Self-management Rehabilitation Capabilities on Older Adults by Persuasive Technology

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July 5th, 2019

Abstract

In the Netherlands, there are more than twenty thousand people getting hip fracture annually. Out of them, more than 87% are of elderly age. The elderly age recovery includes of getting the treatment at hospital before entering a period of rehabilitation, often at a nursing home. The elderly patient's rehabilitation in the nursing home consists of half an hour of physiotherapy session. This amount of exercise is not enough to have the patient recovers well. Therefore, the focus has been on having the elderly patient self-manage themselves by having them do exercises on their own. This paper focuses on exploring the self-management capabilities of older adults by means of persuasive technology.

This research will follow the method of Creative Technology Design Process with an implementation of Behaviour Change Techniques. The design will start from ideation to specification, before being realised and afterwards evaluated. The ideation results to an idea of a modern take of a music box. The idea is to have an activity tracker integrated to the music box, thus, the music box can calculate inactivity and remind the user to start exercising. The music box will remind the user by playing music, with instructions on video and voice prompt given when the user is not sure on what to do. The system utilised speech recognition to allow voice command in consideration to the elderly condition of possibly not able to reach the music box.

Through the user evaluation, it can be concluded from this research that although not perfect the music box has shown to be a valid proof of concept. Music has shown that it can be a persuasive way to motivate elderly people to move their body voluntarily. Technology has been combined to help the elderlies do self-management on themselves. The combination of music and technology shows the possibilities to solve the situation of the elderly lacking the capabilities to self-manage themselves.

Acknowledgement

I would like to thank all the people that helps contribute to this project and all the people that has supported me during the graduation project. First, I would like to thank my supervisors, Miriam Vollenbroek-Hutten and Dieuwke van Dartel, for the support and feedback throughout the project. Thank you for helping to arrange the meeting with the experts and introducing resources that I would not get otherwise. I would also like to thank Michelle Kemerink op Schiphorst, a physiotherapist of Carintregelland, which has shown me around the nursing facility St. Elisabeth and giving me insights towards the exercise of the elderly patient. I would also like to thank the participant of my user evaluation for the willingness to do the test and the insights that all of them gave. Finally, I would like to thank my fellow students for the support and feedback that allows for the iteration of the project.

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Introduction

There are a lot of accidents causing injuries happening to humans and among them, hip fractures are one of the most common types of injuries. According to the CBS StatLine (CBS, 2019), there are 20,560 hip fracture patients in the Netherlands during the year 2017. In addition, out of the 20,560 patients, 17,905 patients are 65 years old or older. The data also shows that there is an upward trendline for the hip fractures from the year 2013 to 2017. This number are expected to keep growing due to the ageing population (CBS, 2018). This is concerning, because as the patients' age are older, they experienced poorer postinjury functioning compared to younger patients (Brown, Cameron, Keay, Coxon, & Ivers, 2017).

After hip fracture elderly patients are treated in the hospital, they are usually admitted into a nursing home for geriatric rehabilitation. In the nursing home, patients receive daily physiotherapy session for at most half an hour with a physiotherapist every weekday. This is not ideal as for the rest of the time, the patients usually do not know what to do or cannot manage themselves to exercise on their own. Unfortunately, there is not enough labour to accommodate all the hip injured patients with intensive course every day. Therefore, there is a need to increase the self-management rehabilitation capability of the patients, in this case, using technology. A persuasive technology could help give motivation to the elderly hip fracture patients recovering from their accident. With motivation to do self-rehabilitation, it might increase the chance of recovery of the patients or decreases the rehabilitation time needed. Therefore, the goal of this project will be to have a persuasive technology to help the self-management of the patient and help them recover.

To reach the goal of the project, the following questions are asked "How should technology be designed to persuasively help improve self-management rehabilitation capabilities of elderly hip fracture patients?". A literature review will be conducted to help make a better design of the technology, as well as to help answer the research question of this project. The review will be integrated into the state of the art section of this paper, which will be the foundation for design choices later in the project.

State of the Art

The project needs a method to motivate elderly hip fracture patients to use their rehabilitation time in a more ideal way. The literature findings on hip fractures and related works will both be discussed in this section.

Background Research

In this section, background research is conducted in order to find a reason for elderly patients' inactivity during their free time. Patients have a dependency on a nurse or physiotherapists for their rehabilitation. If they do not have supervision from nurse or physiotherapist, they usually would not exercise on their own at their free time. The patients need to be able to manage themselves to do the exercise on their own without support or reminder from nurses or physiotherapists. After reviewing the literature, it can be summarised that there are several factors that keep elderly patients from doing exercises on their own.

The first factor is the support that the patients received. As discussed previously, patients receive a lot of support from nurses or physiotherapist during their rehabilitation. This support comes in many forms, nurses and physiotherapist will give knowledge and instructions on how to do an exercise as discussed. Another form of support is feedback and encouragement. Patients who receive feedback are more active compared to the one that did not receive one (Peel et al., 2016). Moreover, Escolar-Reina et al. (2010) state that proper and personal feedback increases the patient's endurance of rehabilitation exercises. Supports for patients are lacking when the patients are in their free time, therefore it is logical that they also feel less inclined to exercise on their own.

The second factor that keeps the patients from doing the exercises themselves is the lack of knowledge. Patients, especially elderly patients lack the necessary knowledge and know-how on performing the exercises themselves. During rehabilitation session, patients are dependent on physiotherapists to guide them on the exercises. Some literature has discussed the importance of knowledge on the recovery of the patients. Escolar-Reina et al. (2010) give some caution that written instructions are often performed incorrectly. Within the context of elderly patients, a wrong exercise performed by the patients could possibly lead to more injuries. However, Varnfield et al. (2014) state that instructional video can replace the physiotherapist in imparting knowledge to the patients. This means that the dependency on the nurse or physiotherapist can be decreased by providing another mean of instruction. Therefore, knowledge transfer to a patient in a correct way can benefit the patient in helping the patient self-manage themselves better.

The third factor is cognitive impairment. It is common in elderly people to experience a decline in cognitive abilities, or better known as cognitive impairment. According to the Centers for Disease Control and Prevention (2010), “Cognitive impairment is when a person has trouble remembering, learning new things, concentrating, or making decisions that affect their everyday life”. Sinclair, Girling, & Bayer (2000) states that a cognitively impaired person is significantly less likely to be involved in self-care. This might be the reason that the elderly patients do not do exercise on their own, as even normal patients already find it difficult to fit the rehabilitation exercises in their daily routine (Escolar-Reina et al., 2010). Therefore, the elderly patients who have cognitive impairment will find it even harder to do a routine of self-care on their own.

