching it is enough.
The FSR's will be distributed through the whole surface and in that way we can determine which ones are touched and which ones aren't. In order to reduce costs and to enhance efficiency a balance has to be found between the number of FSR's used and the number that is really required. This needs to be done by testing and would be the next step after this project.

I created a simple prototype to demonstrate the working principle (Fig 19,20).The prototype was made of a simple bracelet with 4 FSR sensors attached to the inner surface.

Fig 19, 20 Pictures of prototype



To enhance the bracelet's interaction possibilities and to ensure that the user can always call for help we have added the a form of adaptive interaction. This is described in the next chapter

Functionality

In the previous chapter I have already explained the interaction method. However in order to enhance the service we can offer the user we wanted to enhance the interaction by means of adaptive interaction.

The bracelet will adapt to an emergency situation where required. This can be done with the other sensors already integrated within the device. The acceleration sensor can determine a fast increase in speed in a certain direction, usually congruent with a fall. Whenever such an event occurs the user might want to send an alarm as well. Just to make sure that it is has been submitted. When this type of sensor data has been received the interaction required to activate the alarm changes. The user now only has to touch one side of the device, this to make it even easier to send an alarm in an emergency. The sensors embedded in the bracelet are still subject to change. The acceleration sensor and heart sensor are standard however one can imagine that, to facilitate particular health conditions, other sensors can also be used. An example could be a blood pressure sensor or breath rate sensor (usually measured by a band around the chest that measures how much the chest expands and how often). Most of the biosensors cannot be integrated within a wrist device at the moment, at least not without using extra components situated in a different location (breath rate) or without placing a burden on the user.

Added functionality:

In the introduction I had already stated that it was important to determine how we could make this product attractive for a larger target audience. We wanted to enhance the system by adding a feature that would adhere to our initial goal; namely to help elderly to live at home independently for a longer period of time.

To achieve this I started a literature review to determine the most important reasons that cause elderly to move to a nursing home.

From the papers I have read I can conclude that there are a couple of important issues that elderly face when living independently. [10,11]
Most of these issues often result, in combination with other factors, in nursing home admittance. The problems that were most interesting for our project were improper use of medication, lack of exercise and other specific health issues (such as heart problems etc.). I will go into more detail about these issues by listing the disadvantages and advantages associated with these topics if we were to use them for

our project. The most important arguments have been highlighted in the following color

Medication [12,13,15]

Advantages

- Most elderly use at least 3 or 4 types of meds per day [ref] meaning that you would be able to apply to a large market.
- Problem which is recognized by the elderly themselves meaning that it would be easier for them accept such a product.
- Notifications can be easily implemented in a wrist worn device.

Disadvantages

- Close communication with pharmacy/physician needed in case of intelligent system.
- Many reliability issues (in case something goes wrong who is responsible).
- Difficult to sell as an OTC product.
- Difficult to combine the notification and the physical thing (pills).
- Hard to determine non-invasively whether the meds have actually been taken and if the user adheres to the schedule.

Exercise

Advantages

- Does not require any other products. The body is the only tool necessary.
- Exercise for the elderly is a growing market.
- Examples or representations of exercises easy to incorporate in wrist worn device by means of a display.
- Can be done safely within the home environment, when provided with only easy exercise even frail elderly can benefit and risk on injury is minimal.
- Exercise is shown to improve physical status as well as mental status.

Disadvantages

- Motivation could be an issue when they have to do difficult/straining exercises because they don't feel confident about their own capabilities.

Specific health issues/addressing cause of gait/balance disorder

Advantages

- Allows for a lot of different possibilities targeted at specific groups due to large number of biosensors available.
- Can provide attending physician with extra information when an emergency occurs, helps them to determine the cause.
- Problems can be spotted earlier on to prevent further problems.

Disadvantages

- Many biosensors require a large number of components or components that need to positioned elsewhere on the body.
- Implementing a large number of these sensors will greatly decrease battery life which is already an issue.
- Reliability and accuracy is again an issue, who will be held responsible if the measurements are not accurate enough.

Based on this list of advantages and disadvantages it was decided together with the team to focus on the general health and exercise component. The point that was most important for making this decision was that Philips wanted to be able to sell the product through regular sales channels as an Over the Counter product. Therefore medication and monitoring were rejected because they would require medical supervision.

I gathered literature[15,16,17] to get a better view on the topic and to determine if it was feasible to provide the elderly, even the frailer ones, with exercises that they can do at home without requiring supervision.

It was found that there are a number of activities which can also be considered as exercises that can be done within the home environment. These exercises have been approved and suggested by the National Institute on Aging[17] and will serve as a basis for the further continuation of this side project.
We mainly aim to provide the elderly person with suggestions as to how they could implement exercise in their daily life. In order to do so we want to integrate these suggestions in a device that they would otherwise also wear such as our fall detection bracelet. The suggestions are presented by means of iconic representations consisting of one or two images based on the exercise itself. The reason why I wanted to use icons as opposed to text is because it has been demonstrated in other works that text and especially a large amount of text is hard to read for elderly especially on a small device. [34]
I started with creating these icons and first looked at the exercises as described by [17]. I used these suggestions as a starting point and started to convert them into icons (Fig 21).

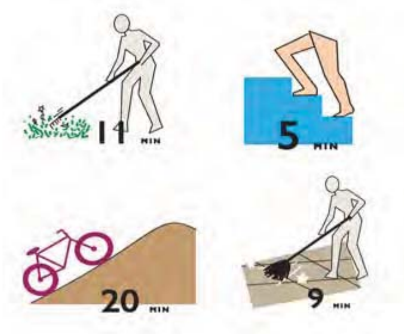


Fig 21 First set of icons

These icons were transferred on to a small mobile phone display as a first test to see if they were still legible.
After this initial test I refined the icons as followed (Fig 22,23):


Fig 22,23 Improved set of icons

Power

The last goal that I had to address was the following : determine a proper power source. The system has to monitor 24/7 which means that the power that is required is higher than when the user has to press a button. This means that the conventional button cell battery is not powerful enough. By starting an exploration into various power possibilities I was able to determine the best possible solution at this stage of the project.

