CONEC

A smart necklace that helps improve social life of the elderly

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Abstract

EN

This thesis aims to design a ICT(Information and Communication Technology) product that helps improve the social life of the elderly. It describes the current status of ICT design for the elderly. A better understanding of these systems allows for a more intuitive and acceptable interface design and could be achieved by using TUI (Tangible User Interface) design methods.

A user survey is performed using the method of Cultural Probe in order to understand the real social practices of the elderly. Several concepts are generated by using the method of ViP(Vision in Product Design). Then the thesis describes the current state of interaction gesture design and wearable device design (researches and products). The final design turned out to be a smart necklace with an interface like the traditional locket. It can transmit voice messages to the address that is written in the RFID tag, which is attached on the back of the photo of the contact person, presented on the locket. The behavior of exchanging contact information (telephone number) is also simplified to become a behavior of exchanging photos (by using RFID tags).

The concept is based on the technology of RFID reading & writing, Bluetooth and GSM communication, allowing a long distance voice message transmission. The prototype that is only for a simulation of the interaction is based on the Arduino platform controller.

Abstract

IT

Questa tesi intende designare un ICT(Informazione e Comunicazione Tecnologica) prodotto che aiuta a migliorare la vita sociale degli anziani. La tesi descrive l'attuale stato del ICT design per anziani. Una maggiore comprensione di questi sistemi e di questo ambito di ricerca è alla base della progettazione del design e dell'interfaccia più intuitivo ed accettabile. Questo scopo si ottiene con l'uso del TUI (Tangible User Interface) design.

Una indagine tra gli utenti è svolta usando i metodi del Cultural Probe per comprendere l'attuale vita sociale degli anziani. In seguito i concetti sono generati con l'uso dei metodi ViP(Vision in Product). Poi la tesi descrive l'attuale stato del design interattivo di gesto e design del dispositivo indossabile (ricerche e prodotti). Il progetto scaturito da queste conoscenze è una collana intelligente composta da una interfaccia del medaglione tradizionale, che può trasmettere i messaggi vocali indirizzati da un tag messo sul retro della foto del interlocutore presenti sul medaglione. Questo sistema semplifica lo scambio degli indirizzi tra gli interlocutori trasformandolo in un semplice scambio di fotografia.

Il progetto è basato sul sistema RFID reader & writer, una comunicazione Bluetooth e GSM per una trasmissione del messaggio vocale a longa distanza. Il prototipo per il momento costruito solo per provare le varie interfacce è basato sulla piattaforma a micro controllore Arduino.

1

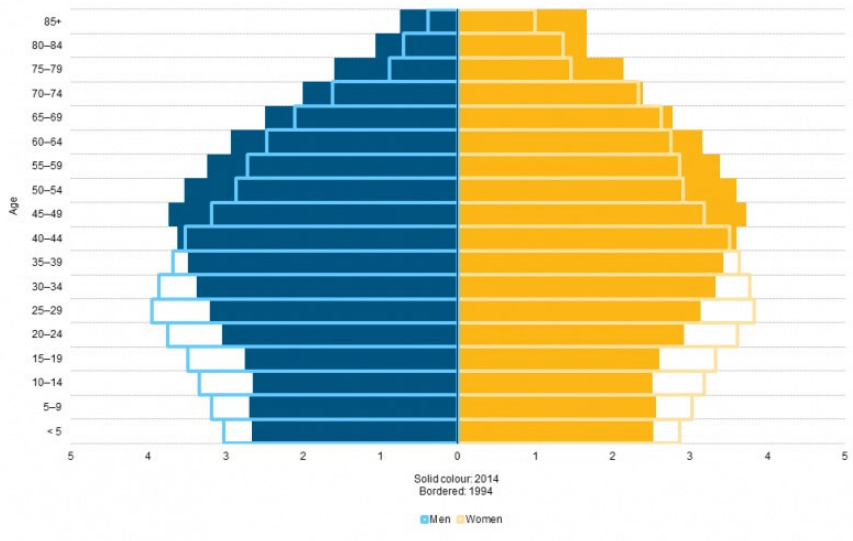
INTRODUCTION

1. Introduction

1.1 The aging society of Europe

During the last three decades, the number of people aged from 60 years or more has risen some 50%. Within 20 years approximately a third of Europe's population will be over 60 years old. The percentage of people over 80 years is growing even more rapidly. Moreover, the ratio between the working and elderly population is dramatically declining [1]. These trends present a real challenge for European society in the years ahead and underline the importance of developing new and more cost-effective ways of providing care and support to the elderly.

Consistently low birth rates and higher life expectancy will transform the shape of the EU-28's age pyramid; probably the most important change will be the marked transition towards a much older population structure and this development is already becoming apparent in several EU Member States. The share of older persons in

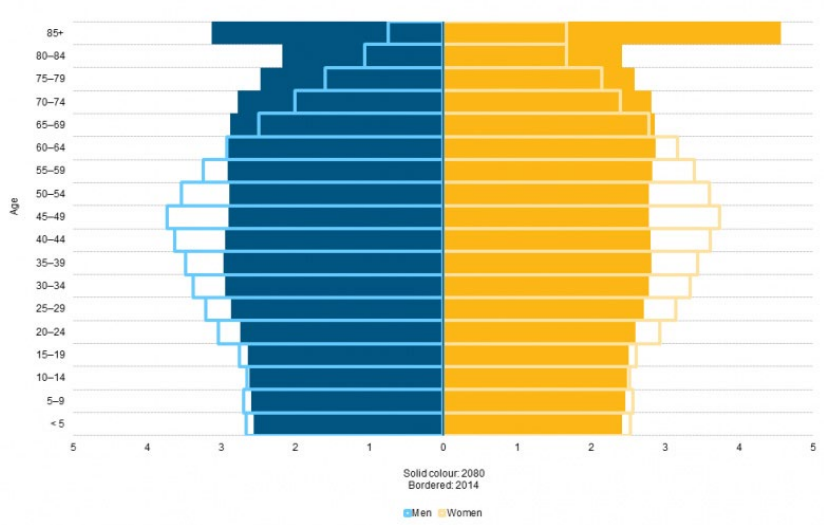


Graph 1.1: Population pyramids, EU-28, 1994 and 2014 (% of the total population)

Source: Eurostat

Graph 1.2: Population pyramids, EU-28, 2014 and 2080 (% of the total population)

Source: Eurostat



the total population will increase significantly in the coming decades. Population pyramids (graph 1 and 2) show the distribution of the population by sex and by five-year age groups. Each bar corresponds to the share of the given sex and age group in the total population (men and women combined).

Population aging is a long-term trend which began several decades ago in Europe. This aging is visible in the development of the age structure of the population and is reflected in an increasing share of older persons coupled with a declining share of working-age persons in the total population. The share of the population aged 65 years and over is increasing in every EU Member State, EFTA country and candidate country. The EU-28's old-age dependency ratio is projected to almost double from 28.1 % in 2014 to 51.0 % by 2080.

The growth in the relative share of older people may be explained by increased longevity, a pattern that has been apparent for several decades as life expectancy has risen. On the other hand, consistently low levels of fertility over many years have contributed to population aging, with fewer births leading to a decline in the proportion of young people in the total population.

1.2 **ICT and the elderly**

The mainstream of this society has quickly adopted Information and Communication

Technology (ICT)as part of their daily life, meanwhile the ever growing group of elderly people (age 60 and older) in our society seems to have been forgotten in this matter[2].

Technology helps elderly keep in touch with families and friends, ensures more safety at home, assisting and facilitating them in health care [3], bringing new stimuli into their lives and providing more access to information. Other studies confirm the role of technology in increasing social interaction and pride [4], self-esteem, life satisfaction , and perceived autonomy [5]. Regarding health support, communication technologies and wireless systems enable health consultations, physiological data collection, safety and environmental control in order to avoid disease, maintain physical and cognitive function, and maintain engagement during life [6].

However, the current ICT products have design problems so the elderly don't have enough access to adopt and benefit form them. According to a European study, more than 60% of people over 50 feel that their needs are not adequately addressed by current ICT equipment and services [7].

1.3 **Objective and approach of the thesis**

The target of the thesis is to create an interaction and experience centered ICT product to let the elderly feel more involved in the community. To understand the target user, a user survey based on Cultural Probe is planed and performed. Then the design concept is developed with the method of Vision of Product (ViP). Finally a wearable communication device of tangible user interface (TUI) is developed (the smart necklace) and an interactive prototype is built.

The thesis is divided into seven chapters. The second chapter talks about the challenges of ICT products design for the elderly. The third chapter is about the user survey. The forth and fifth chapter are for the generation and detailing of design concept. The sixth and seventh chapter are for the development of the product and an interactive prototype. The last chapter is for user feedback and conclusion.

2

CHALLENGES OF ICT DESIGN FOR THE ELDERLY

2. Challenges of ICT design for the elderly

2.1 The current situation of ICT usage of the elderly

ICT largely helps modern people in all aspects of life. However, the elderly have traditionally been ignored in the deployment of ICT. Although their demand for ICT is increasing, the problem of age-based digital divide is still unsolved [8].

ICT can contribute to improve the life quality of the elderly. According to a European study, more than 60% of people over 50 feel that their needs are not adequately addressed by current ICT equipment and services.[9] "The Internet seems well suited to the needs of the elderly, as a fairly sedentary population with considerable leisure time, especially for social networking, hobbies, and services as the home delivery of groceries" [10]. In addition, ICT can reduce dependence of the elderly and promote active and healthy aging.

What is the current situation of ICT usage of the elderly? Studies show that the elderly is the group with the lowest ratio of computer and Internet usage. Eurostat's data on Internet usage of 2011 shows that in 2010, 37% of individuals aged between 55 and 74 used the Internet at least once a week on average (27 countries of the European Union). Meanwhile 90% of the individuals aged between 16 and 24, and 73% of individuals aged between 25 and 54. Studies also show that people over 60 make limited usage of mobile phones, having them mainly for emergencies: mobile phones provide the elderly with some assurance, as they can call someone when needed. The elderly seem to avoid some functions of mobile phones, like SMS and other advanced features [11].

In another study, researchers found that only 78.3% of the participants (300 people, 65-85 years old) used mobile phones. More in detail, in relation to Sex, 59.4% of women and 93.3% of men used mobile phone. [12]

In addition, most of them can't make the usage independently. Their family would set it up for them, and so they could talk to family members and friends through the

Internet. However, they wouldn't touch the keyboard or feel that they could use it on their own. [8]

The situation is similar when it comes to the adoption of other technologies. In one study, it says13-15% of older people with hearing problems, have held hearing headsets. But most of them did not use them, either because they could not understand how they work, or because it was not the perfect device to have chosen, in shape and size. [12]

2.2 The barriers

That fact listed ahead leads to a common impression that the elderly are technophobic. However, studies show that most elderly don't think they have fears, dislike or avoid new technology and don't think they were too old for technology [8]. That means they are positive to accept technology, therefore there must be some objective barriers between the elderly and technology.

2.2.1 Function declinations of the elderly

Heller et al. say about aging: "As people grow older, their abilities change[13]. This change includes a decline in cognitive, physical and sensory functions, each of which will decline at different rates relative to one another for each individual." The elderly suffer from the declination of brain and body functions in many aspects. The function declination is an important reason to the difficulties of utilizing technologies.

Vision

The anatomical changes in the ocular apparatus affect adaptation to darkness, visual acuity, glare, contrast sensitivity, peripheral vision, motion perception and color perception. Omori, Watanabe, Takai, Takada, Miyao (2002), for instance, found that bigger font sizes in mobile phones can increase elderly users' speed and accuracy in reading the display. Schieber (2003) analyzed these changes and proposed 9 design criteria within a human-factor perspective in order to compensate for age-related deficits in the visual system [14]:

- increasing the illumination of environment or task context;
- increasing the levels of luminance contrast;
- minimizing the need to use a device excessively close to the eyes;
- adapting the font size;
- minimizing glare;
- minimizing the use of peripheral vision;
- adopting marking strategies to enhance motion perception;
- using great color contrast;
- optimizing the legibility of spatial forms using computer capabilities.

Pinto, De Medici, Zlotnicki, Bianchi, Van Sant and Napoli (1997, p. 343) analyzed the role of environmental design in case of reduced visual acuity in elderly people and proposed recommendations to improve users' comfort and safety. These recommendations define the values of a list of perceptual properties of areas (e.g. glare index of the walls, opacity of windows and doors, direct and indirect lightning) to reduce the risks caused by poor design of floor, wall, doors and windows, furniture and equipment, direct lighting, indirect lighting [14].

Hearing

The anatomical changes in the ear affect absolute sensitivity, frequency and intensity discrimination, sound localization and speech recognition. For instance, Kiss and Ennis (2001) observed that computer-generated speech, which does not match the rhythm properties of natural verbal production, can be problematic for elderly drivers. Schieber (2003) proposed 9 design criteria, as he did for vision [14]:

- increasing stimulus intensity,
- controlling background noise,
- avoiding the need to detect/identify high-frequency stimuli,
- avoiding long-term exposure to high levels of noise,
- avoiding signal locations with low frequency sound sources,
- using redundant and semantically well-structured speech materials,
- adapting the rate of words per minute,
- asking for feedback from users to calibrate the devices,

- using the Web to provide verbal communication channels for assistance.

Movement Perception

Aging determines problems (arthritis, tremors, particularly for Parkinsonís disease) affecting the manipulation of objects and the perception of sensorial feedback in terms of pressure, vibration, spatial acuity, perception of roughness, length and orientation (for a brief review, see Scialfa et al., 2004). In particular, older adults have a higher threshold of detecting vibrations[8], which has to be taken into account when devising vibrating alerts. In this vein, Liu et al. (2002) realized a system producing a mechanical noise to reduce the vibrotactile detection thresholds in older adults, patients with stroke, and patients with diabetic neuropathy[14].

Motor Function

Age related changes in hand/motor function appear to occur as a decrease in strength, dexterity and range [16]. There is a decrease in grip strength and endurance with age, with force exerted deteriorating from the mid to late twenties (40% decline in strength from 30 to 80 years old) and the average 65 year old user having only 75% maximal strength. [17]

Automatic and Voluntary Processing

Automatic processes are not affected by aging, while voluntary processes, which require a certain amount of attentional resources and awareness, decrease with aging (like fluid intelligence, see above); practice can reduce this decrease through a process of automatization [18], even though its effectiveness depends on the kind of task: for instance, visual search needs attentional resources even after a long practice [18]. As t o the kind of training, Jamieson and Rogers (2000) showed the absence of age-related differences in the acquisition of the ability to perform transactions on a simulated automatic teller machine if the practice schedule was random instead of being organized by blocked sets of trials.

Sustained Attention and Vigilance

Sustained attention means maintaining focus on the same task under continuous stimulation. Vigilance means keeping the focus on waiting for a rare event. Giambra [18] observed contradictory results in his review of past studies; when age-related deficits are reported, they are attributed to functions related to task (discrimination and duration of single stimulation, requirement of working memory effort). Anstey, Wood, Lord and Walker et al. (2005) insert sustained attention among the age-related factors affecting driving performance, linking them to mental workload like other resource-dependent functions [19].

Memory

In general, working memory appears not to decline in relation to storage capacity, but rather processing efficiency declines over time.[20] Processing speed declines but recall stays within Miller's 7 plus/minus 2 chunks.[21] Long-term memory declines with age in relation to episodic memory, however, semantic memory is maintained and deficits are rare. In relation to procedural memory, decline is elevated with the complexity of task and reaction time has been shown to decline with age. Therefore memory retention for prior known faces and places can appear to be good if supported by contextual knowledge but new complex tasks can be problematic for older people.[22]

Learning Ability

Older people maintain the ability to learn, with evidence of neural plasticity. However, the process takes more time, especially with complex material [23].

Language Ability

Skills such as vocabulary and language use are maintained unimpaired until late in life whereas skills that depend on rapid processing, accurate logical thought and spatial ability are markedly affected as people become older [24].

2.2.2 **Mental barriers**

Rejection of a new way of living

About 30 years ago, Gilly and Zeithmal (1987) studied how elderly people adopt new technologies of that time, namely, Automatic Teller Machines, scanner-equipped grocery stores, electronic fund transfers, and custom telephone call services. They found out, that elderly people, who are traditionally considered to be resisting to change, do adopt new technologies, when they are suitable and easy enough to use for them[25].

But the fact is that the older the person is, the more difficult the adoption of technology is likely to be. The elderly may get accustomed to their usual way of living. Even though they are positive to the technology and are also able to use them, they don't want to change their lifestyles. Therefore the new technology that would suit them must be respectful to their old life behaviors and do not make dramatic changes to their life.

Lack of technology literacy

The lack of digital literacy was the major reason to not use a computer or the Internet. Technologies change rapidly and the complexity of new phones increases may require previous experience of earlier generation products in order to understand current designs. However, older users may not possess the required prior knowledge whereas younger users can rely on the mental models they have built up from using previous generations of technology [26].

Lack of confidence

Some interviewees thought that especially elderly people are afraid that they somehow break their mobile devices. And most of the elderly don't have the confidence to try functions when they don't know what are the operations for.

Price

Many elderly tend to think the new devices are very expansive and they will neither need nor be interested in the most new functions that the new devices give. It is reasonable not to pay for the functions that they don't need. It can explain why most older people prefer the older version of the cellphone meanwhile the young people pursue the latest version.

2.3 The current solutions: State of the art

2.3.1 Mobile phone designs for the elderly

Whilst many mainstream phones do not cater for the older user, models are emerging that are designed with the older user in mind. "Older users have identified a number of problems with mobile phones such as displays that are too small; buttons and keypads that are too difficult to use; too many functions; battery life too short; poor sound quality; and a preference for speech input", said by Matthew Pattison and Alex Stedmon[26]. They concluded a series of design guidelines based on human factors of elderly people.

Factor	General effect on older users	Potential design solution
Vision	• more light required • ability to focus deteriorates • ability to deal with glare diminishes	• improve illumination • provide user interface options • if a display is required, use anti-glare coatings to display
Hearing	• loss of sensitivity to higher frequencies • general threshold deteriorates • complex sounds more difficult to process	• do not use high frequency audio feedback • couple auditory feedback with visual or tactile feedback • keep auditory feedback as simple as possible
Hand function	• general weakness (strength and grip) • dexterity often impaired • range of movement is more limited	• design casings that are easy to hold and keys so they are easy to press (oversized and/or easy press). • group keys by use and function.
Cognitive processes	• processing time – with working memory • long term memory (episodic) • reaction time • learning time required • problem solving capacity	• keep menu structures intuitive and consistent • make user interfaces as simple as possible

Table 2.1: Guidlines of design for the senior users

During recent years, many phone designed for the elderly are been released on the market. Most of them payed attention to the human factors of the elderly: they featured on simplified interfaces, large, easy to read buttons and display contents. Some of them also have an SOS button for emergencies.

iBall Aasaan

Like a normal phone for seniors, it is designed with large buttons and has an SOS button on the back.

Fig. 2.1:
Phone iBall Aasaan

Kisa

It is a smartphone with no screen or keypad. It has only contact buttons, on/off, volume, and a SOS button for emergency calls. All the phone has on its front are up to 10 programmable buttons and the names or images of up to 10 contacts. These can be personalized at the time of purchase.

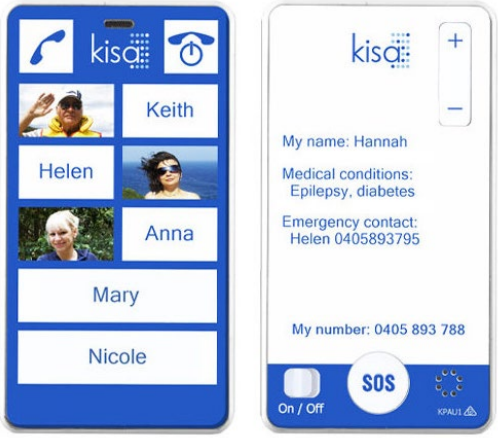


Fig. 2.2: Phone Kisa

Advantages and disadvantages:

The phones for the elderly is a better solution compared with normal phones because they considered the usability for the senior user. But there are also disadvantages. Firstly, the limited functions would let it unable to replace the normal cellphones, even for the elderly. Secondly, the phones are specially designed and look quite different, so they cannot avoid stereotype. Thirdly, the phones still require the mental model of some computer system usage, so they are not intuitive enough.

2.3.2 **A smart bracelet design for the elderly**

A group of students from University of Applied Sciences and Arts Western Switzerland designed this smart bracelet for the elderly. The bracelet acts as a personal assistant during the user's everyday life, monitoring the health status and alerting him or her about abnormal conditions, reminding medications and facilitating the everyday life in many outdoor and indoor activities [27].The designers gave the smart bracelet a non-medical appearance in order to avoid stereotypes. The concept product proposed seven functionalities to enhance the user's daily life:

1. Digital payment for shopping
2. Digital payment for transportation
3. Health monitoring and alert (e.g., hydration)
4. Health data storage, for facilitating healthcare diagnosis
5. Message notification from the smartphone
6. Multimodal interaction with home appliances
7. Reminder

Fig. 2.3: Appearance of the bracelet for the elderly.

To cope with visual impairments of the elderly, they conceived a simplified interface, which provides visual notifications through an e-ink black and white screen. The e-ink screen offers high contrast even in sunlight and avoids glares typical of many commercial OLED or LCD smartphone screens. Information is presented through intuitive icons, avoiding small characters in the interface. Visual notifications will be coupled with simple vocal messages that should help the user to remember the meaning of the icon. Notifications will also be coupled with a haptic feedback produced by a vibration motor.

To cope with motor function decrease of the elderly, they avoided small physical

Fig. 2.4: One function of the bracelet: digital payment

buttons and we simplified the interface to a single and large touch zone over the notification screen. The user will touch this zone to confirm that he or she has noticed the notification or to confirm the proposed action (for example to pay). By covering the bracelet with the whole hand the user can delay notifications or refuse actions.

Advantages and disadvantages:

The bracelet for the elderly is innovative and there is no such product on the market yet. The human factors are considered so it is easy to use, the functions are useful and the appearance can avoid stereotype. The disadvantage may be that using the bracelet daily is not a traditional habit of the elderly, so it would be better to embed the system into a more traditional object, like a watch. Another disadvantage is that the manipulation is not very intuitive so the user still need to learn and remember how to use it.

2.3.3 **The European project GUIDE**

Project GUIDE is an open source software framework based on domestic media platforms such as Web & TV platforms and services(connected TVs, set-top boxes, etc) for building accessible ICT applications to the elderly [28].

GUIDE provides automatic integration and adaptation of various legacy and next-generation user interface technologies, such as gesture interaction, voice control, avatars, second screen multi-touch devices and gyroscopic remote controls. GUIDE-enabled applications and services can automatically adapt their user interface to the specific impairments and preferences of elderly users.

In the toolbox for the developer, GUIDE realizes a “virtual user”-centered design process for developers based on user simulation, to make involvement of user requirements in development more efficient. The project will also develop and

Fig. 2.5: The scenario of users using the interactive multimedia system.

Fig. 2.6: The input and output and user model system of project GUIDE.

standardize a new user model that reflects impairments and preferences of elderly people in order to enable multi-modal adaptation. Relevant design knowledge for application developers will be collected, processed and be shared on a web-based portal.

Advantages and disadvantages

The project GUIDE follows the trend of the emerging smart interior media system, which is a very big field and many big technical companies like Apple, google and Amazon have been participating in. It builds a user model inside the system to adjust to the user's habit. We can imagine that in the future, the elderly will benefit a lot from the smart interior system. The main challenges will be related to technology and business issues.

2.3.4 **Conclusion**

The current solutions for the senior users are effective to some extents and some of them have made commercial success, such as cellphones designed for the elderly. The current solutions have been successfully dealing with various function decrease of the elderly, such as vision, hearing, motor, memory function decreases. However their interfaces are not natural enough so that the user need to learn to get accustom to the input systems. The elderly don't have the required mental model to accept the design immediately.

2.4 **Another solution - Tangible User Interface (TUI)**

Tangible User Interfaces (TUIs) and Tangible Interaction are terms increasingly gaining currency within HCI (Human Computer Interaction). It embeds computing in the everyday environment to support intuitive use [29]. A TUI system relies on embodied interaction, tangible manipulation, physical representation of data, and embeddedness in real space. While in traditional desktop computing the screen is merely a window through which we reach into a digital world, with tangible interfaces we act within and touch the interface itself.

If we can embed ICT in the normal daily objects and embody the interactions of ICT to be the interactions of a non-technical object that is well known by the seniors, the users would have the mental model to use and accept the design without barrier. In the genres of TUI applications [30], there is one genre called Augmentation Everyday Objects, that is exactly for the purpose of lowering the floor and making the design easy to understand.

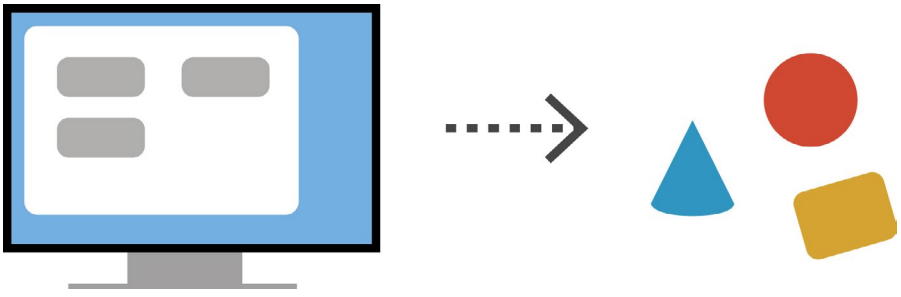


Fig. 2.7: A graph to show the idea of Tangible User Interface. The human - computer interaction turns from the interaction between user and screen to the one between user and tangible objects.

2.4.1 **A framework for TUI**

Eva Hornecker and Jacob Buur proposed a framework for Tangible Interaction [22]. The framework is structured around four themes that are not mutually exclusive, but interrelated, offering different perspectives on tangible interaction. A set of concepts elaborates each theme, providing more concrete handles for understanding their implications. This approach is distinct from other frameworks by not offering taxonomies, but perspectives and themes for analysis and conceptual guidance for design.

Tangible Manipulation	Spatial Interaction	Embodied Facilitation	Expressive Representation
Haptic Direct Manipulation	Inhabited Space	Embodied Constraints	Representational Significance
	Configurable Materials		
Lightweight Interaction	Non-fragmented Visibility	Multiple Access Points	Externalization
	Full Body Interaction		
Isomorph Effects	Performative Action	Tailored Representations	Perceived Coupling

Table. 2.2: The topics and corresponding concepts of the framework.

Tangible Manipulation refers to the material representations with distinct tactile qualities, which are typically physically manipulated in tangible interaction. One manipulates the interaction objects, has tactile contact, feels haptic feedback and material qualities. The main concepts, colloquially phrased, are:

Haptic Direct Manipulation: Can users grab, feel and move 'the important elements'?

Lightweight Interaction: Can users proceed in small, experimental steps? Is there rapid feedback during interacting?

Isomorph Effects: How easy is it to understand the relation between actions and their effects? Does the system provide powerful representations that transform the problem?

Spatial Interaction refers to the fact that tangible interaction is embedded in real space and interaction therefore occurs by movement in space. Interaction with spatial installations or interactive spaces can be interpreted as a form of tangible interaction that is not restricted to touching and moving objects in space, but relies on moving one's body. The main concepts for Spatial Interaction are:

Inhabited Space: Do people and objects meet? Is it a meaningful place?

Configurable Materials: Does shifting stuff (or your own body) around have meaning? Can we configure the space at all and appropriate it by doing so?

Non-fragmented Visibility: Can everybody see what's happening and follow the visual references?

Full-Body Interaction: Can you use your whole body? Performative Action: Can you communicate something through your body movement while doing what you do?

Embodied Facilitation highlights how the configuration of material objects and space affects and directs emerging group behavior. With tangible interaction we literally move in physical space and metaphorically in software space. These define structure that facilitates, prohibits and hinders some actions, allowing, directing, and limiting behavior. The main concepts in this theme are:

Embodied Constraints: Does the physical set-up lead users to collaborate by subtly constraining their behavior?

Multiple Access Points: Can all users see what is going on and get their hands on the central objects of interest?

Tailored Representation: Does the representation build on users' experience? Does it connect with their skills and invite them into interaction?

Expressive Representation focuses on the material and digital representations employed by tangible interaction systems, their expressiveness and legibility. Often hybrid representations combine material and digital elements, each having different representational qualities, e.g. projections onto tangible objects or spatial sound. The main concepts are:

Representational significance: Are representations meaningful and of long-lasting importance? Are physical and digital representations of the same strength and salience?

Externalization: Can users think and talk with or through objects, using them as props to act with? Do they give discussions a focus and provide a record of decisions?

Perceived Coupling: Is there a clear link between what you do and what happens? Are physical and digital representations seemingly naturally coupled?

2.4.2 Examples of augmented everyday objects

COLORADIO, designed by Christopher Nixon, Helen Zhou, Kinyetta Nance and Berenice Vargas, is a speaker which detects the color of whatever object is places in front of it. The speaker plays different types of music depending on the color. You don't need any particular objects, instead, every object becomes a tangible input to start the music [31]. Studies have shown the correlation between color and music. There is an emotional response when listening to music, and colors have an associated emotional measure.

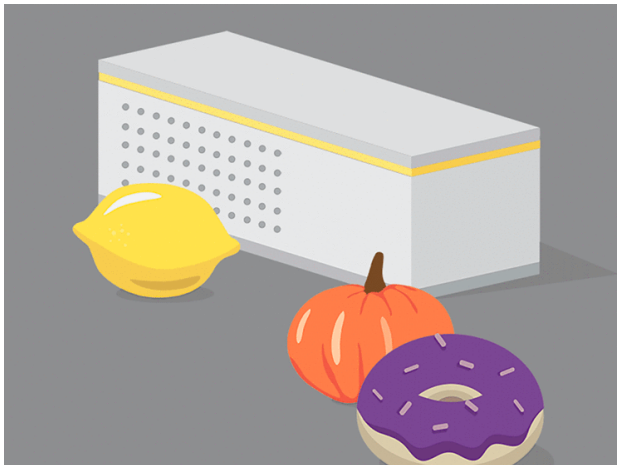


Fig. 2.8: The design of COLORADIO. When an object is close to it, it detects the colour and play the related music.

The iPad Music Box, designed by Joelle Aechlimann, is a music box where the user can interact with little boxes on the iPad screen instead of using fingers on the iPad. The concept consists of a tangible part composed of three separate music boxes which can interact with an application on the iPad. When the user places one of the boxes on the iPad screen, the application will recognize and activate it. The speed at which the box is turned directly affects how fast the music is played and lively animated interactive elements move in time to the tunes [32].

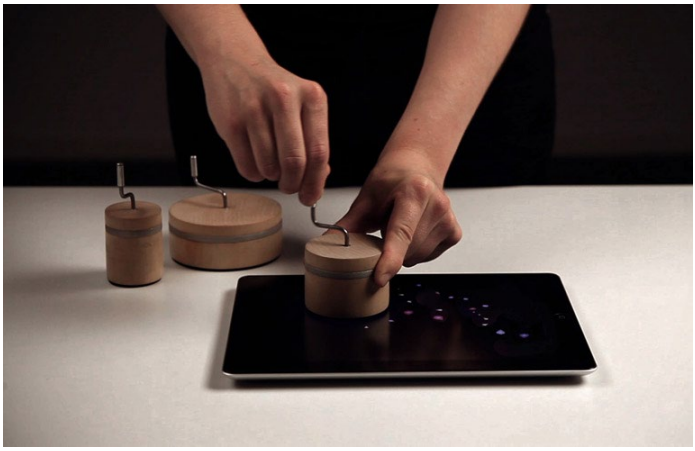


Fig. 2.9: The iPad Music Box

Colour Chaser, designed by Yuri Suzuki, is a miniature vehicle that detects and follows a black line whilst it reads crossing coloured lines and translates this RGB data into sound. Users could draw a randomly shaped circuit using a black marker pen on a piece of paper and the colour chaser followed the line, then add different layers of colour across the black line at intervals, The vehicle detects the colour RGB data and translates that into sound [33].