The fourth factor is the patient’s condition. From the visit to the nursing home, it was found that some patient has difficulty to even stand on their own. Some others have restriction to their movement range due to the treatment or operation that they received. An example of this is patient who just had their operation, they are usually not allowed to put any weight into their legs. This mean that they are not suggested to stand. This rehabilitation phase will last for around four weeks, where with time, they will gradually be allowed to handle more weight. This means that there is a distinction on what the patient can do and achieve on their own. A patient that just got in the nursing home might not be able to do something that a patient that has rehabilitate for several weeks do.

Related work

This section will attempt to uncover the strategies and technologies used in the field. These strategies and technologies show the current situation of rehabilitation by medical facilities. The methods here will be checked for their effects on the patients. However, for some of the technologies, there is not proper research done on them yet, therefore, they could not be said to be successful in helping rehabilitation. However, it would be interesting as a building block to build this project. The interventions found in this literature can be mainly divided into a psychological or technological intervention.

Psychological Interventions

The psychological interventions for the self-management system can be called as support for self-management. Support for self-management in medical facilities has been done before by others. After taking a look into a relevant research paper, the first one concludes that the self-management program improved patients’ self-efficacy, outcome expectation of the rehabilitation, and satisfaction with the performance of self-management behaviour (Lo, Chang, & Chau, 2018). The intervention found in this research includes strategies such as goal setting, modelling, and verbal persuasion. The participants also received a workbook to record their goals of recovery with the related action plan, as well as two DVDs that contain the motivation of successful survivors' experience. Verbal persuasion to encourage the patients were also done. The verbal persuasion includes acknowledging incremental successes, reinforcing expectations of positive outcomes, and stimulating thinking and encouraging practice of strategies.

The second literature concludes that self-management support interventions may improve self-care activities in patients (Zimbudzi et al., 2018). The interventions include at least one of the following intervention components, which is, provider education, provider feedback, provider reminders, patient education, patient reminders, and patient financial incentives, with the provider, in this case, being the nurse or physiotherapists. However, it was not possible to determine which of them were more effective, although interventions that utilized provider reminders, patient education and goal setting were associated with improved outcome. Nevertheless, the result of the literature concluded that support for self-management has allowed the patients to recover better.

The self-management support has shown that there is a common intervention which has a positive outcome. The intervention is goal setting. The definition of goal setting is to set or agree on a goal defined in the behaviour to be achieved, or the positive outcome of wanted behaviour (Michie et al., 2013). Aside from the goal-setting, provider reminder and verbal persuasion also relate to the fact that patients need another entity that can support the patient during rehabilitation. This correlates to the founding in the background research, which states that patients who receive motivation and feedback are more active in their rehabilitation.

Digital Behaviour Change Interventions

Digital Behaviour change interventions are applications which use the behaviour change techniques as the core idea of the application. There are some digital behaviour change interventions in the market right now. The first is the Ubifit, this application uses goal settings to encourage physical activities as the core idea of the application (Consolvo, Klasnja, Mcdonald, & Landay, 2009). The app shows a garden of the flower with the number of flowers being dependent on the goal achieved by the user. Another example is Fittle, as can be seen in Figure 1, is an application that tries to promote positive health behaviour through the use of social support (Du, Youngblood, & Pirolli, 2014).

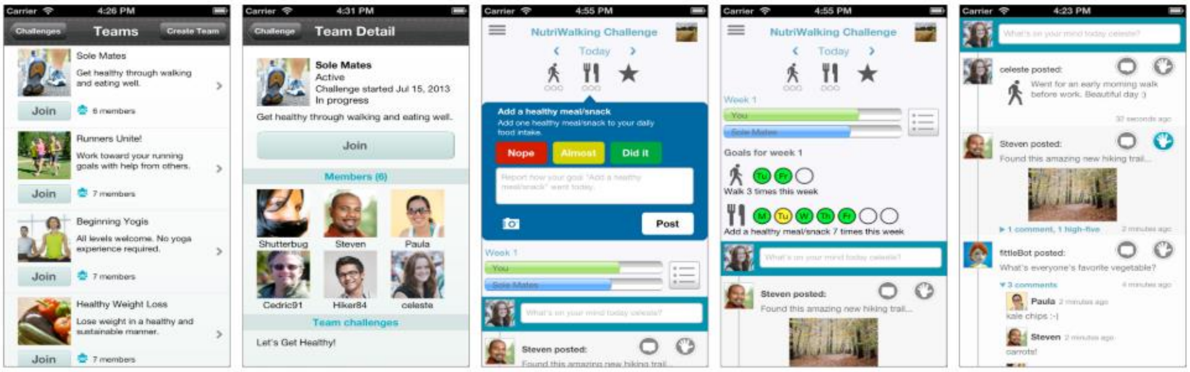


Figure 1 Fittle (Du et al., 2014)

Activity Tracker

In order to sense the patient activities, there is a need for a tracker on the patient. One of the ways to do this is an activity tracker. Activity trackers are not interventions by itself, however, it can be a tool which supports for better intervention. Activity trackers in the form of wearables have been growing in popularity, with astounding adoption rate as cheaper and better wearables are coming to the market. Activity tracker has been found to be suitable to be used by older adults, in addition, the motivation towards the user provided by feedback and activity monitoring has been found to be motivating towards the elderly (Rasche et al., 2015).

One of the wearables usually used in health and fitness areas are Fitbit. Fitbit, as can be seen in Figure 2 below, uses the integrated embedded system in the form of a wearable to gather the data on users' activity. Fitbit is often used in the area as it allows easy retrieval of the data taken. The data tracked are quite extensive including distance, active minutes, calories, heart rate, stationary time, time asleep, time awake and more (Fitbit, n.d.-b). Other competitive trackers include Xiaomi Mi Band and Huawei Band which allows for generally the same feature at a lower price-point. However, the downside is, the data are not as easily exported to be used on another project.

Figure 2 Fitbit Charge 3 (Fitbit, n.d.)

The Fitbit can be accurate to 5.5% at speed as slow as 0.5 m/s which is suitable for injured patient tracker (Singh, Farmer, Van Den Berg, Killington, & Barr, 2016). However, the study states that this accuracy can only be achieved when in the lower limb. For the rest of the body location, the accuracy of the Fitbit will drop according to the distance it is located from the centre of the body, the closer it is to the centre of the body, the more that the accuracy suffers. For elderly hip fracture patients, it might not be possible to record some movement, for example, a patient with a stroller with a Fitbit on their hand. The accuracy of Fitbit would drop as the hands are relatively stable due to the stroller even though the patient is moving. Nevertheless, a Fitbit still shows promising implementation to the system.

Activity tracker has various ways of motivating the user to exercise. By taking an example out of Fitbit, it has a daily goal, a notification for idle activity, and even an innovative way of feedback. Fitbit sends an email once a month with information about the user's activity that month presented in an innovative way. For example, the user has done 180 kilometres of walking distance within that month, then if the user lives in Enschede, it would give feedback that the user has walked to Amsterdam within that month. an interesting way of presenting user's progress.