There are several possibilities to perhaps save energy or create more efficient forms of energy; however these options also have their disadvantages which I will discuss. For more detailed information I would like to refer to the work document.

- The system can lie dormant during longer periods of inactivity. A combination of sensors, for example the acceleration sensor in combination with an altitude sensor can determine whether the person has been in bed for a longer period of time, when the system is calibrated to determine the height of the bed. This option has a lot of consequences which will not increase the safety and usability of the system. The problem is that the person is still able to fall out of bed during his sleep or when he/she suddenly wakes up in the middle of the night to go to the toilet.
- Instead of having a normal battery as the main power source it is also possible to make use of biogenerated power supplies, or in other words human powered energy. Energy can for example be harvested from a slight temperature difference between the human skin and the environment. However the first results of these studies have just been published and therefore not usable for commercialization. [19]. Another method would be to generate energy from movement such as is currently done with the Seiko Kinetic watches. However this doesn't supply the device with enough energy. Up until this point the capacity simply isn't big enough[24]. Movement can also be used in a different way for example by simply walking around, this poses similar problems however because it does not generate enough energy and it would require the user to always wear special garments as is demonstrated in the example used by the scientists[22,23]. Also still in its initial research phase is the development of an implant that is able to draw energy from the human blood. However this technology is besides being under de-

velopment, also very invasive and is probably better in combination with other medical monitoring systems such as pacemakers upon completion[18]. *This option was rejected*

- Next to human powered energy it is also possible to use natural sources to harvest energy from. Obvious examples are the sun (Fig 24) wind and water.

Fig 25 Water powered battey

These methods have already been used at a larger scale however it would be interesting to see whether these can also be used for small devices. The main problem with most of these harvesting tools is that the tool is often in comparison too big for the device it has to power because it is very inefficient. Sun [20]and wind are not only very inefficient sources of energy, it also very difficult to generate enough energy by relying on the everyday activities of the elderly. They are currently trying to promote water powered energy. It basically consists of a small plastic tube with conductive material and charcoal and it was said that it was able to power an alarm clock for a period 3 months [21]. A clock and battery (Fig 25) were purchased and we have done some endurance testing as well as examining the battery.

Fig 25 Water powered battey

However we soon found out that the system was not very reliable (would suddenly fail and moments later work again) and is very dependent on the quality of the water. Also the capacity was not high enough. Seeing as it is very important that the system continues to function 24 hours a day this idea was dismissed. *This option was rejected*

- There are certain battery types that are more convenient in terms of size than the standard AA battery. These batteries are called button cell batteries. Usually these button cells don't have a high capacity; however there are some manufacturers that supply these. The problem still remains that the cell needs to be charged regularly at least once a week. A special wireless docking station could be designed for that purpose so that during the night the person is able to charge the device [35]. The biggest problem that arises here is that when the person wants to get out of bed during the night and forgets to pick up the device again (which is probably very likely to happen) the person is not monitored during that time and a fall could go unnoticed. Another possibility would be the following: currently there are also very small and flat batteries available [25],(Fig 26). These batteries can be connected with one another and integrated in the device itself.

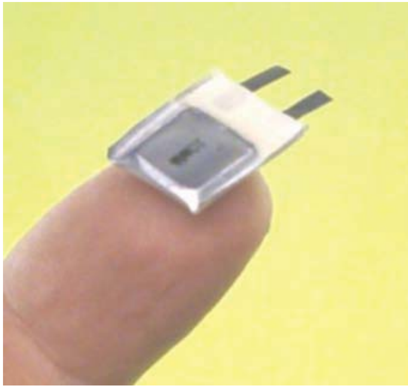


Fig 26 Very small battery

It is still not a desirable solution, because even though you greatly reduce the size you capacity is still not as high as desired. A new type of battery is currently under development namely (transparent) flexible batteries[26,27] (Fig 27).

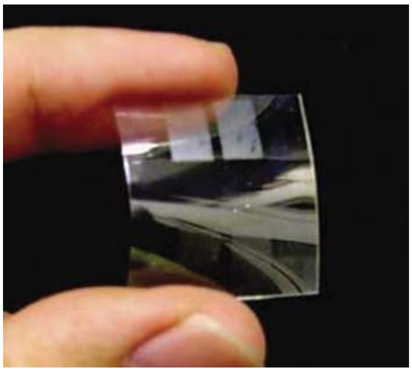


Fig 27 Flexible battery

This would be an ideal situation especially in a bracelet . The batteries are expected to become commercially available around 2009 which would be too late with regards to the launch date of the product. *This option was accepted. For the current prototype we will choose the battery depicted in Fig. 26. For a future prototype it would be ideal to use the flexible battery shown in Fig 27.*

After defining the necessary components I started with the design.
This will be explained in the next chapter.

Design

To make sure that the design would match its function I created a list of criteria for the design.

- The device should overall consist of a smooth surface this to enable the user to grasp the device in any way and in any place he/she prefers.
- The device should be as simple as possible to make sure most elderly are able to use it (no unnecessary additional functions/ buttons etc).
- The device should facilitate the use of a display.
- The device should fit most users and therefore has to be adaptable. The proposed interaction requires for the user to wear the device on the skin so a loose bracelet is not an option.
- The device should not inhibit the user in his/her daily activities so any protruding components should be avoided when possible.
- The device should incorporate an easy fastener similar to a watch or bracelet.

To accommodate these criteria I started sketching shapes (Fig 28, 29) and looked at different fasteners that could be used. (Fig 30, 31)

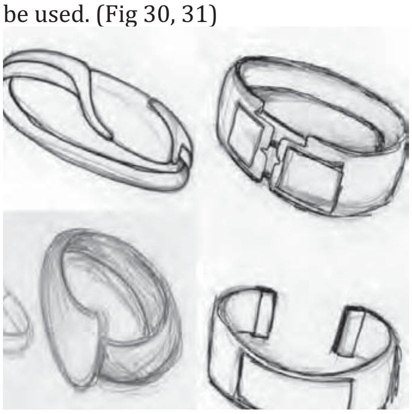


Fig 28 Form explorations 1

Fig 29 Form explorations 2

Fasteners:

I noticed when looking at the various types of fasteners that none of them really did what I wanted them to do. True, they make sure that the device stays in place and that it is to a certain extend adaptable to the user's wrist however a large part of the bottom would then be consumed by just the fastener which will not stimulate the user to interact with the device as intended. After looking at some other watch types I created a semi-open shape.