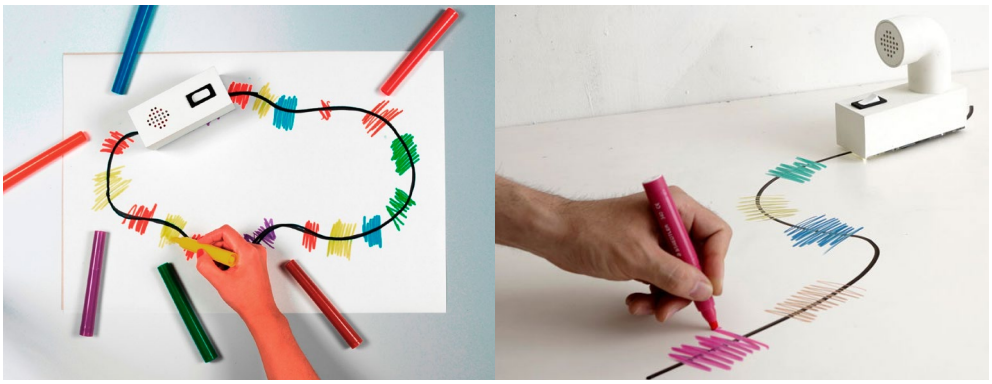


Fig. 2.10: Colour Chaser

3

COMMUNITY SOCIAL LIFE OF THE ELDERLY

3. *Community social life of the elderly*

3.1 **Life quality and social life of the elderly**

When we have a healthy mind and body, the quality of our lives is enhanced. A good quality of life also means having fun and having feelings of being needed. "People at all levels of functioning need to have a quality of life that allows for enjoyment and a feeling of being useful and productive to themselves and others." [34] On the 1995 White House Conference on Aging, focus group participants were asked to answer the following statements [34]: a) The first thing that comes to mind when I think about getting older is ...; and b) I believe the key to healthy aging is ... . Outcomes of these focus group efforts produced a view of the keys to healthy aging:

Meaningful Involvement

Keeping active
Functioning as a productive citizen
Remaining involved in community
Volunteering
Continuing to learn
Continuing to travel
Experiencing new things
Having meaningful work

Positive mental outlook

Developing good mental outlook
Feeling optimistic and hopeful
Maintaining mental and physical health
Being happy
Being joyful
Keeping an active mind
Exercising self-discipline
Being glad for every day

Relationships with others

Giving to others
Having friends
Expressing an interest in others
Displaying kindness toward others
Spending time with family
Showing concern for those with less
Helping make the world a better place

Also, one of the keys to healthy aging is meaningful involvement. People need to pursue various interests, be involved with people, and maintain flexibility. Meaningful involvement leads to a positive mental outlook and usually results in the development of new and different relationships with other people.

3.2 **User survey**

To better understand the real needs of the elderly, a survey is carried out. The survey utilized the method of Cultural Probe.

3.2.1 **Survey set up**

Purpose

The survey aims to discover the feelings of the elderly about their social activities, especially the activities among neighborhood. The survey will find out answers to the questions like: how much do the elderly feel involved in the community? How often do they contact with other people? What do they feel when they have social activities? Then the goals are explicated below:

Goal 1: Understand the elderly's feelings about their neighborhood/ community.

Goal 2: Understand the elderly's everyday routines, habits, problems, difficulties, etc.

Goal 3: Understand the elderly's practices and feelings in social activities

Method

The method that is applied is Cultural Probe with generative tools. It may be called Contextmapping, but in this case the generative session is not included, everything is done inside the probe.

Cultural Probe helps designers to access environments that are difficult to observe directly. Probes are "packages sent into space". [35] The participants will record their life by themselves, so that designers can have the information from the real perspective of the target user.

Conventional user study techniques, such as interviews, observations and focus groups [36], only offer a view on people's current and past experiences, but provide little hold on the future. For learning about potential future experiences, we need to include peoples' dreams and fears, their aspirations and ideas.[37] Sanders introduced generative techniques in the early 1990's. [38] These techniques can reveal tacit knowledge and expose latent needs.[38] Tacit knowledge is knowledge that people can act upon, but cannot readily express in words. Latent needs are those that people are not yet aware of. They are needs that become realized in the future.[37]

The basic principle behind generative techniques is to let people make artifacts to express their latent ideas that cannot be expressed by words. In this probe, I asked participants to make drawings under certain topics.

Fig. 3.1: Examples of cultural probe packs. Usually they also include disposable cameras, but in my case it is not feasible to do it.

Procedure

Cultural Probe packages were made and planed to be delivered to 4 to 6 participants. Gender of the participants were balanced (two or three males and two or three females). The packages were delivered in two weeks, and were received in the next two weeks.

Participants

Recruiting is particularly important and difficult with cultural probes, since they rely on a large investment of participants' time. Participants in cultural probes are expected to spend at least several hours during the course of the activity. In this case, the participants were contacted by acquaintances.

Preliminary mindmap

The mindmap is composed of everything that could possibly play a role in the context. [37] It is useful to get a view about the possible factors of the context before the survey starts.[37] Then after the analysis of survey results, insights were compared to this map.

It is arranged into four groups: 1. Their feelings about their neighborhood; 2.Their everyday routines, problems. etc; 3.Their practice in navigating the city; 4. Technology. For example, group 1: In some communities, there are places that the elderly like to meet each other. In some communities, there are not such places...; Group 2: They usually go to parks, food shops, supermarkets, bars and restaurants...; Group 3: Most of them are familiar with their community, so they don't need a map...; Group 4: Some of them are curious about technology... .

Fig. 3.2: The mindmap of this project. It is done with the help of my tutor's assistant, because usually designers do it together to have more opinions.

Cultural Probe Package

Gaver et al. introduced the Cultural Probes technique. Gaver et al. states that "probes are collections of evocative tasks meant to elicit inspirational responses from people - not so much comprehensive information about them, but fragmentary clues about their lives and thoughts".[39] Here are the materials that are used in the Cultural Probe package.

Drawing Book

It is designed to be a interesting personal workbook so that the participants like to work on it. With drawing, the participants can express their latent ideas spontaneously.

There are two drawing topics inside the booklet. The first topic is : " Please draw a map of your community. Then mark the places that you like (with red pen) and write down the reasons why you like these places. Then mark the places where you meet your friends(with green pen). Then mark the places that you dislike (with blue pen) and write down the reasons why you don't like these places. " By setting this topic, we can find out how familiar the participant is with his/her community, what activities he/she usually do, what does he/she like and dislike in the community, how much the participant is involved in the community.

Fig. 3.3: The appearance of the drawing book. It contains a small card for basic information: age, gender and years of living in this community.

The Second topic is :" Please draw a picture to express your idea of ‘ Being involved in the community’ ." This topic can reveal what does the idea of "being involved in the community" mean to the participants and also their ideal situation in that context.

Diary

The diary is a booklet that let the participant record their social activities and feelings, so we can get the information of how frequent does the participant have social contact with others ,what are the feelings accompanied and what happens there. It also supports the participants to continually think about the subject. Smiley stickers are provided inside the package, so that the participants can use the stickers to express their emotion easier.

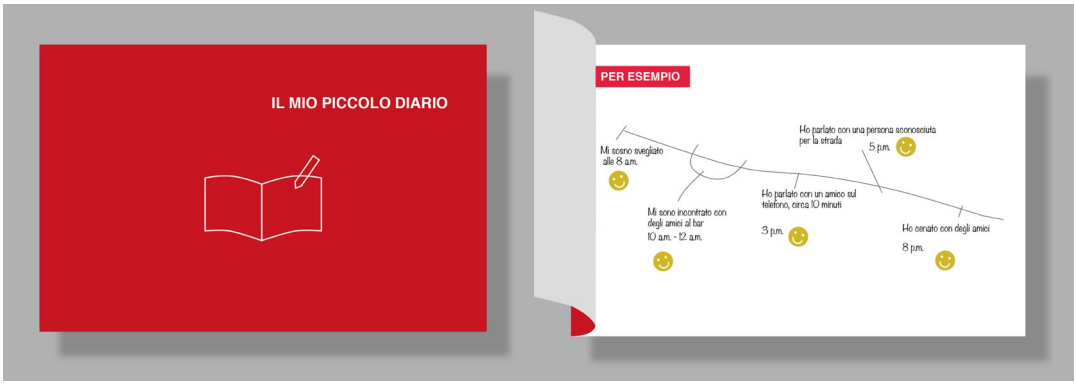


Fig. 3.4: The appearance of the diary. The yellow smiley dots means using the smiley stickers.

Postcards

There are five pre-stamped postcards, every postcard has a little open question. The participant answers the postcard and sends it back(or give it back within the package). Compared to traditional questionnaires, the postcard is a more playful and engaging way to draw the participant’s attention to the subject of the study.
The questions are complements of the diary and drawing book, some of them ask about participant's preference on places and things, some are about their attitude towards neighbors and their practice of social activity.

Questions on postcards

- What places do you like most in Milan? What feelings does it give to you?
(to know their preferences on the feeling of place)
- What do you think of your relation with your neighborhood?

(to know their social status with their neighborhood)

- Tell us about your favorite thing to do in your daily life

(to know their preferences on the daily activity)

- What object do you like most? What feelings does it give to you?

(to know their preferences on the feeling of objects)

- What do you like to do with other people?

Fig. 3.5: The postcards with questions.

The Package

All the materials are arranged into a package, which includes also the color pens and smiley stickers.

Fig. 3.6: The package that contains all the materials.

Fig. 3.7: A small meeting is organized to explain the aim of the survey and deliver the pack to the participants.

(to know their preferences on the social activity)

Delivery

In order to deliver the packs, appointments with participants are arranged. In the meeting, I explained the purpose and the instructions to the participants, then delivered the packages. I picked the packages up after one week.

3.2.2 **Results**

3.2.2.1 **Information acquired**

I collected four copies of the Cultural Probe packages, two from men and two from women. Now I had four different stories of real people. For privacy cases, the names mentioned below are not of the participants.

Fig. 3.8: The responded materials returned. Some of the participants were very motivated and wrote a lot.

Giovani

Male, 66 years old, has been living in his community for 31 years

He is quite familiar with his community, but he has had little conversation with his neighbors, because everyone is busy doing their own things. He likes to go to the parks near home because there are trees so he feels free to walk and run, and there are many people including joyful playing children. He usually meet his friends in the bars near parks and squares.

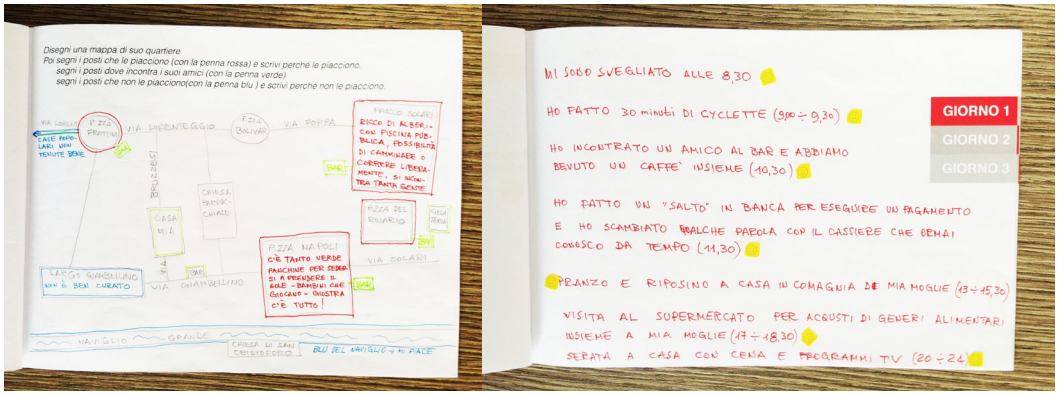


Fig. 3.9: The responded materials of the first participant. Here there is the map of his community and one day of his life.

He likes to talk with people and exchange opinions, especially with family members and friends. For him, it is very beautiful to spend time with friends. In his daily life, his favorite thing to do is reading and he loves well printed books because he enjoys the cultural and human stories. He also likes to walk in the countryside, with beautiful nature around.

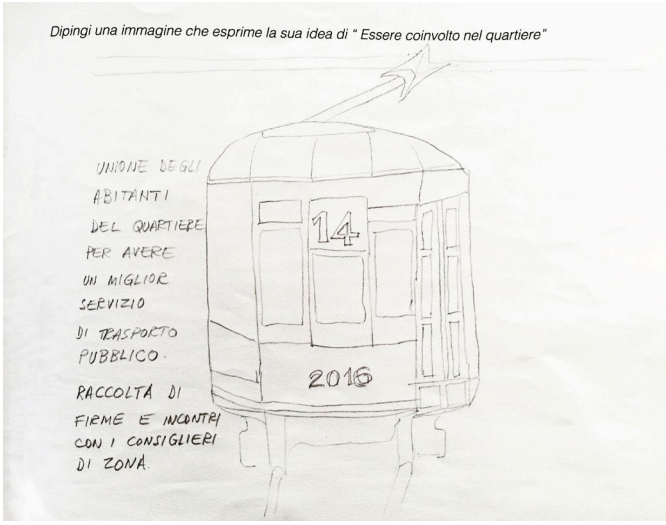


Fig. 3.10: The drawing did by the first participant.

From his drawing we can see that he likes to travel in the community by public transports. To him, "Being involved in the community " means traveling in the community easily and knowing where there are interesting things.

Antonio

Male, 65 years old, has been living in his community for 21 years.

Similar to the first participant, he also likes to go the parks near home and likes to stay in bars for a while everyday. He meets friends in bars and he likes talking with them. He feels unhappy when it rains because he can't go out.

In his drawing, there is a spring and there are trees nearby. The words says:" let's build more springs, save the trees." It implies that he wants to live in a healthier, greener community and he wants to meet people in the park-like environment.

Fig. 3.11: The drawing did by the second participant.

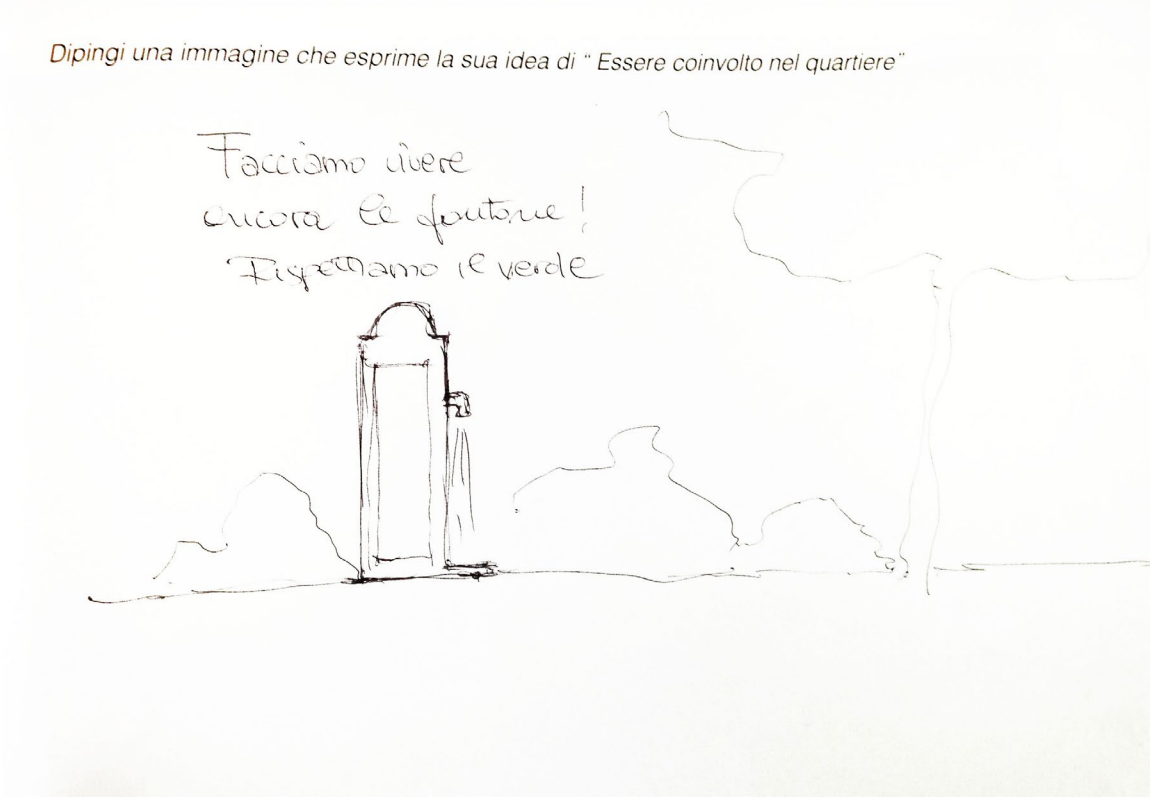
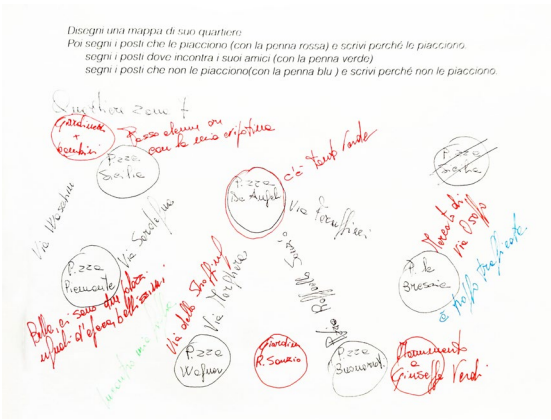


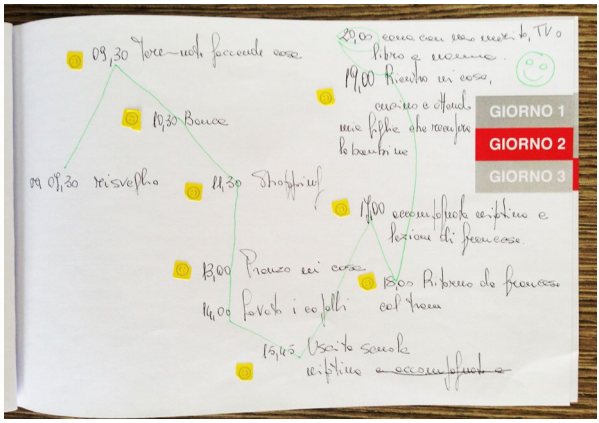
Fig. 3.12: The responsed materials of the third participant. Here there is the map of her community and one day of her life.

Elisa

Female, 67 years old, has been living in her community for 18 years.

She takes her grandson to school and takes him back everyday. In the rest of her day, she does house working and shopping. She watches TV, listens to music and reads books to have rest. She likes to stay in bookstores and parks. When be asked about her neighbors, she only says: "I have good relation with them", it actually shows that she doesn't know much about her neighbors.





In her drawing, there is a shoe store, a building (probably her home), a ice-cream shop and a park. That implies the facilities that meet her and her family members' needs are most important to make her feel involved. It also shows that she usually do things by herself. To her, "Being involved in the community" means having the right place to spend a good time.

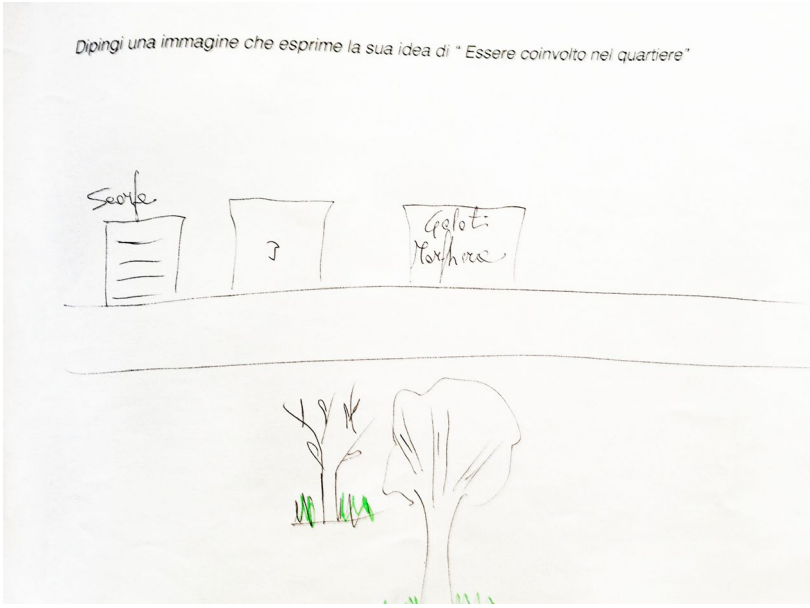


Fig. 3.13: The drawing of the third participant.

Linda

Female, 62 years old, has been living in her community for 30 years

She likes to get out accompanied, however usually she gets out by herself because she doesn't have any chance to know other people after the retirement. She likes to go to local markets, supermarket, parks and churches. She usually meets friends at churches and bars.In her drawing, she drew a church and wrote that she likes to participate in activities of donation and choir. To her, "Being involved in the community" means helping the people who is in need and being accompanied by the people who share the same belief.

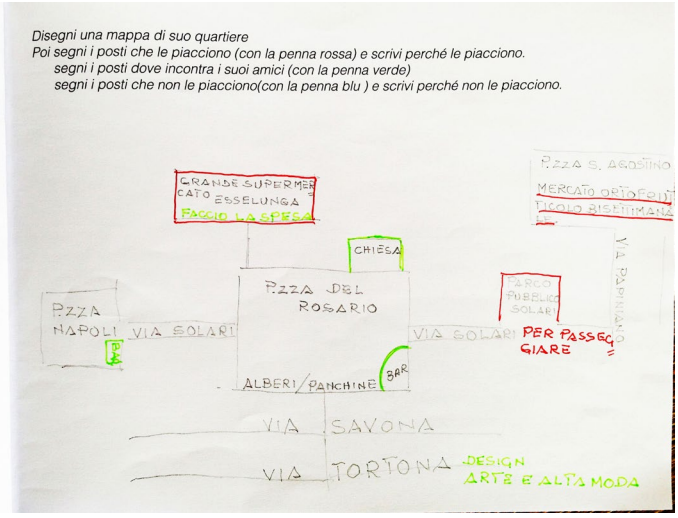


Fig. 3.14: The map drew by the forth participant.

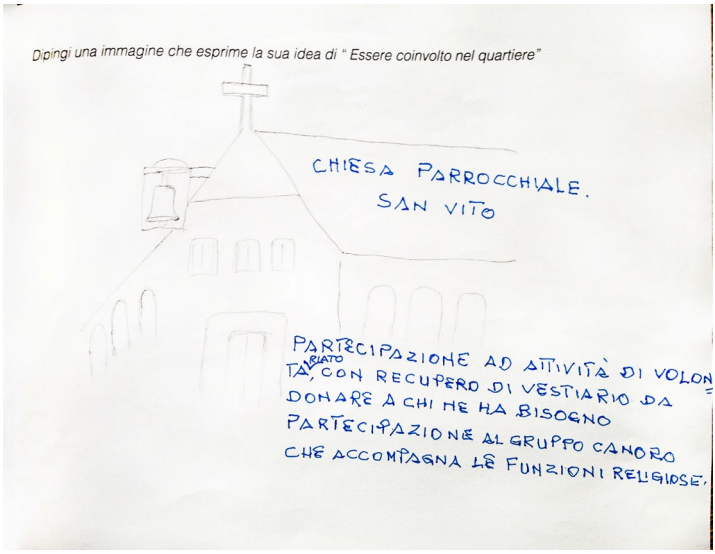


Fig. 3.15: The dawing did by the forth participant.

3.2.2.2 **Analysis and Insights**

With the real stories of people, it is easy to build empathy and then find out insights. Their lives remind me of my own grandfather and my mother who is a housewife. The insights are arranged in four groups according to the goals set before and the answers collected. The four groups are: Neighborhood, refers to the insights about the relations between the participants and their neighborhood; Going out, refers to the insights about their practices and preferences on going out; Contacting friends / people, refers to their practices about contacting others; Preference, refers to their preference on other things like favorite activities, objects etc..

Fig. 3.16: The insights arranged on a board.

Neighborhood

- There are little chance to make friends with neighbors.
- When the elderly get out, they actually have many chances to meet other elderly people, but they have little opportunities to talk with them.
- They are familiar with their community.

Going out

- The elderly like to go out if condition permits. They feel unhappy when it rains because they have to stay at home when it rains.
- Most elderly tend to go to the same limited kinds of places: bars, parks and churches. The women likes to go to markets (mainly food markets, also other various kinds of stores).

- They like to go to the places where there are many people.
- When they go out, they want to be accompanied
- They like beautiful, attractive places like other people.
- Good feeling of a place can be related to the location of their previous workplace.

Contacting friends /people

- They usually meet friends in bars, parks and churches.
- They contact friends with phones, some of them also use apps like Whatsapp.
- They like to exchange opinions with others

Preferences

- Their favorite moment of a normal day is the time spent with family.
- They like watching TV and reading books in the evening.

4

CONCEPT GENERATION

4. Concept Generation

4.1 **Methodology: Vision in Product Design (ViP)**

ViP is a context-driven, interaction-centered design framework, which is developed by Paul Hekkert and Matthijs van Dijk. It helps designers to build a clear product statement based on a future context. And It helps designers to develop a clear vision of how the new product ought to be perceived and experienced by the target customers. [40]

The approach is based on the belief of " designing is about exploring what is possible tomorrow instead of solving problems of today". So the main characteristic of the ViP approach is that it forces designers to free themselves from (apparent) restrictions or requirements and, instead, look for desirable possibilities. [40]

With this approach, designers firstly question the current product(s), product-user interactions and context of those interactions.Then the designers is able to develop the future context, future interactions and future product(s).

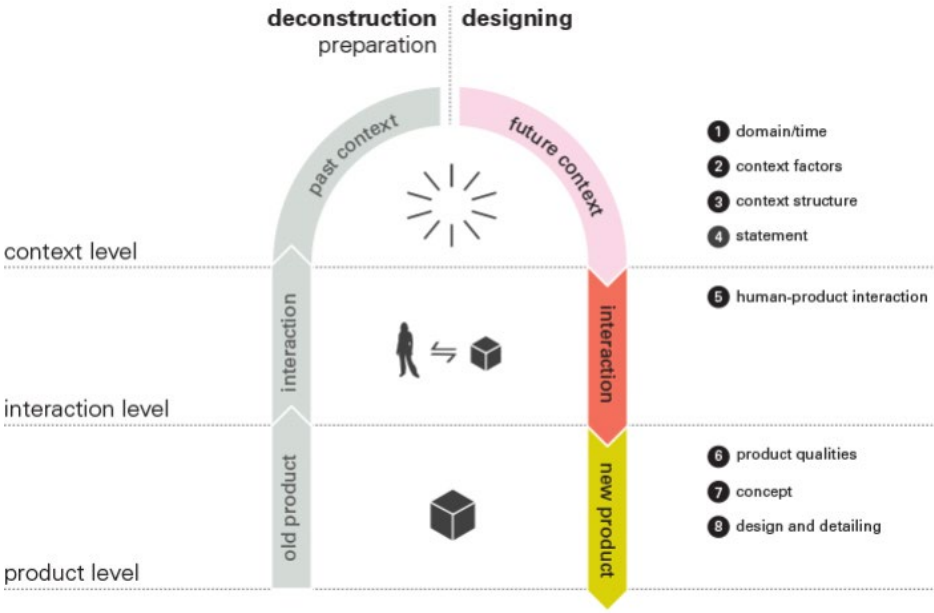


Fig.4.1: It shows the process of Vision in Product Design approach. The process starts from deconstruction of old product / interaction / context to reach the construction of future context / interaction / product.

Step 1. Establishing the domain

The ViP process starts with a definition of the domain: The description of the area where the designer aims to make a contribution. In most cases, the domain should be defined more broadly than a specified function of a product to avoid a direction based on limited information and preconceptions. An open domain allows enough room for context exploration, so that designers can explore possibilities of the future.[40]

Step 2. Generation of context factors

Context factors are observations, theories, laws, opinions and notions about the context. Factors need to be relevant to the domain (appropriate)and interesting so can be able to trigger innovations (inspiring).

Factors can be things that are changing, such as developments and trends, or more stable situations like states and principles. Developments tend to be on the level of culture, technology, politics, economics, etc. Trends are the reflection of the developments in people's everyday life.

Factors can be about people's feelings, thinkings and behaviors (psychological factors) or about people's interaction with others (social factors). Factors may have to do with the economy, technology, biology or many other fields.[40]

Step 3. Structuring the context

To reduce the complexity of the set of context factors, the factors should be turned into a coherent structure to show the relation between each factor. The set of factors can be combined into a smaller set of clusters.

Furthermore, there are two basic relation types between each cluster [40]:

Pattern or storyline: A pattern may unites the cluster into a sort of narrative. This may eventually even be phrased into a new theme.

Dimension: When clusters seem to conflict, they can be placed in one or more polar.

Step 4. Statement definition

A statement explicits what the designer want to offer to the target customer, within the established context.[40]

Step 5. Establishing a relationship: designing human-product interaction

The relationship, or interaction, between the product and the user is the hinge between the product and the context. The interaction defines how the product is used and experienced, and what value arises from the relationship between the product and the user. The quality of interaction, or interaction characteristics, is the feelings and experience that the relationship gives to the user. To define the appropriate quality of interaction, the designers can trust their intuition or think of an analogous situation in another domain and use a metaphor, while keeping in mind the coherence between the context and the statement.[40]

Step 6. Defining product qualities

Product qualities are the product characteristics that express its "personality" and indicate the way to use and interact with it. The product qualities should work coordinately with interaction qualities to fulfill the statement.[40]

Step 7. Concepting

Concepting is the process of translating the product vision (statement, interaction and product quality) into a combination of features that can literally be perceived, used and experienced. Only on this stage the designer start to decide what the final solution should be: a physical product, a multimedia application, a service, a policy or any kind of solution. As the coming concept should match the vision, on this step the designer have built solid ground for idea generation and evaluation.[40]

4.2 Concept generation

4.2.1 Defining the product vision with ViP

Defining the domain

Improve community social life of the elderly

Building context factors (from current context to future context) and factor structures

The whole context factors will be the insights that are mentioned on the end of last chapter, and plus these factors that are expected to happen in the future. The future context factors are clarified as follows:

- The elderly will have more social activities because the population ratio of the elderly is rising.
- The elderly will accept the technology more than today because the technology will be ubiquitous in the future.
- More old people will have technology literature because they were familiar with technology when they were young.
- The elderly will have younger spirits than today.
- The elderly will have a later retiring age.
- More olde people will do some work of their interests after retiring.
- People's average life expectancy will be increased.
- Olde people will have more activities with the younger people. They will share more common interests.
- More daily things will be connected to the Information Technology, because Internet of Things (IoT) is developing fast today.
- There will be communities with more old people living in because there will be more old people in the society.
- Information Technology will be more tangible and perceivable.
- More products will be personalizable.

For the current context factors (the insights that are mentioned on the end of last chapter), they are re-organized into different clusters. The storyline pattern of relation between the clusters are shown with arrows. The whole structure can give me a clear view of the factors.

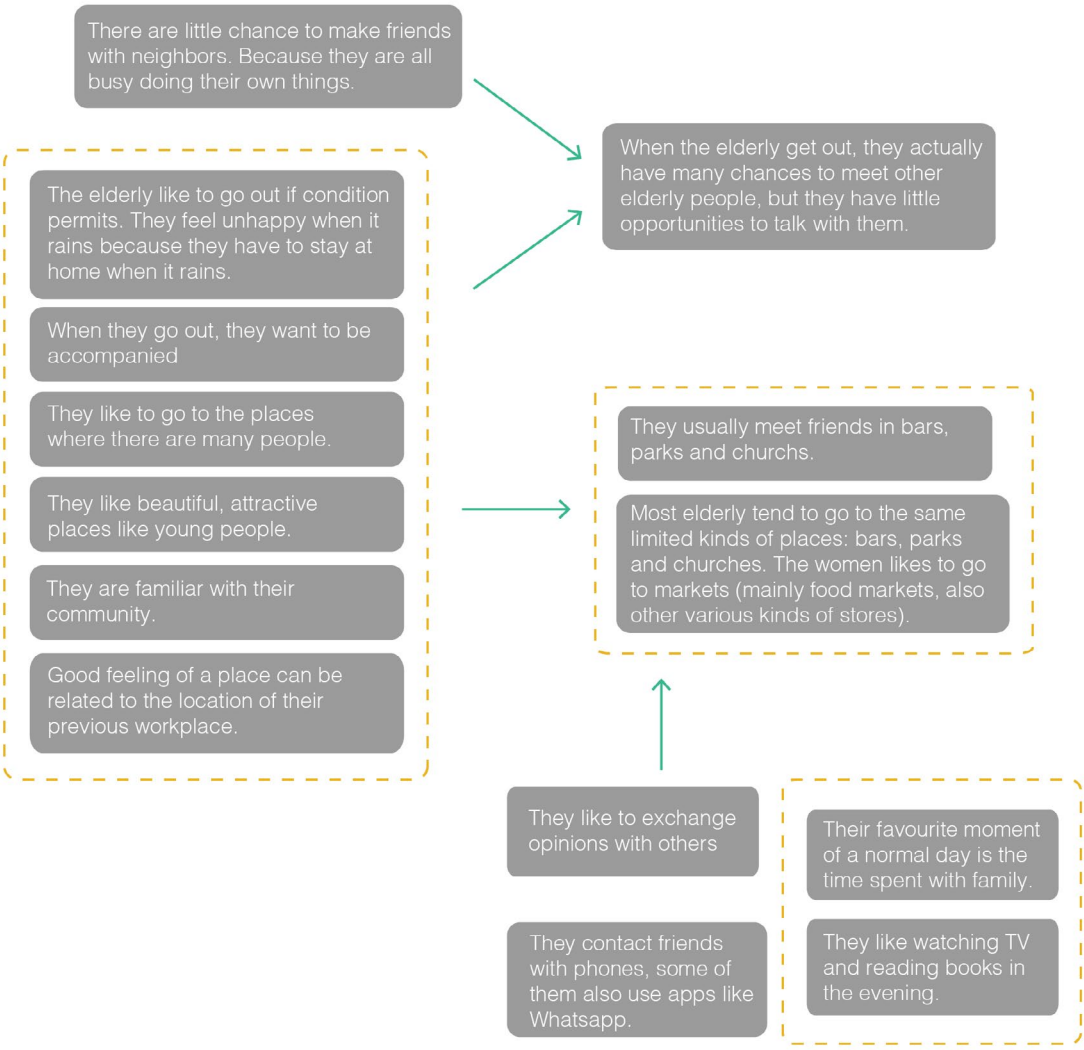


Fig.4.2: Structure of current context factors.

