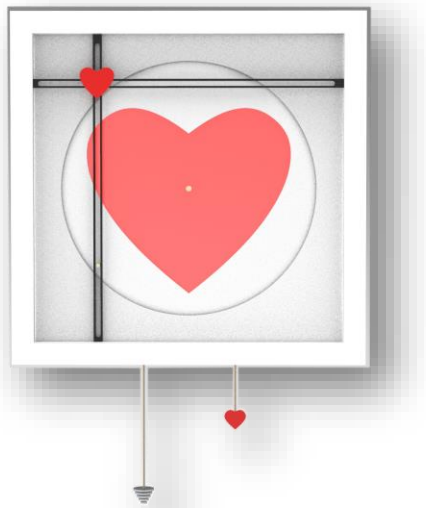

# Heart Palette

A novel way to connect empty-nest seniors and their loved ones in the distance

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# Acknowledgement

This graduation thesis introduces the outcome of my semester-long senior project. It not only showcases the effort that have been dedicated in this last semester of my undergraduate study, but also represents the zenith of my growth at the Rensselaer Polytechnic Institute Design Innovation and Society program over the last four years. As an interdisciplinary student major in design as well as mechanical engineering, I have applied my knowledge and skills in both design and engineering field to my best in this interdisciplinary project, hoping to make our world a better place step by step.

As this design research project is coming to an end, I would like to thank the following people. Without their input and support, this thesis would have been far less rich and complete.

First and foremost, I am extremely grateful to my supervisor Professor Raquel Velho for her encouragement, which made me to invoke my identity as a designer as well as engineer in this project bravely. I have met several obstacles in my past experiences trying to challenge the boundary between disciplines. Without her support, I would have not pursued this track on this project. Throughout the process, she also guided me to keep a good balance between the two disciplines so that the final product came out as an integrated artifact.

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# Table of Content

# List of Figures and Tables

# I. Introduction

As we are stepping into a brand new decade, the last group of baby boomers is also starting to join the demographic that is widely considered as senior citizens. Since the beginning of this century, society has seen a continuous growth in senior citizen population, and with the average life span of human being are constantly increasing, we can expect a more substantial senior population in the near future.

The health and living quality of senior citizens has long become a popular topic in today's society. Many researches and designs have been done to provide a better life for older adults, and resulted in some drastic positive impacts on the way that many of these seniors live. However, most of these improvements are only seen in the physical welfare of the seniors, there are not many products or services that have specifically set their design goals on improving the mental benefits of older adults. Even though the psychological health is just as important as the physical performance in enhancing the living quality of senior citizens, the emotional needs of seniors are often sidelined in the status quo. For independently living seniors in particular, the feeling of loneliness induced degradation in their living quality could be more devastating than a bad physical performance.

In order to fulfill the niche space, this project identified a design opportunity gap on how we can build an emotional, perceptual, and voluntary connection for independently living seniors with their children or grandchildren in the distance through concrete interactions. Utilizing the Integrated New Product Development method (iNPD), a mechanical interactive installation concept was proposed as the respond to the design opportunity gap.

This thesis is the accumulation of the outcome of this semester-long design research project, and it consists of four sections. The first section will present literature reviews on the status quo regarding the product and service design for seniors. It facilitated the exploration of the problem space. The second section will introduce the design narrative of this project. It describes the detailed product opportunity gap, social responsibility of the project, and the proposed solution. It

functioned as the guidance for ideation. The third section will walk through the design process. It documents the process of concept selection and the making of prototypes. And last but not least, the fourth section will look into the next step for this project to improve in the future.

**Keywords**: senior, empty-nester, psychological experience, interactive installation, kinetic art.

# II. Literature Review

The challenge that accompanies an ageing society is much more than how to keep people living longer. It involves many social as well as technological aspects such as living qualities and health care systems across the generations. This section will explore the current actions taken by the society addressing such challenges, and identify the room for improvements on the status quo that eventually lead to the development of this project. This literature review sets the fundamental framework of the project and put together a narrative regarding to improve the psychological benefits of senior citizens through design of products and services.

## 2.1 The Status Quo of Design for Seniors

Niche markets around senior citizens have been developed and expanded quickly in recent years. Believing in adequate strategies can effectively mitigating the negative effects on social and economic system due to the progressive ageing of the society, companies and organizations have rolled out numerous products and services, aiming to respond to the recognized phenomenon (Pericu, 2017).

Debates and discussions around the ageing society can often settle on the idea of improving the living quality of the senior demographic group (Konstantinidis et al., 2014). The concept is often referred as the *active and healthy ageing*, which was introduced by the World Health Organization (WHO) as “the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age” back in 2002 (WHO, 2002). The *active ageing* often involves the active participation in activities that improves the quality of living such as working on interested projects, engaging in social activities, or keeping physical exercises. On the other hand, *healthy ageing* often involves passive methods to maintain the physical performance of seniors through assistance on various levels (Pericu, 2017).

Although it has been more than a decade since the ageing trend among societies have been recognized, and many efforts have been put in to understanding the phenomenon, the outcomes of addressing such problem seem to be not satisfactory: many everyday products and services designed for seniors are still not welcomed among senior populations (Wright, 2004). While this is partially due to the designers in younger generations tend to have “personal perceptions based on negative stereotypes that may prejudice the design” (Wright, 2004), it is more important to recognize that most designs did not met the expectation because they failed to place themselves in the right quadrant on a Product Positioning Map, which is designed to ensure the product could meet the user requirements (Cagan and Vogel, 2002). And problems on two aspects may contribute to the later.

### 2.1.1 Unclear sub-user group:

Design is a process of deconstructing the problem and reconstructs the solution, which often involves oscillation between sub-problems and sub-solutions (Cross, 1997). It is crucial to correctly deconstruct the problem space and tackle each of them accordingly. Unfortunately, this doesn’t seem to happen in the case of current product design for senior citizens.

While there is hardly an “official” standard stating what people are considered as senior citizens, a common practice is to categorize people above the age of 60 or 65 as the whole demographic (Tinker, 2002). But there is more than ages. Just within the senior citizens who are above the age of 65, there are also independently living seniors and dependently living seniors. These more segmented groups share many common similarities, but would also have drastically different needs (Reed et al., 2014). A perfect one-for-all universal solution simply does not exist in this market. To design a user centered product or service for older adults, a clear sub-user group within the general senior citizen population to work with is a must.

### 2.1.2 Lack of a holistic view:

Recall the WHO's *active and healthy ageing* includes two aspects: psychological and physical. However, most existing products for older adults only fulfilled the needs of the later (Yang, 2011). Complicated medical care equipment, wearable assistant devices with unfriendly user interface, and bulky facilitation installations especially designed for elderlies, there are many examples of such designs which only took the physical performance of the user into the consideration, left out or even degraded the subjective emotional experience of its users (McCane, 2008). All products and services that succeeded were rolled out telling the correct story at the appropriate time to the appropriate people. It requires a holistic evaluation that includes the social, economical, and technological point of views to get there (See SET Analysis in later sections). The absence of this holistic view prevented many products and services from success (Cagan and Vogel, 2002). Losing the sight on users' emotional experience in these "unwelcoming" senior products is certainly an example of such failure.

## 2.2 The Value of Psychological Benefits

Compare to psychological experiences, problem space around physical performances are more explicit and often have clearer path that lead to respect technical solutions. As a result, designers tend to consider improving the physical performance with higher priority, which eventually results in the status quo mentioned above. However, contrary to common beliefs, a person's subjective feelings could have heavier impacts on the living quality compare to the physical performance (Ziółkowski et al., 2015). Researches have shown that a high quality successful ageing for senior citizens can be achieved by fulfilling 1) maintaining good health in both physical aspect and mental aspect; 2) active participation in community and society; 3) the feeling of security (Ziółkowski et al., 2015). This indicates that a mere improvement in the physical performance may not necessarily improve the quality of life of older adults. This also explains why those existing products that only focused on improving the physical performance failed to address the problem properly.

Although the wellbeing on psychological aspect does not have as much impact on mortality as the physical aspect, a poor psychological health would potentially induce more serious physical issues. One example would be that the loneliness among independently living seniors could directly result in depressions (Adams et al., 2004). A finding from 1982 suggests “loneliness is distinct from the objective state of being alone or socially isolated” (Peplau & Perlman, 1982). It is found that the absence of small close social networking can cause loneliness easier compare to the absence of large organized social networking because the emotional communication of senior citizens depends more on intimate relationships that are more familiar and have the control over (Adams et al., 2004).