Active Video Games

Another related work that was found is gamification of the rehabilitation process. The gamification made rehabilitation to be more fun to do. Active Video Games are defined as a game where users have to physically interact with on-screen avatars (Zeng, Pope, Lee, & Gao, 2017). According to this definition, then platform such as Nintendo Wii, Xbox with Kinect as well as Virtual Reality are included for this term. Research has found that older adults enjoy using Active Video Games (Zeng et al., 2017). Another research has also pointed out the possibility of replacing regular rehabilitation program with the active video games. Moreover, there are some benefits to doing so. It is stated that besides improvements during rehabilitation, patients perceived improvements in their physical, social and psychological well-being (Peng, Crouse, & Lin, 2013). The acceptance of the gamification of the rehabilitation process has been positive. Research has shown that older adults use games on a regular basis if they are available, moreover, the game can be used in self-management rehabilitation (Martini et al., 2019).

Figure 3 SilverFit Active Video Games

Nintendo Wii, Xbox Kinect and virtual reality console allow for movement in the real world to be detected and translated into virtual value. This allows for active video games in which the user can ‘exercise’ while playing the game. However, there is some limitation on these platforms. Most of the games developed for the platform are developed for healthy people in mind. Therefore, there is a lack of games that is suitable for elderly people, even more so for elderly hip fracture patients. SilverFit, as seen in Figure 3, is one example of a system that uses Xbox Kinect for the rehabilitation of elderly people (SilverFit, n.d.). SilverFit were designed with rehabilitation movements made into a mini-game. This allows the user to do their rehabilitation in a more competitive environment. This type of system has to be well developed, taking into accounts the necessary movements for the recovery of the patient, while also keeping in mind the limitations of the patient’s movement.

Based on the publication found, active video games were found to be a positive influence on the rehabilitation program. However, the limit for active video games for elderly patients are also clear. Virtual reality technology is unlikely to be implemented as an elderly can easily get disoriented and possibly suffer from an accident due to using the technology.

Meanwhile, the Nintendo Wii and Xbox Kinect are also not perfect. The limits of patients' movement are a clear limitation to the playability of the system. Only a specialised program like SilverFit might possibly be an added value for the rehabilitation program.

Social Robots

Robot and technologies are taking over the roles that can only be filled with a human before, making everyday life easier. Some types of robots have previously been used in rehabilitation settings before. One of them can autonomously administer a questionnaire to elderly patients (Boumans, van Meulen, Hindriks, Neerincx, & Olde Rikkert, 2019). The robot managed to complete 39 out of 42 interviews, or a rate of 92.8%. The downside of the robot is that it takes a significantly longer time to do the interview compared to a human. Even with the downside, it is still concluded that social robots may effectively and acceptably assist healthcare professionals in interviewing older adults.

Social Robots, such as shown in Figure 4, is designed to be a companion for humans. This type of robot has also shown potential in medical facilities. Socially assistive robots have been developed and tested on medical facilities. Robot in medical facilities can help encourage patients and give feedback to the patient. Research has shown acceptance for robotic services with older adults (Cavallo et al., 2018). However, another research in the use of socially assistive robots in elderly care has shown that although many publications had shown a positive outcome, a large proportion of them had methodological issues (Abdi, Al-Hindawi, Ng, & Vizcaychipi, 2018). This might be something to be checked again if the social robot is going to be used in the medical facilities.

Figure 4 Example of Social Robots (Weir, 2018)

Social Robots has been proven to help in medical facilities. However, there are still some doubts left about the acceptance of robots by elderly adults as research had shown that there is still uncertainty within the acceptance of the robot (Abdi et al., 2018). This might change in time, when the robot becomes the norms then it could finally be used in the facilities. The robot still needs time to be accepted to the populace, and it would be unwise to introduce a robot and make the elderly patients uncomfortable. In the end, there still needs to be further research done on the attitude of elderly people towards the robot.

Rehabilitating Flower

Rehabilitating flower, a project by Wittrock (2019), is a flower that represents the inactivity of the user. As the user becomes more and more inactive, the flower will go dangling down, and only when the user starts to move again then the flower will rise again. It supported speech recognition which allows it to give instruction and feedback to the user. The sensing was done by a pressure mat, so when the user sits, it sensed and started counting how long the user is sitting. The rehabilitating flower is full of potentials. However, this project was developed only until the prototype stage, so there are not conclusive evidence or testing done towards elderly patients.

Conclusion

The literature review has shown that there are indeed some methods to help increase the patient's post-injury outcome expectations. The chance of the patient's mobility at post-injury could be better by these methods. The behaviour change technique intervention by goal setting for the patients works well for elderly patients. Feedback and motivation also take part in helping the patients recover better. There are also some digital behaviour change interventions that utilize the behaviour change techniques on the market, however, the effectiveness of such applications are not known yet as the studies had not conducted user testing.

There are also other technological interventions that have taken part in helping elderly patients rehabilitate better. Activity tracker had been shown to motivate elderly patients using their feedback system. Activity tracker shows high suitability in being used in the medical facility due to the sensitive sensor. Meanwhile, literature have also shown that rehabilitation can be gamified, therefore, possibly increasing participation of patients. Active video games can take over the rehabilitation session by providing the same movement to the patients. The robots as of now are functionally ready to take part in the elderly care rehabilitation system, however, there is still some doubt about the acceptance of the robot by elderly people.

Finally, it can be concluded that there is still some work left in the field. The interventions done now are still not optimal. Especially, there are not many technological interventions yet in medical facilities. There are still a lot of technological interventions that can still be tested and developed in order to help the patients better. For the ideation of this project, a broad range of ideas might come up, therefore, there is a need to do a quick elimination as well as to implement feedback for a future iteration of the project.

Method

The method used for this project is based on the Creative Technology Design Process by Mader & Eggink (2014). The methods are then modified to fit the circumstances of the project. The foundation of the process is a Divergence and Convergence Model. A process used to generate a lot of ideas effectively. This model is then followed by processes that have a logical order of steps in the design process. In the creative technology design process, the design phases consist of four phases, which is, ideation phase, specification phase, realization phase and evaluation phase. Figure 5 shows the workflow of this design process.