Similarly, the future context factors are structured into clusters. The arrows indicate the storyline pattern of relation between the clusters. The dimension pattern of relation is not indicated directly, but we can see that according to different directions of arrows.

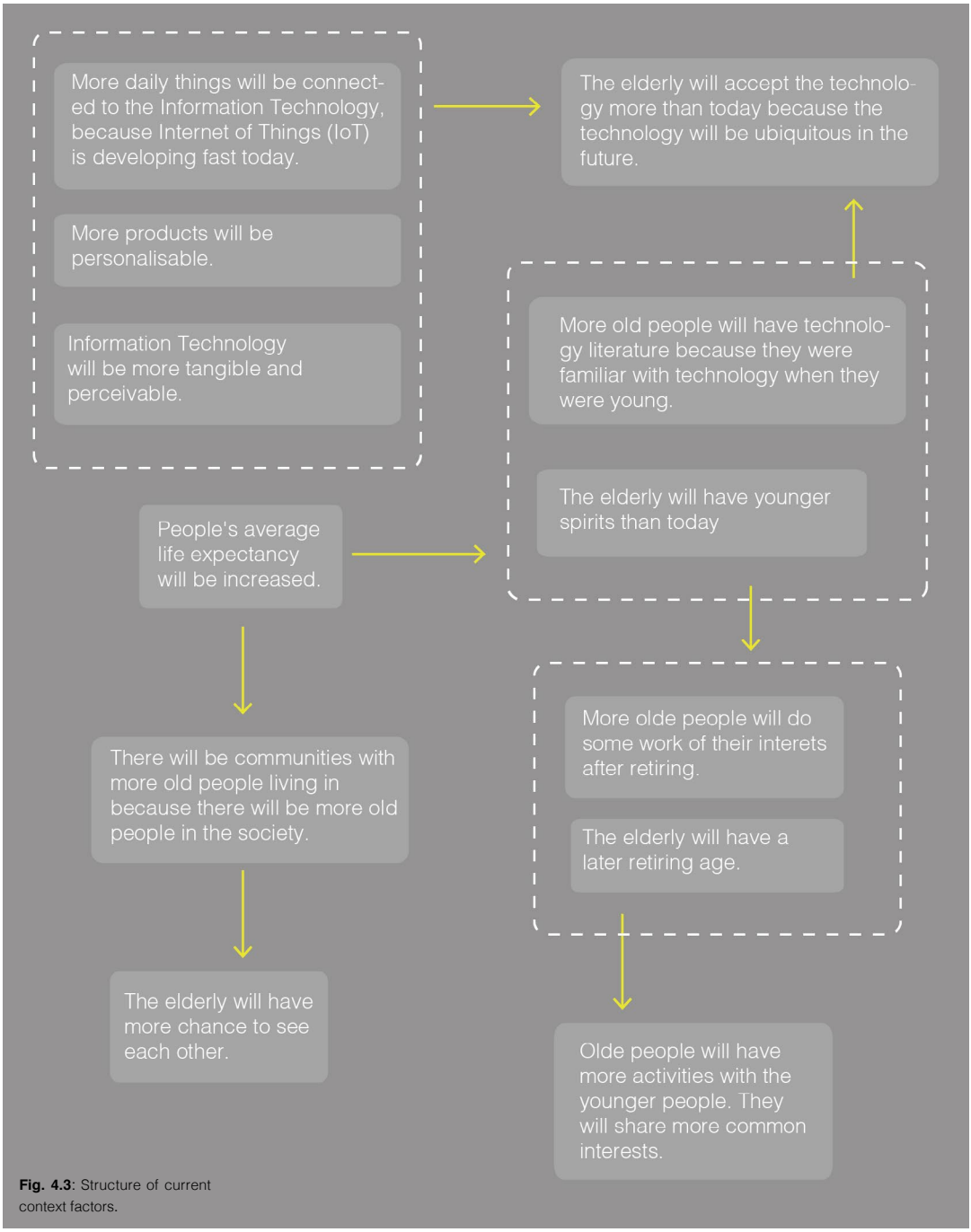


Fig. 4.3: Structure of current context factors.

Defining Statement

Let the elderly have more chance to contact with friends (in the community) and feel involved.

Defining interaction qualities

Interaction qualities are the characteristics that the relation between product and the user should have. According to the statement and context, an analogous situation could be a face to face chat with friends or an accompanied walk with friends. So the interaction characteristics could be "giving involvement" or " accompanying".

Fig. 4.4: Defined Interaction characteristics.

Defining product qualities

The product qualities are the "personalities" of the product. According the defined statement and interaction qualities, a metaphor of the product could be " an amiable, always smiling, listening and considerate friend who is always by your side". So the product qualities can be defined as "amiable", "listening", "considerate", "touchable".

Fig. 4.5: Defined product quality.

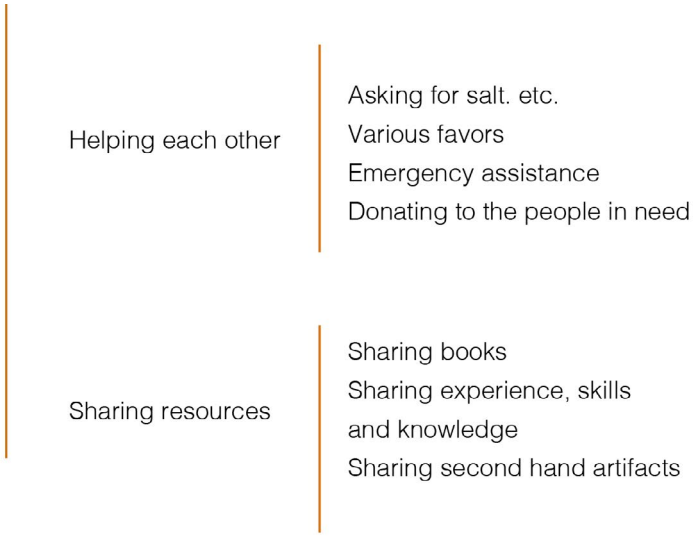
4.2.2 **Correlative activities and contact points**

To embody the product vision into a product concept, the appropriate certain aspects of product should be defined: which activity of the elderly will the product get involved? Where will the product work? To answer the questions, two sets of information have been arranged: one is a series of relevant activities of the elderly; Another one is a bunch of the possible contact points where the product could build interactions with the elderly user.

Correlative activities:

Here is the collection of the activities that are able to improve old people's social life. By encouraging the elderly to take part in these activities more frequently or making these activities easier to do, the product will probably reach my goal.

Fig. 4.6: Correlative activities



Contact points:

To define exactly where the interaction will happen, the possible contact points are listed. By thinking of these places, I can come up with possible concepts that meets the product vision.

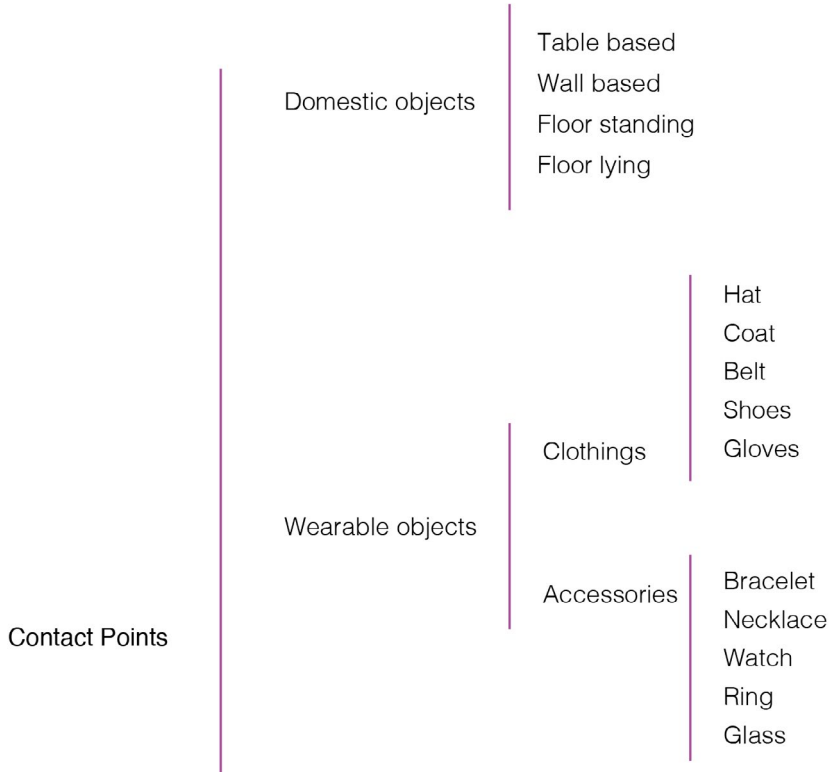
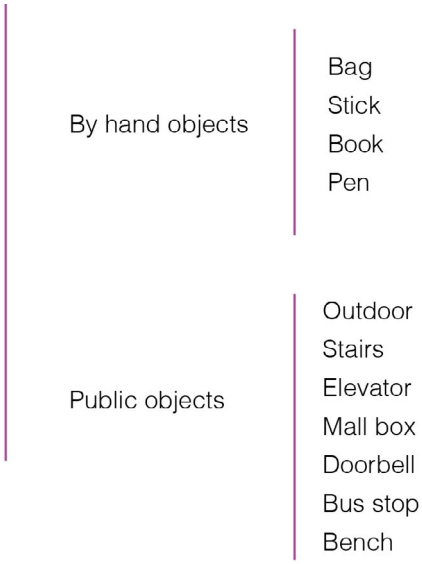


Fig. 4.7: Contact points



4.3 **Concepts**

After defined clearly the statement, context factors, product vision, relative activities and contact points, the feasible concepts are generated.

4.3.1 **CONEC**

It is a smart necklace that help the elderly to invite neighbor friends to come and meet. The user can add pieces on to the necklace, each piece connects to a friend. When the user presses the button, a vibration will be sent to all the friends who are connected to the necklace.

Even though the pieces of the necklace will be very limited, it will still help improve user's social life because for a normal person the core circle of social activities is not big, and for the elderly the core circle is much smaller.

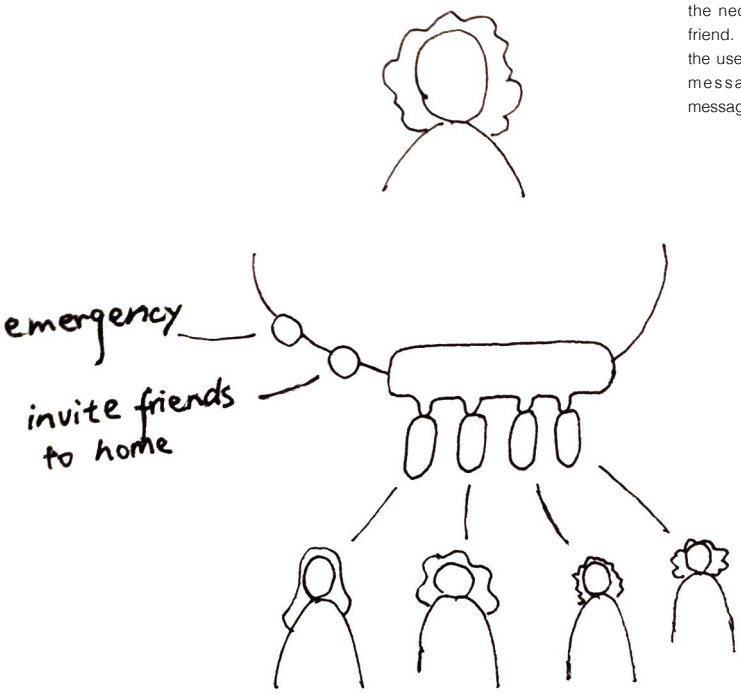


Fig. 4.8: Each piece on the necklace connects to a friend. By press the buttons, the users can send invitation message or emergency message to friends.

Fig. 4.9: User can add or reduce pieces easily.

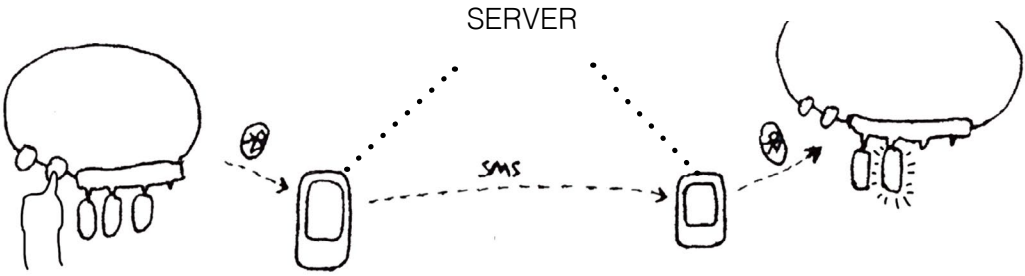


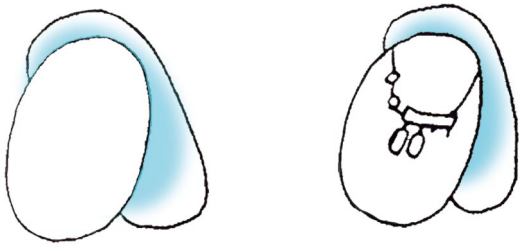
Fig.4.10: Principle of signal communication

The principle of communication could be like this: The necklace is communicating with the user's phone with bluetooth. Then the app in the phone will receive the commands from the necklace and the app will send commands to the user's friends' phones. This may need to be done with an online server. After received a command, the necklace on user's friend will vibrate. Only one piece that connects to the sender will vibrate, so the user knows who sends the notification.

To distinguish each piece, the material, texture, color of the pieces will be different. The user can choose to use what appearance of the piece to represent which friend.

To know what message does the vibration mean, the user can type in a SMS, it will be sent together with the vibration message. So the receiver gets not only a notification but also a readable SMS.

Fig.4.11: A necklace stand functions as charger and notifier.



The concept also includes a necklace stand. When the user don't want to wear the necklace, she can put it on the necklace stand. The necklace stand functions as a depositary and a charger and notifier at the same time. After the user deposits the necklace, it can be charged by wireless charger inside of the stand automatically. There is a light on the stand, so when a message arrives, instead of causing a vibration it lightens a light. The color of the light differs from each message senders, so the user can distinguish the senders.

Fig.4.12: In a scenario the elderly make new friends by giving the smart necklace as a gift.

It can also give the elderly more chances to make new friends in neighborhood. From the insights mentioned in the last chapter, we see that the elderly meet other senior people in the parks and in the bars, but they don't have much reason to make friends with each other. The necklace gives them the reason: they can call each other to get accompanied in a very easy way. So they can give the necklace as a gift to the neighbors so they can accompany each other when they feel boring or when they get out.

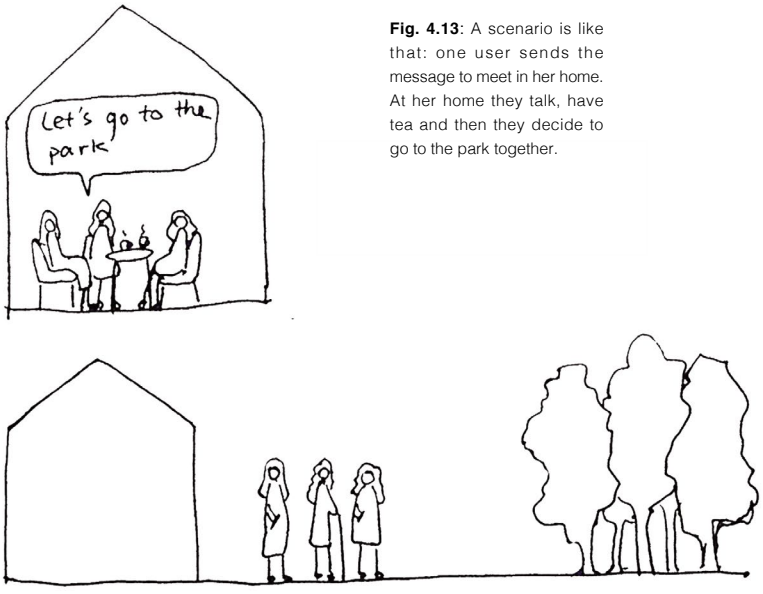


Fig. 4.13: A scenario is like that: one user sends the message to meet in her home. At her home they talk, have tea and then they decide to go to the park together.

Fig.4.14: A sketching of the necklace. It is made of several modules. So no matter how many pieces they user want, the necklace always looks as a whole. There is also led inside each piece, so the user can better distinguish which piece is giving message.

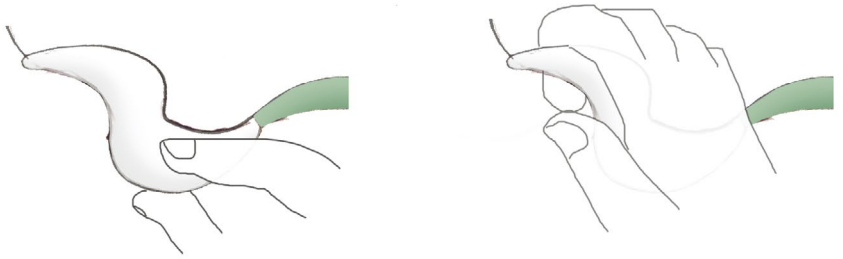


Fig.4.15: The sketching of the interaction: when the user touches this main piece (the biggest piece), it sends a normal message to friends. When the user grasps the main piece, it sends an emergency message to ambulance center and also family members and friends.

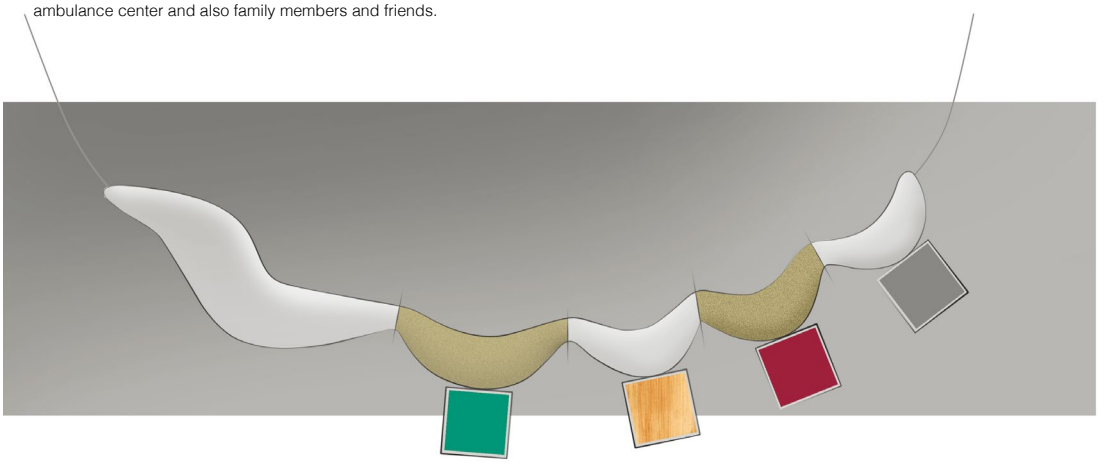


Fig.4.16: Another modular design, the difference is the modules are not connected one by one. User can choose the color and texture of each piece of module.

Fig.4.17: The sketchings of necklace stand design.

4.3.2 ROPO

ROPO is a set of toy-like device that provides the elderly with a playful way of inviting friends to come and meet. On the plate, there are four roly toys, like the previous concept, each of the roly toy connects to one of the user's friends. One of the toy represent the user himself / herself.

The scenario is like this: When an old man feels boring and wants to have activities with his friends, he simply waves the toy that represents him. Then the device in every home of his friends will be activated: the toy that represents the man waves in everyone's home. So his friends will know that he wants activities. Then his friends can reply in this way: they wave the toys that represent them, then the toys will wave in everyone's home. In this way they can know who is likely to join the activity launcher. Then they can give each other a telephone call to confirm the further information about the activity.

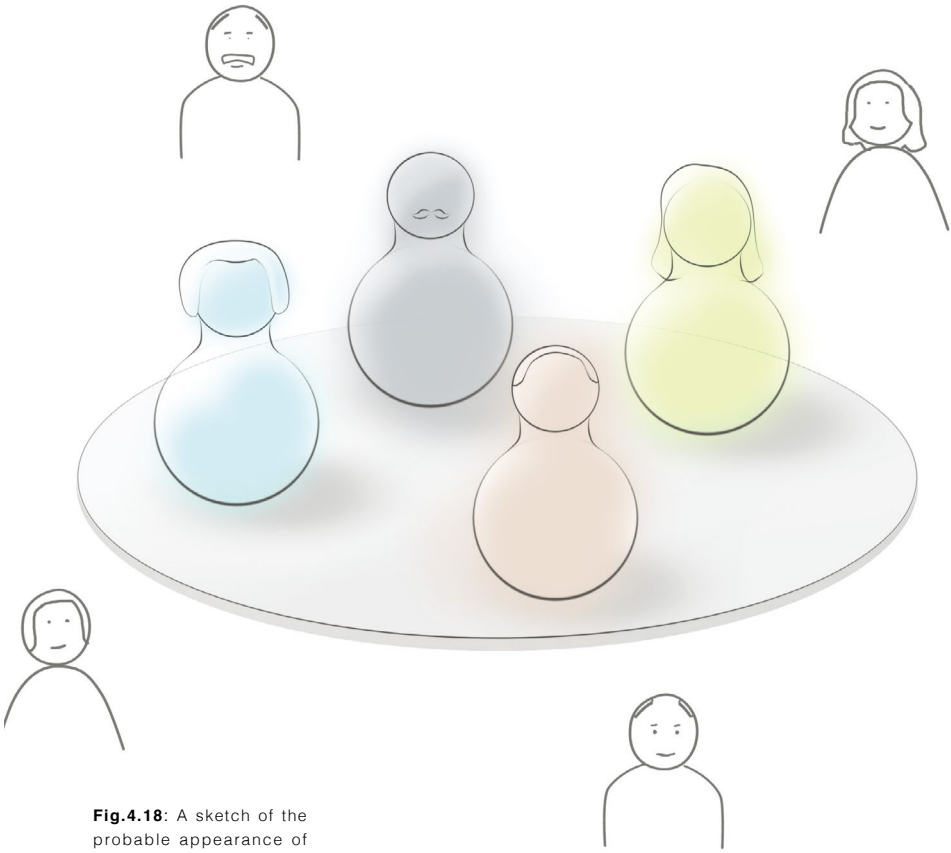


Fig.4.18: A sketch of the probable appearance of ROPO

Fig.4.19: The scenario : User A wants to have some activity, so she waves her toy. In the home of user B, he sees the waving toy of user A. Then he waves his toy to show he is going to join. So does user C.

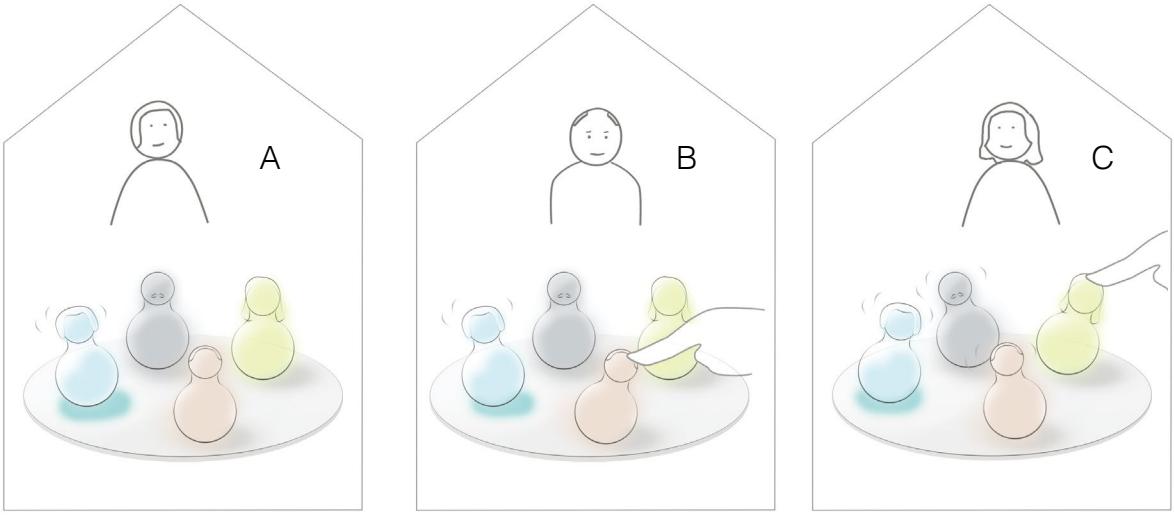


Fig.4.20: A sketch shows when everyone is going to join the activity. The toy with light indicates who is the activity launcher.

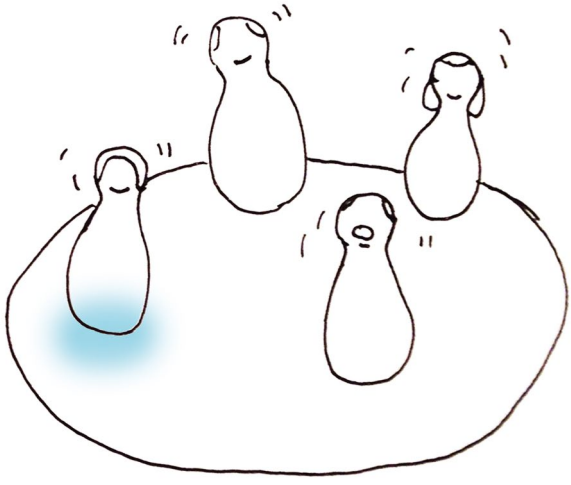
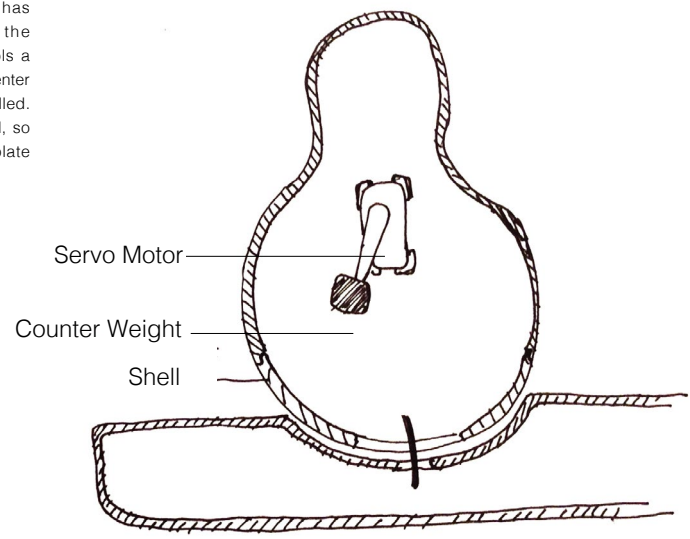


Fig.4.21: The probable structure of the toy. It has a servo motor inside the body. The motor controls a counter weight so the center of weight can be controlled. Because the toy is small, so it is connected to the plate physically with wires.



4.3.3 LEAD

LEAD is a guiding device to help the elderly's navigation in the city. It mimics the feeling of someone's holding on your hand while leading you the way. The elderly tells the system where he wants to go, then the device leads the way by pulling the user's hand.

One possible way to realise the concept is a glove-like device that locates on user's hand. It mimics the pressure by using vibration motors. According to a study made by Leonardo Bonanni et al. (2006), proper configurations of vibrating motors and solenoids can closely simulate the pressing of another people. Thus when the guiding system thinks the user should go right, it simulates pressing on the left side of the user's hand.[41]

Fig.4.22: Prototype of TapTap, a haptic wearable for asynchronous distributed touch therapy. The flexible i/o haptic insert tucks into the felt scarf (left) and connects to central power through conductive steel snaps (right)

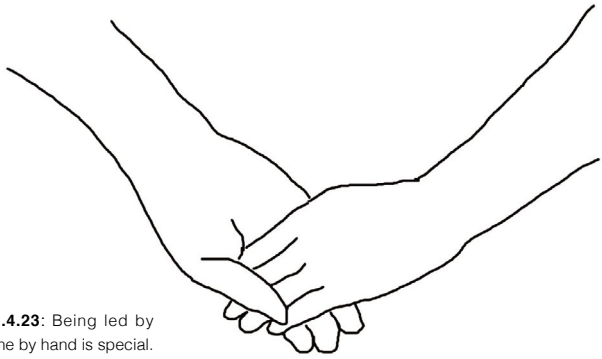


Fig.4.23: Being led by someone by hand is special.

The feeling of being led by someone by hand is very special: it usually happens when walking with the intimate ones - lover or relatives. So it gives people a feeling of security and being accompanied.

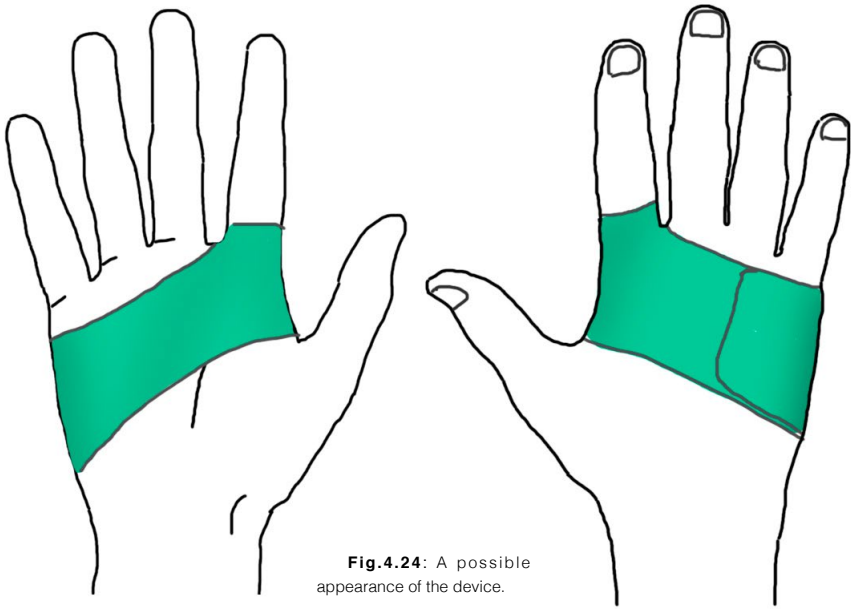


Fig.4.24: A possible appearance of the device.

The device is like a hand band or glove, made of fabric. Vibration motors will be inserted inside the fabric all over the palm. There is an accelerate sensor to detect the direction of the user's walking. To inform the user which way to go, the device vibrates at the proper part on the palm, simulating a feeling of someone's pulling the user's hand to that direction.

4.4 Concept evaluation

To decide which concept will go further into development, the concepts are evaluated according to the following criterions:

Desirability

It evaluates how useful the product will be for the target user. Will the product really be helpful? Do the target users need it?

Feasibility

It shows how feasible is the concept to be developed.

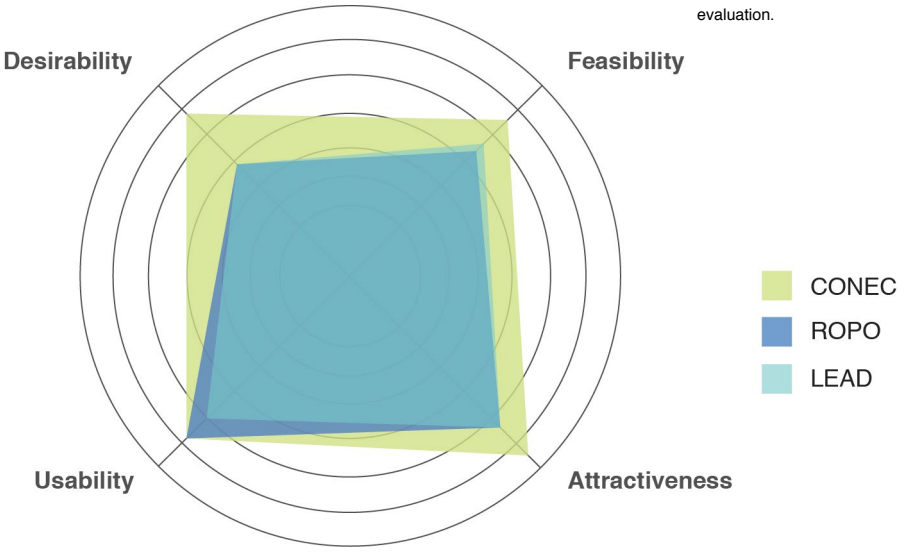
Usability

The intuitiveness of the interaction. Is it easy to understand and use?

Attractiveness

It means how attractive is the product. Will the target user like it emotionally?

Graph 4.1: Concepts evaluation.



After the evaluation, we can see the first concept CONEC is better than the other two concepts. So the decision is to develop the concept of the smart necklace CONEC. As necklace is only proper for women, the possibility of a smart bracelet of the same function for men is also taken into consideration.