As a result, a significant improvement in senior citizens’ living quality can be only achieved by enhancing the physical performance and psychological experience altogether at the same time. The value of psychological benefits is just as important as the value of physical performance, if not higher.

## 2.3 Emotionally Connecting with Seniors

In order to contextualize the elements that would impact the subjective feeling of senior citizens, we must emotionally connect with them. And there are several ways to do so.

### 2.3.1 Communicate through concrete subjects

Although senior citizens and young children seem to be at the opposite extremes of a spectrum, it is not strange to see the two developing a strong bond. One theory to explains this phenomenon is that the young and the old shares similar mindset that they used to percept everyday things around them (Frego, 1995). The thought of children is in a development process from the concrete contextual information to abstract understandings (Brainerd, 1978), whereas seniors gradually percept the world from a more abstract point of view back to a very practical and specific viewpoint (Labouvie-Vief and Blanchard-Fields, 1982). The attention to the concrete subjects brought the two distinct demographic together. Therefore, in order to bridging the gap with senior populations, a

concrete narrative is more than welcomed.

### 2.3.2 Utilize multisensory interactions

All of human's interactions with outside surroundings are the result of the collaboration between all senses (Schifferstein and Spence, 2008). The more sensory modalities are engaged during the interaction, the richer that experience would be and could last a clearer memory (Spence, 2002). Among all five senses that human features, the vision and touch play the most important roles in providing the users with detailed information regarding the object. Especially in the event of interrupting haptical performance, a substantial amount of the perceptual information would be lost as a result (Schifferstein and Spence, 2008). In conclusion, a rich and immersive interactive experience can have better effects in connecting with the people emotionally.

### 2.3.3 Interact with natural elements

Horticultural therapy has an extensive history of practice in psychological treatments (Seo et al., 2015). Service animals are also known to be very therapeutic (Hudson et al., 2020). People have been connecting personal feelings to the objects and elements naturally exist in surroundings for a very long time. The soft feeling of hugging a fluffy cat and the satisfaction watching drops descending from the top of a waterfall are no stranger to many people. These interactions with the nature can leave the abstract perceptions behind and allow one to merely focus on the concrete interaction (Seo et al. 2015). Even in the case of a robotic pet, the animal liked behavior such as barking and hugging can help to build an emotional bond between the user and the pet (Hudson et al., 2020). The user is able to relate these figures to something that they have a personal connection with. This suggests that an interaction that mimics the behavior of a plant or an animal would be potentially more acceptable to senior users who are more used to the concrete objects.

In conclusion, products and services can closing its gap to the senior users by applying above findings, thus make the product more welcoming to the older adults emotionally.

# III. Design Narrative

As mentioned in previous section, a huge block is currently missing in providing senior citizens products and services that can help enhancing their psychological experiences. In modern days, a huge factor that has negatively affecting the mental health of seniors is the feeling of loneliness among those who lives independently (Adams, 2004). With the globalization of our society, it is not strange to see children and grandchildren living at places from tens of miles to thousands of miles away from their ageing parents or grandparents who have to live independently. To fulfill this niche, this project aims to build an effective emotional connection for independently living older adults with their loved ones who live in the distance.

## 3.1 Product Opportunity Gap

Although the niche around the problem space is clearly defined, it is not enough to design a successful project merely based off of this. In order to ensure the project is answering the demand of its user, a specific product opportunity gap (POG) is clearly defined before the concept generation.

### 3.1.1 Sub-user group

The sub-group within the general senior citizen demographic that has been affected the most by the loneliness is those older adults who still live independently (Adams, 2004). The lack of social, emotional communication, and the feeling of “bereaving” would significantly degrade the quality of living for these seniors.

When children or grandchildren grew up, they often leave the family house to start a new

chapter in their lives. This made the elderlies who “stay behind” an “empty nester”. The term describes those “parents who have raised children and find themselves bereft when the last or only child leaves home” (Piper and Jackson, 2017). For children who is leaving home, it’s the beginning of a new adventure; but for their parents, this means worries, disconnection, and loneliness.

The depression feeling of family members’ departure is most devastating to independently living older adults because compare to their counter parts who live in senior nursing homes or communities with assistants, these independently living seniors have to bear the emotion all by themselves while maintaining regular everyday life at the same time. Needless to say, this sub-group needs more psychological attention comparing to those who lives with an assistant.

### 3.1.2 Opportunity Gap

While there is a great deal of products and services in telecommunication field targeting to connect people in the distance, most of them only achieved the very basic demands. A great number of needs are still unfilled. From the most explicit to the most implicit, these unfilled needs can be classified into different tiers as shown in Figure 1 below:

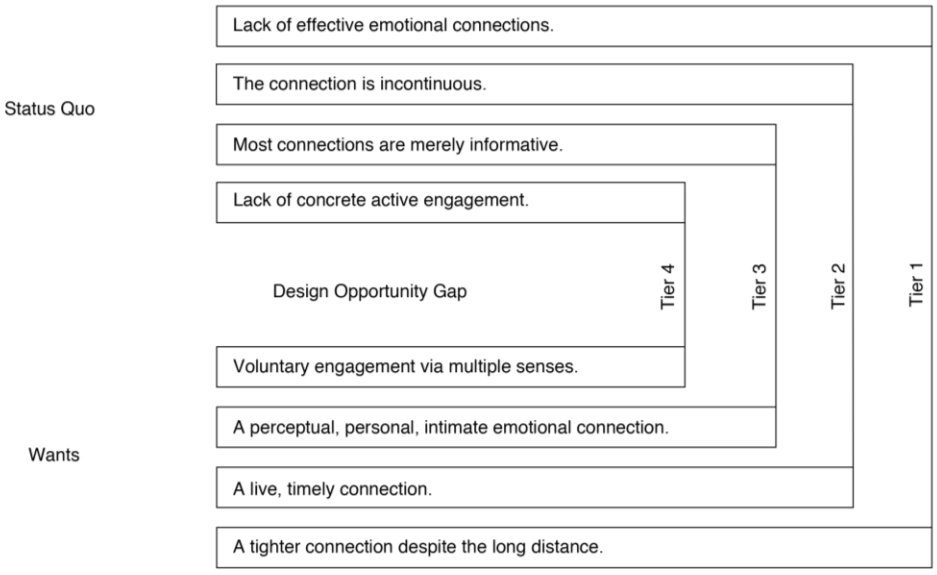



Figure 1 POG map

users.

Existing solutions often requires extensive knowledge in computer or electronic devices in order to operate properly, this excludes senior citizens from the user group. Older adults also have the needs to be emotionally connected with people remotely just like other generations, it is not fair to exclude this demographic from the user group.

Tier 2: connecting through telecommunication applications such as text messages or FaceTime is incontinuous. The emotional exchange only lasts in the duration of the call. As families can be separated in different continents nowadays, time difference added another barrier for effective emotional communication. The essence of fighting loneliness is to create a sense of companion, therefore the continuity of the connection is very crucial. “Empty nesters” need a continuous connection that can last through times.

Tier 3: many existing solutions can only achieve informative connections. The perceptual feeling of human is often conveyed and received by the combination of series of verbal, facial and corporal expressions. Thus, it is very difficult to share feelings through a simple phone call. Not to mention that emotional feelings are not something that every individual would be comfortable to express explicitly, especially for many seniors.

Tier 4: current solutions lack of a concrete engagement for seniors to express and exchange their feelings with their loved ones. As introduced in previous section, older adults percept surroundings and objects in a very concrete logic, abstract interactions would not make sense to many seniors (Labouvie-Vief and Blanchard-Fields, 1982). In contrast, some concrete behaviors such as interacting with a small gadget would be more welcoming to these older adults comparing to existing solutions.

By examining the status quo within the context, the product opportunity gap became clearer between the status quo and user needs. To conclude, the POG can be described as “how can we help independently living seniors to build an emotional, perceptual, and voluntary connection with their children and grandchildren in the distance through concrete interactions that lasts through times?”