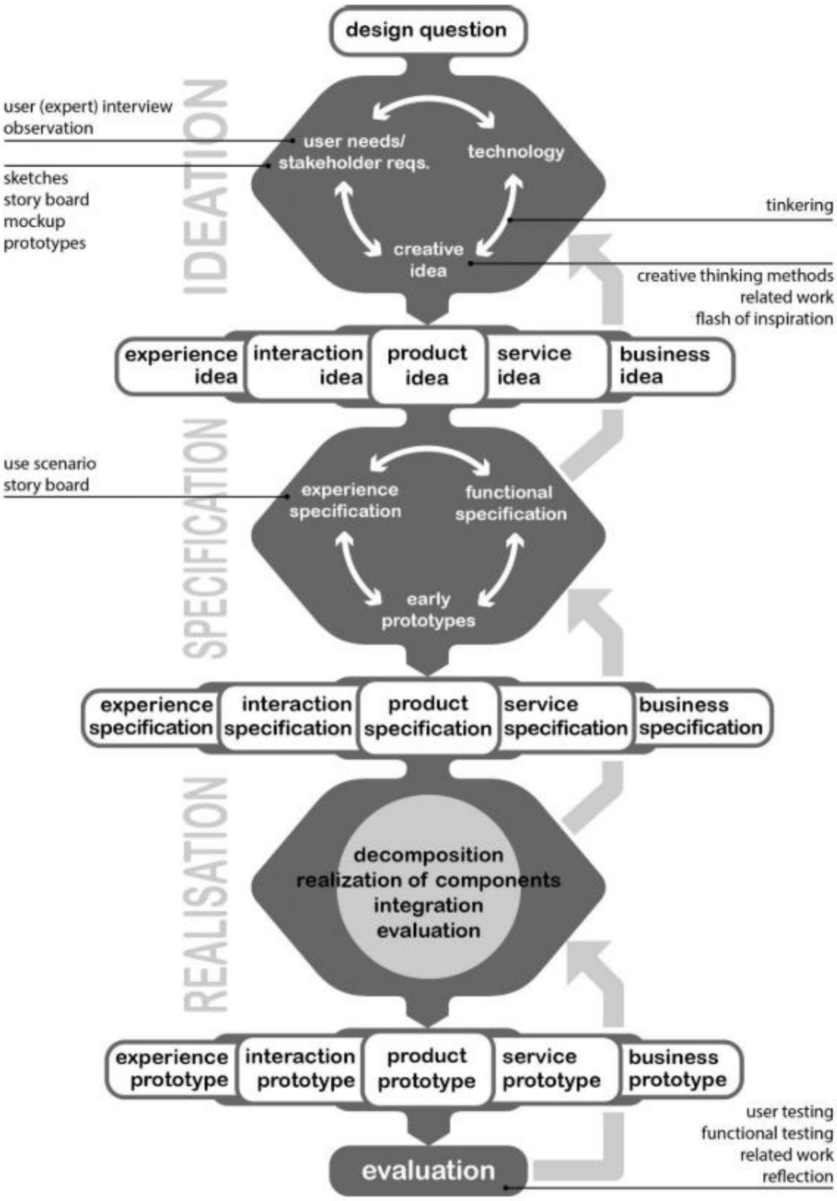


Figure 5 Creative Technology Design Process (Mader & Eggink, 2014)

Ideation Phase, this phase is based on utilising different techniques to generate creative ideas and possible solutions. Design requirements are set up in this phase to determine the direction of the idea. These requirements will be the starting point for the specification phase.

Specification Phase. this phase builds upon the output of the ideation phase. User experience specifications are developed in this phase. In this phase, design priorities are refined and specified. Early prototypes are done in this phase, with the feedbacks taken to improve the realisation phase.

Realisation Phase: In this phase, the possible implementation solutions are explored. The components of the system are realised. The components will then be integrated to a single system, which will be the final prototype. a functional test of the final prototype will then be executed.

Evaluation phase: This is the last phase of the design process. A review of the system based on the design priorities and design requirements are done in this phase. The design priorities are checked if they get implemented. User testing will be conducted to determine whether the final prototype match the user requirements in the design process.

Aside from the creative technology design process, this project will also implement the behaviour change techniques by Michie et al. (2013). This behaviour change techniques are a set of specified techniques that can be implemented to change the behaviour of a person. In this project, the implementation of the behaviour change techniques was done in hope that the behaviour of the elderly patients towards doing activity will change.

Ideation

This section is focused on the ideation phase of the creative technology design process. This section follows the divergence and convergence model of the creative technology design process. At the start, the project will be brainstormed to generate many ideas effectively. State of the art and related works may also be a source of inspiration to build something new. These ideas will then be eliminated according to feasibility and design requirements. These processes were repeated two times in this project. The requirements of the system will be described in this section. These requirements are partly influenced by the visit to nursing facility St. Elisabeth in Delden. Aside from the requirements, some ideas will be listed in this section, as well as the final chosen idea.

Design Requirements

Engagement

The system needs to be able to engage the user automatically if the user is not active enough. This includes attracting the user attention so that the user pays attention to the user. The system needs to be able to get the attention of the user to start the interaction with the user. Aside from that, the system also needs to remind the user when the user has not moved for some time. This means that the system needs access to the activity tracker that is placed on the user, however, for the scope of this project, the activity tracker itself will not be part of the project.

Instruction and Feedback

The system needs to be able to give instruction and motivation to the user. Instructions are needed to direct the user into doing a certain exercise. The instructions need to be clear, as well as safe. Feedback, in this case, could be in the form of motivation or reward for doing a certain activity.

Comfortable Usage

The design of the system needs to keep in mind that the target user of the system is elderly hip fracture patients in the nursing facilities. This means that if the system is not designed properly, then the user might not be able to interact with it. An example would be if the elderly hip fracture patients are not able to walk yet, then buttons interaction in the system would not be possible as the system might not always be by the user side.

Non-pervasive System

The system should be in the environment of the user without making the user feel disturbed by the presence of the system. The system will, therefore, need to be in a form that allows the user to be comfortable with it, blending into the environment.

Persuasive

The system should be persuasive, encouraging the user to do something rather than forcing the user to do it. This means that the system must have an element of enjoyability to it, rather than just a system that told you to do something.

Ideas

These are some of the final ideas as the result of the diverging and converging process. There are many more, however, they would not be listed as they would not be relevant enough to the project.

Integrate the television inside patient's room into the system

This is the most practical solution. Every room of a patient in the nursing facilities is equipped with a television. The television is a non-pervasive system as it is already there in the environment of the elderly patient. By combining the television with input from a computer, then the television could be used as both a display and a speaker for the patient to see the instruction and motivation from the system. This idea also allows for a comfortable usage by the elderly patient as the television is big enough to be seen, while the audio volume is also high enough for them.

The system will work by having the computer determine the input from an activity tracker. If the tracker shows that the user has been inactive for 20 minutes, then the system will start to interact with the user through the television. It will show instruction for the user to do, and after the user does it, then it will give feedback and motivation to make the user keep up with the exercise.

However, the problem with the television is the feasibility of the concept, to do this, then the system needs to be able to override the channel input in the TV to the system input. This cannot be done easily. The system might also be too forceful instead of persuasive to the user. In the case that the user is watching the television, then the override by the system might cause disturbance to the user.

Mini human figure doing exercise

This idea came to be from the human figure which drawers usually use to sketch human. The idea is to control the human figure to give a demonstration of the exercise. This could be done by using a string attached to a motor that will then move the joint of the body.

This idea ends up being eliminated due to the feasibility of the idea. This idea is too complicated to be implemented, with a lot of further research needed to do the mini human figure movement. With the time constraint of this project, this idea is not possible to do.