5

CONCEPT DETAILING

5. Concept Detailing

The concept that is decided to be further developed is the smart necklace (and bracelet if possible), therefore the next step is to define the exact proper interaction gesture of the concept. For doing this, a classification of possible interaction gestures is done. Then as it is defined as a wearable product, it is also necessary to look up the state of art of wearable interaction researches and latest wearable devices on the market.

5.1 Interaction gestures and examples

It is a general classification of possible interaction gestures to help clarify the possibilities. The classification is based on people's natural gestures, in this way people will only need intuition to understand the product. Because of the features of the concept, interaction gestures of all human body are not taken into consideration.

Touching & Pressing

It is a very common interaction nowadays in ICT field. Different from keyboard and mouse, an interface based on direct touching & pressing on the information is much more natural.

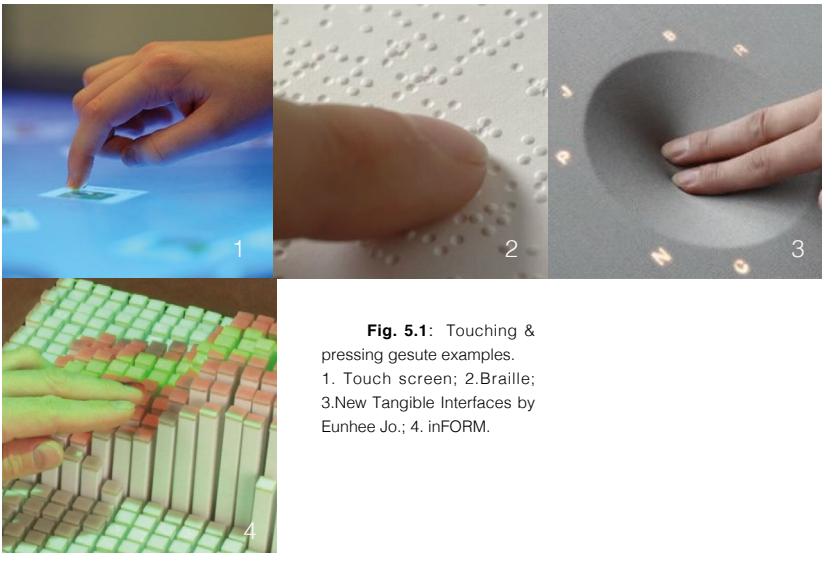


Fig. 5.1: Touching & pressing gesute examples. 1. Touch screen; 2.Braille; 3.New Tangible Interfaces by Eunhee Jo.; 4. inFORM.

Pinching

Pinching is more tangible than just touching and pressing, it makes you feel a tangible and soft surface. Even though a flat touching screen support the gesture of pinching, it feels better to really pinch something.

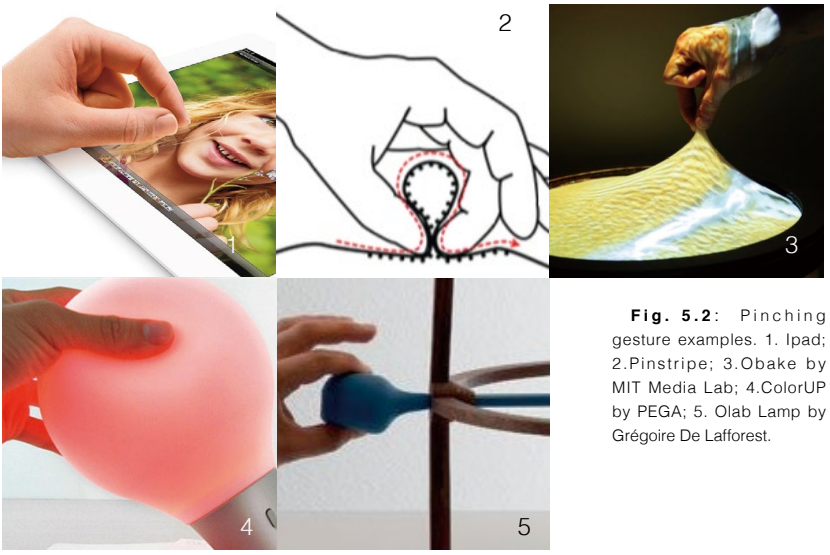


Fig. 5.2: Pinching gesture examples. 1. Ipad; 2.Pinstripe; 3.Obake by MIT Media Lab; 4.ColorUP by PEGA; 5. Olab Lamp by Grégoire De Lafforest.

Moving & Placing

One of the most usual gestures in people's life is moving and placing something, it is very tangible and very natural, so it is popularly used in TUI design.

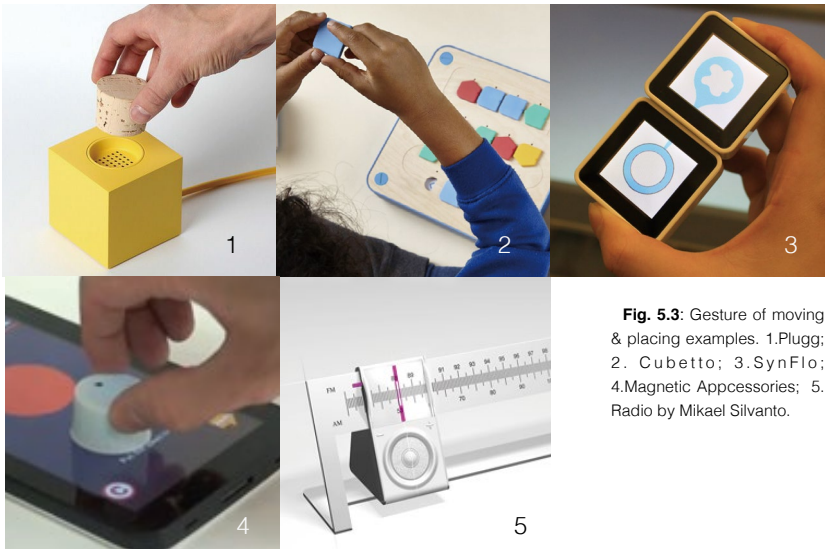


Fig. 5.3: Gesture of moving & placing examples. 1.Plugg; 2. Cubetto; 3.SynFlo; 4.Magnetic Appcessories; 5. Radio by Mikael Silvanto.

Opening & Closing

It is another interesting interaction that usually gives surprise. It is common to see in the design of lights.

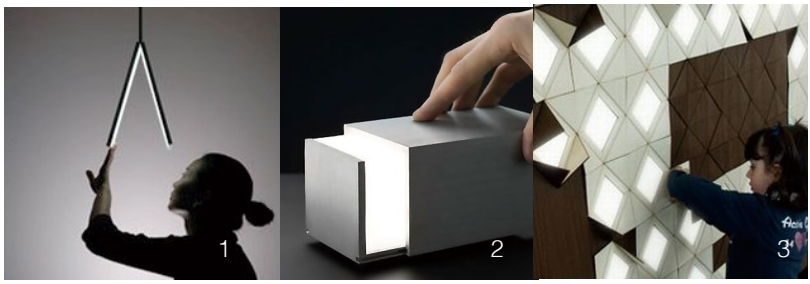


Fig. 5.4: Opening & closing examples. 1. Butterfly Light by Vinta; 2. Box Light by Hakaniemi; 3. Light Form by Gualeni & Co.

Twisting & Rotating

It is common to see on the traditional rotational bottom, but today rotating the whole object is an interesting gesture in physical interaction design.

Fig. 5.5: Twisting & rotating examples. 1. Align; 2.Ondo music editing mobile concept by Pilotfish; 3. Sculptures in multi-touch gestures, by Gabriele Meldaikyte.

Pulling

Pulling is also a special gesture which is not common in electronic products but is very common in primitive objects such as ropes and it is very intuitive.

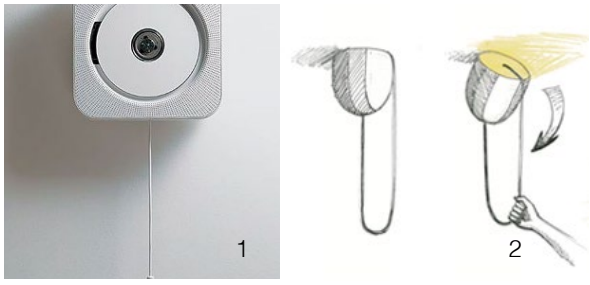


Fig. 5.6: Pulling gesture examples. 1.Muji CD player; 2.A tangible interaction concept.

Pushing

Pushing is a very simple gesture that makes people feel no effect is needed. It suits the application such as switch.

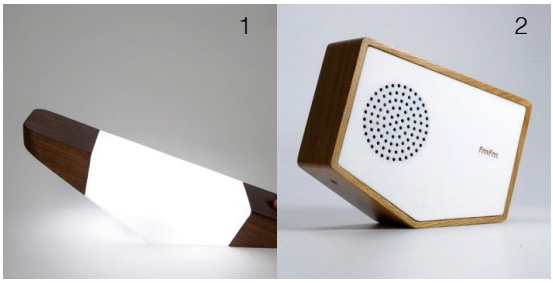


Fig. 5.7: Pushing examples. 1. Unkonwn; 2. Tilt radio by Luka Or.

Blowing

Blowing is not a very comfortable or convenient gesture but is very interesting. So it is not good for a product that people use it often but is good for an emotional design.

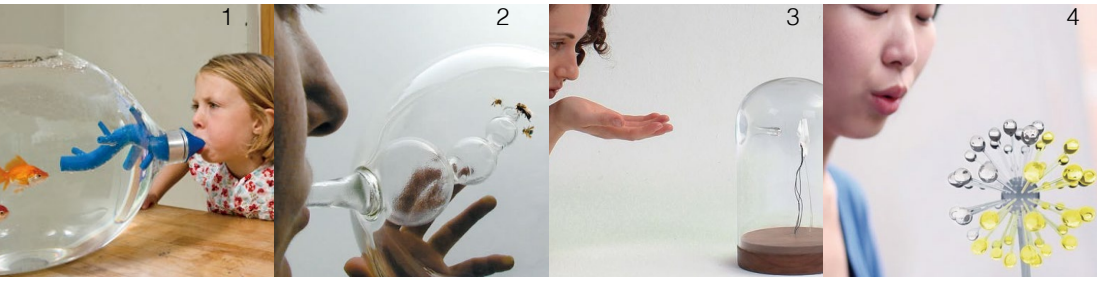


Fig. 5.8: Blowing examples.
1. Gifed, by Will Carey 2. A device for detecting cancer and other serious diseases using trained bees, by Susana Soares; 3.Sending a Kiss; 4. Dandelion Lamp.

Non-contact gestures

It is a big field of interaction design. They are convenient and intuitive. But they are not tangible and they are complicated sometimes.

Fig. 5.9: Non-contact gestures examples. 1. P.A.C.O. by Digital Habits; 2.SixthSense; 3. Myo gesture control armband; 4. Leap motion controller.

5.2 **State of the art: Wearable device interaction researches**

After the brief conclusion of interaction gestures, it is necessary to know what interaction gestures are implied in latest researches of wearable device. Because of the features of the concept, researches that utilize vocal control or body gesture detection are not taken into consideration.

HoverFlow

This paper explores the design space of around-device interaction (ADI). This approach seeks to expand the interaction possibilities of mobile and wearable devices beyond the confines of the physical device itself to include the space around it. This is particularly attractive for very small devices, such as wrist watches, wireless headsets, and future types of wearable devices such as digital jewelry.[42]

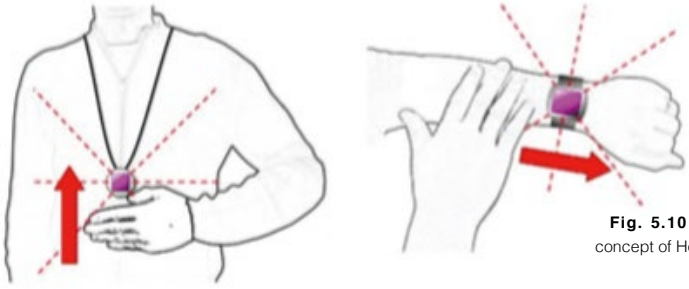


Fig. 5.10: The general concept of HoverFlow.

HoverFlow is an example application for the Apple iPhone that demonstrates the use of a sensor-based interface for detecting coarse hand-gestures above small mobile devices. [42]

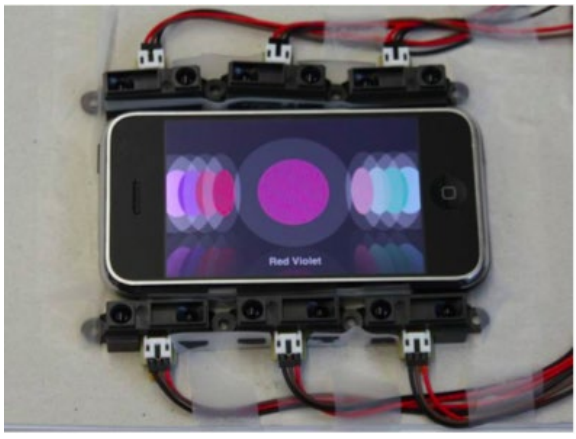


Fig. 5.11: The set of prototype of HoverFlow

They mapped the user's movements in the following way: if her hand moves across the device from left to right (Figure 3A), the color palette scrolls from left to right, and vice-versa (Figure 3B). A hand-edge movement from left to right (Figure 3C) makes the color palette scroll 5 colors to the right and vice-versa (Figure 3D). A color is selected when the user moves her hand swiftly towards the device (Figure 3G). A color is deselected when the user moves her hand rapidly away from the device. Rotating the hand towards the left (Figure 3E) or right (Figure 3F) permits the user to scroll directly to the beginning or end of the palette, respectively.[42]

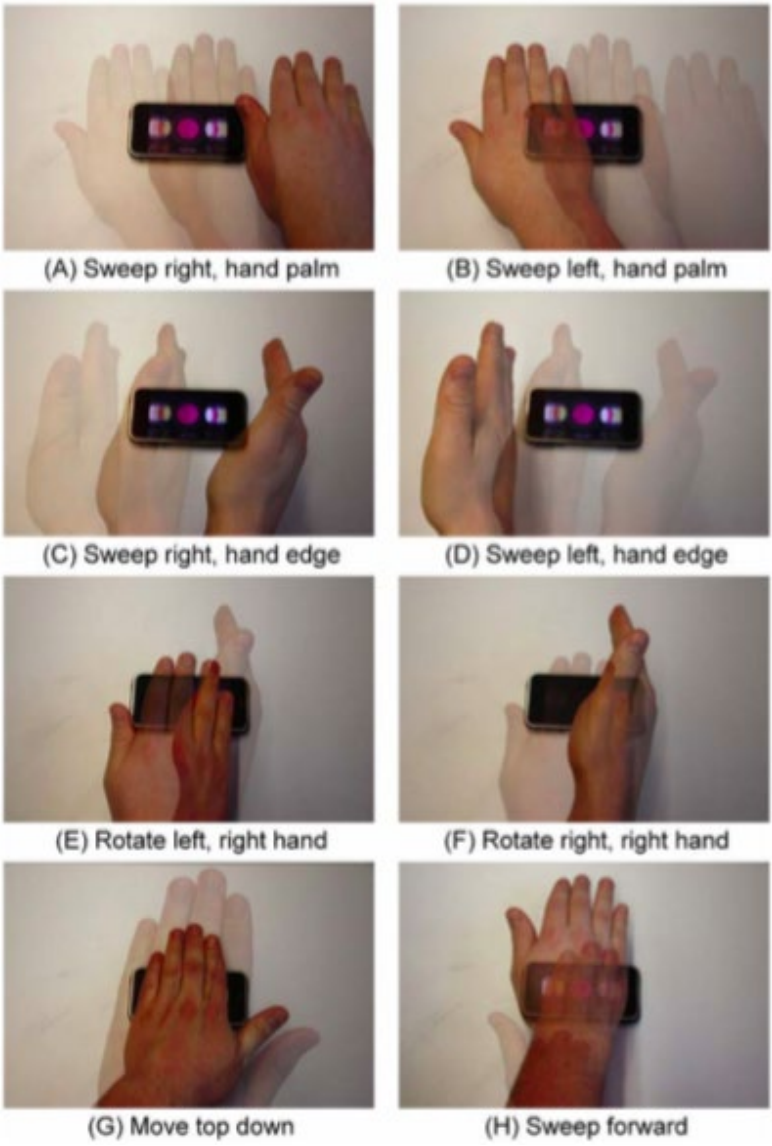


Fig. 5.12: Gestures of HoverFlow.

A Haptic Wristwatch for Eyes-Free Interactions

The research represents a haptic wristwatch prototype that makes it possible to acquire information from a companion mobile device through simple eyes-free gestures.The wristwatch uses a custom-made piezoelectric actuator combined with sensors to create a natural, inconspicuous, gesture-based interface. Feedback is returned to the user in the form of haptic stimuli that are delivered to the wrist.[43]

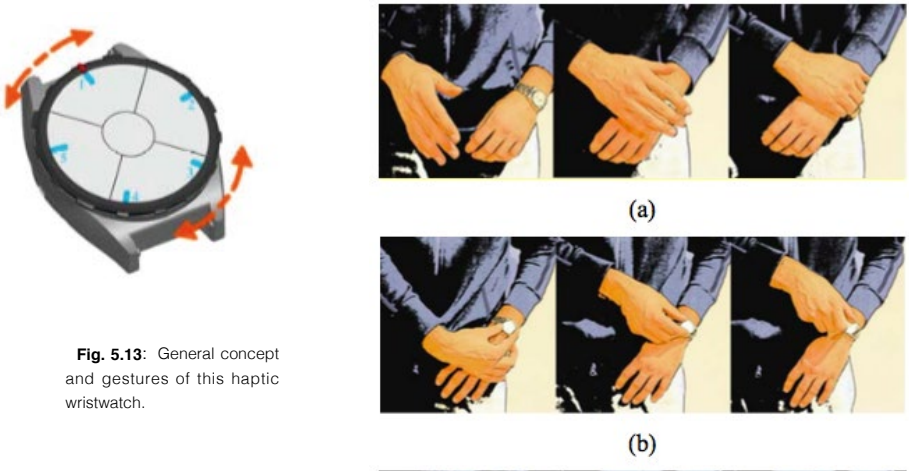


Fig. 5.13: General concept and gestures of this haptic wristwatch.

Gesture	Function	Type	Sensor	Feedback
Cover the watch face	Mute a phone call	Reactive	Capacitive sensor	The phone stops vibrating
Turn the watch bezel	Set a ringing profile mode	Control	Hall-effect sensors	Haptic confirmation on the watch
Swipe a finger over the watch face	Navigate through a music play list	Control	Capacitive sensor	A new music track starts playing
Shake the hand in a dismissive manner	Snooze a calendar reminder notification	Reactive	Accelero-meter	Haptic confirmation on the watch
Touch and hold the watch face	Sense the number of unread emails in inbox	Query	Capacitive sensor	Haptic confirmation on the watch

Table. 5.1: Gestures, fucntions and feedbacks.

WatchIt

WatchIt extends interaction beyond the watch surface to the wristband. Because the small screen of wristwatch computers suffers from visual occlusion and the fat finger problem, they investigated the use of the wristband as an available interaction resource.[44]

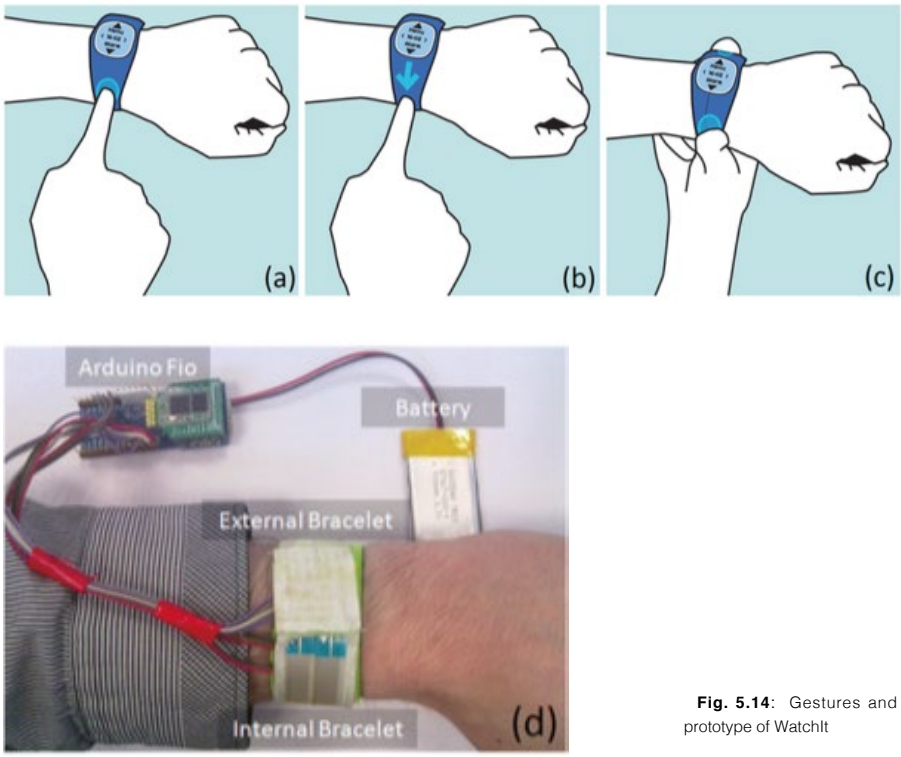


Fig. 5.14: Gestures and prototype of WatchIt

WatchIt enables interacting with the wristband using simple gestures: (a) with a finger pointing on the internal strap, (b) with a finger sliding on the internal strap, (c) with two fingers on opposite straps, (d) the final experimental WatchIt prototype. Gestures (a) and (b) can also be performed on the opposite, external strap (not shown).[44]

Nenya

Nenya is a new input device in the shape of a finger ring. Users make selections by twisting the ring and “click” by sliding it along the finger. The ring—the size of a regular wedding band—is magnetic, and is tracked by a wrist-worn sensor. Nenya’s tiny size, eyes- free usability, and physical form indistinguishable from a regular ring make its use subtle and socially acceptable.[45]

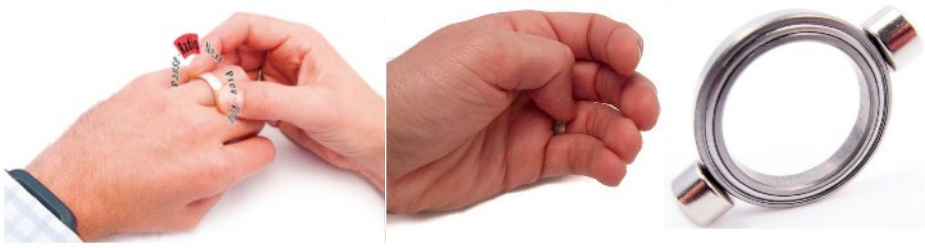


Fig. 5.15: Gestures of Nenya. On the left, gesture with two hands; one the right, gesture with one hand.

Twisting the ring enters a 1D parameter; here rotation is used to select the menu item “radio”. Users confirm a selection by sliding the ring along the finger. Nenya’s tiny size is due to it being magnetically tracked by the wrist-worn bracelet. The lines illustrate how the magnetic field changes through a 90° ring rotation. When users spin or slide the ring, the magnetometer in the bracelet senses the change in the magnetic field.[45]

Fig. 5.16: Principle of Nenya

Pinstripe

Pinstripe is a textile user interface element for eyes-free, continuous value input on smart garments that uses pinching and rolling a piece of cloth between your fingers. The input granularity can be controlled in a natural way by varying the amount of cloth pinched. Pinstripe input elements physically consist of fields of parallel conductive lines sewn onto the fabric. This way, they can be invisible and can be included across large areas of a garment.[46]

The key idea of Pinstripe is to build upon two characteristic affordances of textiles: grasping and deforming. The main gesture is rolling the fold between fingers (Figure A). This rolling movement changes the relative displacement of the two sides of the fold, which is measured by conductive threads sewn into the fabric, and interpreted as a continuous change in value. Pinching a large fold in the textile allows coarse control over a wide range of values. Pinching a smaller fold yields more fine-grained control (Figure B). [46]

Possible applications of Pinstripe are situations where users want to control mobile devices without the need to take the device out of the pocket and without the need for eye contact.[46]

Fig. 5.17: Gestures amd prototype of Pinstripe.

5.3 **Benchmark: Wearable devices on the market**

This benchmark is for understanding the wearable devices on the market now. Specifically for knowing their functions, interaction designs, advantages and disadvantages.

Fitness Bracelets

They track walking distance, calories consumption, sleep quality and heart rate. Some of them have functions of clock, alarm, text notifications and music control. Input interface is still based on buttons. Feedbacks are caused by vibration motor. They give motivational information with a small display or led arrays.[47]

Fig. 5.18: Some examples of fitness bracelet. From left to right: Fitbit bracelet, Fitbit watch, Nike bracelet.

Advantage: They caught a good user demand.
Disadvantage: Their interaction design are very basic.

Cuff

Cuff has a hidden button you can press in case of emergency. You can also program the alert to connect to specific people by tapping twice, or three times for example.[48]

Fig. 5.19: The prototype of Cuff.

When you are in an emergency, you can give your jewelry a long, extended press, and people in your Cuff network will receive an SOS that includes your phone's GPS location, and whatever information you've programmed in for worst-case scenarios.

Advantage: It totally hides technology under a jewelry so it is very socially acceptable.
Disadvantage: The market need of only emergency alarm is not strong.

Mica

Mica (My Intelligent Communication Accessory) produced by Intel works as a standalone communication device and is connected by AT&T's mobile broadband network. It brings you social notifications from the likes of Facebook, Gmail, text messages and Yelp alerts. The interaction is based on a touch screen so it operates just like a smart watch.[49]

Fig. 5.20: The product of Mica.

Advantage: It uses materials and textures as a jewelry and looks very socially acceptable.
Disadvantage: The interaction is very basic so the experience is not good.

Purple

Purple is a digital locket that keeps precious photos close at hand. The point is not to extend the number of people we're connected to, but to winnow them. It tries to find an experience that can enrich the core people you care about. To use it, you simply use the Purple app to designate a few close friends, and their social feeds are forwarded to the locket. [50]

Fig. 5.21: The prototype of Purple.

This design starts from a recognition that social networks aren't necessarily designed to keep us close to the people we care most about. Purple is meant to allow you to tag and save memories you'll always want to be reminded of, rather than losing them in the torrent of your social feeds.

Advantage: The product has a clearer and better meaning compared with other social wearable products.
Disadvantage: The real market demand for this product is unknown.

Miragii

Miragii is a smart social necklace that vibrates to alert you of an incoming message and projects texts and calls onto the palm of your hand. Miragii's functions come alive with hand gestures. Wave the hand in front of the projector's lens and then place out front to read messages on your palm. An incoming call can also be sent straight to voicemail with a simple hand wave.[51]

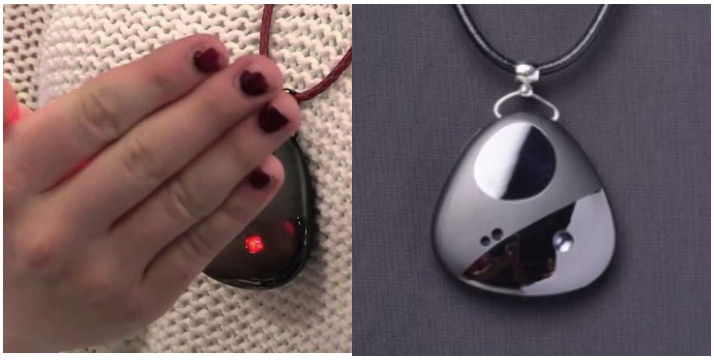


Fig. 5.22: The product of Miragii.

Advantage: It uses gesture control and it projects information on your palm, so the information can be displayed bigger and the interaction can be easier than other wearables .

Disadvantage: When the information is projected outside, it may cause problems of privacy issues.

5.4 **Developed concept**

The developed concept is based on the interaction of the traditional necklace model: locket. When the user opens a locket, she can speak and send voice message to the person connected. The interaction gesture being used here is opening & closing.

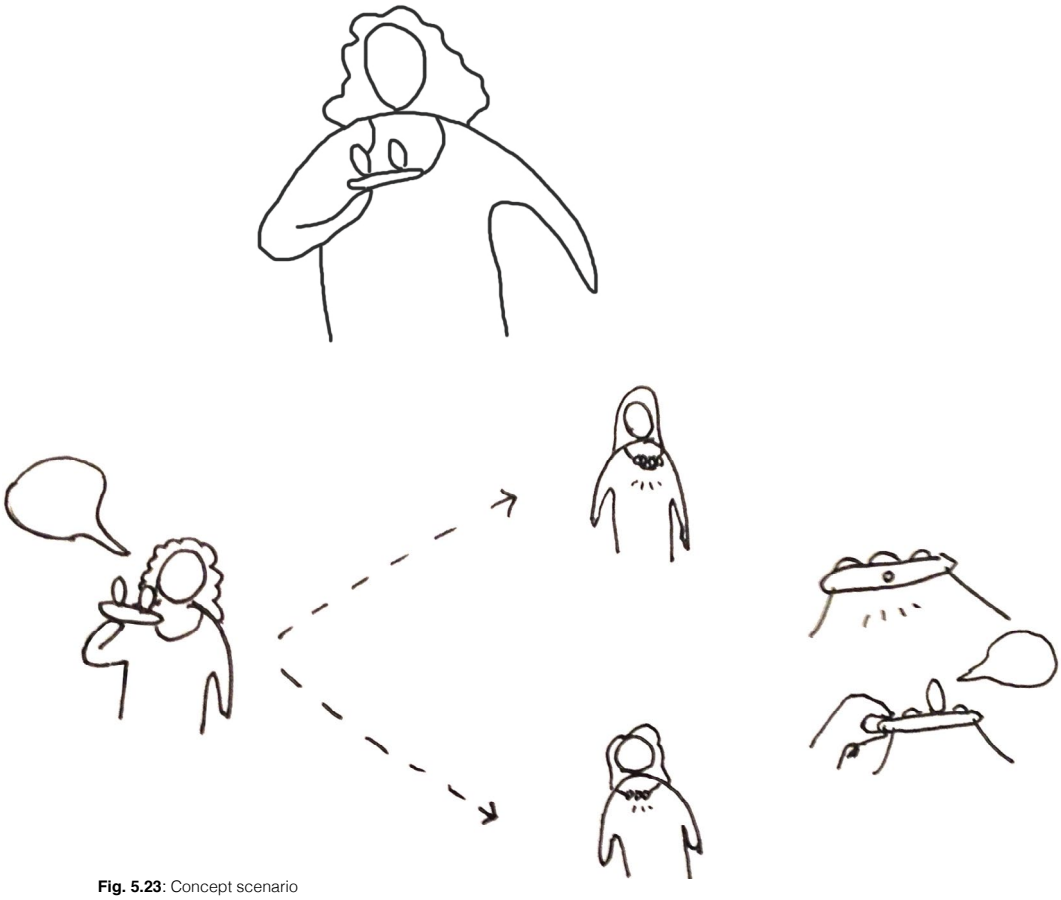


Fig. 5.23: Concept scenario

The locket is very traditional so it only needs very common mindset to use it. You open a locket, see the photo of the contact and you speak. Then you close it and it is done. You can also speak to many people at one time, so it is like a tangible Whatsapp,

There can be many lockets on the necklace, but it becomes big when there are many. With a primary prototype, I find six lockets may be the maximum limit.

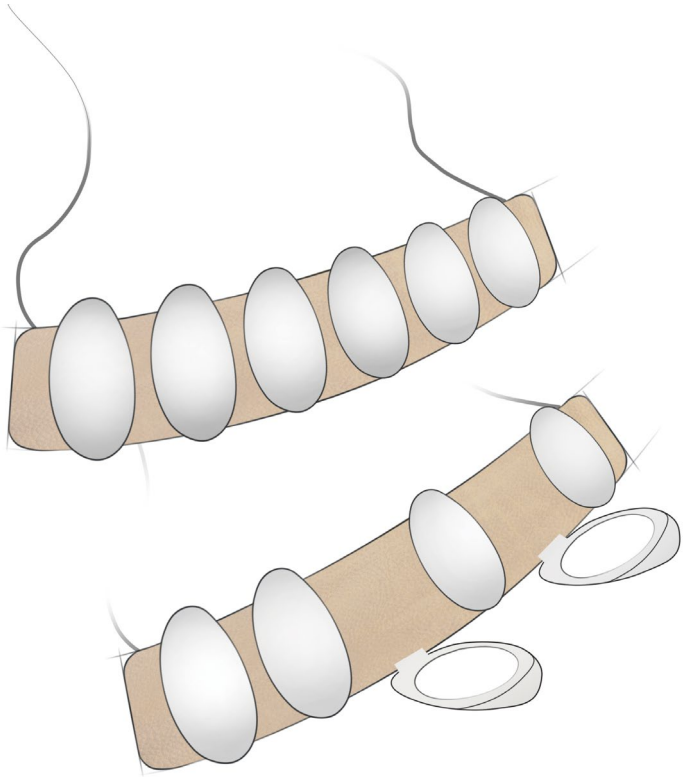


Fig. 5.24: Sketch and mock up of the concept.