Fig 30 Fasteners 1

The ends of the device consist of metal pieces with small indentation. The indentations can be used to press the sides of the bracelet closer together to fit snugly around the wrist. There is a clear distinction between the material used for the bracelet, the "interactive" part, and the material used for closing the bracelet. Additionally the first time the bracelet is fastened to the wrist will not yet be activated but when it touches a large enough part of the wrist the device can be used.

Fig 31 Fasteners 2

The display fulfills two functions. In then first place it can show the exercises and second it gives feedback about the activation, whether it was successful or not. Next to this display I also propose a series of LED's distributed alongside its edge to enhance the distinguishability.

This resulted in the following preliminary design proposal (Fig 32, 33, 34, 35):

The previously mentioned design proposal does not take the required components and materials into account.
I will therefore now explain how everything can fit together and what is needed to manufacture the prototype.

Fig 32,33 3-renderings of design proposal. Shown are front and side view

Fig 34 , 35 Sideview of design as well as multiple color possibilities

Outer shell material:

The most important thing is that the bracelet is comfortable to wear. I will briefly give an overview about some of the possibilities and their (dis)advantages. These are based on the previous exploration (chapter 6)and common sense.

Cloth:

Advantages
- One of the more natural solutions.
- Easy to process.
- Available in various colors, types, thicknesses etc.

Disadvantages:
- Easily damaged.
- Too flexible, requires extra materials to make sure it can retain shape.
- On its own usually not waterproof
- Uncomfortable when worn close to the skin in case of warm weather.

Metal:

Advantages:
- Easy to process.
- Strong.
- Still flexible so it can be adapted to a persons individual preference

Disadvantages:
- Cold to the skin.
- Can become fairly heavy due to shape and components inside.

Heat moldable plastic:

Advantages:
- Perfect for adapting product to individual.
- Strong.
- Fairly lightweight.
- Comfortable on skin.

Disadvantages:
- Need oven to get material to desired temperature for molding.
- Can use body heat but only works under ideal circumstances (couple of days intensive used combined with right temperature and sweat such as case with skishoes/ice hockey skates).
- Will continue to "work" even after preferred shape is established. Sensitive to for example hot weather or hot water.

Plastic:

Advantages:
- Easy to process.
- Strong.
- Fairly lightweight.
- Comfortable on skin.
- Not affected by external influences (water, heat).

Disadvantages:
- Difficult to have it bend but at the same time retain shape (too strong or too flexible).

As shown in the list of advantages and disadvantages none of the materials are a perfect match for this concept. That's why I decided to combine two materials that enabled me keep the good features and solve the problems associated with the separate materials. For the final prototype I suggest a combination of metal and plastic. The outer shell of the product is made of plastic, because it is strong, comfortable on the skin and can give a nice finish. The inside of the bracelet is strengthened with a metal strip. This strip is used to facilitate the bending process and make sure that the product retains its shape.

Many types of plastic are possible for

the end product however one of the materials that I have experimented with is vinyl which is available in many colors and types. It is very easy to process and still retains some of its flexibility so it won't break when the bracelet is shaped around the wrist.

I experimented with the combination of these materials and this proved to be successful see Fig. 36

Fig 36 Test protoype with materials

The bracelet endings are made of metal for example aluminum.

Components:

A number of components were necessary based on the design proposal. I will go through the list of required components and explain why certain choices were made.

- The use of the FSR-sensor has already been explained in chapter 7.
- The chosen batteries have been mentioned in chapter 9.
- The sensor node is already in use by Philips and has been tested in combination with the FSR which was successful. They are still refining the node which at this time it is about the size of a coin [28].
- The type of screen has been chosen based on the design requirements. The resolution should be sufficient for displaying various colored images. The screen should be small, light and preferably flexible. I started by looking at mobile phone displays and noticed that more and more of these displays are OLED (Organic Light Emitting Diode) based. The biggest advantage over traditional LED displays is that OLED displays do not require backlight. This means that they draw less power and as a result can operate on the same battery for a longer period of time. Because of the fact that backlight is unnecessary, the displays can also be thinner. Currently they are also manufacturing flexible OLED`s which can reduce the size of the product[30,31].
- As an addition to the acceleration sensor I have also added the heart-rate sensor for monitoring. This is necessary to determine the right exercise level for the individual elderly.

This brought me to the following list of required components:

3x FSR round shape : Ø 18mm

1x FSR strip
sensing area : 5.08 mm
total width : 15.24 mm

Batteries:
Thickness : 2 mm
Voltage : 3.7 V
Capacity :10-70mAH
TxWxH :2x15x15mm
Weight : 0.43-0.5 g

Sensor node (see Fig 37):
Aquis Grain v2/SAND node

Screen (see Fig 38):
Flexible OLED display as demonstrated by Sony
Thickness : 0.3 mm

Heart rate sensor:
As used in watches for example Sportline Solo 910 Heart Monitor

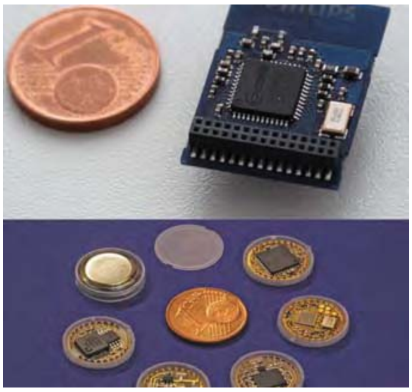


Fig 37 Aquis Grainv2 and SAND node

Fig 38 Sony flexible OLED display

If we implement all these components in the design we will get the following schematic end result (See next pages Figures 39,40,41,42). All components used in this rendering are based on their real-life dimensions. This has been done to demonstrate how everything can fit together.