### 3.1.3 SET Analysis

To avoid missing a holistic view like many existing solutions did, Social Economic Technology Analysis (SET Analysis) is used in the development of this product as shown blow in Figure 2. SET analysis is an important component in the Integrated New Product Development Method (iNPD). It helps to oversee the bigger picture from a holistic point of view which includes social study aspect, economic aspect, and technology aspect, and identify the correct quadrant for the product on the Product Positioning Map (Cagan and Vogel, 2002).

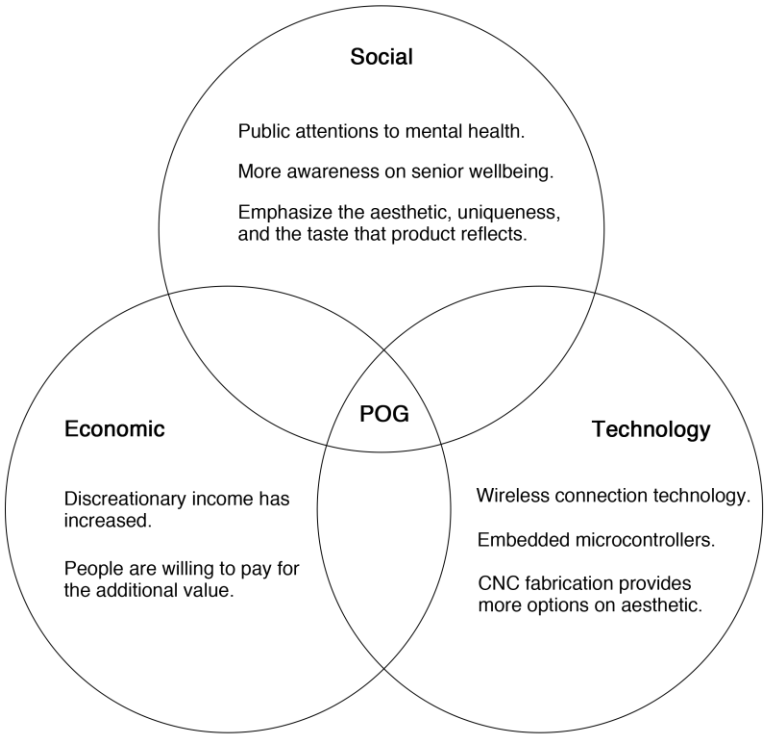



Figure 2 SET analysis

From the social study point of view, people started to pay more attention to the mental health nowadays. The general public is also more aware on the welfare of senior citizens. When purchasing and using products that serve users' mental wellbeing, people often emphasize on its uniqueness, quality, and the taste that product reflects.

From the economic point of view, the discretionary income has exponentially increased among

middle and upper class in the past decade. The majorities are willing to pay for the additional value of a product. As a result, it is acceptable to focus more on enhancing the value of the product other than restrain the concept within the manufacturing cost limit.

From the technology point of view, wireless interconnection technology has being applied widely in various industries. Microcontrollers like Arduino and Raspberry Pi have also became more mature, providing much more functions with a much lower cost. The Computer Numerical Control (CNC) manufacturing allows more possibilities on the shape and form, significantly reduced the cost of fabrication. These improvements in technologies laid the foundation of this project.

Gathering all the insights and contexts, it is determined that this product should target the upper right quadrant on the product positioning map as shown in Figure 3. The modality can be a household interactive art installation that utilizes the microcontroller and wireless transfer technologies.

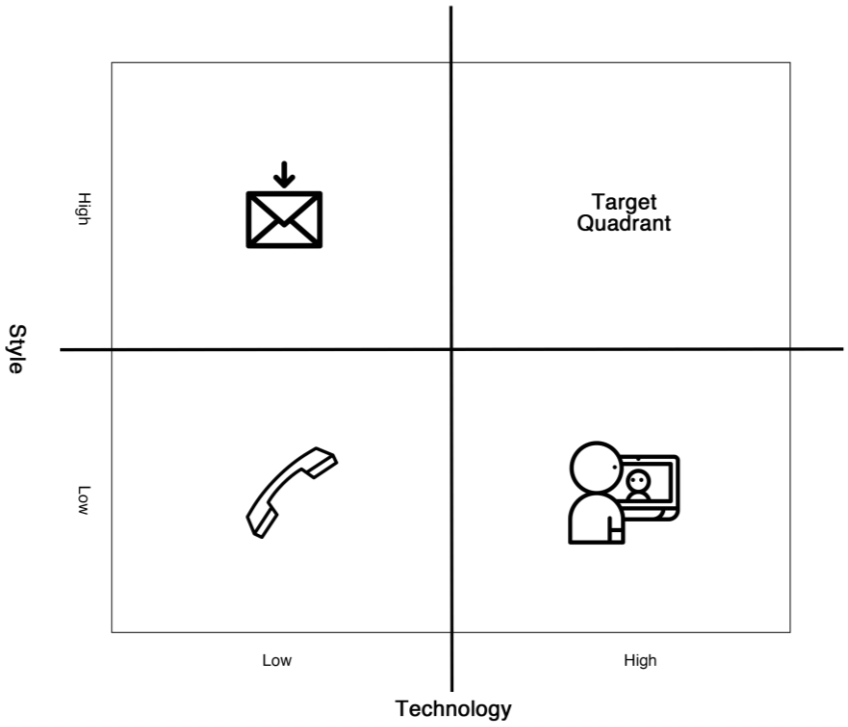



Figure 3 Product positioning map

## 3.2 Social Responsibility

Senior citizens have been considered as a marginalized population for a very long time. As the demographic growing larger and larger, and taking on more portion of the overall human population, the wellbeing of older adults has been gaining much more attentions in the past decade. With the increasing average life span of human being, we can expect a more substantial senior population in the near future. Therefore, raising the living quality of senior citizens by enhancing their psychological experience would have huge social impacts.

On the social aspect, a higher living quality for older adults would result in less intervention required from the society. Picture a scene where all of senior citizens' physical and emotional needs are fulfilled, younger generations would have the freedom to allocate more of their vigors in other works. As a result, less society's resources are needed and both the old and the young can enjoy the happiness without any worries.

On the economic aspect, the investment needed to enhance the psychological experience is relatively smaller compare to the investment in enhancing and maintaining the physical performance. A perfectly designed interactive installation that cost no more than a hundred dollar could potentially prevent a psychological induced physical performance degradation, and the following treatments that could easily cost few thousands dollars.

## 3.3 Proposed Solution

The proposed solution to the product opportunity gap identified above is a mechanical interactive installation as shown on next page in Figure 4. It is named Heart Palette. The Dutch De Stijl aesthetic style made it not only an interactive toy to play with, but also an art piece for decoration. The main structure of the installation is a plane board with frame structure. Two slide bars would move within the structure's frame. The vertical slide bar is driven by a user controlled eccentric wheel, whereas the horizontal one is driven by a motor that maps the input of a paired user in the distance utilizing microcontroller and wireless transfer technologies. At the intersection of the two slide bars, a small heart shape gadget is installed to emphasize the intersection. A heart shape LED light strip is installed on the backboard.