Etched Glass in a photo frame

This idea is an idea based on etching plexiglass and then have a LED strip around it to shine at it, then the plexiglass will show the etched image. On normal condition when the LED strips are not turned on, the picture behind the glass can be seen, and this frame is just a normal picture frame. Based on the trigger sent by the computer which determined that the user has been inactive for some moments, then the LED strip will turn on then display the image of the exercise which is etched on the plexiglass. An external speaker will also try to get the user attention, while also giving out instructions and motivation. The frame will have to allow for ease of change of the glass so that the exercise done by the user can be alternated.

This idea ends up being eliminated because this idea does not fulfil all the design requirements. This idea is not user-friendly to the targeted user group, which is the elderly patients. The elderly patient, in this case, will have a hard time to recognise the picture and its intention. The elderly might also have some deterioration with their vision causing them to not be able to see the figure etched in the glass.

LED Flower

The LED flower idea is an that use plexiglasses that is laser cut to flower shape, where the flower will then light up to attract the user attention and allows the system to further interact with the user. The system will prompt the user through the external speaker to do exercises and activity. As it is flower shaped, the reward to the user for completing the exercise would be a nice fragrant of the flower aside from the congratulatory word.

This idea did not fulfil all the design requirements, therefore, this idea did not get chosen. This idea does not attract the elderly enough to get their attention. The LED attracts the user based on the light that they emit, however, if the user does not have the LED within their vision, then they would not notice the LED. Moreover, with the elderly, they might have vision deterioration which might cause them to have even less awareness of the LED flower.

Music Box

Figure 6 Early design idea of the music box

The final chosen idea is to make an installation in the form of a music box to motivate the user to do exercise. Figure 6 above is an early ideation form of what the final form could look like, there might be changes to the design along the way. The form of a music box is chosen as it is a common form that can be implemented into a room without being out-of-place. The music box will get the user's attention by playing music. After the system gets the user attention, the music box will have a voice prompt to ask the user on whether they are willing to do some exercise. The user can answer to the system and the system will have speech recognition to get the user's answer. Then after the user does the exercise, then the system will give feedback and reward to the user.

This system, therefore, fulfils the design requirements set for the ideation. It engages the user by playing the music. The system has the capability to instruct and give feedback to the user by a voice prompt. The idea of speech recognition is to make the elderly patient more comfortable in the interaction with the system. The elderly patient that are not capable of getting to the device can speak from where they are, and the system will pick it up. The system is also non-pervasive and persuasive, elements of music brings a more comfortable atmosphere to the otherwise monotone exercise routine.

Specification

The chosen idea, music box, still needs further elaboration to be realised. There are design choices that need to be made. This section will go further into specifying the music box system. Following the design requirements, the user experience design of the music box is described in this section.

User Experiences

The early framework of the system could be seen in Figure 7 Early framework of the system below.

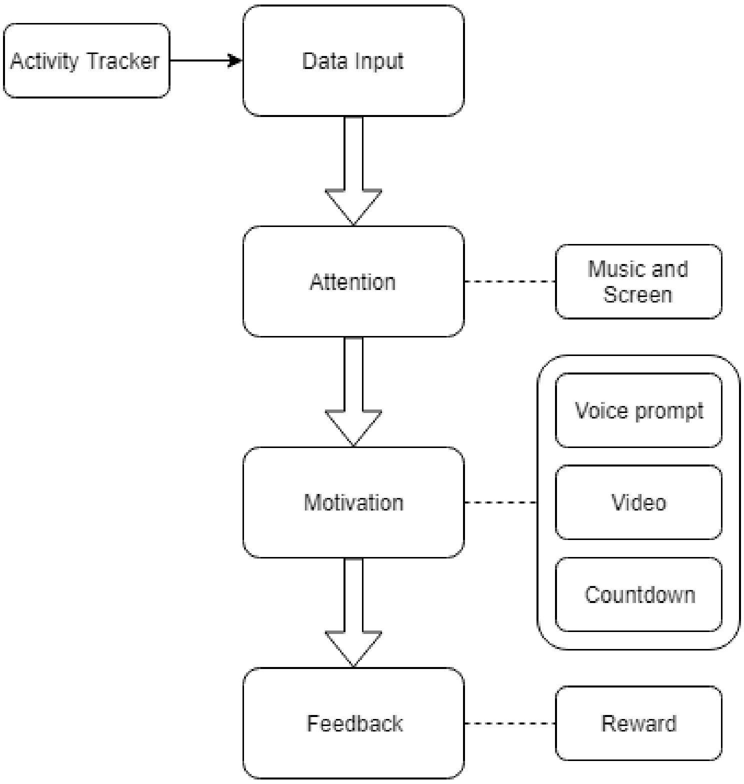


Figure 7 Early framework of the system

The first thing that the system does is retrieving data from an activity tracker to determine if the user has not moved for a certain period. In the scope of this project, this trigger is done manually as the project has no access to the activity tracker. Then the system will get into the second phase, where the system tries to get the attention of the user. In this system, the music box will try to get the attention of the user by playing a pre-arranged music of user's choice. The music will be played at a relatively high volume so that the target user can take notice of the sound. Afterwards, the system will try to motivate the user into doing an exercise which has been allowed by the physiotherapist in charge of the user. This is done by giving voice prompt on asking the user if the user is interested in doing an exercise, as well as showing the exercise on a screen built into the system. After the user reply and the system receives confirmation of user participation in doing an exercise, the system will show the exercise video once again and then the user will be asked to start the exercise, after a while, the system will ask if the user has done the exercise and gives further motivation to the user if the user has done their exercise.

The framework above contains several components of user experience. These user experiences listed here explored possible solution of design implementation.

Activity Tracker

the focus of this project is to the self-management of the elderly and the way to give them the motivation to exercise rather than to obtain the activity data of the elderly. Thus, the activity tracker in this project will be omitted, more so that the project has no access to the activity tracker. Therefore, for this project, the trigger for the activity data will be replaced with manual input. This could be a mouse pressed or key click or even some button. However, the most likely scenario would be a mouse pressed or key click.

Display and Sound

In the literature review, it was found that just displaying an image of an exercise might lead to the patient doing the exercise correctly. A video is a more suitable platform to instruct an exercise to the patient. Therefore, for this project, the system will have a screen which will help display the instruction to the patient.

For this project, the way that the music box is designed to engage with the user is by playing music so that the user can take notice of the music box and later do interaction with the music box. Therefore, there is a need for a speaker in the system. The speaker will need to be loud enough to be heard by the target user, the elderly patient.

In order to be able to display something on the screen and play some music to the speaker, the computer is needed. There are several options for this, the system could use an external computer, or it could use a micro-computer such as Raspberry Pi. Both options will be considered and will be further tested in the prototyping stage.