Fig 39

Fig 40 : *1 = Battery compartment*
2 = FSR strip inside
3 = Metal strip inside
4 = One out of 3 FSR sensors
5 = OLED display
6 = Sensor node

Fig 41, 42 Top and side views of inside bracelet

Conclusion

In the introduction I had stated four goals that I wanted to accomplish:

1. Test the current prototype through a field trial.
2. Develop an interaction and design that facilitates the automatic fall detection.
3. Reduce the amount of false alarms that take place through accidental activation. The interaction should facilitate this.
4. Enhance the functionality of the product to make it more attractive for a larger target group.

During the course of this project I have been able to complete all of these, some more successful than others:

1. The field trial was executed at a nursing home in Shanghai. (See chapter 3). Unfortunately it was less successful as planned. In order to evaluate the final design proposal a new field trial should be started. One of the most important success criteria would be to have it evaluated by the exact target group in the target market (e.g. Europe or the USA, not China)
2. A design and interaction have been created suited to the capabilities of the elderly. (See chapter 7, 9). In chapter three I already mentioned that the final product should not look like your "average" personal alarm system because the elderly do not want to show to the outside world that they might require assistance. I feel that with my design this has been accomplished. You might argue that if and when the product would become a success everybody will recognize it, but that is only the case for people familiar with these types of products. Others would still think of it as a watch or bracelet.
3. The interaction requires a deliberate yet intuitive action, which can reduce the risk of a false alarm. Basic testing has been done with the prototype, which demonstrates the working principle, however more calibration and testing is necessary. (See chapter 7, 8).
4. Literature studies enabled me to determine what kind of issues elderly face when living independently. An overview was presented in chapter 8. Exercise was one of these issues. Its possibilities were explored, which led to an addition to the design proposal. We wanted to provide the elderly with suggestions as to how they could enhance their daily life with simple exercises.

General Recommendations:

There are of course always a number of things that can be improved or altered. For instance, the power issue has been addressed but not completely solved. At the time of writing a lot of new developments are on their way: flexible batteries (see chapter 9), batteries that can be charged in under a minute , and remote charging stations which can be integrated in various objects [35]. All these new applications could enhance the product in terms of size, weight and efficiency (longer lifespan on one battery).

The sensors also have to be calibrated and tested further in a real-life situation.

Design Recomendations:

The design as it is now, is intended to fit the wrist of the average elderly through its shape and closing method. (The metal parts at the end used to close the bracelet around the wrist). However in order to further enhance the design and the wearability of the product more exploration is needed. The wrist is not exactly round and as such a rigid round shape does not completely fit the wrist at all points. This is also supported by the following facts:

- The average circumference of the wrist of a male is approximately : 177 mm and for a female is : 161 mm[36].
- The average wrist depth to wrist width ratio is 0.69[36].

The wrist is next to its shape also limited by its movements. The wrist can flex and bend in certain directions up to a certain angle. This is shown in the following list [37]:

Flexion - 80 degrees (Fig 43)
Extension - 80 degrees (Fig 43)
Ulnar deviation - 30 degrees (Fig 44)
Radial deviation - 20 degrees (Fig 44)
Pronation - 80 degrees (Fig 45)
Supination - 80 degrees (Fig 45)

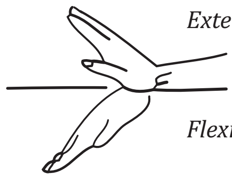


Fig 43

Fig 44

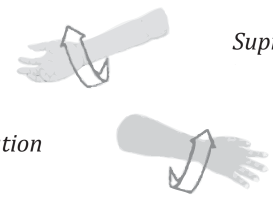


Fig 45 (Google images adapted with Illustrator also 43,44)

In order to accomodate the exact shape and the movement possibilities of the wrist I suggest the following adaptations to the design: The material used can be slightly thicker and less flexible on top (Fig 46a - ODM) and thinner, more flexible towards the ends of the bracelet. The top surface of the bracelet is relatively flat so the material used there does not have to be as flexible as it should be on the side. This does mean that the batteries should be distributed in a slightly different way to facilitate the bending.

Fig 46
a : watch with rubberband(O.D.M)
b : Bracelet (Google images)
c : Watch/remote (Nike)
d : Bluetooth headset concept (Nokia)

Another possibility could be to use small intertwining links as shown in Fig 46b, Fig 47. In order to protect the components from external influences an very thin rubber shell could be used (Fig 46c). At this point I cannot say which solution is best because it would require more exploration and real-life testing however, like I said, it is something that could further enhance the product.

Fig 47
Hardwood screen (Matt Gagnon)

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Appendix 1

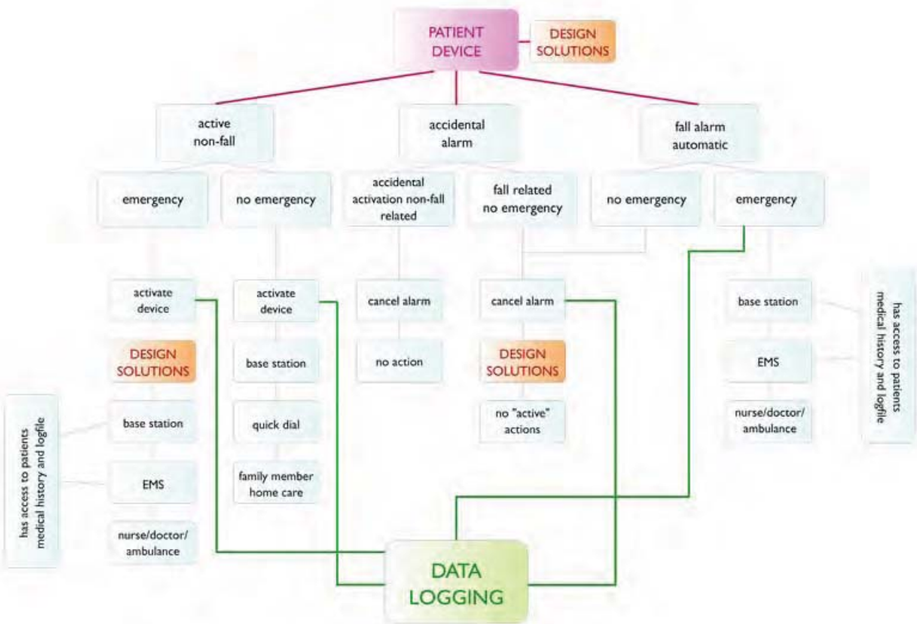

Fig 1

Field trial:

1. General Information

1.1 Conducted between:

2nd of August 2007 – 31st of August 2007
Hong Mei Block Nursing Home in Shanghai China

1.2 Introduction:

This first field trial has been conducted at a nursing home in Shanghai. Even though the residents of that nursing home were not part of our target group as specified by the client we believed that conducting the trial there would provide us with more support and control. We cannot at this stage, guarantee the reliability of the device and it was expected that a number of false alarms would be generated during the course of the experiment. If an Emergency Response System(ERS) were to handle these calls a lot of unnecessary costs would be involved and their workload would unnecessarily be increased. The nurses were able to monitor the patients as well as the operational aspects of the device and provided us with feedback they received from the inhabitants. The nurses in our case have functioned as a basic ERS.