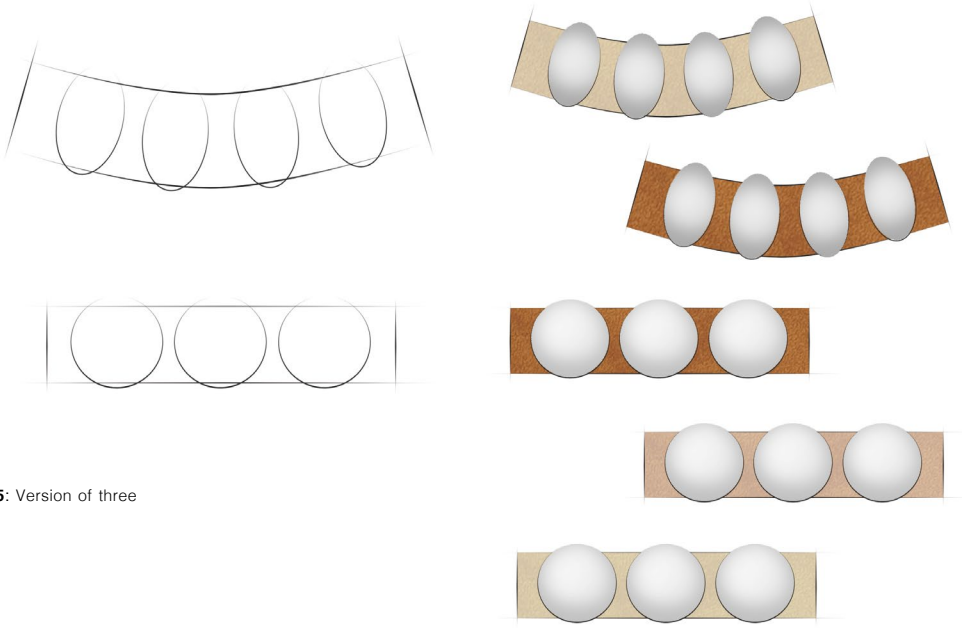
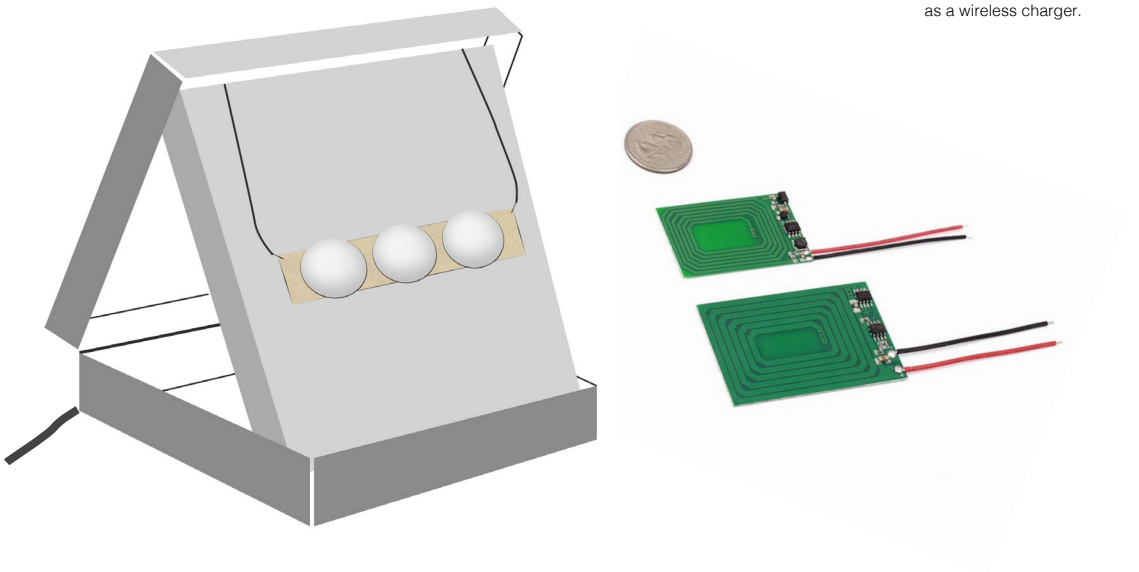


Fig. 5.25: Version of three lockets.

From the appearance's prospect, three lockets would be much better and three core contacts may be enough for the elderly, anyway it will not replace the mobile phone and will be an ancillary communication tool.

To make it easy for the elderly to charge the device, the box of the necklace will also function as a wireless charger, so the user only need to place the necklace into the box to charge it.

Fig. 5.26: Concept of box as a wireless charger.



To avoid complicated operations with an app like common wearable devices, a new method of setting contacts is designed. The user attaches her photo to a RFID tag which has her contact information (telephone number for example), and then she gives that photo to her friends. After her friend gets the photo, she just put it into a locket on the necklace and it is done. The system will read the contact information and set up by itself. The contact information can be written into the tag by a service or by the user with a RFID writer inside the necklace.

Fig. 5.27: Concept of setting up a contactor.

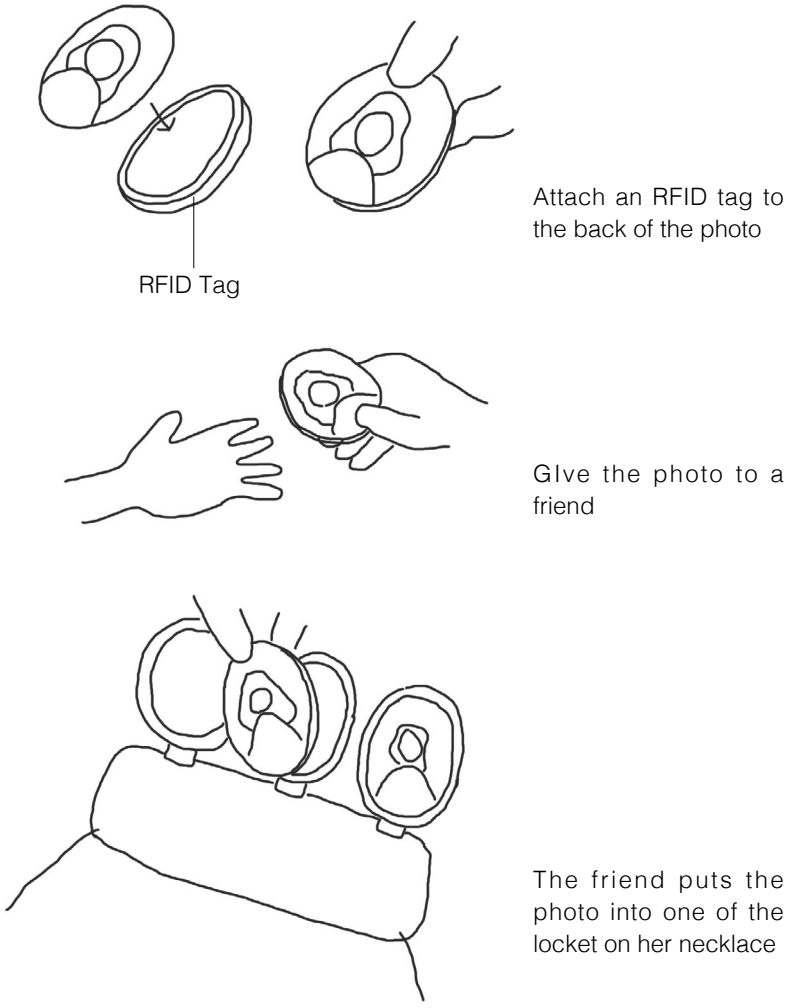
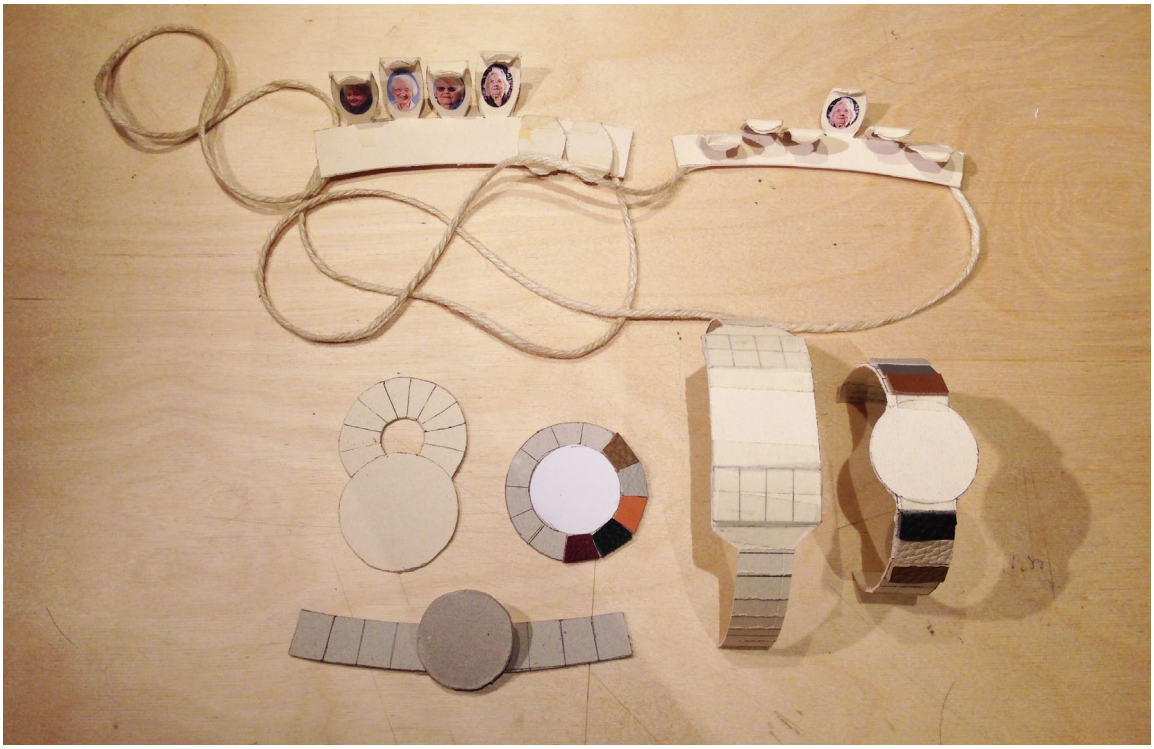


Fig. 5.28: Mockups of the concept under development.



I also tried different interaction gestures in order to design a good bracelet for men, but the result is not good enough. Also the other gestures for designing the necklace are not good (not easy to use).

6
Final Design

6. Final Design

6.1 Description and general specifications

CONEC is a smart necklace that works as a communication tool. It features to let the senior users communicate easier with each other and improve their social life. Unlike a mobile phone, it doesn't have any keyboard or screen, and it supports a communication with three people at the same time. Even though the contacts are very limited, keeping the core social circle active is more meaningful than having a long list of contacts, especially for the elderly.

To use it, user only need to open a locket, she will see the photo of the person to contact, and she speaks to the necklace and close the locket, then the voice message will be sent to the contact person. The user can send voice message to three persons together if she opens all the lockets. When she receives a message, the necklace will have a notification of vibration. Then the user will find a light under the locket of message sender. She opens the corresponding locket and she can hear the voice sent out.

The elderly can also use the necklace to contact family members like husband and offsprings. Her family members can use the smart necklace or use a corresponding app on their smartphones to contact with the user.

Dimension: 82 mm (L) x 37 mm (W) x 20 mm (H)
Dimension of photo: 23 mm x 30 mm
Weight: about 60 g

Fig. 6.1: General appearance of CONEC.

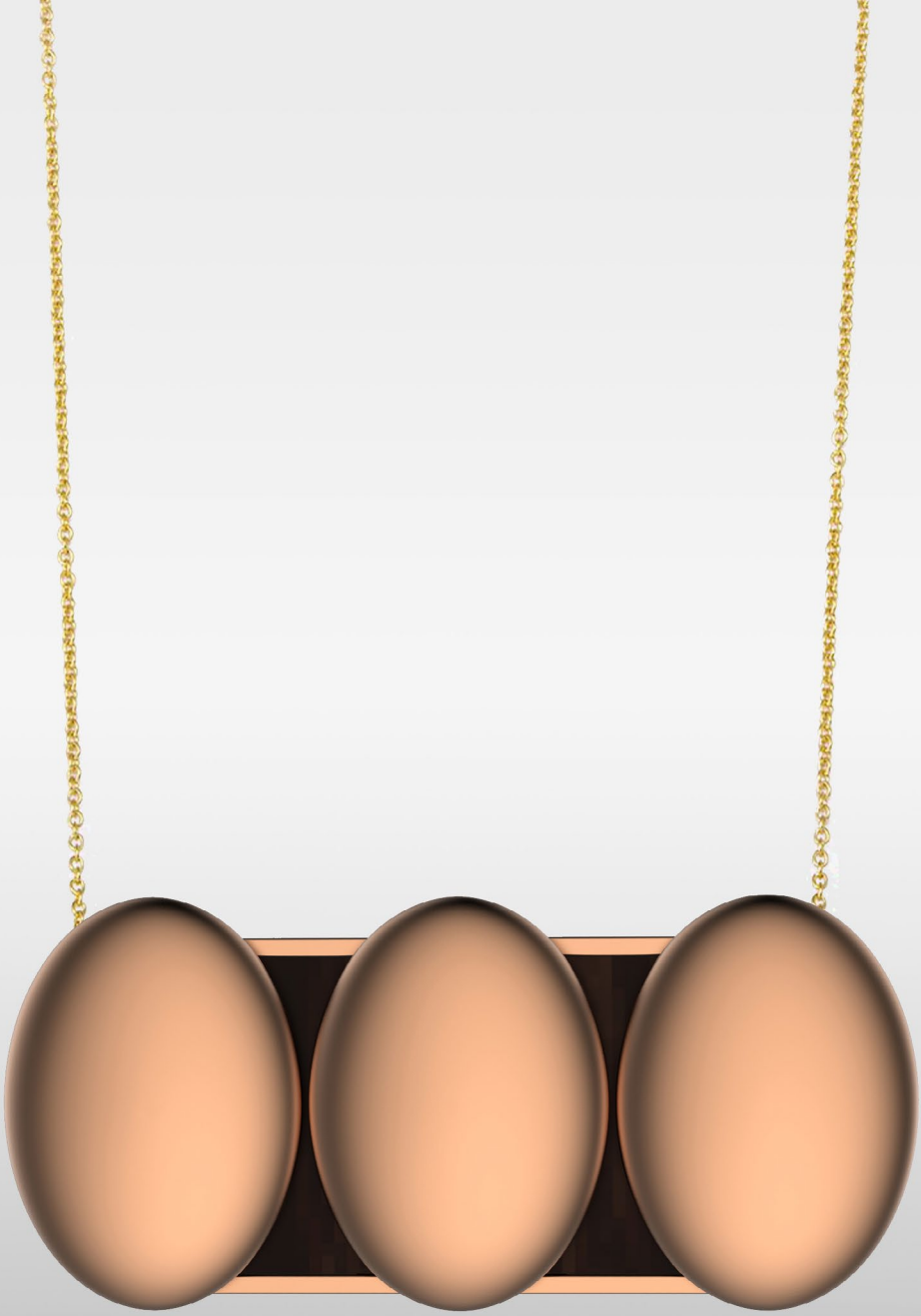


Fig. 6.2: Rendering of CONEC.

Fig. 6.3: Speaking to CONEC. The user opens two lockets to send a voice message to two people.

Fig. 6.4: Receiving a message.There will be led brinking and vibration notification on the receiver necklace. Then a led is lighten on to show which person is the message sender.

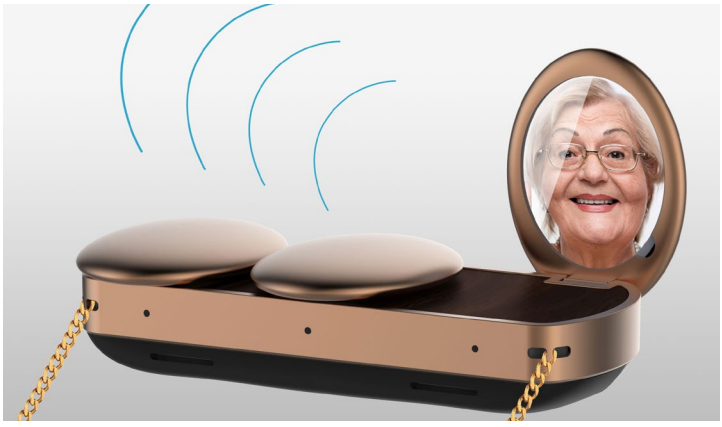


Fig. 6.5: Listening to a message. The user opens the locket to listen.

Fig. 6.6: Wearing the CONEC

Principle of the system

When the necklace is connected with mobile phone, it works with an app in the phone. The app will receive command from the necklace and send voice message to another phone. The app in another phone receives the voice message then it gives command and sends voice message to its necklace. The communication between two phones will be based on an online server. The users use the app only to connect the necklace to their phone.

Fig. 6.7: Principle of the system.

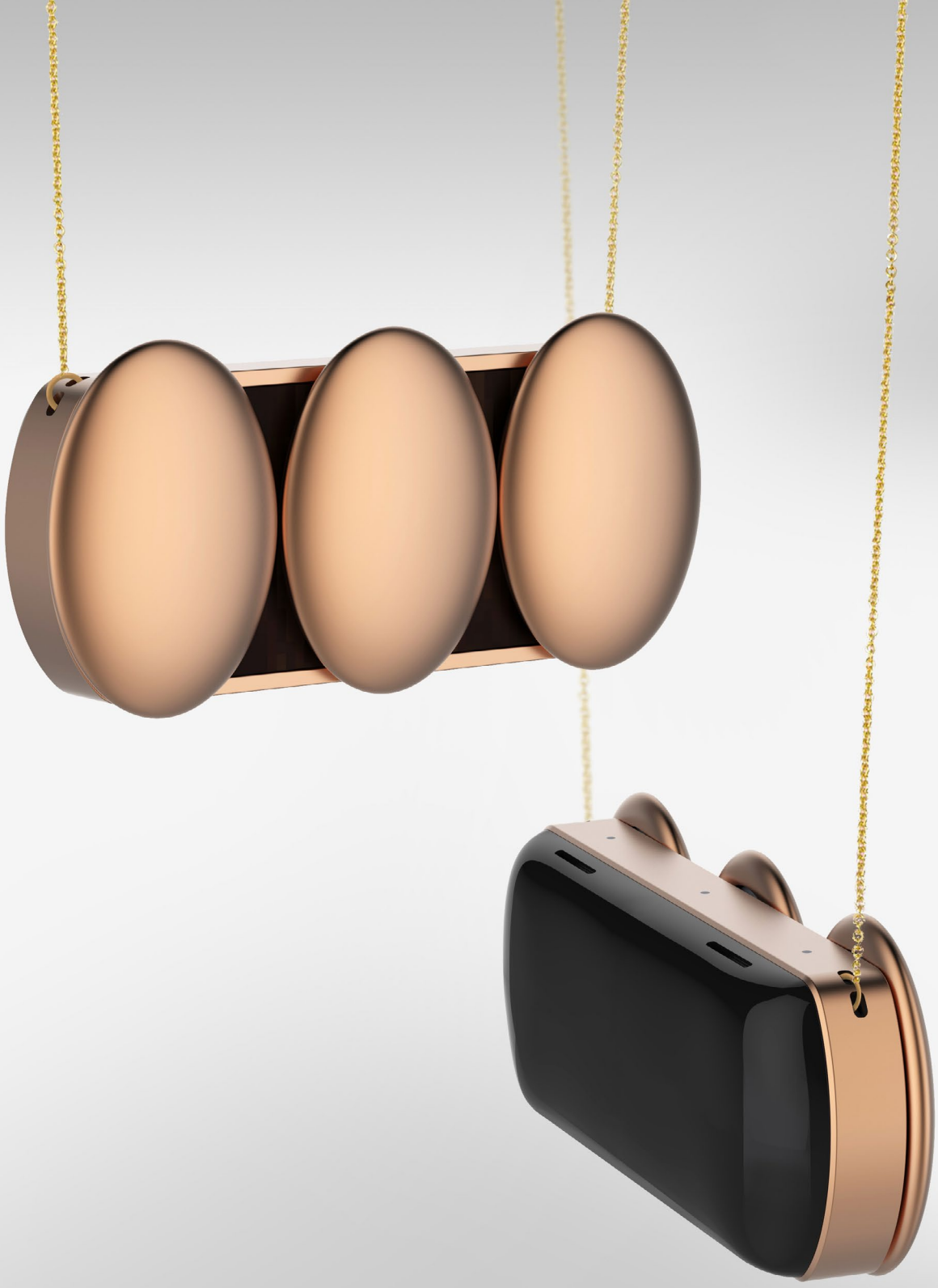
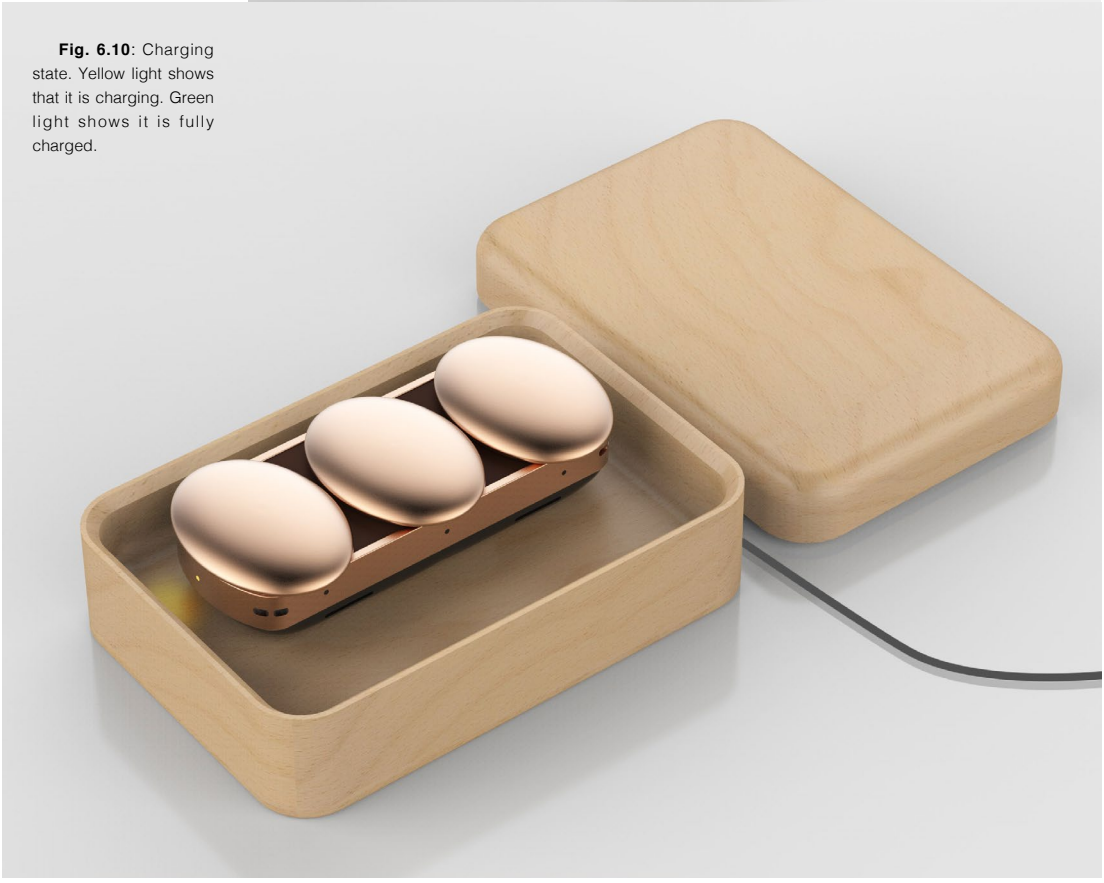


Fig. 6.8: Different angles of view

Fig. 6.9: The container is a wireless charger.

Fig. 6.10: Charging state. Yellow light shows that it is charging. Green light shows it is fully charged.



6.2 **Way of use (storyboard)**

Character

Eva is 70 years old, she is retired and lives alone. Her son is working in another city. She has one friend not very far from her home.

Setting up and exchange of contact information

When she received the smart necklace CONEC, the sale system has a service to customize her photos to fit the size of lockets. Together inside the package there are ten RFID sticky tags. First she connects CONEC to her phone with bluetooth, then she adheres one tag to the back of her photo. Then she puts her photo on the surface of the necklace. The system will automatically write her telephone number to the RFID tag. A state light will brink to show it has finished the process. In this way she saved her contact information into her photo.

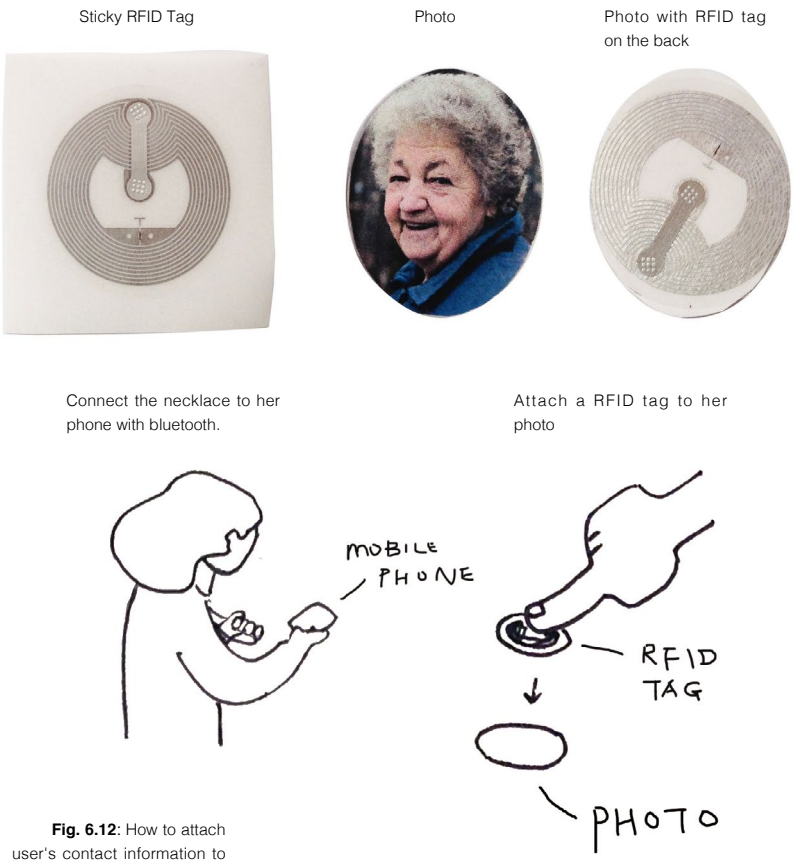
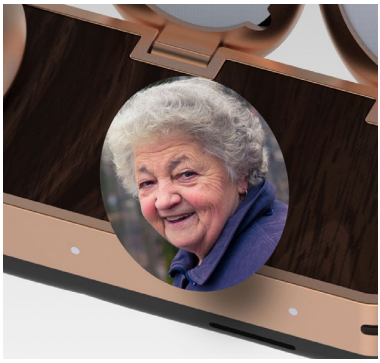


Fig. 6.12: How to attach user's contact information to her photo.

Place the photo on the surface of the necklace. If the RFID tag is blank, the RFID writer inside the necklace will write the telephone number of the user into that tag, automatically.



Now she has two photos with her contact information. She decides to give one photo to her friend first, who also has a CONEC. They meet in a bar near home and exchange the photo. After she got the photo of her friend, she put it into one locket on the necklace, the necklace reads the information in the tag on that photo automatically and builds a contact.

Meet a friend

Exchange photos with RFID Tag

Attach the photo to one locket

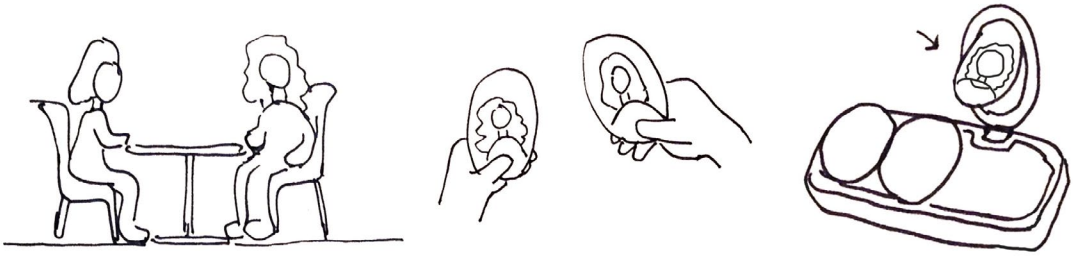


Fig. 6.13: Exchange photo and set contact

Contacting people

One sunny day , Eva wants to have a walk, so she opens the locket to send a voice to her friend. Soon she gets a reply and they agree to go to the park nearby.

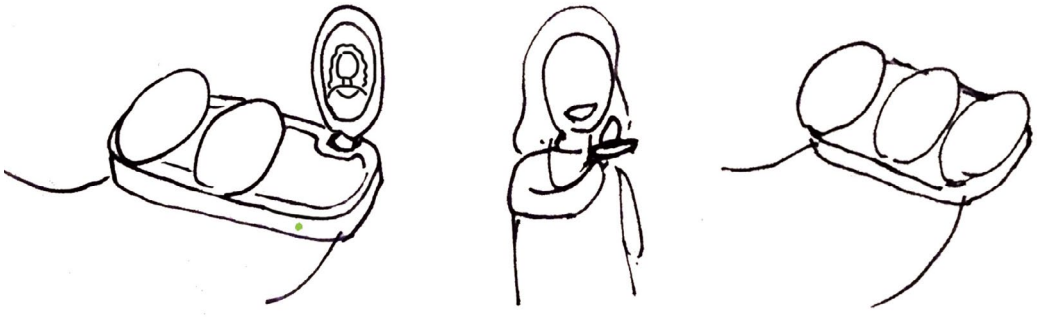


Fig. 6.14: She opens a locket to speak. Then she closes the locket to send the voice.

Making new friend

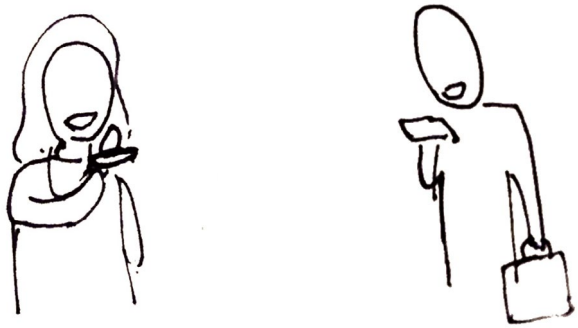
When she gets out, she meets her neighbor, who is also retired and she knows for years but never talked before. She finds her neighbor also has the same smart necklace. So she asks maybe they can contact each other sometimes. Her neighbor agrees and they exchange their photos.

Fig. 6.15: How to make new friends with CONEC.

App for the other people

Because Eva always think about her son, so she wants to contact her son easily as well. Although her son doesn't use that necklace, but he can use an app to send and receive voice message from the necklace of her mother.

Fig. 6.16: How to contact the people who don't have the CONEC.



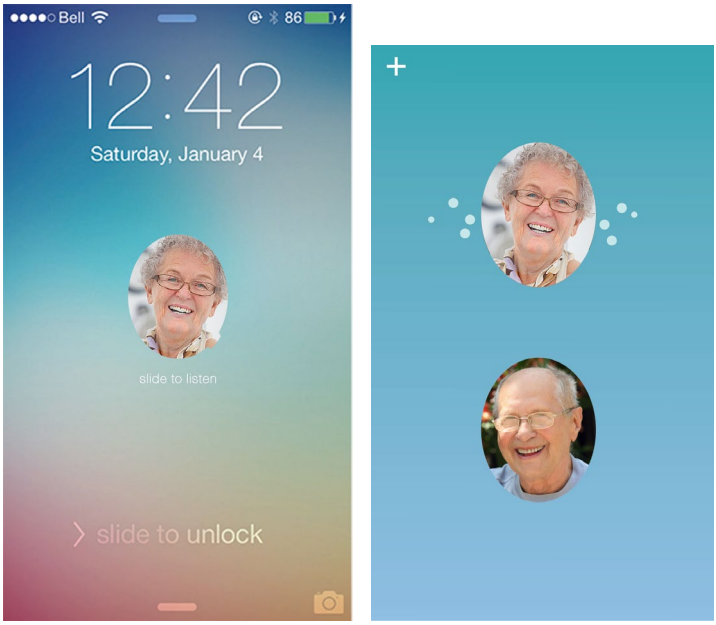


Fig. 6.17: A possible interface of the App. Left: the user gets a voice message when he is not using the phone, he can slide to listen. Right: the user gets a voice message when he is using the app, he can tap on the icon of photo to listen and then tap again to speak and send a voice message.

Charge the device

Every night, Eva takes off the necklace and put it in the box, which is also the charger. When she wakes up the next morning, the necklace will be fully charged and can last at least two days.