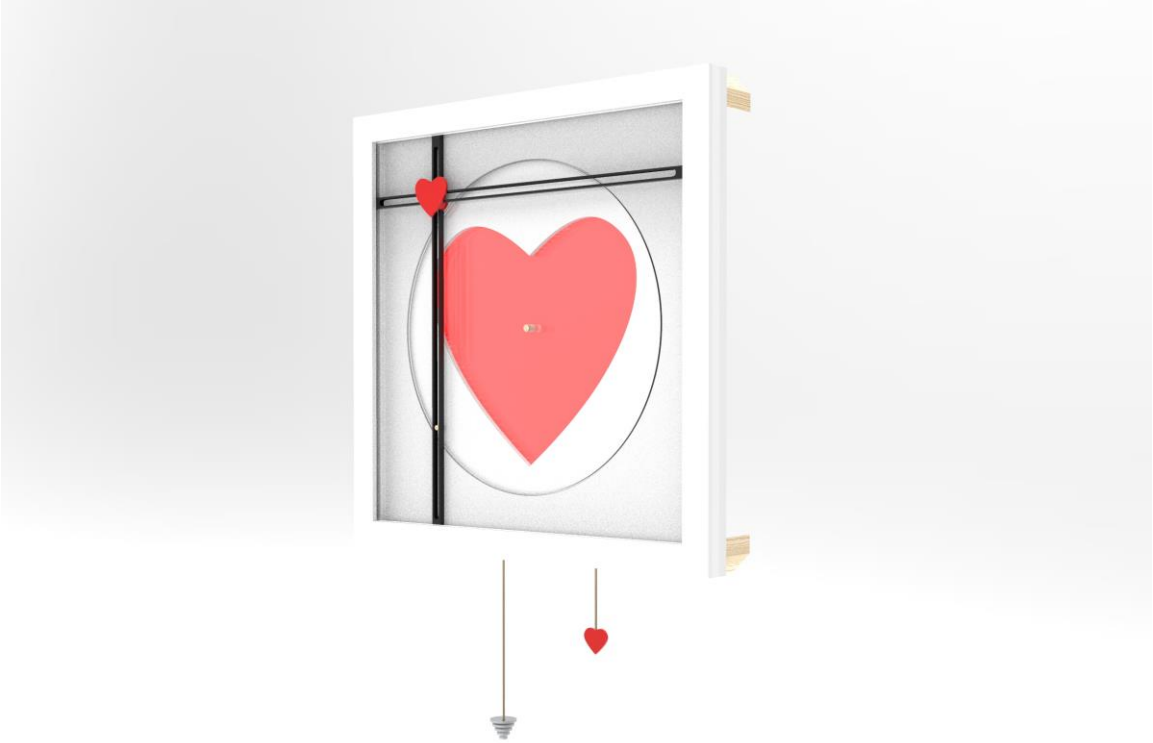


Figure 4 Proposed solution: Heart Palette

Two units of Heart Palette can be paired up through WiFi network remotely. One user would interact with the host unit by pulling the weight pulley underneath the frame, which would move the vertical slide bar to slide from left to right. The other user operates the paired client unit in the distance in the same way, only his/her input would be mapped and output as the movement of horizontal slide bar at the host unit. When the small heart shape gadget at the intersection of two slide bars enters the region surrounded by the LED light strip, the strip would light up the big red heart on the backboard. If the user is not directly engaging the installation, the weight pulley would drag the eccentric while and keep the slide bar to move for a short period of time, and eventually stop at one side of the frame.

The idea behind this installation is that two users in the distance can now cooperate it together. Two participants have to work together in order to get the small heart gadget into the big heart on the backboard that represents the family tie and light up the LED strip around it. If the piece is left unattended, the gadget at the intersection of two slide bars will forever stay at the outside of the big heart. The design requires users to engage with it once in a while and collaborate with their loved ones remotely in a very concrete way, thus making the experience less informative but more

emotional, and create a feeling of companion. The name Heart Palette also suggests similar concept on emotional connection. As is discussed in the literature review and earlier in this section, currently there is no product that is designed specifically with the goal of emotionally connecting older adults and their remote family members. With the introduction of this project, the opportunity gap on the seniors' mental health support is expected to be fulfilled, thus enhance the living quality of senior citizens.

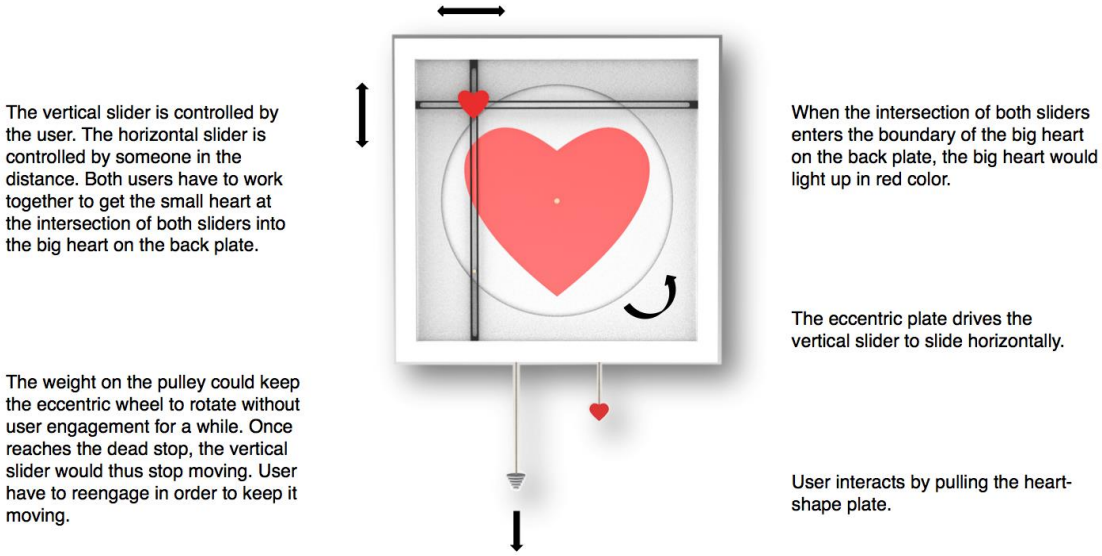



Figure 5 Detail descriptions of Heart Palette

# IV. Design Process

This section documented the development process of the Heart Palette project. It introduces the findings from the preliminary research, the selection of potential concepts, and the making of both the mechanical structure verification prototype and the aesthetic demonstration prototype.

## 4.1 Preliminary Research

The preliminary research looked into a previous work that aimed the same design opportunity gap, evaluated its effectiveness and identified several rooms for improvements. The research also took some time to explore the possible shape and form, as well as the mechanical structure. The outcome of this preliminary research laid the foundation for the later ideation step, it functioned as a more specific guidance for the potential concept generation.

### 4.1.1 Previous work: Pontem

Pontem is a household interactive installation that also aimed to build an emotional connection for independently living seniors with their children or grandchildren who live in the distance. As shown on next page in Figure 6, the main components of Pontem include a planter vase, and a structural support that integrated a neodymium magnetic pendulum, several reed switches, two LED light strip and a microcontrollers inside. Two units of Pontem are paired through WiFi network remotely, when one of the users switch the neodymium magnetic pendulum to a spot above a specific reed switch on the host unit, the LED light strip on the paired client unit would light up in the corresponding color. The other user can change the color of the light strip on the host unit from the client unit in the same way as well. Five reed switches correspond to five different colors, which

represent five different feelings. Users can express their mood to their loved one in the distance by switching the magnetic pendulum to a respective spot.


Figure 6 Pontem

fulfilled the unmet needs of its target user group: the lasting ambient light created a sense of companion, and the emotional connection was built by exchanging feelings through the changing light color. However, user feedbacks also pointed out that using ambient light with different colors is still very informative and requires an abstract logical thinking in order to really match the feeling with the select color.

As introduced in literature review section, product designed for seniors should not require abstract thinking and interpretation. But the dilemma here is that mood itself is a very abstract concept. A group of researchers from Delft University of Technology stated that “Mood is literally a gut-feeling. One reason why it is difficult to describe moods is that they come with a variety of manifestations.” (Desmet et al., 2019) As a result, the new product described in this thesis decided to build off from the concept of Pontem: using the similar communication structure, but instead of building the emotional connection by allowing users to exchange feelings, let users to physically interact and collaborate with each other by stimulating their senses. This tenet also reflects the theory of “more senses results in richer experience” introduced in literature review section.

### 4.1.2 Possible Shapes and Forms

Per described in literature review section, it is found that natural objects and movements are more acceptable for elderlies. To explore possible aesthetic form for the project, a mood board about natural elements theme in Figure 7 below is created to facilitate the brainstorming.