1.3 Goal:

The goal of this field trial was to determine whether the first version of the device figuur, positioned at the waist was comfortable for the patients to wear for the course of a month, and if the device itself functioned properly. The product itself hadn't been designed as such for this field trial however it had been optimized to facilitate the testing of the fall detection algorithm. It was from a design perspective also interesting to see how the position at the waist would influence the daily activities of the elderly.

1.4 Hypothesis:

The new system will reduce the risk of a false alarm and at the same time will be more individually oriented. This will provide the elderly with better care and will increase their sense of well-being and safety. Eventually the system should enable more elderly people to live by themselves for a longer period of time due to the fact that emergency situations will be spotted when they occur

It is assumed from a design point of view that the waist positioned device will inhibit the people too much during their daily activities such as walking, sitting down and doing household chores that require them to bend down often.

1.5 Method:

The field trial will consist of a pretest and an evaluation afterwards.
The pretest will consist of a number of questions aimed at the resident's current attitude towards the emergency response system in place (cord with button) and expectancies towards the new system (they will be introduced to the system).
The evaluation will again consist of a number of questions aimed towards getting the experience from the user with regards to the new system. This will enable us to determine the positive points and the negative points associated with the new product.

2. Pretest

2.1 Goal:

This test will be mainly used to establish an idea about the way they use the current system and how the new system can contribute to a more comfortable way of living. It is also used as a tool to discover their expectations with regards to the new system. The users will get an introduction as to how the system works and what will be required of them during the experiment.

Next to the patients input we also want to receive some more into depth information from the nurses. We want to find out how they see the current system, how the patients use it, and what in their opinion would benefit the new system.

2.2 Participants:

11 divided over 3 rooms
5 are female and 6 are male
Unspecified number of nurses (depending on availability)

2.3 Questions:

See Appendix 2 Pages 48-53

3. *Pretest Results*

Note: Not all questions have been answered

1. How often do you receive calls from one patient on average?

	1 to 5	5 to 10	10+	unanswered
Calls per day	x	x	2	1

2. How many calls per week/month/year are due to a fall (per patient)?

	1 to 5 a yr	1 to 5 a month	> once a week	unanswered
Calls due to fall	x	2	x	1

3. What are the three top reasons for patients to call the nurse? (All three nurses answered the same thing)

    1. Ordinary everyday requirements (not specified)
    2. Feel uncomfortable
    3. Go to toilet

4. Does a patient fall down more easily after he/she has fallen once? Why do you think this is, and to what extend do you think the risk of falling will increase? (All three nurses answered same thing)

    It not does not happen very often that a patient falls down again soon after a first fall, this is more an incidental occurrence

5. How often does a patient on average generate a false alarm?

False alarm	1 to 5 a day	1 to 5 a month	< 1 a month
	x	1	2

6. Has there ever been a situation where a patient had fallen down and wasn't able to call for a nurse or have someone else call for a nurse? Please check the appropriate answer, if the answer is yes, please explain the situation. (Again similar answers)

When a person cannot get up anymore the people who he/she shares a room with will call the nurse so she will discover it in time.

7. Do you think that if the patients wear this system as much as possible, that it will improve the care that you can give them? E.G. respond quicker to emergencies, detecting problems earlier on?

		Yes	No
Detect problems		x	3

8. What kind of patient information would you like to see on the system? (Again similar answers)

The patients name, bed number and location
There should be a really clear audio signal when an alarm is generated

9. Are there other problems that should be monitored by the system? For example breathing problems, heart problems etc. If so, what are the main problems you feel we should address?

1. Breathing problems
2. Heart problems
3. The person should be able to activate the device himself by pressing a button

10. In case of a flawless system (no false alarms etc) which amount would be reasonable to invest in such a product per patient?

		20 Yuan	30 Yuan
Price		2	1

11.In case of a flawless system, how often would you be willing to change the batteries

	once a month	once a year	< once a year
Change batteries	3	x	x

3.2 Discussion:

We presented the nurses as well as the patients with a questionnaire. Unfortunately none of the patients completed it due to their inability to read/write/answer them properly.
Only three of the nurses completed the questionnaire (see results above) but the quality of the responses is not very high. This form was given to them to get a clearer understanding as to why the system would be beneficial to the nursing home. However, either the nurses don't see the system as useful or they did not completely understand the purpose of the system which made it difficult for them to realize its potential. We believe that it is the latter one, mainly due to the fact that the system probably has not been explained in detail enough. The nurses received a short briefing but they did not really pay that much attention and did not seem interested in the system. This can also be seen in most of the answers, most answers are basically copies of what is asked in the question. Another problem was that the trial itself was initiated by the manager. This meant that the nurses were not able to tell us that they did not want to cooperate, they had to whether they wanted or not. They already know the old system and know that that works and probably see no reason why the new system should make a difference. Hopefully the field trial itself will change their attitude towards the system and make them appreciate its potential. (This was just part of the pretest, the nurses had not used the system up to this point)

3.3 Conclusion:

Most of the answers were unusable as representation for nursing homes in China due to the lack of quality of the answers, as well as the few completed questionnaires we have received. The lesson learned from this pretest was very valuable.
We now know that we won't be able to present the patients with a similar questionnaire to evaluate the use of the system. Instead of asking them to read and write we have to interview them and ask them specific questions. The people we interview also have to be selected carefully with help of nurses and manager. We need to know who we can approach and who is able to give us satisfying answers. The nurses should be approached accordingly. During some later visits we saw that they were not unwilling to talk to us about the system so an interview/discussion would yield a lot more interesting results.
The manager also has to be involved for the next phase because she is the one who is interested in the system so it is very important to find out why. She will be able to give us a better perspective on the value of this system for her nursing home and how much a nursing home in China is able to invest in such a system.