Voice Prompt and Speech Recognition

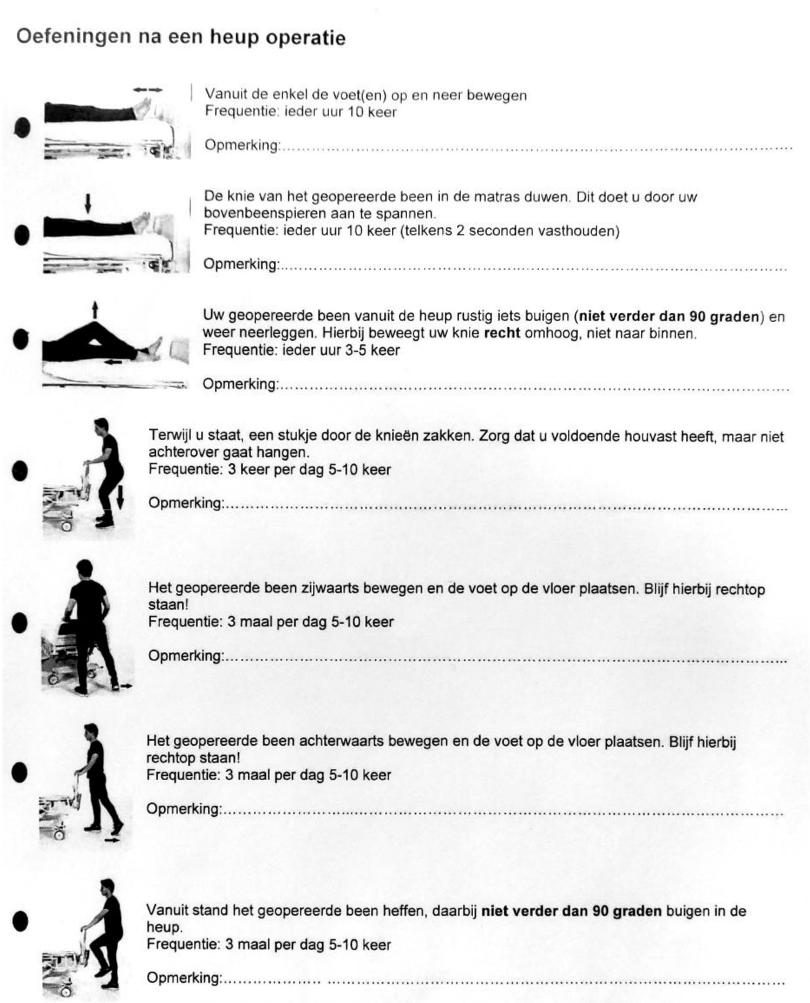
The voice prompt and speech recognition are important components of the interaction of the system. These two components relate to the interaction of the user with the system. The voice prompt gives out instruction meanwhile the speech recognition is needed to obtain the command of the user.

An easy way to implement a voice prompt would be to play a pre-recorded instruction. However, during the research to do speech recognition, a library was found that offers both the speech recognition and text to speech capabilities. Text to speech capabilities will allow for an easy update to the instruction where the text only needs to be added to the text editor to have a new voice prompt. The library found are P5.speech library, made for the platform P5 which is based on JavaScript.

Both the speech recognition and text to speech are part of the P5.speech library, and this library needs to be connected to the internet to work. The reason behind this is because this library makes use of the Google Cloud API to process the data and deliver the result back. Therefore, it could be said that this library is a shortcut to connect to the Google API. As it is based on Google API, the result of the system should be trusted enough, however, this still needs to be further tested.

Instructions

The instruction to the user will be done using the display and sound in combination with the voice prompt. The instruction will be done on a video with an accompanying voice prompt explaining the exercise. The instruction itself will be based on the exercise brochure that are available to the patient in the nursing facilities. This exercise brochure can be seen in Figure 8.



Oefeningen na een heup operatie

- Vanuit de enkel de voet(en) op en neer bewegen
  Frequentie: ieder uur 10 keer
  Opmerking:...
- De knie van het geopereerde been in de matras duwen. Dit doet u door uw bovenbeenspieren aan te spannen.
  Frequentie: ieder uur 10 keer (telkens 2 seconden vasthouden)
  Opmerking:...
- Uw geopereerde been vanuit de heup rustig iets buigen (**niet verder dan 90 graden**) en weer neerleggen. Hierbij beweegt uw knie **recht** omhoog, niet naar binnen.
  Frequentie: ieder uur 3-5 keer
  Opmerking:...
- Terwijl u staat, een stukje door de knieën zakken. Zorg dat u voldoende houvast heeft, maar niet achterover gaat hangen.
  Frequentie: 3 keer per dag 5-10 keer
  Opmerking:...
- Het geopereerde been zijwaarts bewegen en de voet op de vloer plaatsen. Blijf hierbij rechtop staan!
  Frequentie: 3 maal per dag 5-10 keer
  Opmerking:...
- Het geopereerde been achterwaarts bewegen en de voet op de vloer plaatsen. Blijf hierbij rechtop staan!
  Frequentie: 3 maal per dag 5-10 keer
  Opmerking:...
- Vanuit stand het geopereerde been heffen, daarbij **niet verder dan 90 graden** buigen in de heup.
  Frequentie: 3 maal per dag 5-10 keer
  Opmerking:................... ....

Figure 8 Exercise brochure in nursing facility

Open the lid of the music box

The music box lid can be opened by a microcontroller connected to a motor. An Arduino Uno is suitable for this system as it is of suitable size. In addition, the Arduino is able to communicate through a serial port, allowing for convenience in using it alongside other application. There are several options for the motor, the motor could be a DC motor or a servo motor. Both options can be implemented to obtain the desired result, which is opening the lid of the music box.

Behaviour Change Technique

In this project, the behaviour change technique from Michie et al. (2013) is also implemented. The technique that is chosen to be integrated into this system is the habit formation. According to her, the technique habit formation is done by prompting rehearsal and repetition of the behaviour in the same context repeatedly so that the context elicits the behaviour.

In this system, this implementation takes place in the interaction of the system with the user. The system plays music first without telling the user anything to do. If the user does not start any activity after the music started, only then will the voice prompt start. This design choice was made in hope that later, the user will remember to do exercise from listening to music, before the voice prompt start. The end goal of the habit formation would be to change the behaviour of the user so that the user has a habit of doing exercise without anyone prompting the user to do so.

Design Priorities

From these lists of user experience design in the specification, there are different priorities to each component. These priorities are based on the design requirements which has been done in the ideation phase. Therefore, the list of priorities will be presented below in Table 1 with information about the level of priorities, with 3 noting that it is of a high priority, and 1 as a low priority. The user experience component with a high priority will receive a higher focus on the prototyping of the system.