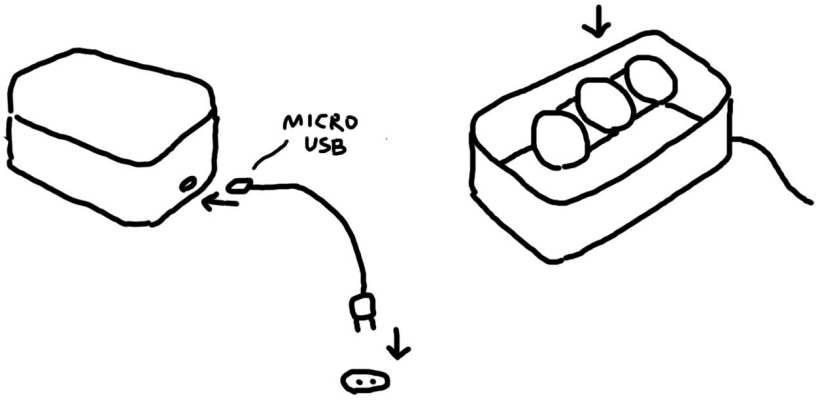


Fig. 6.18: The sketch of charging the necklace.

6.3 **Electronic components**

6.3.1 **Component list**

The functions that need to be realized can be listed as follows: Recording voice; Sending voice file to smartphone via Bluetooth; Playing voice file; RFID tag reading and writing; Wireless charging.

So the following components are chosen:

CPU: ATMega328
It is a high-performance Atmel 8-bit AVR RISC-based micro-controller combines 32KB ISP flash memory

Audio Decoder Chip: VS1053
A single-chip Ogg Vorbis/MP3/AAC/- WMA/MIDI audio decoder and an IMA ADPCM and user-loadable Ogg Vorbis encoder.

Flash Memory Chip: CFeon EN25F80
The EN25F80 is an 8M-bit (1024K-byte) Serial Flash memory, with advanced write protection mechanisms, accessed by a high speed SPI-compatible bus.

RFID Reader & Writer: MFRC522
The MFRC522 is a highly integrated reader/writer IC for contactless communication at 13.56 MHz. The MFRC522's internal transmitter is able to drive a reader/writer antenna designed to communicate with ISO/IEC 14443 A/MIFARE cards and transponders without additional active circuitry.

Power Management Chip: RC5T7315
RC5T7315 is the Power management LSI that integrates Regulators, Battery Charger, and RTC in one chip.

Bluetooth Low Energy Chip: Nordic nRF52832
The nRF52832 SoC is a powerful, highly flexible ultra-low power multi-protocol SoC ideally suited for Bluetooth® Smart ANT and 2.4GHz ultra low-power wireless applications.

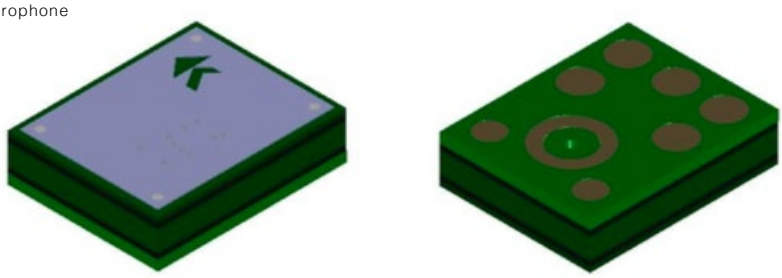
Amplifier Chip: LM386

LM386 is a power amplifier designed for use in low voltage consumer applications.

Microphone: SPM0408LE5H-TB

It is a miniature, high-performance, low power, bottom port silicon microphone. The size is 3.76 mm x 4.72 mm

Fig. 6.19: Microphone SPM0408LE5H-TB



Speaker: CDS-18138A

It is a micro speaker that is suited for low power and small size applications. The size is 18 mm x 13 mm x 2.5 mm.

Fig. 6.20: Speaker CDS-18138A

SMD RGB LED: 1210

SMD LEDs are micro LEDs that can be embedded on PCBs directly. Size of 1210 is 2.8 mm x 3.5 mm.

Fig. 6.21: SMD RGB LED 1210

Vibration Motor: RVN1004

Size: Φ10 mm

Fig. 6.22: Vibration Motor RVN1004

Wireless Charging Receiver: TDK WR221230-36M8-G

It is the receiving coils for wireless charging. These coils are designed for Max 2w output. Custom design is available based on each design requirements.

Size: 22 mm x 12 mm

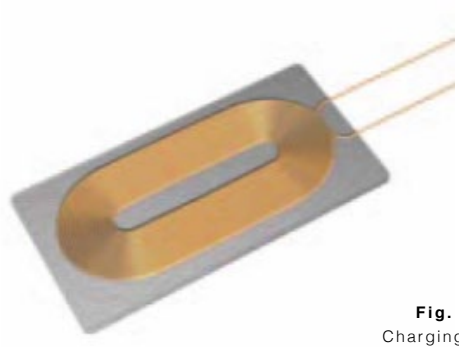


Fig. 6.23: Wireless Charging Receiver TDK WR221230-36M8-G

Lithium Battery:

3.7v, 350mAh. Custom design is available based on each design requirements.

Size: 36mm x 20mm x 5.6mm

Fig. 6.24: Lithium Battery

6.3.2 **Components Arrangement**

All the chips except for RFID reader/ writer are all micro chips so they can be embedded in one PCB(Printed Circuit Board). Three RFID reader/ writer will be embedded in another PCB. The two PCBs will be connected with board-to-board connectors.

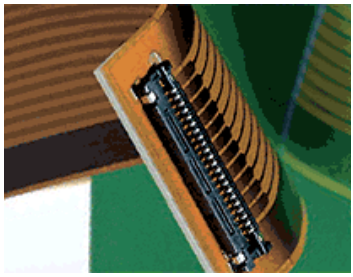


Fig. 6.25: Board-to-board connector

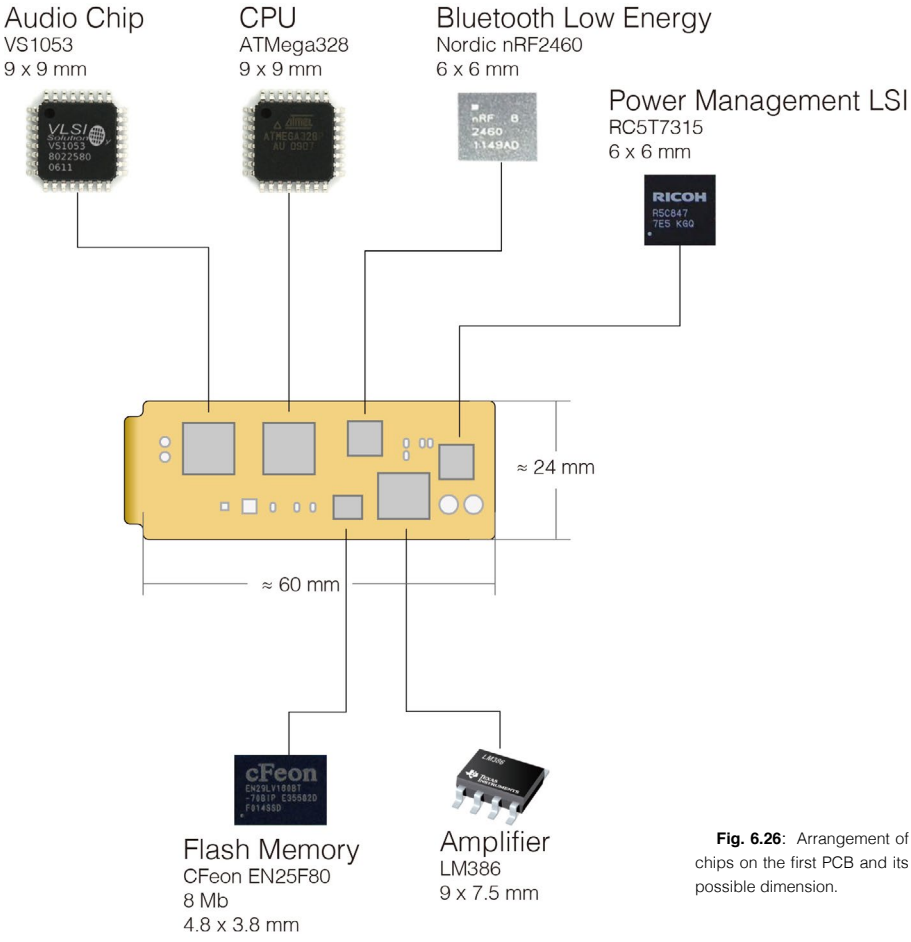


Fig. 6.26: Arrangement of chips on the first PCB and its possible dimension.

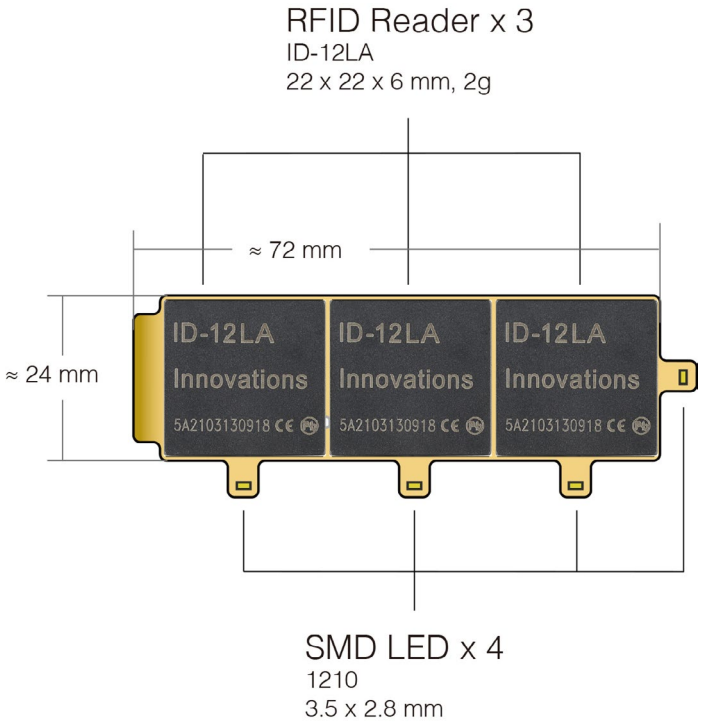


Fig. 6.27: Arrangement of components on the second PCB and its possible dimension.

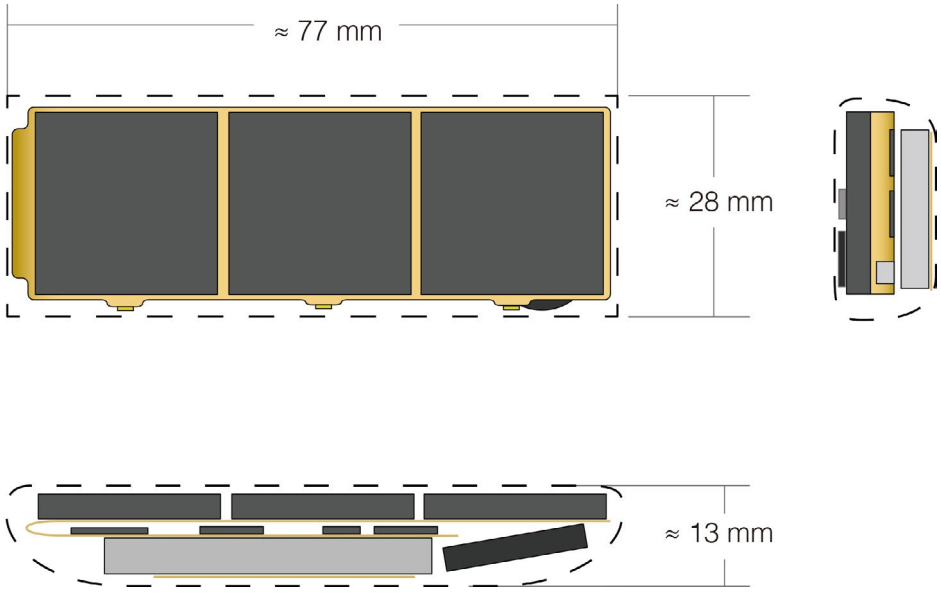


Fig. 6.28: The overall estimated dimension.

6.4 **Physical Structure**

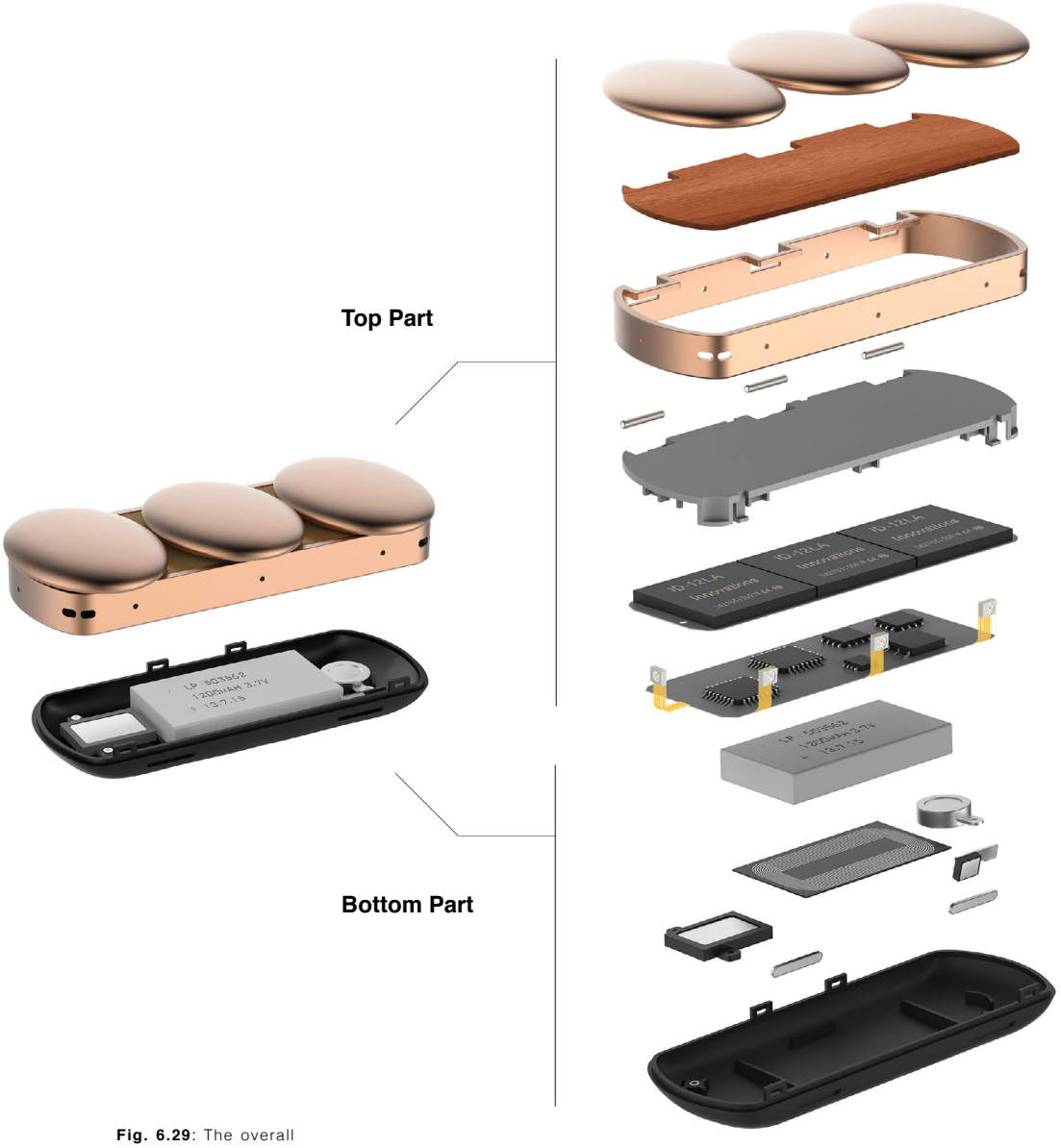


Fig. 6.29: The overall explosion of components.

Top Part Explosion

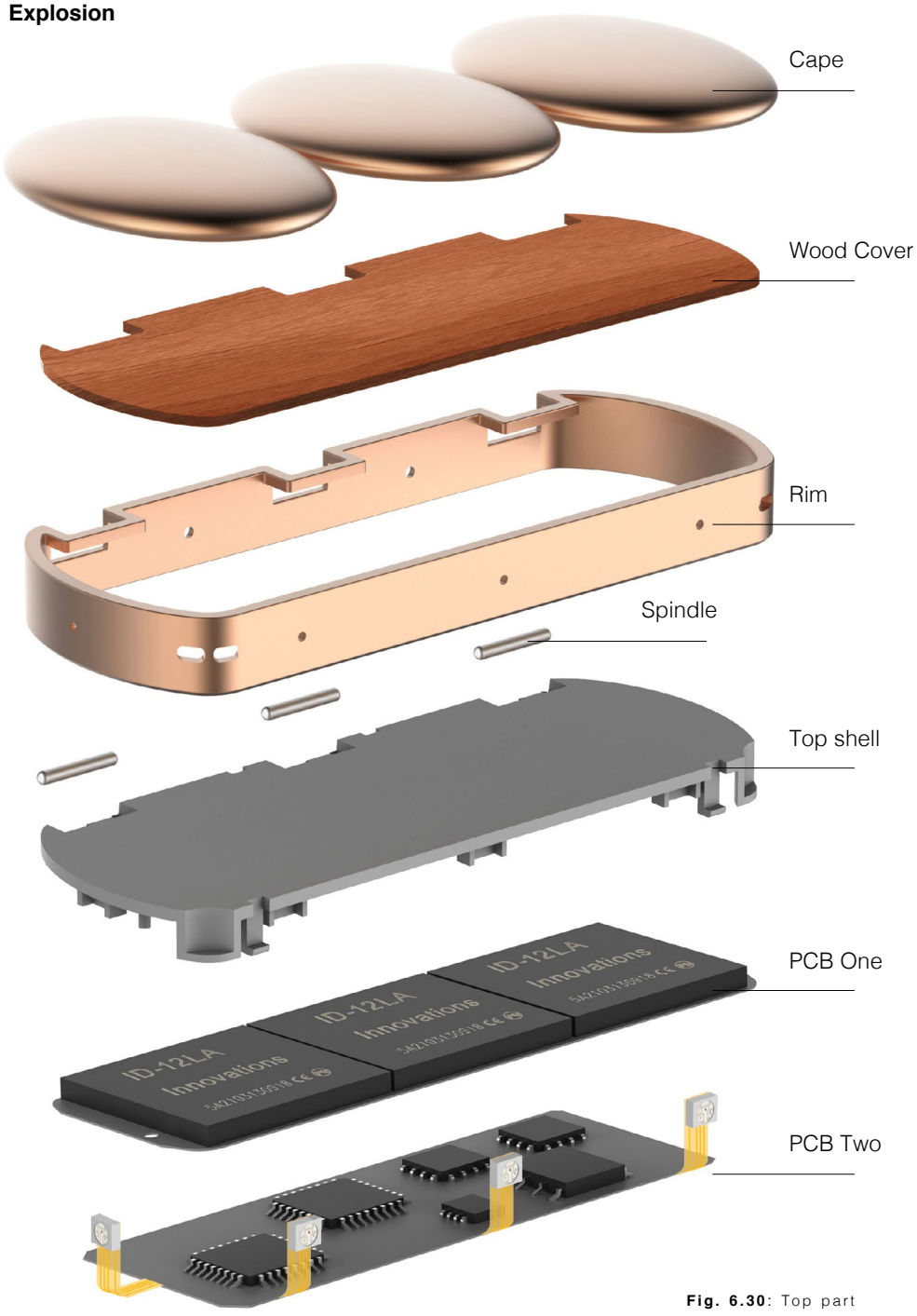


Fig. 6.30: Top part explosion

Bottom Part Explosion

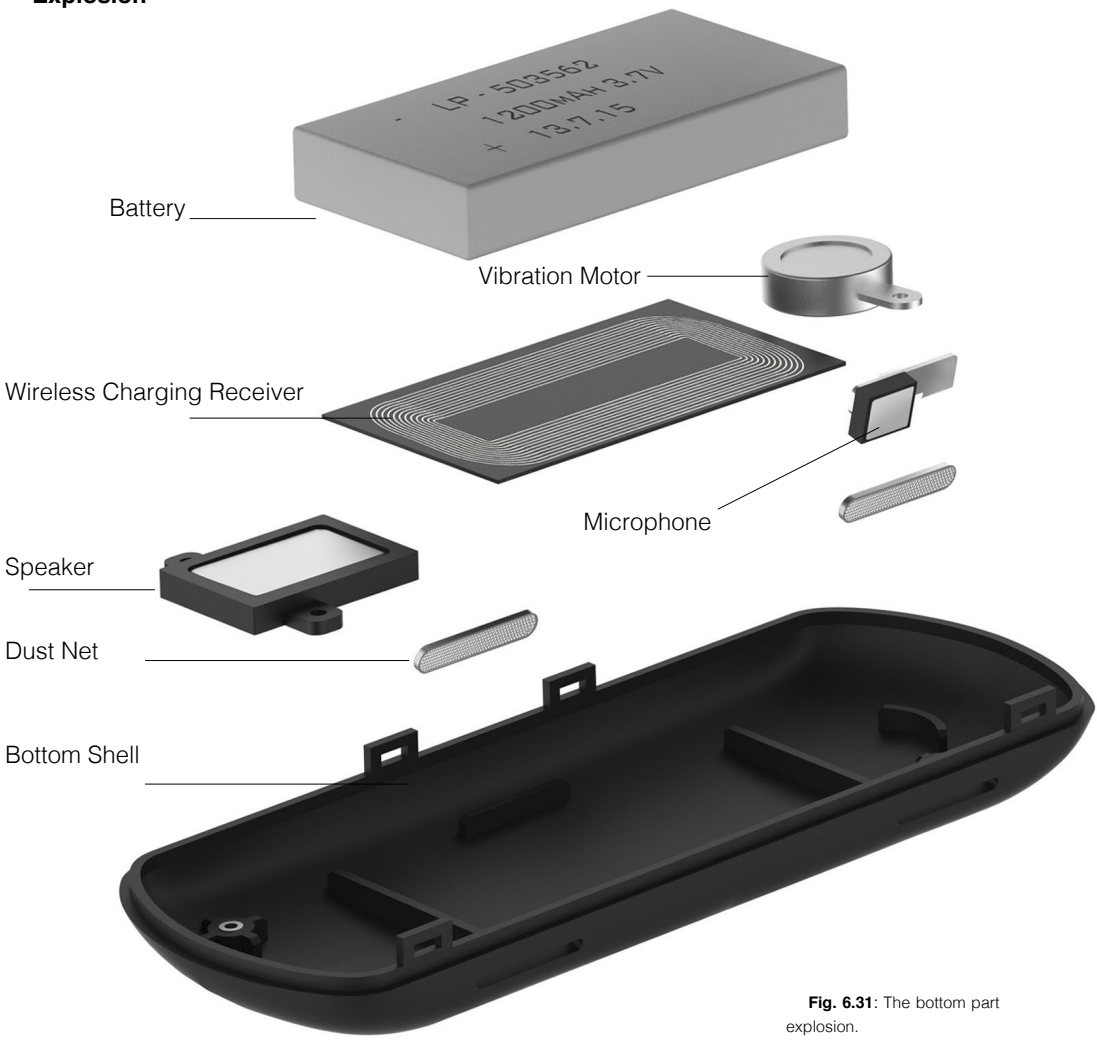


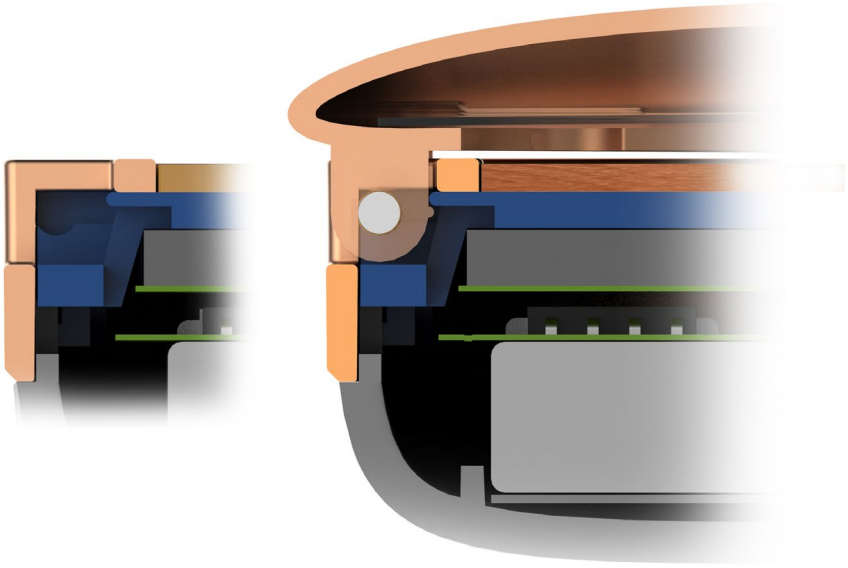
Fig. 6.31: The bottom part explosion.

An Overall View of Assembly

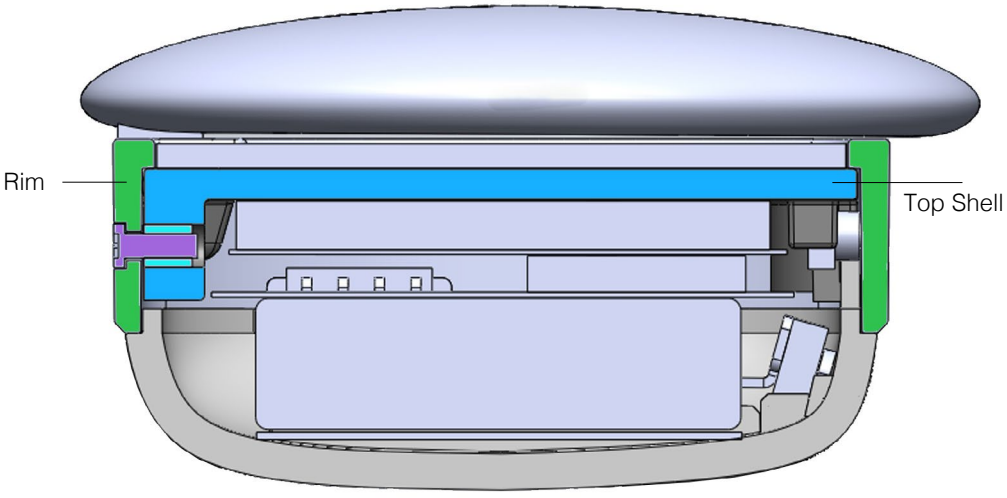
Fig. 6.32: The overall view of assembly

Fig. 6.33: Top part assembly and bottom part assembly.

Fig. 6.34: The detialed structure .

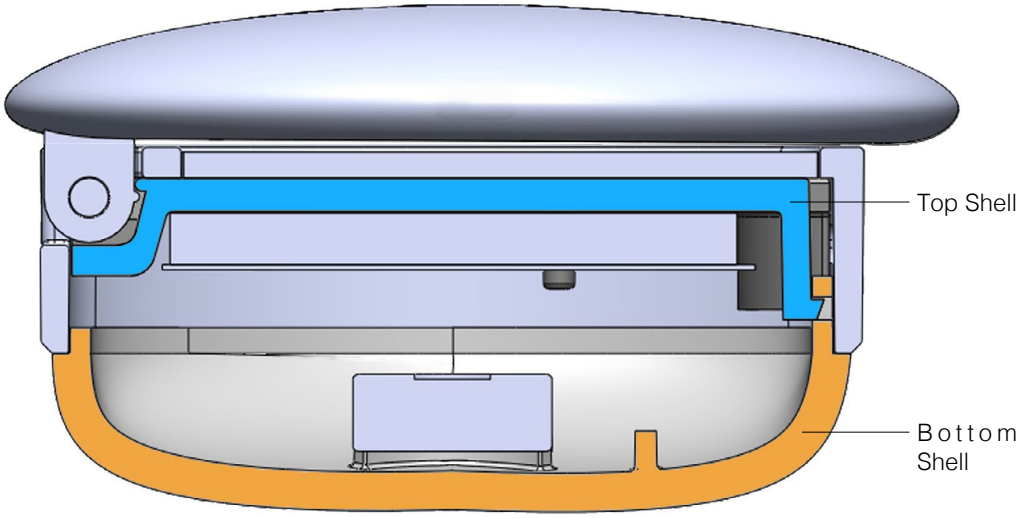


The structure for fixing the hinge of lockets and a micro snap fit to hold the locket when it is closed.

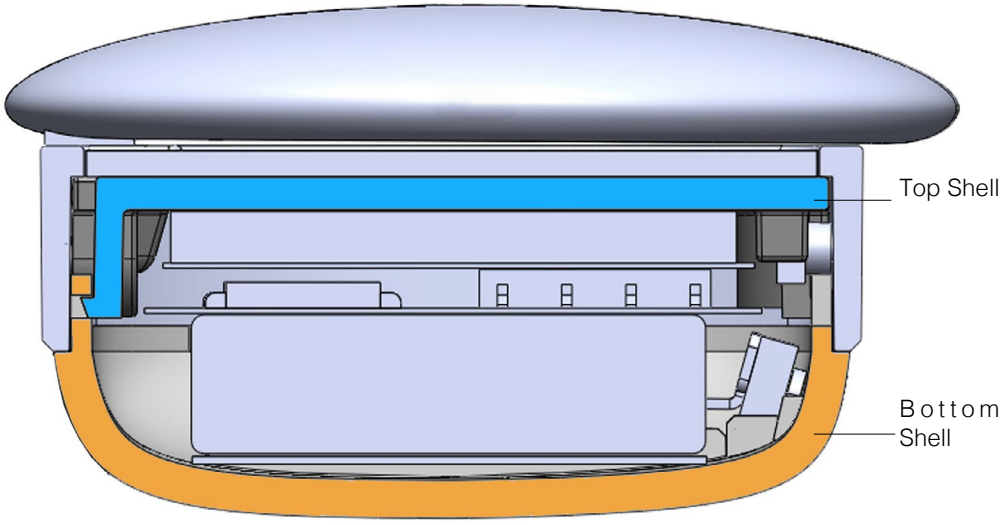


The structure for fixing the inner shell with the metal rim.

Connection between top and bottom parts



The snap fit for fixing the top and bottom shells.

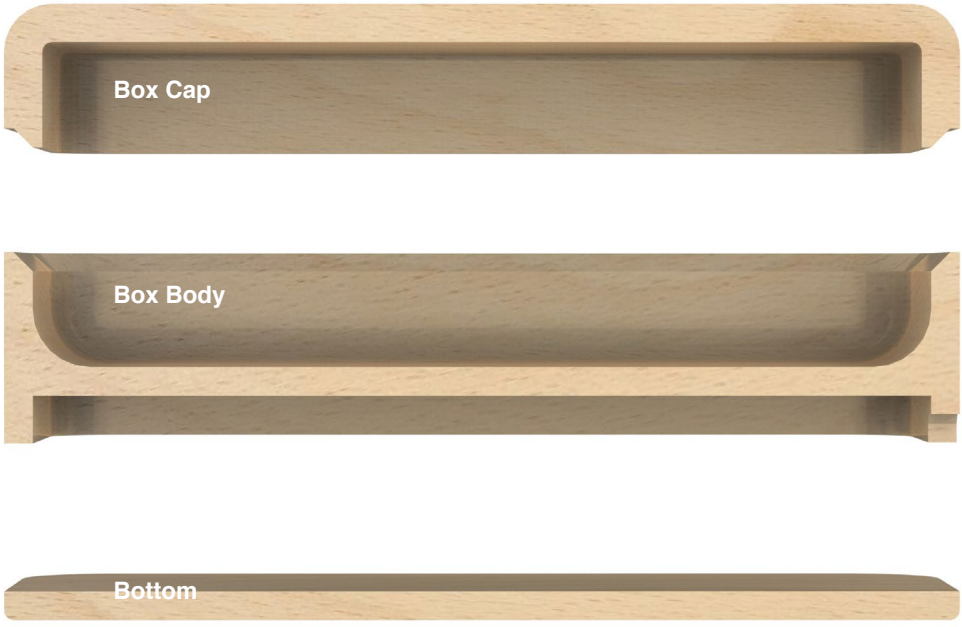


The snap fit on the other side for fixing the top and bottom shells.

Container

It will be made in wood and processed with CNC machine.

Fig. 6.35: The structure of the container.



6.5 **Manufacturing process & Material Selection**

Four parts need to be manufactured: cap, rim, top shell and bottom shell.

6.5.1 **Cap**

Process

It is a special part that may involve some handicraft into the process. It can be made in this way: The body part of the cap can be made with curling process. The hand part of the cap can be made of die casting. Then the two parts are welded.