4. Evaluation

4.1 Evaluation set up:

During the visits to the nursing home we had already realized that a lot of the inhabitants didn't fit our target user profile (see discussion for more explanation). Therefore we had a limited number of patients that we could interview.

In order for us to get as much feedback as possible we decided to take a different approach as we had used during the pretest-phase. Instead of providing the inhabitants and nurses with a written survey, that they had to complete themselves, we engaged them in a conversation. During this conversation we asked a number of questions that touched upon the most important issues.

All of the conversations were recorded with a MP3 player (all in Chinese) translated and analyzed accordingly.

We were able to involve 8 people in total, namely:

4 Residents
3 Nurses
1 Manager

The questions asked during these conversations were handled according to a script we had defined earlier.

For the Questions see Appendix 2 53-54 pages

5. Evaluation Results:

Only one person fell down recently, and this was due to a condition that he had suffered from earlier. The patient mentioned that he wanted to sit down, but lost his balance which caused the fall.

The opinion about the wearability is divided. Two of the patients indicated that the waist position was comfortable, and that it wasn't in the way. The other two patients said that the device was in the way during certain actions (for example when going to the bathroom).When we asked them about other possible positions one of the interviewees mentioned something that also became one of my concerns during the design process, namely that, especially for men, a necklace is seen as too feminine.

According to the nurses the wrist would be preferable (also following from complaints they received from the patients) or, a different solution has to be found to attach the system to the waist. They mentioned that most patients complained about the way the bag was attached to the rope and how the rope was tied around their waist. The device tilted too much during the day because the point of gravity was not low enough, and as a result the bag poked the stomach of the patients. If the device were to be stationary at the left or right side close to the hip, it would be better. The only concern the patients had with regards to this comment was that during the night they would prefer to move the device to a different position. It is interesting to learn that even though only half of them indicated that the device was uncomfortable, all of them said that they had moved the device around or removed it during certain periods of the day.

Two of the patients said that they did not consider the reliability to be an issue. They felt that in case of a fall the device would most certainly call the nurse. The other two patients said that they would prefer extra auditory feedback, not only for them but also because fellow patients might be able to act as a safety net.

The nurses all indicated for the base station they needed an extra type of feedback to indicate that a fall/alarm had occurred. They were often with patients or on their rounds so the alarms in the nurse room often went unnoticed. The most important information that they would like to see displayed on the system is the patient's name and his/her bed number

5.2 Discussion:

The biggest problem with this trial was something we didn't foresee when we contacted the nursing home. Even though we knew that the target group (independent elderly) would not be reached with this trial, we did believe that the inhabitants would provide us with enough useful information. Unfortunately most of the elderly people were not in a very good mental and physical condition. This prevented them to answer questions that we posed for the pretest to get an idea about their current situation and how this new device could enhance their life. Second, this was also a problem for the final evaluation; we were able to interview four people. However the response was limited and we had to rely more on the feedback we got from the nurses than on the feedback from the patients. Another issue that arose during the trial was that most of the people weren't very mobile; they sat in their chair or lay on their beds most of the day. This did not necessarily decrease the risk of a fall but it does mean that they did not leave their room so often or that they went outside. The idea was to see if, by having this device, they would feel "safer" to move about on their own and we could not test this with the inhabitants of this nursing home.

The comfortableness was also hard to measure, initially we thought that the inhabitants would remove the device, or ask the nurse to remove the device for them if it was uncomfortable. It turned out that most of the patients were "forced" to wear the device so they could have also decided against complaining too much because it was already determined that they would have to wear the device for a longer period of time. A lot of the patients were also not in a state to complain, they did not really have a clue as to what was going on. The question remains whether they really registered the fact that they were part of a, to a certain extend, voluntary experiment and that they actually had a say in what was happening. The patients that we were able to interview were appointed to us by the manager based on their capability to give reasonable answers to our questions. It is striking to see that all of the patients had fiddled around with the device and its position but that only two of them confessed to it being uncomfortable. It has to be noted that the manager was present at most of the interviews so it could also be because of her that they did not provide us with the "full" story if there would have been further complaints. Unfortunately it was difficult to conduct the interviews without the manager because she occasionally had to act as an interpreter and explain to the patients what the question was.

This indicates yet another minor issue. Because of several translation/interpretation steps : From English to Mandarin to Shanghainese Dialect and back to Mandarin and English we cannot be completely certain that no information got lost along the way. However we do feel that we grasped the most important facts.

Another difference compared to the original target group was that these people do not live independently; they did not have to do household chores, grocery shopping, work in the garden, etc. This also makes their daily pattern completely different. It limits the number of locations and situations where falls could otherwise occur. Because they did not have to conduct these activities, their perception of wearability might be different. The target group might have extra requirements that we did not get from this field trial.

5.3 Conclusion:

The number of people involved was too few to get a significant and representative result. We cannot say that the data we gathered holds true for the Chinese elderly person in a nursing home in general however we can use their feedback for the next trial phase of the product. The trial did not provide us with a lot of information aimed at the target group however it gave us a new insight as to what the possibility for this system could be in China and especially in the nursing homes and community services.

We knew that for our next field trial we needed to improve the device, at least for the waist position so we will be able to get more information with regards to the functionality.

Additionally in order for us to get more information about the target group we launched another questionnaire to be filled in by independently living elderly in the Netherlands. The description and results of this will follow in the next paragraph.

6. Extra Study

6.1 Introduction:

During the pretest and evaluation at the nursing home we came to the conclusion that the residents of the home did not belong to the target user as initially specified by Philips. In order for us to compliment our results and to get a better overview we decided to also get some feedback from the intended target user. We presented them with a short and relatively easy questionnaire that they would be able to complete in about 5 to 10 minutes. The conversations and discussions that

followed were noted and valuable comments were written down.
The questionnaires were distributed amongst of group elderly people living in Nieuw-Weerdinge (The Netherlands). Most of them lived alone or as a couple but all independently. Most of them were over 75 years old and still in good mental and physical condition.