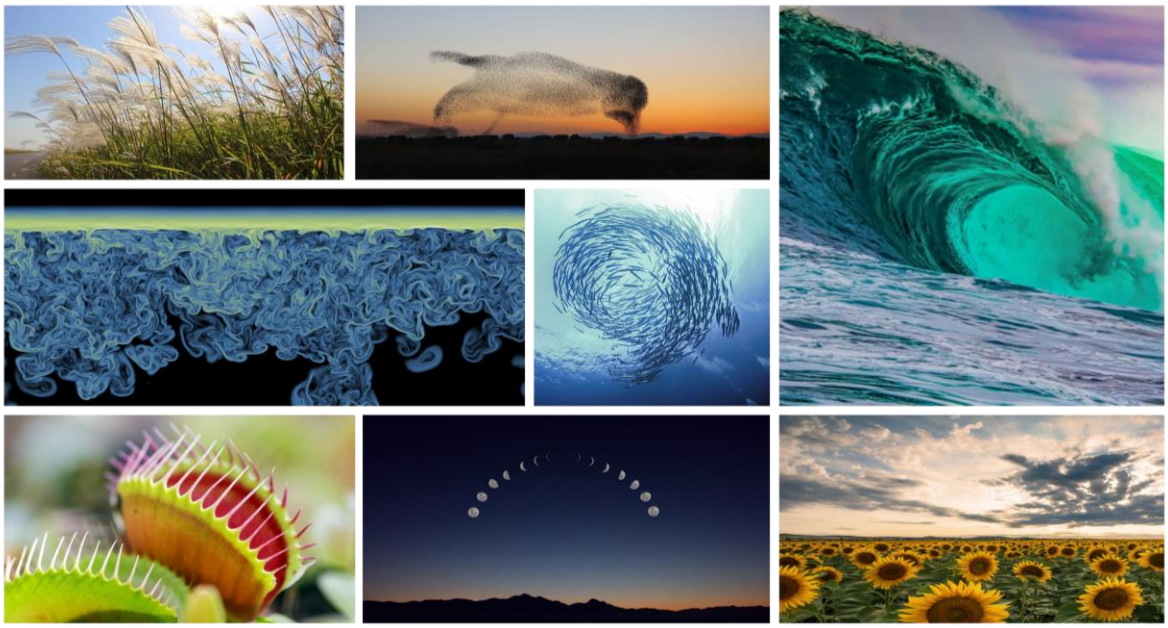


Figure 7 Moodboard of possible shapes and forms

As shown in the mood board, reeds swaying with the wind would give people a soft and relax feeling. Experiences with gardening work often arouse senior's empathy with plants (Seo at el., 2015), thus made plants or plants mimicry objects a great media to interact with elderlies. Wave motion is another common movement seen in the nature. Its transformative and patterned characteristic shows its uniqueness. The fact that it is so attractive and satisfying for many people made it as another perfect candidate in modeling. Other examples of natural elements stimulating people's feeling include school of fish and formation of birds can arouse the feeling of distance and family ties; the symbol of moon and shooting stars reminds people of the hollowness, vastness, and the periodicity of the surrounding space. These concepts are very specific and concrete, all of them can be found and have been seen in everyday life. Therefore, using these symbols as the

media makes it easier to emotionally connect with the senior user.

### 4.1.3 Possible Structures

In order to interact with the user with multiple senses, an appropriate structure design is very crucial. As shown below in Figure 8, another mood board is created to help identifying the best structure choice.

Figure 8 Moodboard of possible structures

This mood board looked into some notable mechanical kinetic interactive installations. Compare to those cutting edge computer numerical controlled electronic installations, these mechanical kinetic installations have relatively lower costs yet still unique and engaging, and most importantly, they seem to be less of a techno solution. Therefore, this project is determined to be build on a mechanical structure.

The options of structural frame and mechanisms include layer cut, eccentric wheels, hinges, multi-linkages, topology meshes etc. These internal structures can also be very aesthetically pleasing if they are placed symmetrically with each other or fit the Golden Ratio, thus raise the

overall taste of the installation.

Although these interactive installations have very different designs, all of them are either in the form of human directly interact with the piece, or in the form of a human controlled object interact with another object. It is also worth to note that all these examples have integrated the interactive input to the structure and the movement with a distinct number of degree of freedom so that there is a clear logical connection between the user input and system respond. These factors are very crucial in the design of a mechanical interactive piece.

## 4.2 Ideation and Concept Selection

Drawing the findings from the preliminary research, several potential concepts were generated as shown in the Table 1 below.

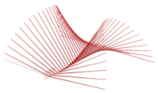
| Concept |  |  |  |  |  |
|---|---|---|---|---|---|
| Mechanical Structure | Hoberman Sphere | String-Pulley | String-Pulley; Hinge | Hinges | Eccentric Wheel |
| Degree of Interaction | 1 | 2 | 2 | N | 2 |
| Concreteness | High | High | Medium | Medium | High |
| Expandability | Low | Low | Medium | High | High |

Table 1 Concept evaluation matrix

These potential concepts were put into above matrix for evaluations. Each of them was evaluated on their value and feasibility. The evaluation criteria include the feasibility of the structure, the degree of freedom, expandability of the concept, and the concreteness of the interaction. In another way, can they actually provide the feeling of connection? Are they concrete enough to make sense for the user?

In this specific project, the goal is to connect the senior user with their loved ones. Therefore, at least two degrees of freedom is needed to allow two users to interact with each other using this product as the media. As a result, the first concept with the Hoberman structure was eliminated from the selection first because it only has one degree of freedom. The second concept that features the pulley-string mechanism was abandoned because of its low expandability. The structure seemed to be bulky and aesthetically unpleasing. The third concept of parametric spikes was mimicking a swimming stingray. However, it was not considered because of its abstractness, people have mistaken it as a crawling caterpillar and felt very uncomfortable with it. The forth concept with the hinges provide more degree of freedoms that allow users to customize the product on their own, but the complicity of its structure limited the feasibility, therefore was not selected. As the result, the last concept that features an eccentric wheel, slide bars and pulley stood out, eventually evolved into the final design because of its high expandability and concreteness. The concept allows two users to interact with each other through the movement of slide bars, making this a two participant activity, thus bridges the separation between the senior and their loved ones. The Dutch De Stijl movement leader Pieter Mondrain's work inspired aesthetic also made this a simple yet decorative art piece, appropriate for household decoration. The concept is named Heart Palette.

## 4.3 The Making of Prototypes

Due to the time and resource constraints, only two demonstration prototypes were made for Heart Palette at this stage. The first one was a rough prototype used to verify the feasibility of the mechanical mechanism. The second one was a high fidelity prototype demonstrating the final effect of the product. A fully functional prototype was not in the scope of this semester-long design research, which will be discussed in the next section.

### 4.3.1 Mechanical Mechanism Verification Prototype

The mechanical mechanism verification prototype shown on next page in Figure 9 was made with 5 mm PVC foam board to justify the eccentric wheel and the slide bar combination. All parts used in this prototype were fabricated in real size using a laser cutter.

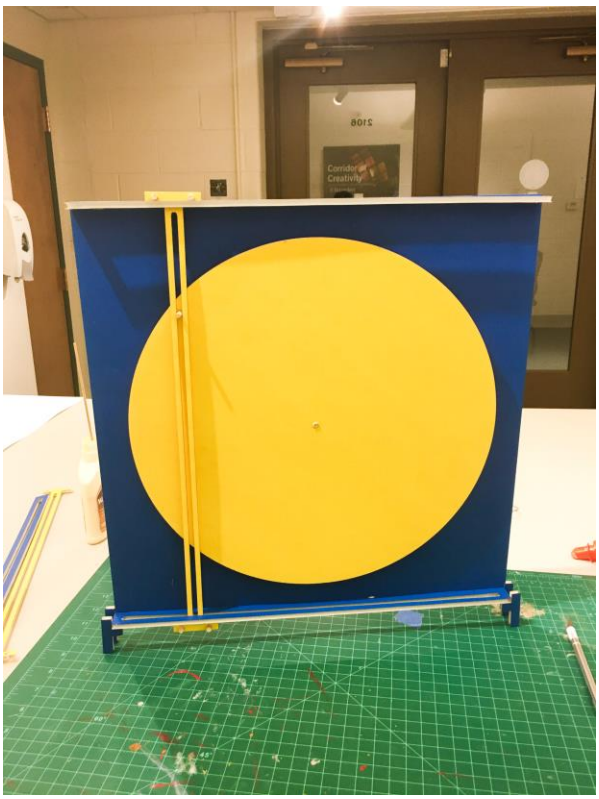


Figure 9 Mechanical mechanism verification prototype

The key point of this verification is to justify a) the eccentric wheel and slide bar combination is physically feasible, so that the slide bar can be driven by the eccentric wheel as designed; b) the slide bar can slide in the rails freely without any resistance. Due to the time limitation, only the backboard, vertical slide bar, horizontal slide rails, and the eccentric wheel were made for this prototype. The horizontal slide bar, vertical slide rails, LED lights strips, the pulley and the frame were not installed on this prototype.