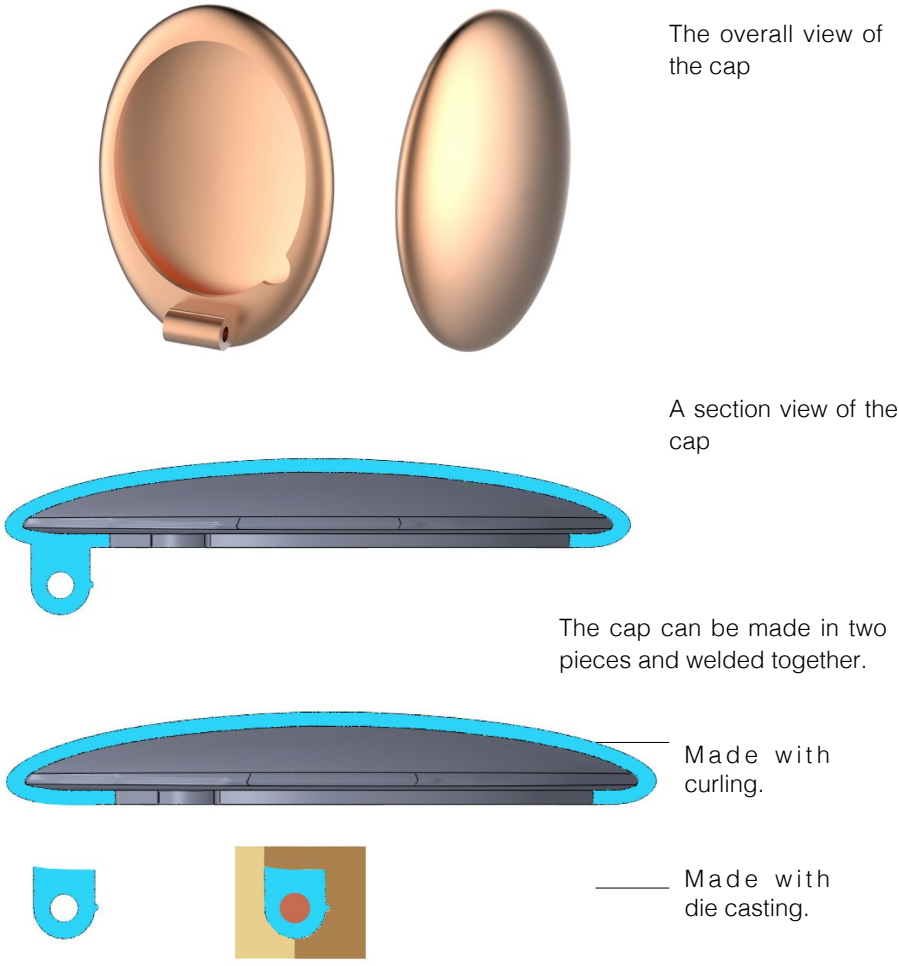


Fig. 6.36: Process of the cap.

Material Selection

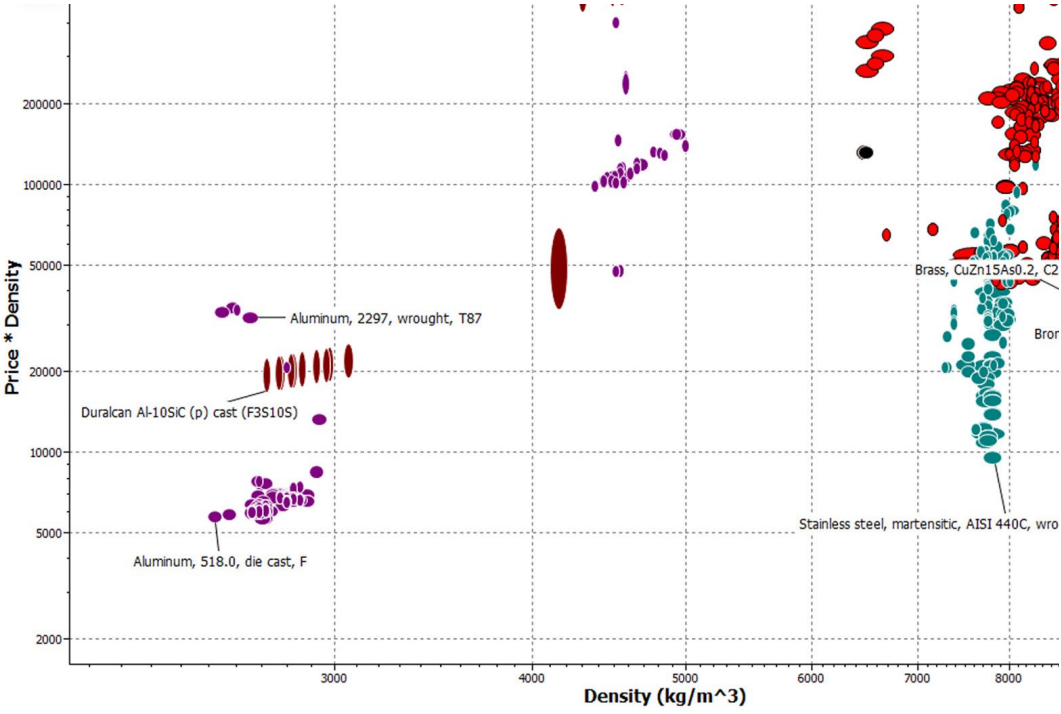
Constrains

1. Should be metal.
2. Can be processed by curling , die casting and welding.
3. Maximum service temperature > 50 °C (considering the high temperature of some places in extreme weather)
4. Minimum service temperature < - 20 °C (the same reason of the previous constrain)
5. Good surface finishing
6. Enough stiffness, toughness and hardness
7. Excellent corrosion resistance to fresh water and salty water.

Objective

1. Minimum cost
2. Minimum weight

Graph 6.1: Material selection of the cap.

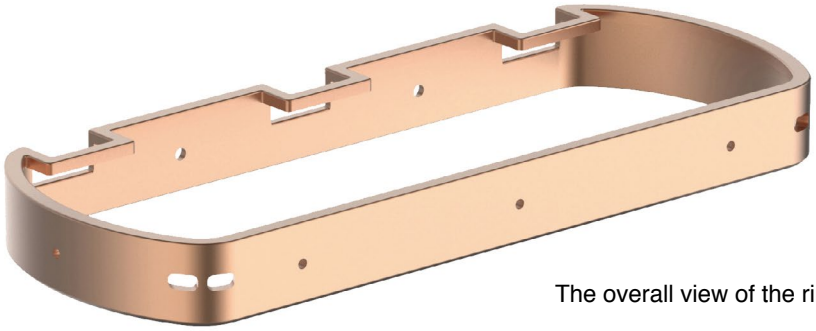


According to the graph, the best choice can be: Aluminum, 518.0, die cast F, which is 92.5% of aluminum, 1.8% of iron and 8.5% of magnesium.

6.5.2 **Rim**

Process

It need to be metal because as a smart jewelry it should deliver a nice quality of material to the user. The process can be die casting. The small holes will be drilled later by laser. The big holes for fixing the necklace chain may be done by a moving part in the mold, or by laser drilling.



The overall view of the rim

A section view of the rim and its casting die

Fig. 6.37: The process of the rim.

One option to make it look better

If we use Laser Micro Drilling, we can make the LED holes invisible when there is no light. Using Laser Micro Drilling, we can drill 91 micro holes of 20 µm diameter inside the area of 1 mm diameter. In this way, the user can see the hole only when the LED is turned on.

Laser Micro Drilling - 20µm exit hole

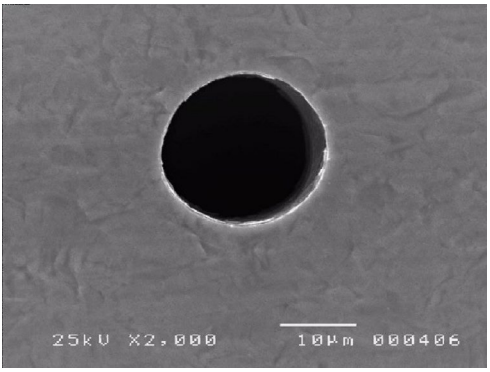


Fig. 6.38: Using Laser Micro Drilling to make the LED holes invisible

misfit shine used Laser Micro Drilling to make the LED holes almost invisible.

The imaginary effect of using Laser Micro Drilling for CONEC

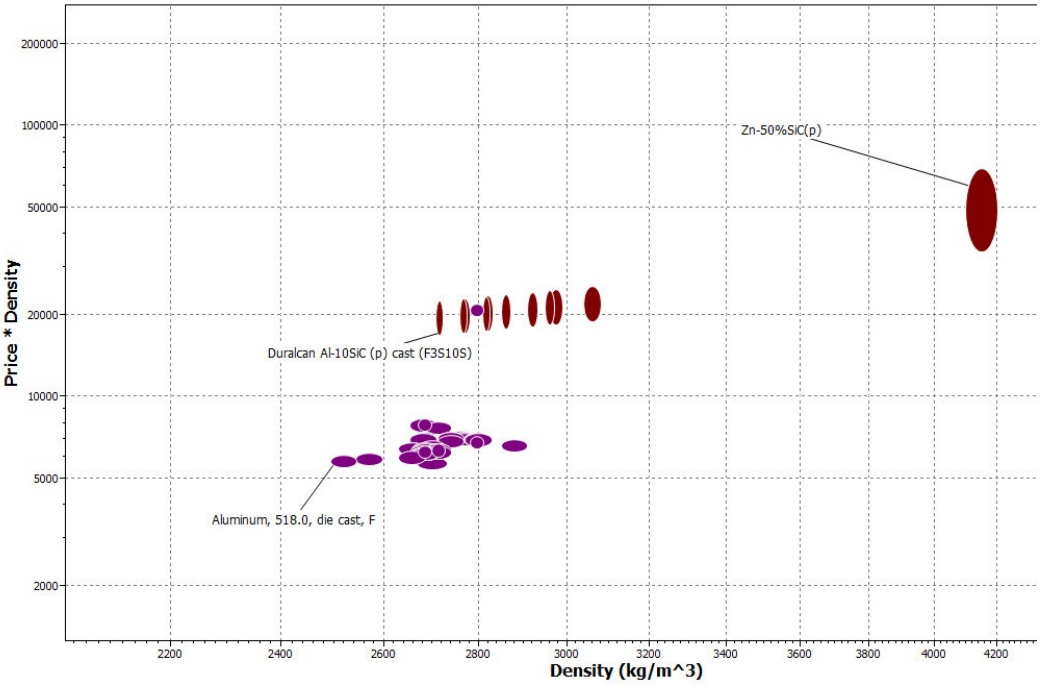
Material Selection

Constrains

1. Should be metal.
2. Can be manufactured by die casting.
3. Maximum service temperature > 50 °C (considering the high temperature of some places in extreme weather).
4. Minimum service temperature < - 20 °C (the same reason of the previous constrain).
5. Good surface finishing.
6. Enough stiffness, toughness and hardness.
7. Excellent corrosion resistance to fresh water and salty water.

Objective

1. Minimum cost
2. Minimum weight



According to the graph, the best choice can be: Aluminum, 518.0, die cast F, which is 92.5% of aluminum, 1.8% of iron and 8.5% of magnesium.

Graph 6.2: Material selection of the rim.

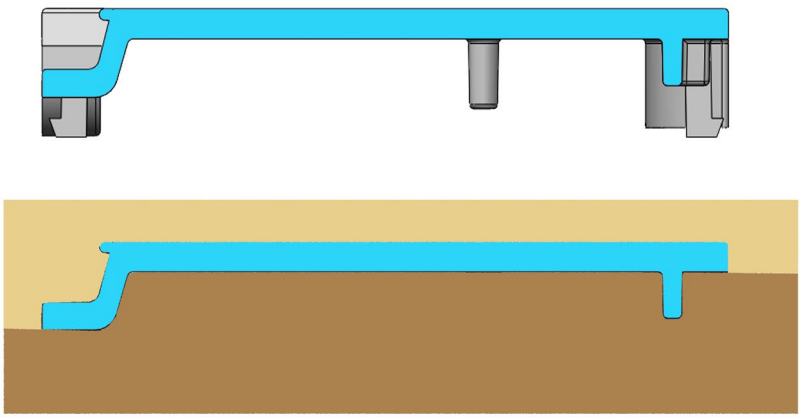
6.5.3 **Top shell**

Process

Because RFID communication can be blocked by metal, this part should be plastic and it needs to be made with injection molding.

In section A there is a micro undercut, but it is a micro snap fit so it can be removed from the die without problem. In section B there is no undercut.

Section A



Section B

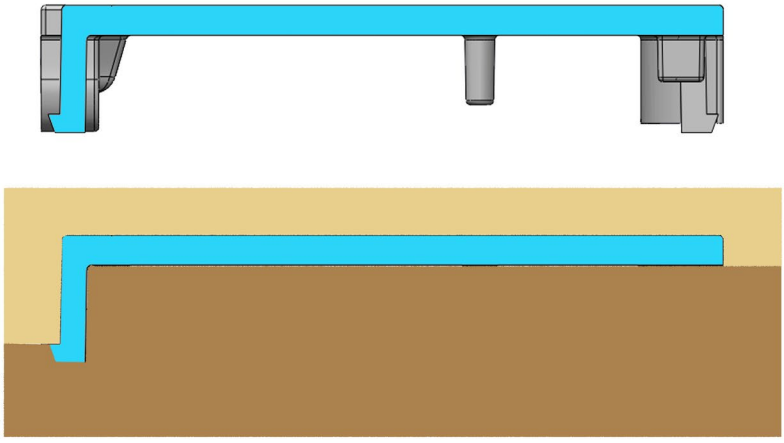


Fig. 6.39: Process of the top shell.

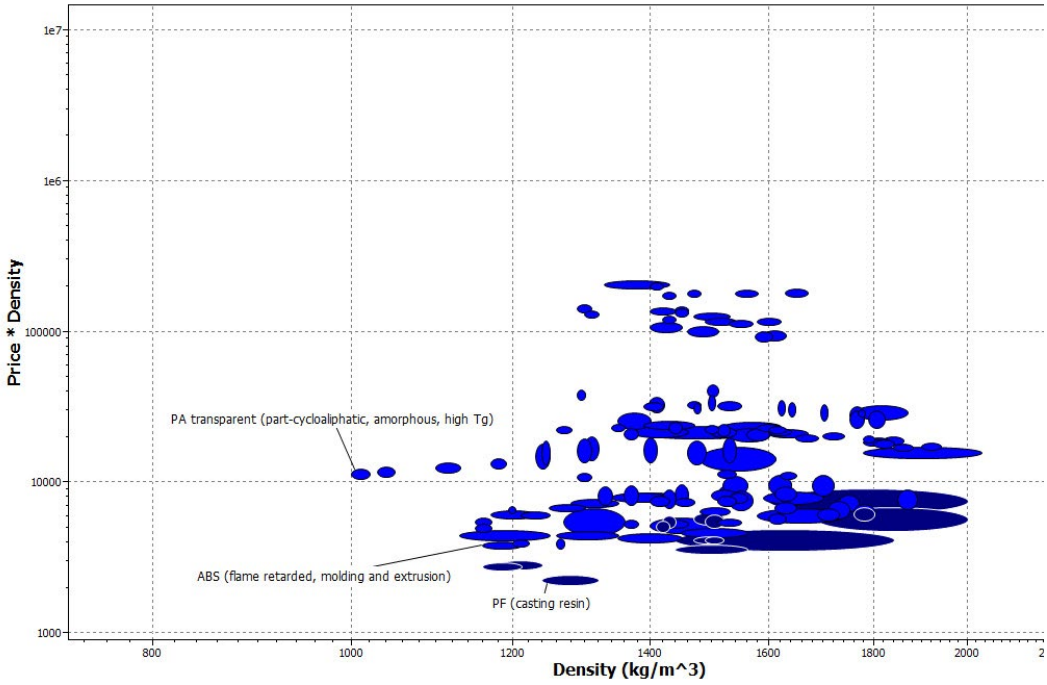
Material Selection

Constrains

1. Should be plastic
2. Can be manufactured by injection molding
3. Maximum service temperature > 50 °C (considering the high temperature of some places in extreme weather)
4. Minimum service temperature < - 20 °C (the same reason of the previous constrain)
6. Enough stiffness, toughness and hardness

Objective

1. Minimum cost
2. Minimum weight



According to the graph, the best choice can be: ABS (flame retarded, molding and extrusion).

Graph 6.3: Material selection of the top shell.

6.5.4 **Bottom shell**

Process

This part is better to be plastic because of price and density, and it needs to be made with injection molding.

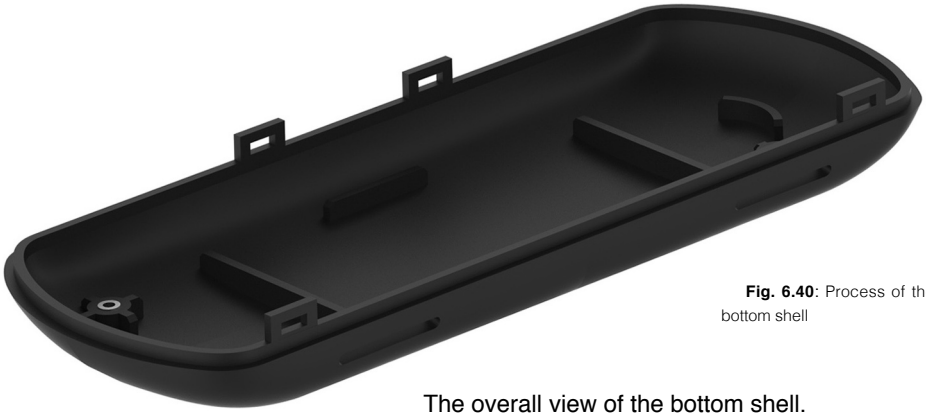
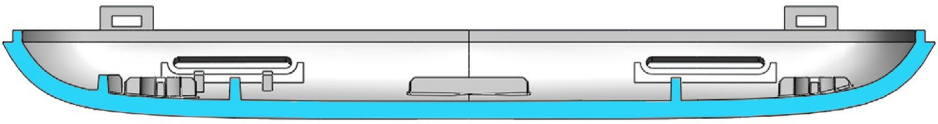


Fig. 6.40: Process of the bottom shell

The overall view of the bottom shell.



A section view of the bottom shell and its mold.

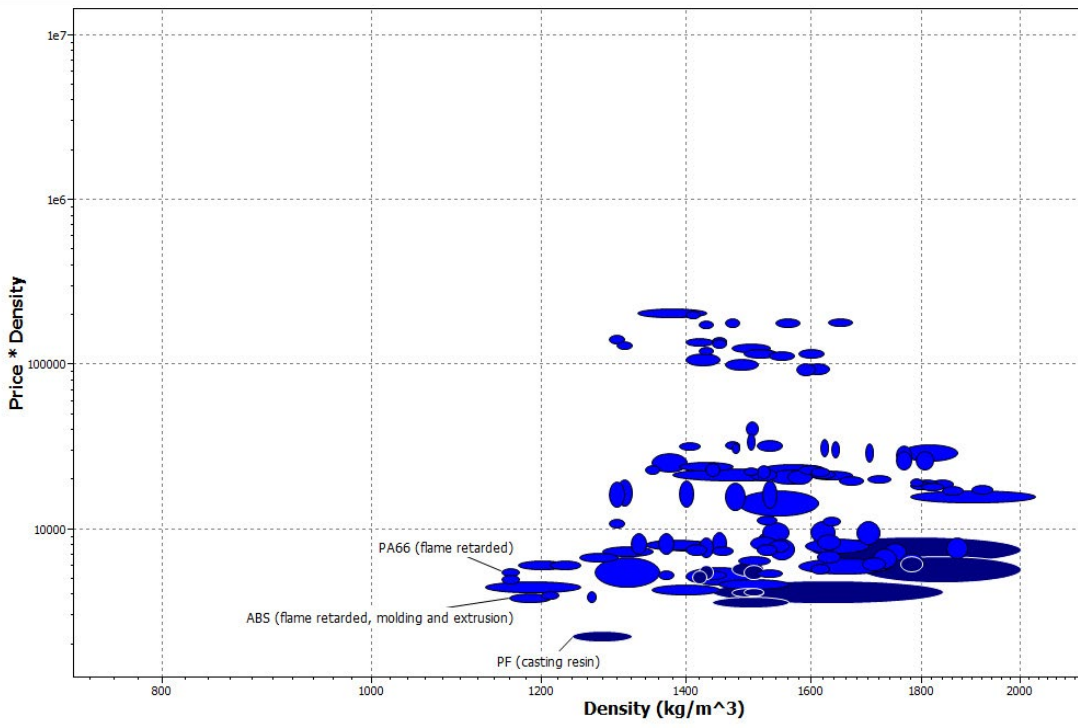
Material Selection

Constrains

1. Should be plastic
2. Can be manufactured by injection molding
3. Maximum service temperature > 50 °C (considering the high temperature of some places in extreme weather)
4. Minimum service temperature < - 20 °C (the same reason of the previous constrain)
6. Enough stiffness, toughness and hardness
7. Good surface finishing.

Objective

1. Minimum cost
2. Minimum weight



According to the graph, the best choice can be: ABS (flame retarded, molding and extrusion).

Graph 6.4: Material selection of the bottom shell.

7
PROTOTYPING

7. Prototyping

It is a simulation prototype only for a test of interaction. It is not a working prototype.

7.1 Arduino prototyping

Objective

Making the electronic part of a demonstrate prototype which can simulate the main part of the interaction.

Plan

One arduino board (sender) will communicate with another arduino board (receiver). The receiver plays a voice message (pre-recorded) out. The user interacts with the lockets of necklace, so the locket's opening and closing will trigger the commands.

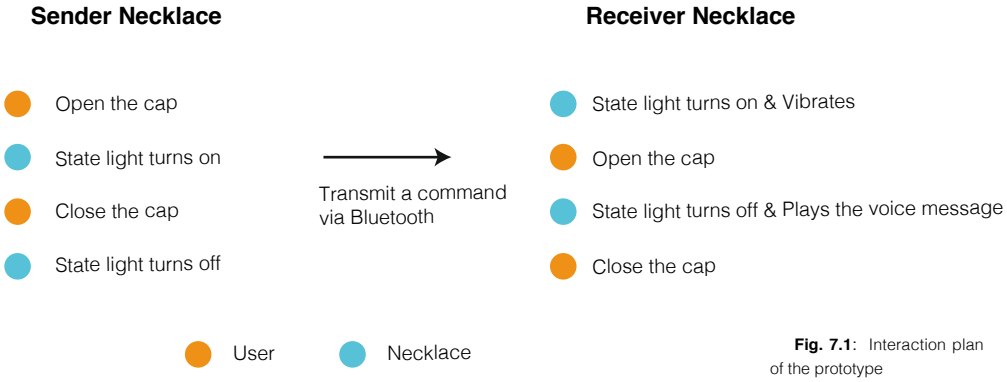


Fig. 7.1: Interaction plan of the prototype

Material

Arduino Uno x 2

Serial Blue Tooth Module x 2

MP3 Player Module x 1

Amplifier x 1

Speaker x 1

Led x 2

Hall Effective Sensor (to detect if the cap of the locket is open or closed) x 2

Vibration Motor x 1

Magnets x 6 (work with the hall effective sensor and let the lockets close)

Iron Piece x 6 (work with magnets for closing the lockets)

Schematics

Sender Necklace

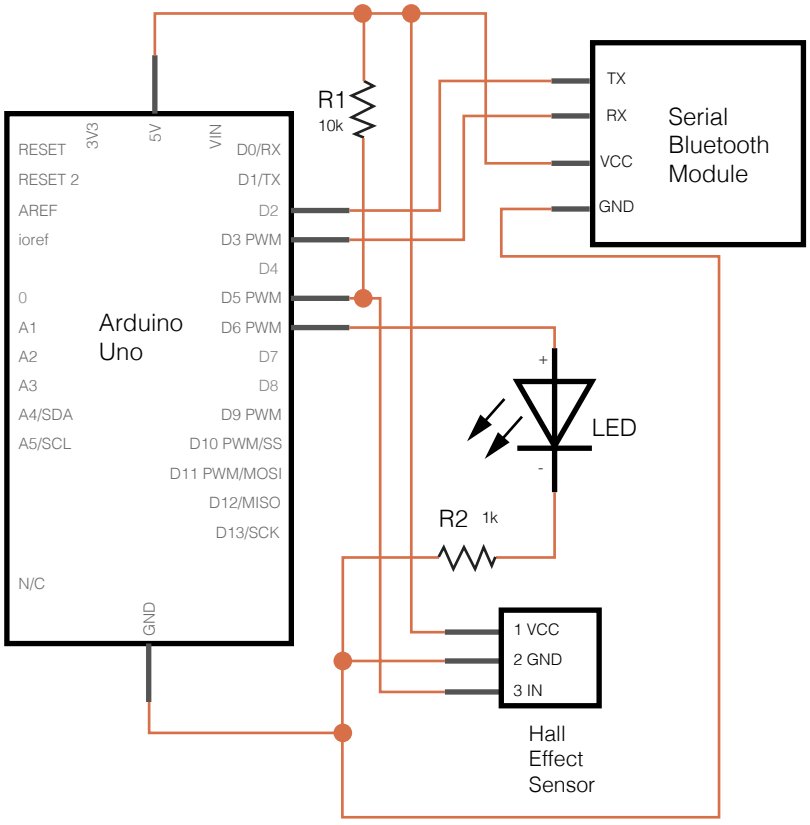


Fig. 7.2: Schematic of the sender necklace.

Receiver Necklace

Main Circuit

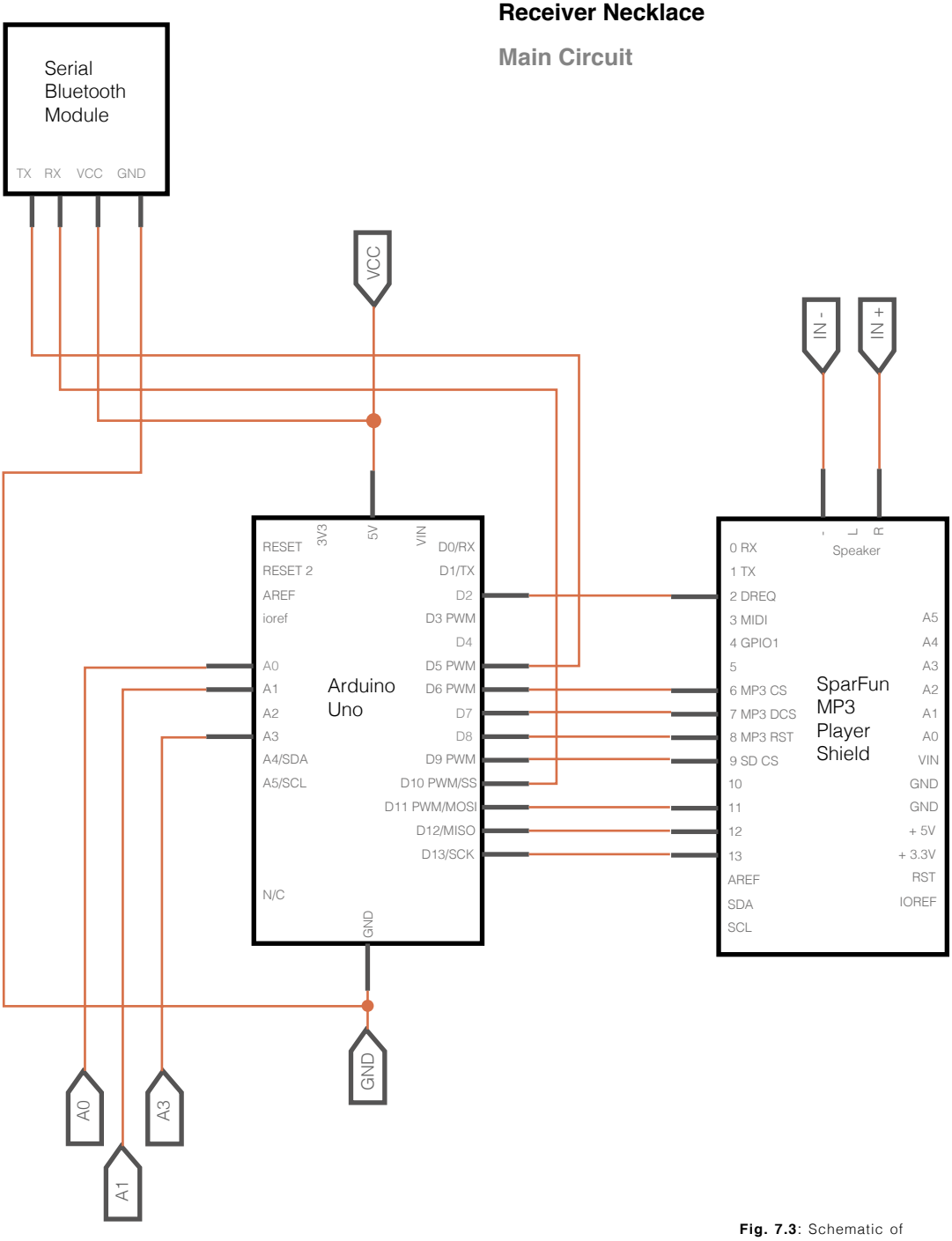
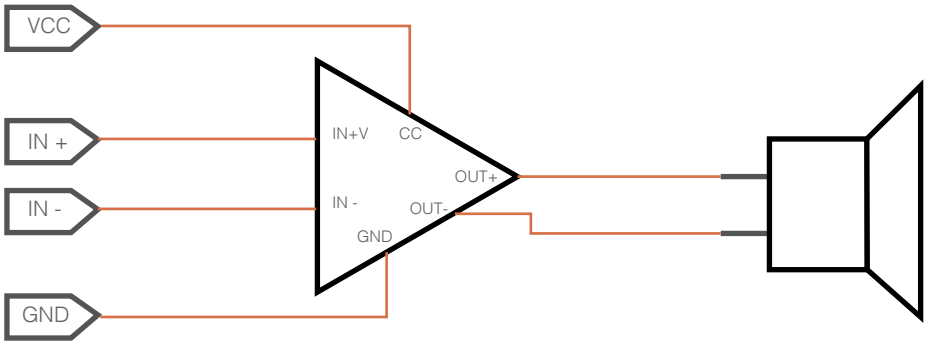


Fig. 7.3: Schematic of the main part of the receiver necklace.

Fig. 7.4: Schematics. Upside: Schematic of the speaker circuit of the receiver necklace; Downside: Schematic of the Hall Effect and feedback circuit of the receiver necklace.

Speaker Circuit



Hall Effect and Feedback Circuit

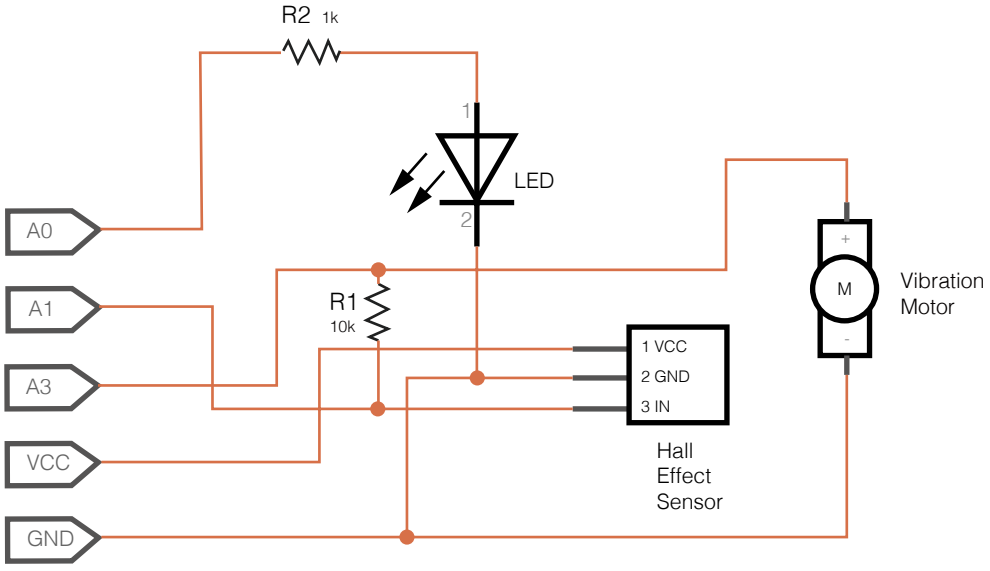


Fig. 7.5: The codes of the sender necklace.

Codes

The codes of the sender necklace includes the codes for setting up the bluetooth, the codes of sending command via bluetooth and that of controlling a LED.

For setting up the Bluetooth, Setup part.

```
void setup()
{
  Serial.begin(9600);  // Begin the serial monitor at 9600bps

  bluetooth.begin(115200);  // The Bluetooth Mate defaults to 115200b
  bluetooth.print("$");  // Print three times individually
  bluetooth.print("$");
  bluetooth.print("$");  // Enter command mode
  delay(100);  // Short delay, wait for the Mate to send back CMD
  bluetooth.println("U,9600,N");  // Temporarily Change the baudrate
  // 115200 can be too fast at times for NewSoftSerial to relay the d
  bluetooth.begin(9600);  // Start bluetooth serial at 9600
```

For setting up the Bluetooth. Loop part.

```
void loop()
{
  if(bluetooth.available())  // If the bluetooth sent any characters
  {
    // Send any characters the bluetooth prints to the serial monitor
    Serial.print((char)bluetooth.read());
  }
  if(Serial.available())  // If stuff was typed in the serial monitor
  {
    bluetooth.print((char)Serial.read());
  }
```

For controlling the LED.

```
value = digitalRead (hall);
if (value == LOW)
{
  digitalWrite(led, LOW);
}
else{
  digitalWrite(led,HIGH);
}
```

For sending command to the receiver necklace.

```
if(bouncer.update() == true && bouncer.read() == LOW)
{
bluetooth.println("1");
}
```

Fig. 7.6: Codes of receiver necklace.