6.2 Goal:

The goal of this questionnaire is to find out what the needs and requirements of the target group are with regards to the new system. We need to determine if they have experience with previous devices and if not how they envision this new product and how it could assist them.

6.3 Hypothesis:

We assume that the elderly people will have fallen down at least once and that that has probably changed their behavior. We also believe that some of them will have had experience with the existing device and as a result that they might prefer the necklace system.

Questionnaire:

See Appendix 2 pages 54-55

7. Extra Study Results:

*PAS = Personal Alarm System

1.

		Male	Female		Total
Sex		8	14		22

2.

		70-75	75-80	80+
Age		4	15	3

3.

		Yes	No
Own PAS		5	17
Percentage		23	76

4.

		Yes	No
Satisfied		2	3

5.

		Yes	No
Fallen down		3	19
Percentage		14	86

6.

		Yes	No
Hospital admittance		0	3

7.

		Yes	No
Could not reach		0	22
Percentage		0	100

8.

		Yes	No
Change behavior		2	1

9.

		Yes	No
Interested in PAS		22	0
Percentage		100	0

10.

		<10 Euro	>10 Euro
Amount to invest		22	0
Percentage		100	0

11.

	Necklace	Wrist	Waist	Pocket	Leg	Ankle	Other
Position	7	11	2	2	0	0	0
Percentage	32	50	9	9	0	0	0

12.

		PAS	Jewelry
Noticability		0	22
Percentage		0	100

7.2 Discussion:

Even though initially we though that this group would represent the target user group, only a small part of the respondents had fallen down as of late. This doesn't mean however that they are not aware of the fact that it can happen easily. They all have met people who have fallen down, broken for example a hip and were admitted to a hospital as a result. From the talks we can conclude that all of the users are very interested in such a system mainly because they are concerned with their own living situation. Most of the respondents live alone and therefore a fall can go unnoticed very easily. What is striking is that currently at least in the Netherlands the devices are often recommended by a doctor and are covered by insurance. This basically means that there first has to be an indication that falls are likely to occur before they are given the device. This also explains why they all were surprised by the question as to how much they were willing to spend. They all saw it as a normal fact that the device would be supplied to them for free whenever it seemed necessary. Most of them did not realize that such a device is also available for purchase commercially but all said they would definitely consider buying it if enough information was provided. (This is due to a lack of advertisement, at least in the Dutch media.) As far as the position is concerned we still cannot draw a definitive conclusion due to a limited amount of respondents however it provides us with some clues for the next phase. Something that we can probably conclude is that, at least for the participants in this questionnaire it is important that other people cannot at first sight see it is a PAS, they did not want to show the fact that they have an increased risk of falling and that basically their physical abilities are declining.

7.3 Conclusion:

The combination of all interviews and questionnaires has given us an idea about the desirability of the system however up until this point we can not definitely say for which position we should the design the system. The initial three positions that we described, wrist, waist and neck were all on the preference list of the users and there was no real "winner". After another field trial we can probably get better results, and the most important thing is to design a system that is comfortable to wear no matter at what position the user wears it. Depending on the interaction and shape of the system it would also be a possibility to design a system that can be worn according to a users individual preference just by simply changing the way it is attached to either a cord, belt or around the wrist.

Appendix 2

Questionnaire used in nurse pretest. (English Version)

Thank you for helping us during this trial, we greatly appreciate it!

Name :
How many people do you have to look after for? :
Are these patients mostly male or female? :

Could you please describe for each patient (that is under your supervision) what their physical status us (E.G. To what extend are they able to walk around for themselves, go to the toilet/bathroom by themselves or get to bed)

Name of patient :...
Status :...
Name of patient :...
Status :...
Name of patient :...
Status :...
Name of patient :...
Status :...
Name of patient :...
Status :...

Questions should be answered by marking the answer with a cross. For example
Are you a nurse at the nursing home?

Yes No

1. How often do you receive calls from one patient on average?

1-5 times a day 5-10 times a day >10 times a day

2. What are the three top reasons for patients to call the nurse?
   1) ……………………………………………………………………………………
   2) ……………………………………………………………………………………
   3) ……………………………………………………………………………………

3. How many calls per week/month/year are due to a fall (per patient)?

1-5 calls per year 1-5 calls per month >once every week

4. Does a patient fall down more easily after he/she has fallen once? Why do you think this is, and to what extend do you think the risk of falling will increase?

………
………
………
………

5. How often does a patient on average generate a false alarm?

1-5 times per day 1-5 times per month <1-5 times per month

6. Has there ever been a situation where a patient had fallen down and wasn't able to call for a nurse or have someone else call for a nurse? Please check the appropriate answer, if the answer is yes, please explain the situation.

Yes :…………………………………………………………… No

7. Do you think that if the patients wear this system as much as possible, that it will improve the care that you can give them? E.G. respond quicker to emergencies, detecting problems earlier on?

Yes No

8. Do you think that if the patients wear this system as much as possible, that it will improve their every day life? E.G. That it will enable them to move around more freely and do more things, because the risk of falling down unnoticed will decrease significantly?

Yes No

9. What kind of patient information would you like to see on the system? For example would you like to just see the patients name or location or also whether the patient has called for help themselves or that the system

has called for help?

....
....
....
....

10. Are there other problems that should be monitored by the system? For example breathing problems, heart problems etc. If so, what are the main problems you feel we should address?

1)..
2)..
3)..

11. In case of a flawless system (no false alarms etc) which amount would be reasonable to invest in such a product per patient?

....Yuan

12. In case of a flawless system, how often would you be willing to change the batteries ?

once a month　　　once a year　　　every five years or more

Questionnaire as distributed to the nurses (Chinese)

飞利浦研究实验室　　　　护工调查问卷表

为了更好地了解您的意见和建议，请您填写下面的调查问卷，非常感谢您对本次活动的支持！

您的姓名　　　：
负责护理的老人人数 ：
其中男性　　........ 人　　　女性 ...... 人

老人的姓名 ：...
身体情况　 ：...
老人的姓名 ：...
身体情况　 ：...
老人的姓名 ：...
身体情况　 ：...