By making this prototype, it was found that although the slide bar could move along the sliding rail, when the single contact point between the eccentric wheel and the slide bar is away from the center of the bar, a rotational moment on the sliding bar body would results in the bar tilting and

jam the rail, as shown in Figure 10 on next page. Since the contact point would not be at the center of the sliding bar body for the majority of the time, one more constraint is needed to prevent the slide bar from tilting due to the eccentric wheel induced rotational moment.

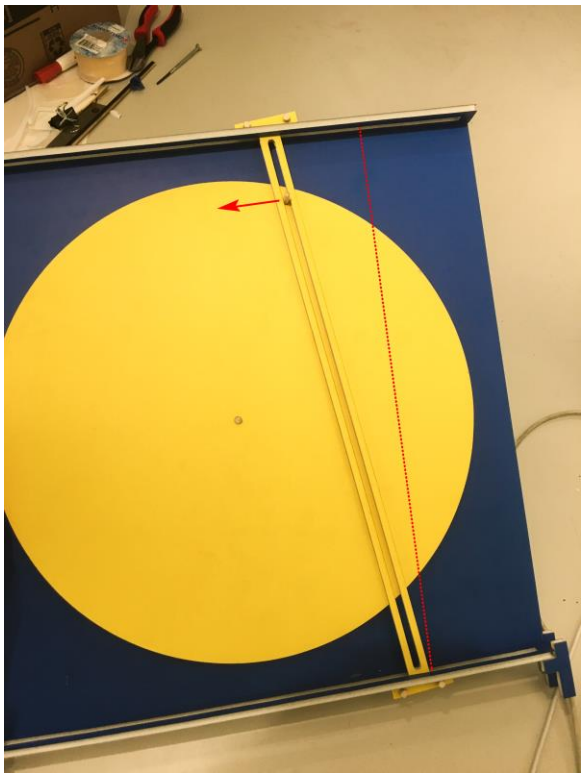


Figure 10 Tilted slide bar jammed in the sliding rail

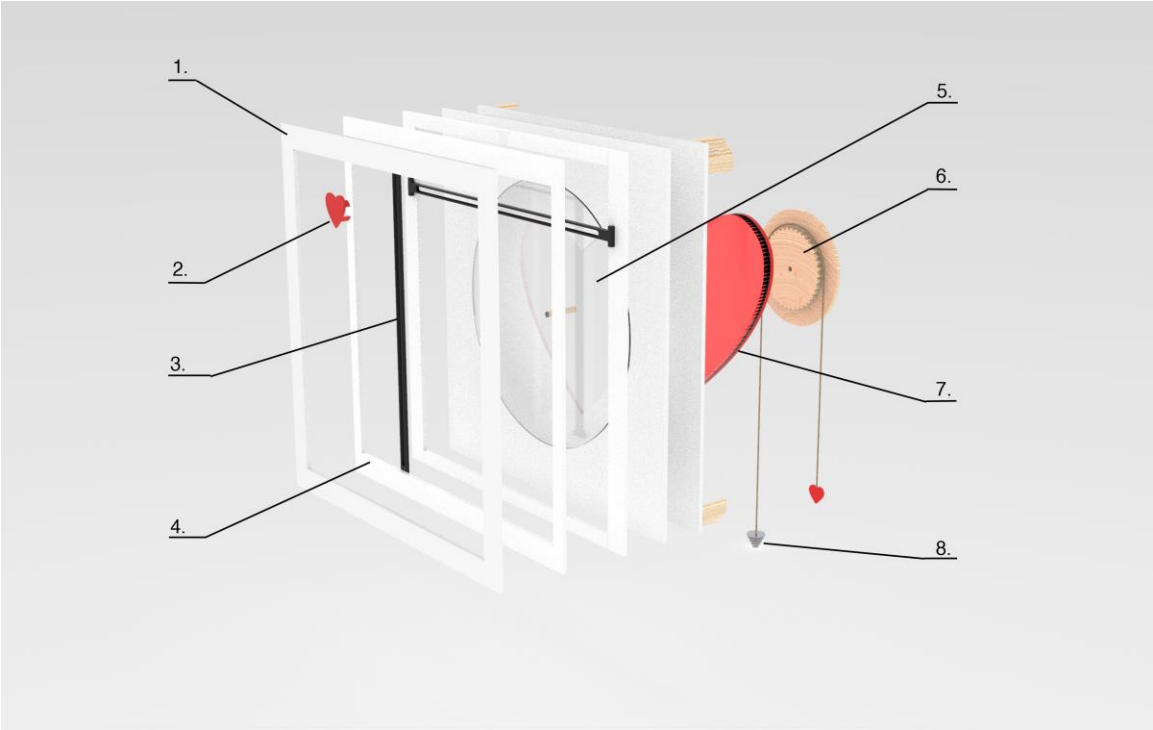
### 4.3.2 Aesthetic

## Demonstration Prototype

Figure 11 Aesthetic demonstration prototype

The aesthetic demonstration prototype was built to reflect the final effect of the Heart Palette. Shown in Figure 11 on the previous page, it is built in full size with designated materials, and painted with spray primer and paint.

Drawing the lesson learned from building the mechanical mechanism verification prototype, the design of the slide rail was modified. The frame was built in layers, so that the sliding rail can be integrated into the frame structure. The length of the slide bar was also extended in order to allow it prop on the frame layer, thus prevent the slide bar from tilting due to induced rotational moment. The entire structure can be divided into seven layers as shown in Figure 12 below.




1. Frame 2. Small heart shape gadget 3. Slide bar 4. Sliding rails 5. Acrylic eccentric wheel
6. Pulley 7. LED light strip and Acrylic body 8. Bob-weight

Figure 12 Prototype exploded view

Most of the structure is made out of 5 mm plywood sheets. The eccentric wheel and the big heart on the back of the backboard are made out of 3.3 mm and 5 mm acrylic sheets. All of these components were fabricated on a laser cutter. These components formed the three dimensional

structure by stacking up together. The small heart shape gadget installed at the intersection of two slide bars are thermal printed with grey scale resins. It was then painted in red with a spray primer and paint. Figure 13 to Figure 19 on following pages documented the fabrication process in detail.