User Experience Components	Level of Priorities	Reason
Activity Tracker	2	The trigger for an activity tracker is needed to do the simulation of inactive state, however, it is not the main component of the system.
Display and Sound	3	Display and sound are an integral part of the system which has to be done in the realisation. These components relate to the engagement and interaction from the design requirements of the system.
Voice Prompt and Speech Recognition	3	Voice prompt and speech engine are an integral part of the interaction to the system and the system cannot do without this component. These components relate to the interaction and comfortable usage from the design requirements of the system.
Instructions	2	Instructions are an integral part of the system that could have received the highest priority rating of three, however, as the list of exercise are already available, this component's task is only to make a video of the exercise. This lowers the priority of the user experience components to two
Open the lid of the music box	1	This component would be nice to have, but it would not affect the purpose of the system if the system lacks it either, therefore, this component is more of a decoration feature.

Behaviour Change Technique	3	Behaviour change technique is an integral part of the system. The system needs to do more than just a decoration on the room, but an actual behaviour changing device for the elderly patient. This component relates to being persuasive to the user.

Table 1 Design Requirement Priorities

Early Prototype

Activity Tracker

For this component, an actual activity tracker is not used, instead, a manual input are tested. For the manual input, a combination of delay and mouse pressed are tried. As the P5 platform already has a mousePressed() function, the function does not have to be done manually.

Display and Sound

As the display and sound are one of the most important components, these features need to be made sure to works well. On the early prototyping, the screen and speaker used for the prototype are the laptop's screen and speaker. This is done to test the way the platform P5 handles images, videos and music. From this prototyping, it could be said that there are no technical difficulties for the platform to handle the images, videos and music. The P5 platform already handles the communication with the screen and speaker well, so there is not much work that needs to be done in this component.

Voice Prompt and Speech Recognition

The speech recognition is tested on its own first before being integrated with the rest of the system. The speech recognition uses P5.speech libraries to connect to the Google API and process the data, therefore there is a need for an internet connection for this setup to work. A local server was hosted using python command http.server, which allows for easy creation of a local host. Then the P5.speech library is tried and tested.

The text to speech works well and there is no issue with the text to speech engine. The speech recognition feature also works well, and it can mostly get what the user said, however, there are some further steps that are needed to set up the speech recognition. Originally, the speech recognition will start as soon as the web application starts, and if it did not have any data after five seconds, then it will stop automatically. This is not suitable for this project as the speech recognition are needed to get the user's command after the voice prompt. After looking through the documentation, a workaround that could solve this issue is to start the speech recognition after the end of the voice prompt.

Early Prototype and Feedback

This early prototype uses a laptop as the screen and speaker. A program was made to simulate the situation. A trigger by mouse pressed will lead to the system starting the music, afterwards, there is voice prompt and at the end of the voice prompt, the speech recognition starts. The speech recognition accepts a yes or no answer for the question of does the user want to exercise. For this early prototype, videos were not implemented, instead, there is only a picture of the exercise on display.

This prototype was reviewed with the supervisor of this project. From this prototype, some problems were found. The music was found to be interfering with the speech recognition if it is too loud, however, it still needs to be loud enough to be heard by the elderly. There should be a balance between the music and voice prompt, sometimes the voice prompt cannot be heard clearly. The supervisor also notes down that the elderly might not be able to understand the voice prompt if it is only played once, the voice prompt should be repeated so that the elderly can properly understand the context.

Another suggestion from the supervisor is the way the exercise was introduced. At that time, the exercise was introduced as an exercise, however, the supervisor proposed that it is done as a dance routine. The voice prompt to ask the user can be changed from, "would you like to do an exercise?" to something like, "can you follow the beat with your feet?". This is a good idea as the elderly will have less resistance to do a dance to the music rather than doing an exercise. The movement is the same, however, just by changing the prompt, the system can get a lot more motivation out of the user.

Conclusion

In this specification phase, the design priorities were made with the display and sound, voice prompt and speech recognition and behaviour change techniques have the highest priorities to be realised. Activity tracker and instruction component of the design receives a second design priority which means that it should be realised, but it is a comparatively smaller work compared to the highest priority components. The electrical and mechanical part of opening the box are deemed as the one with the lowest design priorities as it does not have any value added aside from decoration and nostalgic purpose.

The early prototype was done in this phase and has several key takeaways. Among them, the method of instructions will be changed into that of a dance or a movement following the beat instead of an exercise session. The voice prompt should be played more than once to avoid the confusion of the elderly. The volume of the music needs to be lower than the voice prompt so that the voice prompt can be heard properly. These takeaways from the specification phase will be part of the consideration while building the system in the realisation phase.

Realisation

This chapter covers the installation of the system as a whole, as well as the final prototype. The final prototype will be based on the results of the specification phase. Based on the specification of the system in the previous section, as well as the result of the early prototype, the framework of the system is updated. Figure 9 is the final designed framework for the system which will be the overview of what will be realised.