老人的姓名 ：...

身体情况 ：...

以下问题请在选定的答案前打叉，例如

您是养老院的护工么?

是 否

下文中出现的“现有系统”指代求助按钮，“本系统”指代跌倒检测系统。

1. 您所护理的老人使用现有系统的频率为 ：

每天1-5次 每天6-10次 每天多于10次

2. 其中，由跌倒引发的求助频率为 ：

每年1-5次 每月1-5次 每周至少1次

3. 老人使用现有系统最主要的三个原因为 ：

....

....

....

4. 一些之前有过跌倒经历的老人，是否之后又出现再次或多次跌倒情况，如果是，请列出您认为增加其跌倒风险的原因 ：

....

....

....

5. 老人在使用现有系统过程中，出现误报的频率为 ：

每天1-5次　　　　　　　　每月1-5次　　　　　　　　少于每月1次

6．是否出现过老人跌倒后无法按墙上的求助按钮的情况，或者需请他人帮忙才可使用现有系统，如果存在，请对当时的情况进行描述。

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

7．您认为是否老人长期佩戴本系统，将有助于您所进行的看护工作？（例如，在发生跌倒时，是否有利于更早发现问题，以便提供及时有效的帮助？）

是　　　　　　　　　　　　　　否

8．您希望从本系统中获取怎样的信息？例如，老人的姓名或方位？

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

9．是否有其它需要监控的健康问题？例如，呼吸或心脏疾病等等？如果存在，请对其进行描述。

1）…………………………………………………………………………………………

2）…………………………………………………………………………………………

3）…………………………………………………………………………………………

10．对于一个完美的本系统（保证系统无误报），您认为以怎样的价位为每位老人配备此系统比较合理？

..............元

11．本系统采用电池供电，因而需更换电池，您认为怎样的频率较为合理？
每月1次　　每年1次　　少于每年1次

Questions used for the interviews conducted during the evaluation

Questions Inhabitants Nursing Home :
Question 2 and 3 are only valid for those who fell down.

1. Did you fall down during the past 2 months?
   Yes / No
2. Can you describe the situation that caused the fall?
3. Can you describe how you fell (for example forwards, fell on behind, fell against object or wall)
4. Did you ever find yourself in a situation where you were unable to activate the alarm, when you felt that the situat ion required so? Please check appropriate answer and explain the situation if your answer is yes.
   Yes/No
   Which Situation
5. a. Did the device ever feel uncomfortable ?
   Here we can explain also the meaning of uncomfortable so give examples such as,
   Was it in the way when you walked or sat down. Was the material of the bag uncomfortable etc.
   Yes / No
   b. Did you ever move the device along the rope to change the position?
   Yes / No
6. If you generate an alarm how would you want to device to tell you that it has been send?
   Again we can give some examples such as a beep, or a light that turns on etc
   Answer :

Questions Manager :

1. What was the main reason for you to agree to work with us for the field trial?
   If the answer to this question is similar to the next question, skip question 2
2. In your opinion, how would this device improve the patients' lives?
3. Have you received many complaints from either nurses or patients about the device?
   Ask the manager to specify which ones
4. How many false alarms are tolerated from such a device?
5. What kind of information do you think would be useful to display on the nurses system
6. How much would you be willing to invest in this system (when the number of false alarms is very little and read ings are accurate)?
7. Would you be willing to invest more if that means the response time of the nurses will increase? Because each of the nurses gets his/her own separate device?

Questions Nurse :

(it is probably better to just start a discussion with the nurse instead of asking static questions she will be able to give as a better idea on how the patients experience the system)

1. Have you received many complaints from the patients about the system?
   For example that they wanted to have it removed or that it was in the way, etc?
2. What do you think can we improve about the system?
3. Do you think that having two base stations in the nursing home works well, or did you find that you were never in the vicinity of the system, so that it actually did not help?
4. Is there something we can change about the base stations that will help you to react faster?
5. What kind of information is important for you to see when you get a fall alarm (for example name, location etc etc)

Questionnaire distributed for the extra study

Dear Sir, Madam

I am a student at the University of Eindhoven and I am currently doing my graduation project at Philips Research in China. As part of the project we are developing a system that can automatically recognize when a person as fallen down and as a result can alert an ambulance or doctor when necessary.

Ik zou u graag een paar korte vragen willen stellen in het kader van dit onderzoek.

I would like to ask you a couple of questions as part of this study.

Thanks in advance,
Alice Verdonk

The questionnaire consists of 10 questions, most of them can be answered by yes or no. Please encircle the appropriate answer.

Sex	:	Male	/	Female
Age	:		……	years old

1. Do you currently own a personal alarm system (such as a necklace with push button or a
in-home system?)

   If so, what kind :
   No

Is uw antwoord nee ga dan verder naar vraag 3
If your answer to this question is no, please continue with question number 3

2. Are you satisfied with the current system in terms of functionality/appearance

   Yes / No

3. Have you ever fallen down around or inside the house?

Yes / No

4. Were you ever committed to a hospital as a result of a fall

Yes / No

5. Did you ever find yourself in a situation where you had fallen down and were unable to call for help
Yes / No

If the answer to question number 3 was no, please continue with question number 7

6. Did you as a result of a fall change your behavior? For example did you become more careful in and around the house or did you refrain from doing certain activities?

If so please describe the change……………………………………………………
No

7. Would you be interested in a system that automatically detect a fall and call for help accordingly?

Yes / No

If the answer to question number 7 was no I would like to thank you for your cooperation otherwise I would like to ask you to answer the last three questions..

8. How much would you be willing to invest in such a system
……………..euro

9. If you were to carry this device with you 24/7, on which position of the body would you prefer to wear it?

As a necklace
Bracelet/Watch
Around the waist for example attached to the belt
Pants pocket
Around the leg
Around the ankle
Other :………………………

10. Should the device clearly indicate (through its appearance) that it is intended as a personal alarm system or would you prefer it to look like a piece of jewelry?

Alarm system / Jewelry

Thank you for your cooperation!