The codes of the receiver necklace includes: the codes for setting up the bluetooth (same of the sender necklace); the codes for controlling a LED and a vibration motor; the codes for controlling the music player shield.

Partial codes of set up part.

```
#include <SPI.h>            // SPI library
#include <SdFat.h>          // SDFat Library
#include <SdFatUtil.h>      // SDFat Util Library
#include <SFEMP3Shield.h>   // Mp3 Shield Library

SdFat sd; // Create object to handle SD functions

SFEMP3Shield MP3player;
const uint8_t volume = 0;
const uint16_t monoMode = 1;

int stopPin = A5;
int triggerPin = A1;
char val= 0;
int led = A0;
int motor = A3;
```

Partial codes of controlling music player.

```
  //music
    if (digitalRead(triggerPin) == HIGH)
    {
      uint8_t result = MP3player.playTrack(2);
    }

  if (digitalRead(stopPin) == LOW)
  {
    if (MP3player.isPlaying())
      MP3player.stopTrack();
  }
}

void initSD()
{
  //Initialize the SdCard.
  if(!sd.begin(SD_SEL, SPI_HALF_SPEED))
    sd.initErrorHalt();
  if(!sd.chdir("/"))
    sd.errorHalt("sd.chdir");
}

void initMP3Player()
{
  uint8_t result = MP3player.begin(); // init the mp3 player shield
```

First arduino prototype

The first prototype is assembled with a breadboard. Later I changed the MP3 Player Module to a MP3 Player shield so I can decrease jumpers and make everything better organized.

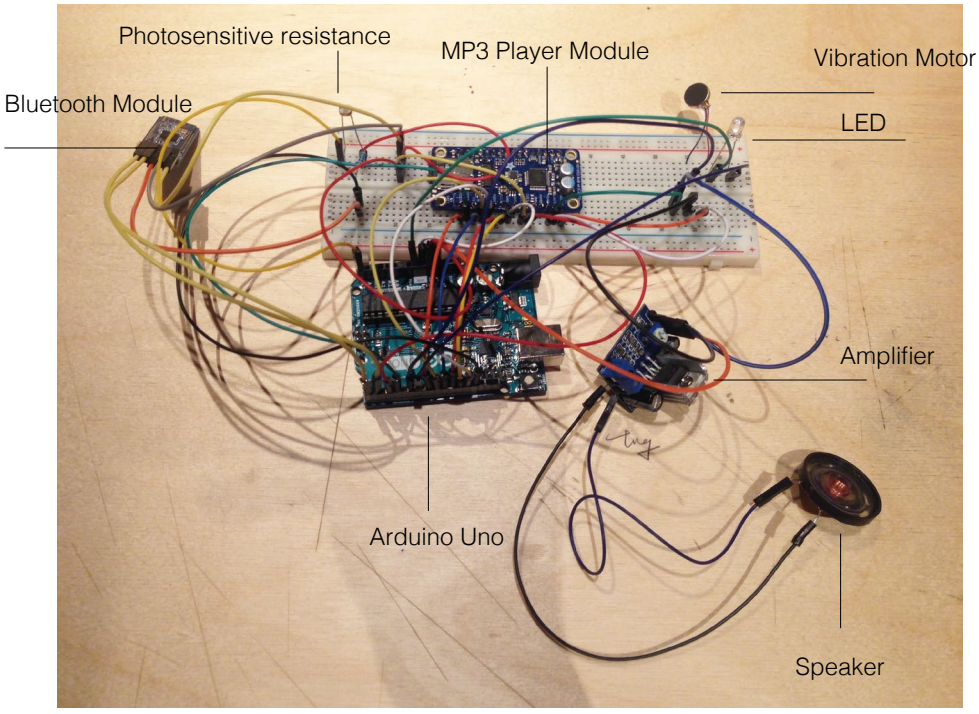


Fig. 7.7: First prototype.

PCB cut with a CNC machine

In order to organise the components, that have direct interaction with user, into a interactive model, I used CNC machine to make a rapid PCB.

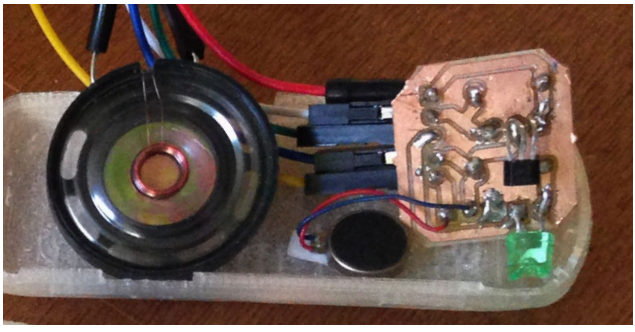
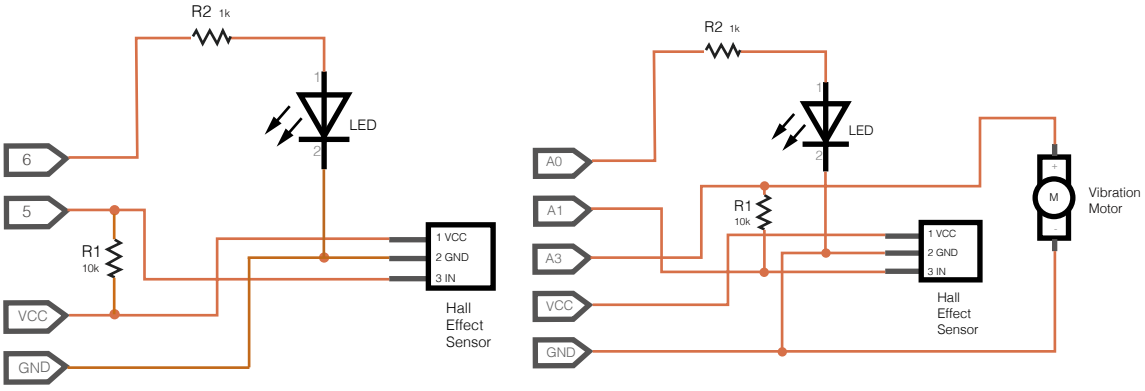


Fig. 7.8: Interaction components embeded in a PCB which is made by CNC machine.

Circuit on PCB

The circuits are of the components that have direct interaction with people. The circuits are already mentioned above.



Interaction part of sender necklace.

Interaction part of receiver necklace.

Fig. 7.9: Circuit on PCB

The programme called KiCad is used to design the PCB

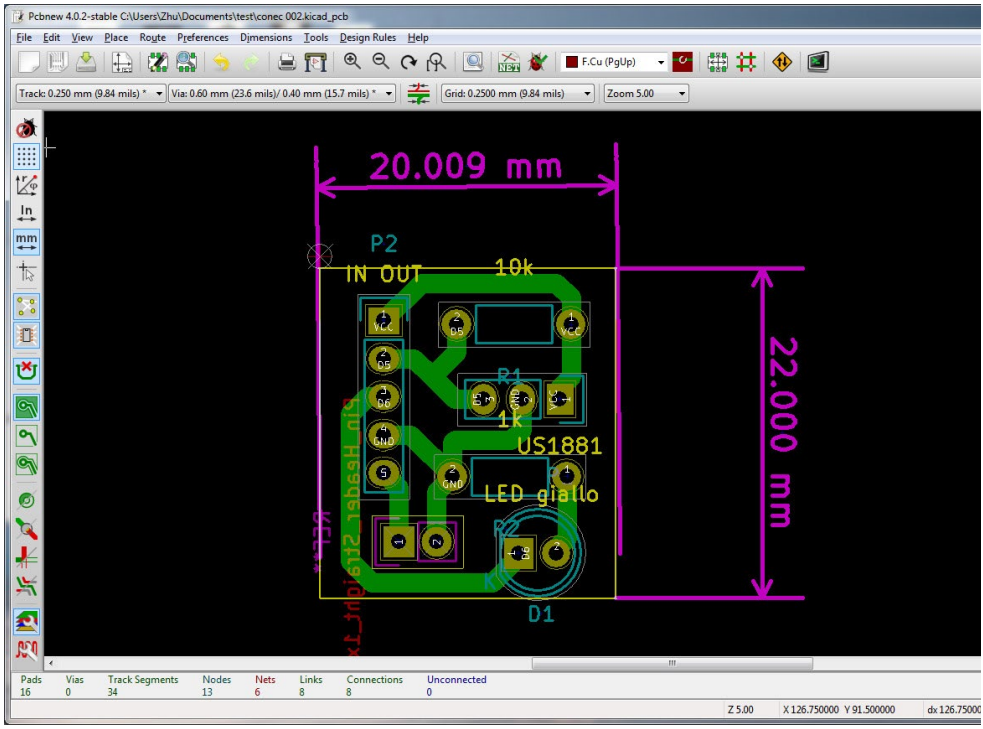
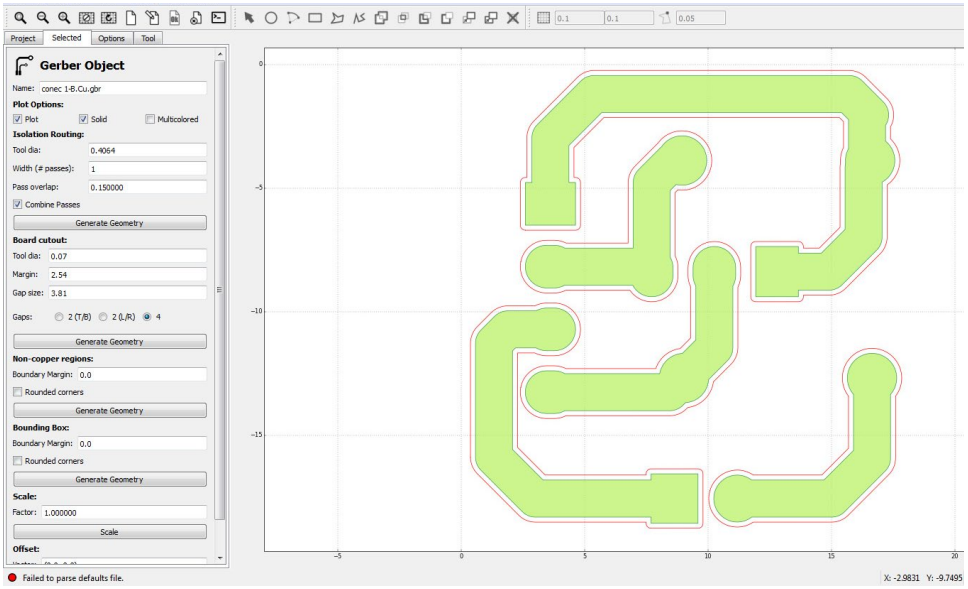
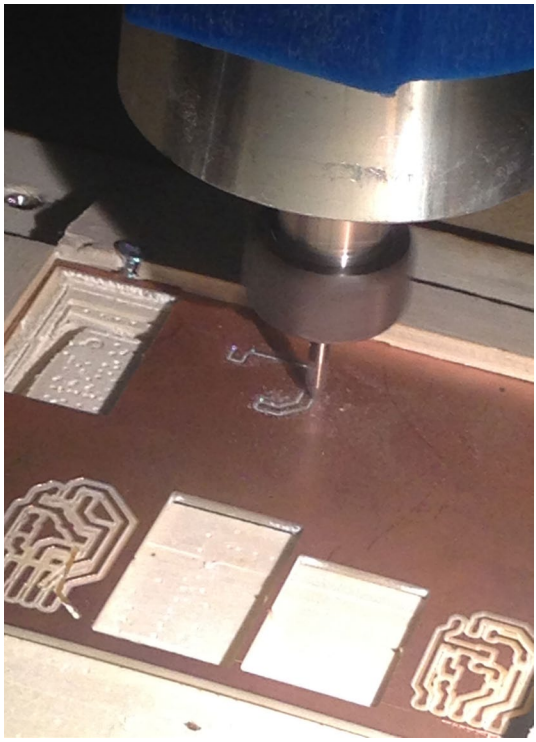


Fig. 7.10: Inferface of KiCad.

Fig. 7.11: Interface of FlatCAM.

A program called FlatCAM is used to transform circuit design into Gcode to let CNC machine make a PCB.





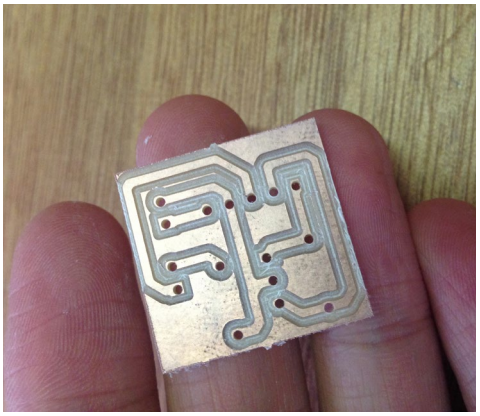


Fig. 7.12: The rapid PCB cut by CNC machine.

Second arduino prototype

The second prototype used a Sparkfun Music Player Shield, a Sparkfun Amplifier and a Sparkfun Bluetooth Modem, so everything works better. The interaction components are embedded in the PCB and be assembled in the 3D printed shell of the prototype.

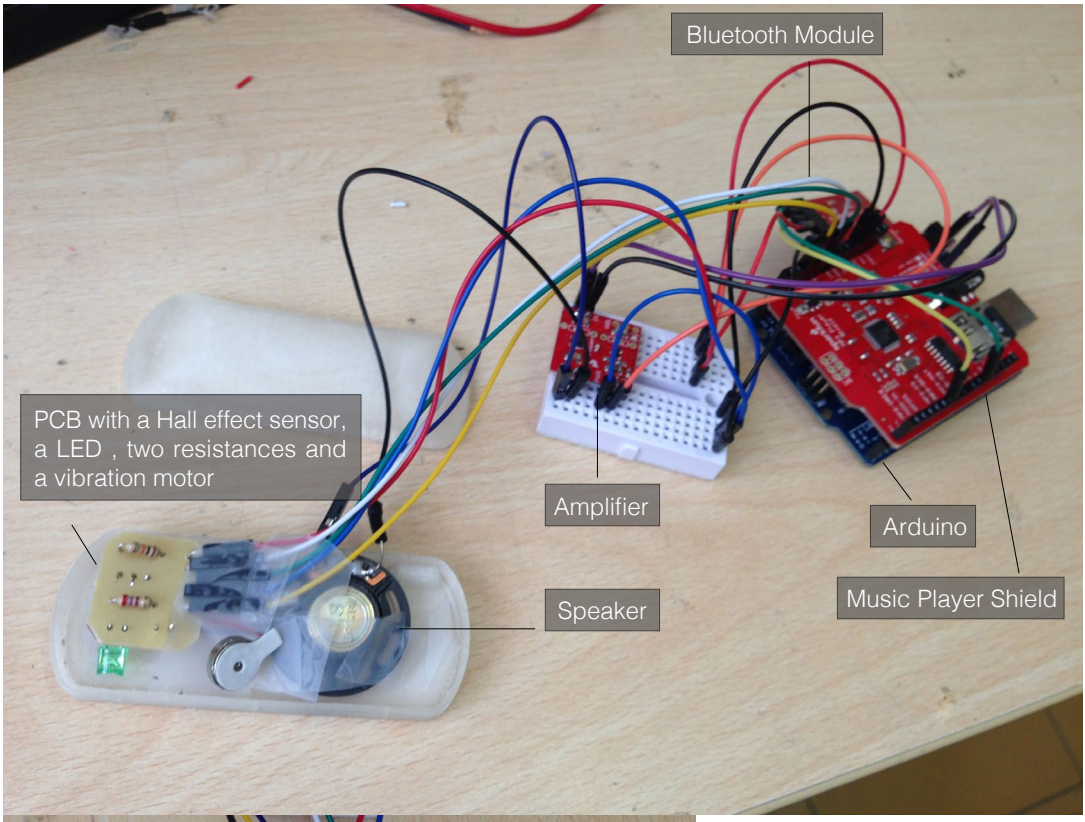
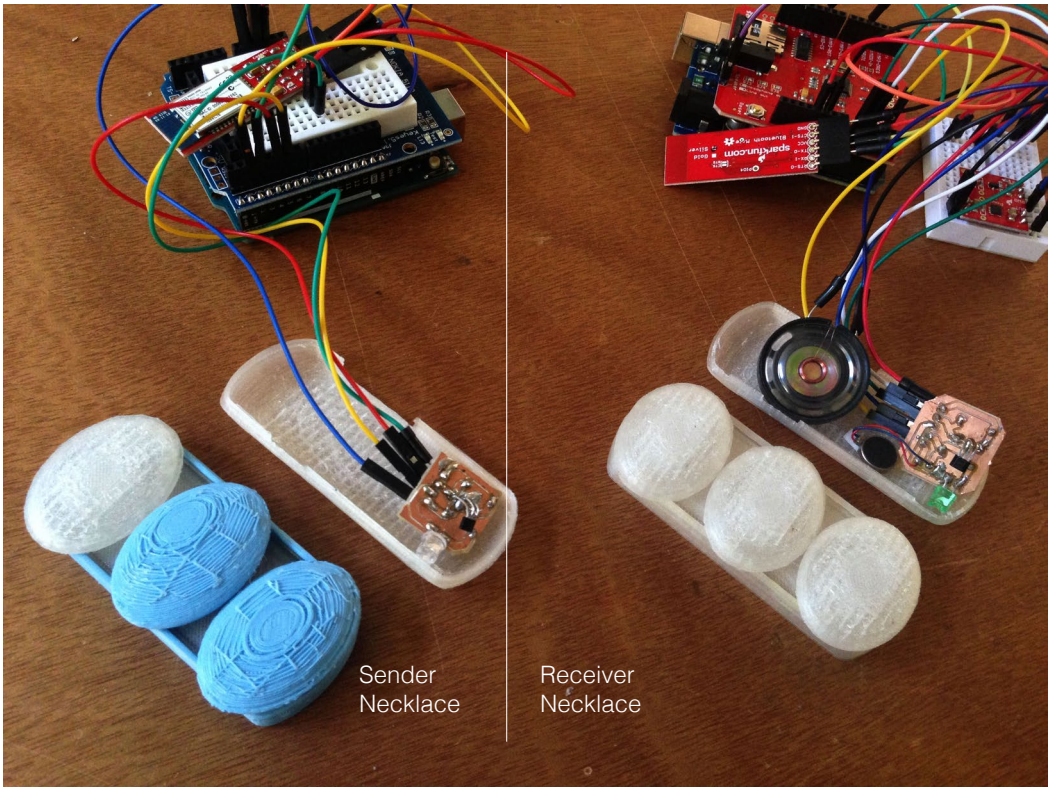


Fig. 7.13: Prototype of the receiver necklace.

Fig. 7.14: The second prototype of both sender and receiver necklace.



7.2 Final simulation prototype

Fig. 7.15: The parts made by 3d printing. Left: before surface treatment; Right: After surface treatment.

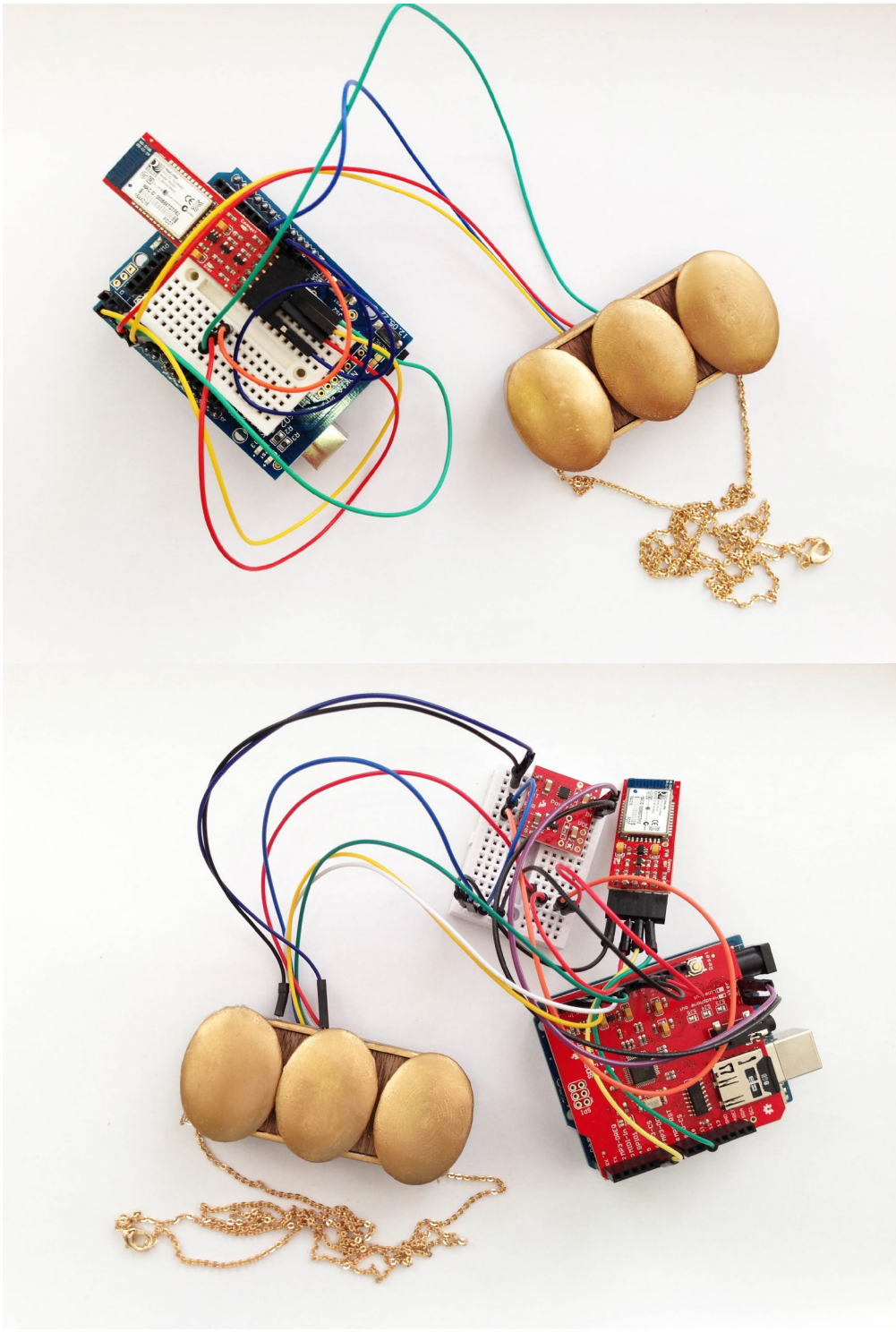


Fig. 7.16: The final simulation prototypes. Upside: Sender necklace; Downside: Receiver necklace.

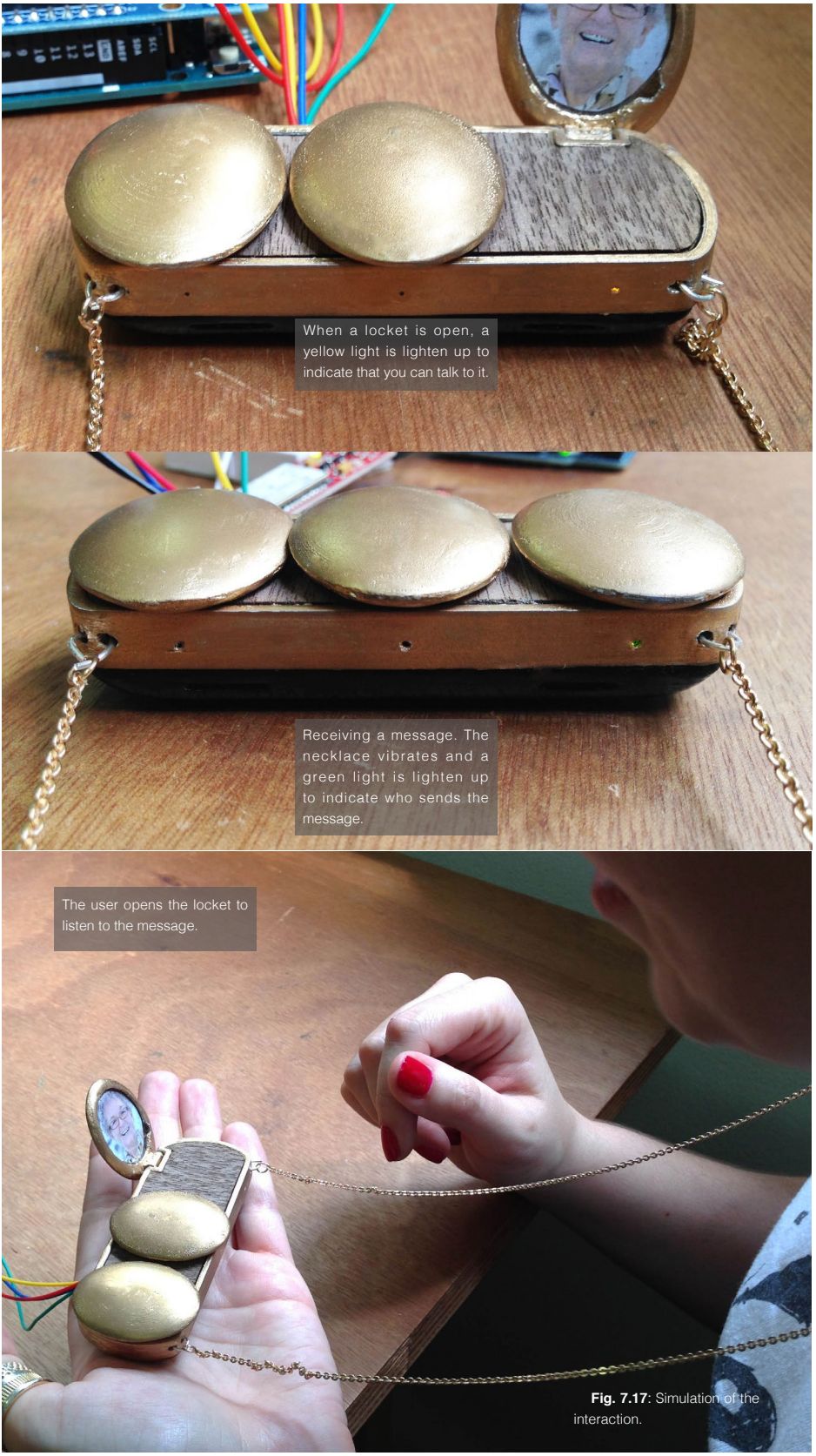


Fig. 7.17: Simulation of the interaction.

Fig. 7.18: Different wood surfaces

Fig. 7.19: A non-functional model to show the appearance of the product.

Fig. 7.20: Wearing the CONEC

8

FEEDBACK & CONCLUSION

8. Feedback & Conclusion

8.1 User feedback

This feedback is for knowing what do the target users or potential customers think about this product and what do they think can be improved. To get the feedback, I delivered questionaries and present my work to 6 women of around 65 years old. The results are shown as follows:

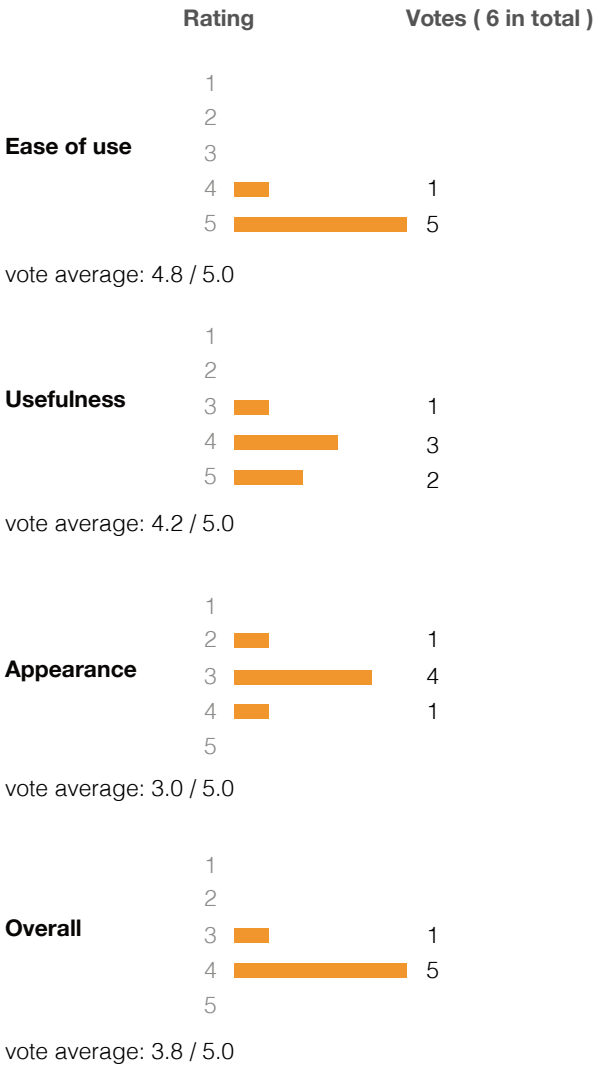


Table. 8.1: User feedback results.

From the results we can see that most people are content with its meaning and its interaction. The drawbacks of the design are mainly about the appearance and the size.

They also gave suggestions at the end of each interview. They suggested that the

appearance should be improved. Most of the participants don't like the appearance. Some think it looks too old style, some think it looks like a technical device. Then they think the size should be decreased. And it is better to have more notification feedbacks like buzz other than light and vibration. Because they think sometimes perhaps they don't feel the vibration or don't see the lights.

In the purchase intention inquiry, one participant votes on the option of "not at all". Her reason for this is that she is very familiar with technology so she believes she will always use the normal smartphone (she is 64 years old). It is true that in the future less and less elderly will be unfamiliar with technology, but there will always be some elderly people who have difficulty to use smart phones. And people suffer form function decline while getting old. In this case, even if they know technology very well, they may still have difficulties.

Some participants also think the setting up is confusing because they got used to set up contacts with telephone numbers, so that they need instructions to know that they can put a RFID tag on the back of their photo and save the telephone number into the photo.

Some participants also mentioned about the limitation of contacts. Although if there were more contacts, it would fit the need of more people. But the space is very limited, because more lockets will make the necklace very big. Therefore this device is designed for an easy contact with close friends and relatives, and it cannot replace the mobile phone.

8.2 **Summary of thesis**

This thesis aims to design a ICT(Information and Communication Technology) product that helps improve the social life of the elderly. It describes the current status of ICT design for the elderly. Key topics include their characteristics, interaction design, principles and main weaknesses. A better understanding of these systems allows for a more intuitive and acceptable interface design and could be achieved by using TUI (Tangible User Interface) design methods. Then a user survey is performed to deeply understand the real social practices of the elderly. Several

concepts are generated by using the method of ViP(Vision in Product). Then the thesis describes the current state of interaction gesture design and wearable device design (both researches and products). The final design turned out to be a smart necklace that can transmit voice messages to the address that is written in the RFID tag, which is attached on the back of the photo of the contact person, presented on the locket. The behavior of exchanging contact information (telephone number) is also simplified to become the behavoir of exchanging photos by using RFID tags.

Improving social life of the elderly

This design improves social life of the elderly by helping them contact with each other easier, so that they can communicate more frequently. The design also simplified the method of exchanging contact information to encourage them to make new friends with neighbors (and other people).

Activating the core circle of friends

"The point of improving social life is not to extend the number of people we're connected to, but to winnow them".[50] It is very true especially for the elderly. This design let the user select three important people, then contact them and have activities with them more easily and frequently.

Hiding technology inside a non-technological object

This design hides the information and communication technology and its interaction inside a necklace-like object and a necklace-like interaction. In this way, the users need the lowest effect to accept it and to use it.

New interaction design of ICT product

Instead of using regular method (button, keyboard, mouse, touchpad, etc.) to input commands, this design used a tangible interaction gesture, opening and closing, to record and send voice to the receiver. Furthermore, instead of exchange telephone number to set up contacts, it using exchange photos to accomplish that.

New meaning of smart accessary

The current smart accessaries encourage people to exercise (Jawbone, Fitbit, etc.) or help people get noticed by messages and e-mails (smart watches). This design helps the elderly communicate with each other directly and easily, and that leads them to a better social life and a higher life quality.

8.3 **Future activities**

The potential value of wearable communication device is great. Human want to be connected to core friends and relatives closely and a wearable accessory is suitable for that application. With the development of technology, the smart necklace can be made much smaller, so that the appearance can be improved a lot to be more social acceptable. The other possible improvements includes: using a touchscreen together to have more contacts within only one locket; using modular design to make it customizable (appearance and so on) ; The setting up method also need to be more intuitive for the user.

8.4 **Acknowledgements**

First of all, I would like to thank my supervisor Professor Monica Bordegoni. In the period of thesis, she has given me a lot of good advices and great help. I did not try to develop a product with complicated technology before the thesis, so I proposed many concepts that I am actually not capable to develop at all. She pointed out my mistakes and led me to the right direction.

Then I would like to thank my assistant supervisor Serena Camere. In the period of user survey and concept generation, she taught me the methods of Contexmapping and Vision in Product Design, and she helped me a lot until I came up with a right concept.

Furthermore, I would like to thank the fablab Wemake, I will never make the demonstrate prototype without their help. I asked the engineers for code debugging and rapid PCB making. And the equipments there are also helpful for the prototype.

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