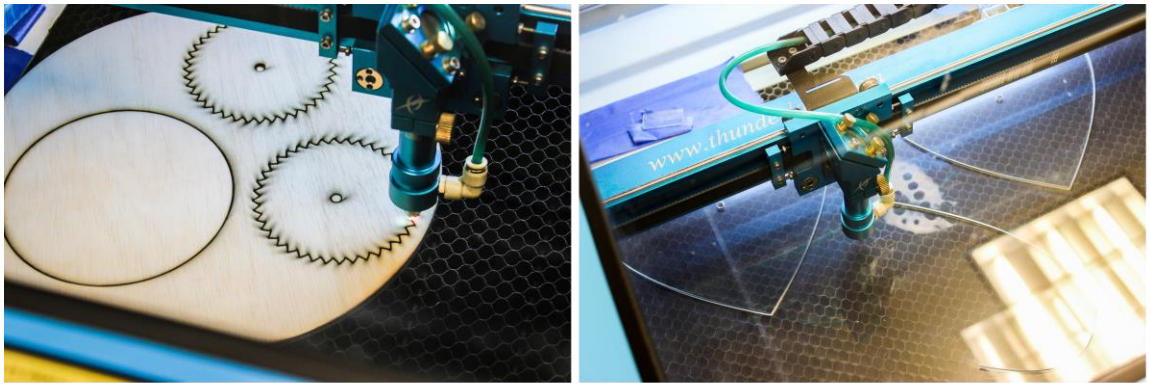


Figure 13 Major components fabricated with laser cutter

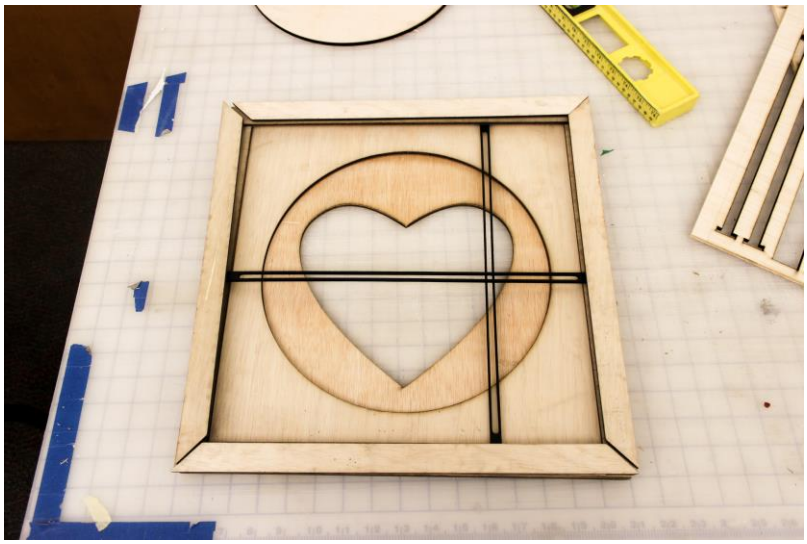


Figure 14 Mock assembled structure

Figure 15 Color applied using spray primer and paints

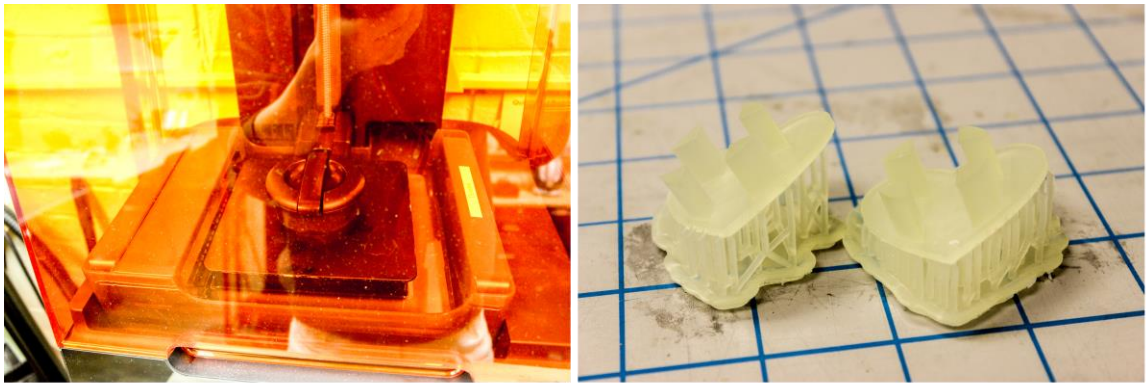


Figure 16 The small heart shape gadget connecting two slide bars printed with resins

Figure 17 Light assembly built with 5mm Acrylic sheet

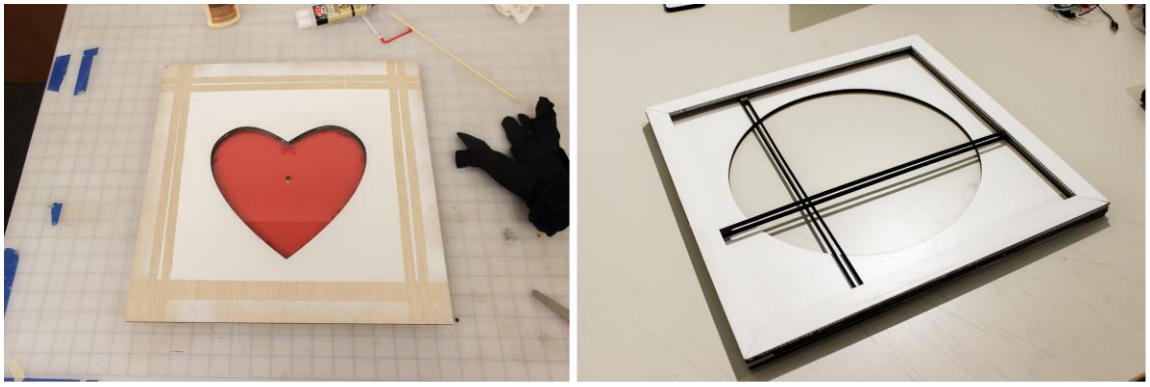


Figure 18 Final assembly

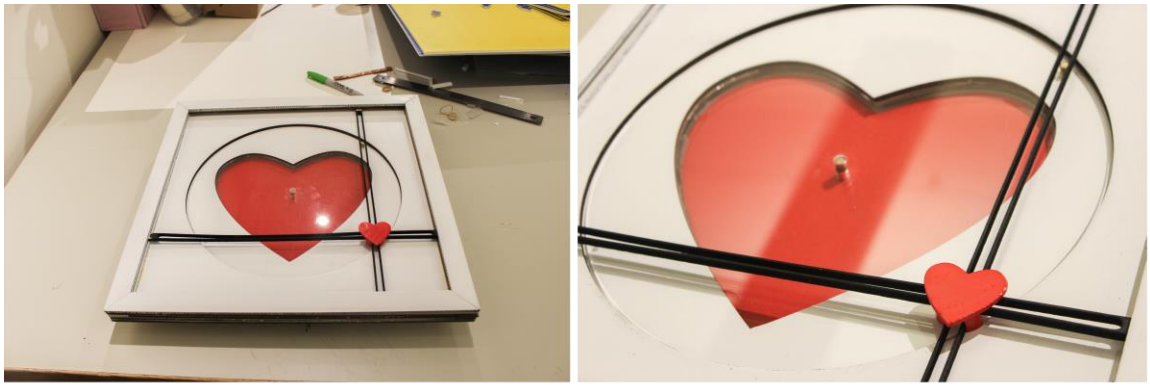


Figure 19 Finished prototype

By making this aesthetic demonstration prototype, the visual effect of the structure and selected material were justified, some room for improvements were identified as well. Due to the physical property of the plywood sheets used in this prototype, the actual strain on the structure exceeded the predicted strain, resulted in structural deformation. Therefore, this prototype is only a static demonstration prototype.

# V. Next Step

As mentioned in the previous section, a fully functional prototype is not in the scope of work introduced in this thesis, but a fully functional product is considered for future development. From the field user testing done with the Pontem, where this project was built off from, many positive feedbacks were received regarding the identification of the problem space. This affirming the necessity of addressing this niche space and the overall path is correct. Therefore, it makes sense to develop the Heart Palette into a mature product for the market.

Due to the time constraint, no more iteration has been done on the design other than fixing the problems found in the mechanical mechanism verification prototype. Therefore, a fully operable and user testable prototype is necessary before moving forward. Issues with the aesthetic demonstration prototype should be fixed by using stronger materials such as pinewood instead of the plywood sheet for the backboard, and metal for the slide bar. This fully operable prototype will justify the effectiveness of such interaction, suggesting room for improvement if there is any.

Other than the mechanical part of the project, the electrical part is just as important. In fact, the whole remote interaction would not be feasible at all without these electrical components. Thus, a system of hardware and software also needs to be developed and tested. The hardware components mainly consist of time of flight sensors, servos, and a microcontroller with Internet access such as Raspberry Pi, as shown in Figure 20 on next page. The theory behind the design of the software system is that an array of time of light sensors located in the sliding rail could detect the position of the vertical slide bar. This information would be record as a list of binary data using 0 and 1 on the microcontroller. The microcontroller of the host unit could then send this data in the list form to the Internet server and let the server pass it along to the microcontroller of the client unit in the distance. The client unit's microcontroller could then interpret the data in the list and translate it into a position data for the servo, and let the servo to slide the slide bar on the client unit through a belt. The system diagram is shown in Figure 21 on next page. Because of the uniqueness of the

aesthetic of Heart Palette, existing off-the-shelf electronics may not be applicable. Customized hardware components are required for this product.

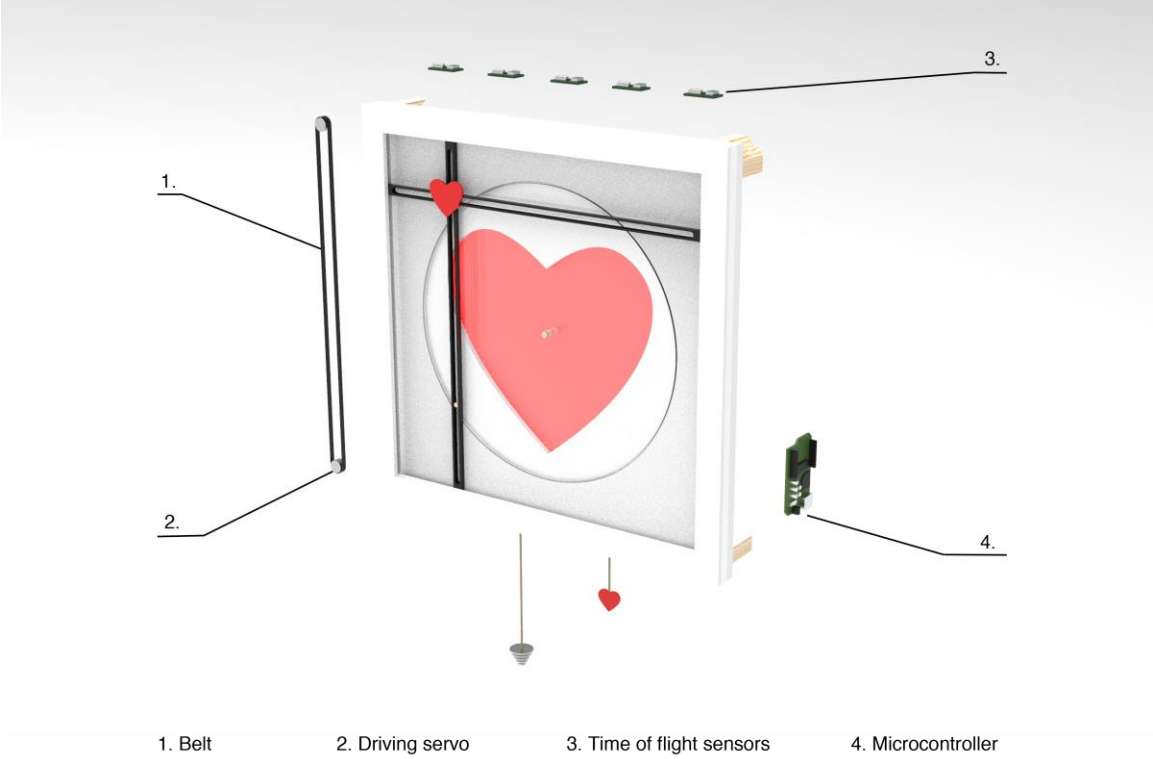



Figure 20 Electronic components

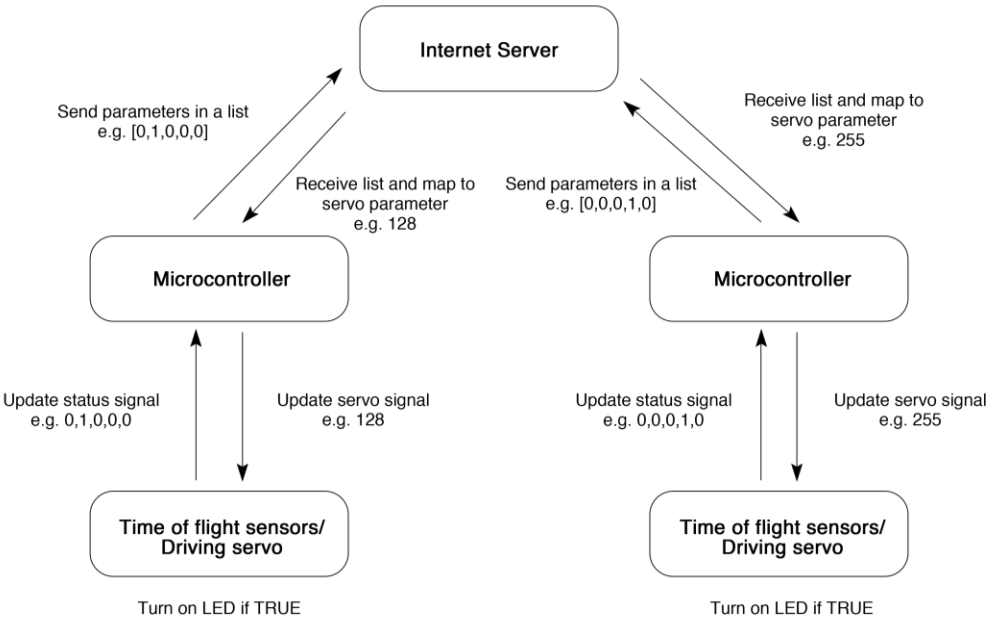



Figure 21 Communication system schematic

small

batch of 50 to 100 units of fully functional testing prototypes could be distributed to focus groups for further testing. If necessary, more iteration could be conduct to refine the design. When fully developed, the Heart Palette could secure a patent and sell to a bigger company that would be interested in such product as a kick-starter, or, create its own brand and sell directly to the public market.

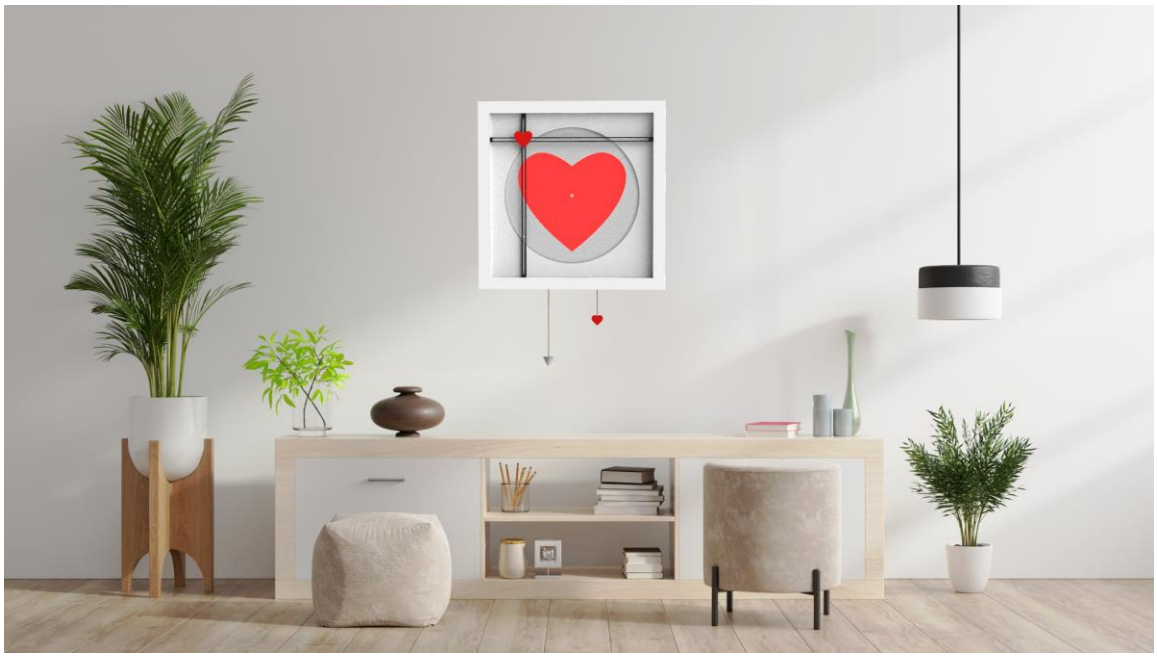


Figure 22 Rendering of Heart Palette in use

# VI. Conclusion

For decades, products designed for seniors have been merely focusing on improving their physical performance using advance technologies. However, the fact that psychological health is just as important as physical performance when it comes to the living quality of seniors should not be ignored. As the globalization is impacting our way of living drastically, loneliness has became the number one “killer” of the “empty nest” seniors and significantly degraded their quality of life. With more and more senior citizens in our society require our input, it is time to address such problem space specifically.

Through this design research project, the problem space was refined and a design opportunity gap was identified. Using the iNPD development method, an effective design concept was proposed as the respond to the problem space. The Heart Palette is expected to close the distance gap between the independently living seniors and their children or grandchildren in its own way, that is, a concrete emotional interaction.

Senior citizen caring is a great field to study and design. It can have tremendous positive social impacts in public society. While this specific product may have limited impact to raise the living quality of senior citizen population to a whole new level, it is a good point to start with. To this end, this project is also an exploration of a practical framework for senior product design to put forward, guiding designers and engineers to develop products for older adults with user-driven design thinking instead of the traditional technology-driven thinking. Thus, making products that are not only useable to our senior users but also desirable for them, because after all, taking good care of them is taking good care of ourselves in fifty years.

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