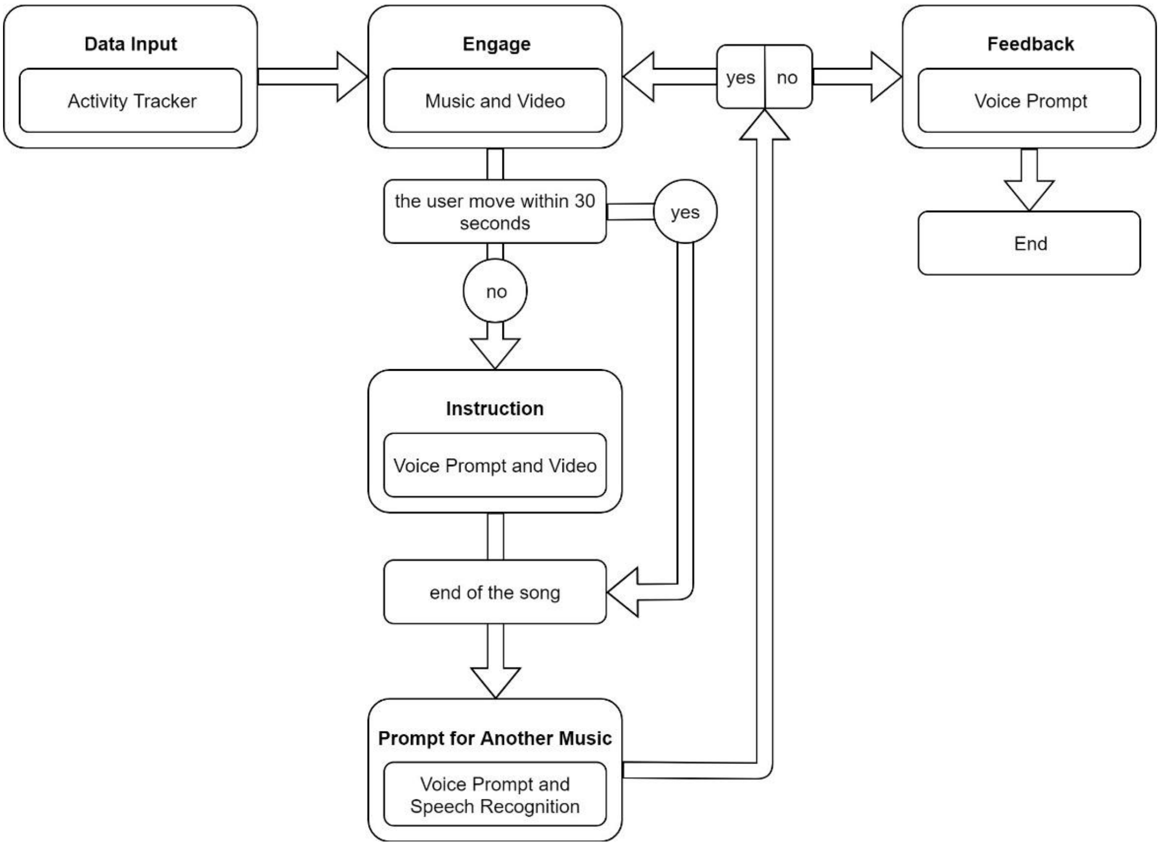


Figure 9 Framework of the System

As can be seen in Figure 9, the system will start by processing the data input from the activity tracker, in this case the activity tracker are done by manual input. The system will determine when the user has not moved by having a threshold of 30 minutes of inactivity, then the system will engage the user by playing some music. The user that starts moving their body before the threshold for the start of instructions will be left alone to move on their own. However, when the music has already played for 30 seconds and the user is still inactive, then the system will start playing some video along with a voice prompt asking the user if the user want to dance, and to follow the beat with a movement of the user's legs. The music will keep playing until the end of the song, where it will then start the prompt if the user wants another music to play. If the user want another music, the system will start another music for the user, however, if not then the system will give compliment to the user if the user moved.

Components

From the final framework of the system, the components needed for the system are decided. These components are listed down in this section.

Raspberry Pi

The components listed here such as the speaker, microphone and screen, needs a computer to work. The choice of computer in this project is a Raspberry Pi. The choice of Raspberry Pi was made because it is compact, a suitable size to be placed in a music box form factor. Even though the Raspberry Pi is compact, it is still full-featured, with the capability to handle the microphone, speaker and screen. The new Raspberry Pi also has a Wi-Fi integration, allowing for wireless connection to the internet. This will make for an easier implementation of the speech recognition which requires an internet connection to work.

Speaker

The music box needs to be able to engage the user. The design choices must be made while taking into account the fact that the target user is elderly people, and therefore, they might have a hearing impairment. As the Raspberry Pi also does not have an internal speaker, this leads to the choice to use an external speaker as the actuator of the system.

Microphone

The chosen method of interaction is speech recognition. Therefore, the needs of a microphone in the system. Speech recognition is chosen while taking into consideration the condition of elderly patients. Some of the elderly patients, mostly the one that just had their treatment for the hip fracture might not be able to move by themselves. A speech recognition system is suitable to be used in this case, so the elderly can do the exercise at their place and interact with the system by their voice. The Raspberry Pi does not have an internal microphone, therefore there is a need to use an external one. An advantage with an external microphone is that the microphone can be placed quite far from the speaker, therefore minimising the risk of having the music to interfere with the speech recognition.

Screen

The chosen screen for the music box is a small 3.5 inch diagonal, or about 8.89 centimetres. The screen has a resolution of 480 by 320. The compact size makes it suitable to be used in the music box form factor. This screen can be attached directly to the Raspberry Pi, it also has touch screen capabilities. The touch screen is useful as when it is on the music box, other peripherals such as mouse and keyboard are hard to be connected to the Raspberry Pi. The touch screen could to some extent replace the need of a mouse.

Software

P5 platform based on JavaScript is chosen for this project as it offers all the feature needed to do the project. The speech recognition and text to speech engine also use a library of the P5 platform called P5.speech. The software will handle all the mouse pressed action, delay, setting up the system, playing the video, and music. Everything will be handled by the software. The complete code for this prototype can be seen in Appendix A.

Voice Prompt

The voice prompt is using the text to speech engine, part of the P5.speech library. The voice prompts take care of the instruction of the exercise. As the voice prompts are spoken, the video of the exercise will also be played on the screen. The other part that is taken care of by the voice prompt are the feedback on the user's performance at the end of the song and the prompt if the user wants to continue listening to music. This prompt will be combined with the speech recognition to let the user choose to stop the music or let the music continue.

The voice prompts were set to be played at 70% speed of what normal text to speech engine does. The instruction voice prompts are repeated three times in consideration of the elderly hearing abilities. The other voice prompts that asked the user's choice of continuing the music will also be repeated when the system does not have an answer from the user within five seconds or if the answer given is not valid.

Speech Recognition

The speech recognition is used to get the command of the user. This feature is currently mainly used for the user to continue listening to the music or stopping the music. The system is set to recognise the keyword from the string that is the result. The keyword, in this case, is "yes" or "no", to indicate a positive and a negative command. In this case, this means that even if the user gives a different command such as "yes, please", the system can recognise the "yes" out of the string and get the intention of the user.

Installation

The installation of this system was done on several phases. This section will go through all the phase of putting the system together. The installation starts by having the software in the Raspberry Pi. This is just a simple file transfer to the Raspberry Pi.

The next thing to do is to set up the software to work in Raspberry Pi. It not only has to works, but the software was set to start automatically on bootup of the Raspberry Pi. On bootup, the Raspberry Pi is to set up a local server, and afterwards, start the software automatically. This was done due to several considerations. The system could turn on directly to the system, as well as eliminating the need for unnecessary interaction with the outside environment.

The screen did not work as soon as it is attached to the Raspberry Pi. Raspberry Pi default video output is through the HDMI output, not the input-output pins. The screen is attached through these input-output pins as it needs to be configured as it is a touch screen device. In order to configure this, there are some lines of codes that needs to be inputted to the Raspberry Pi. Figure 10 shows the codes used in the form of a code snippet. These codes get into the repository in GitHub to access the necessary file to install the driver. Afterwards, it commands the Raspberry Pi and to show it in a 3.5-inch LCD touch screen which is the device in this project.

```
sudo rm -rf LCD-show
git clone https://github.com/goodtft/LCD-show.git
chmod -R 755 LCD-show
cd LCD-show/
sudo ./LCD35-show
```

Figure 10 Code Snippet of Touch Screen Configuration

The speaker and microphone cannot both be attached directly to the Raspberry Pi as the Raspberry Pi only has one 3.5 mm jacks for sound. Moreover, this jack only has support for output, and not for input, meaning that it cannot access the microphone. The workaround for this project is a USB sound card with two 3.5 mm jacks, for input and output. This was connected to the Raspberry Pi with a USB extension cable due to the space inside the music box not allowing for a direct connection.

Prototype

The final prototype combines all components. Figure 11 is the final prototype, with all the components integrated into one device, the music box. The way that the system works, when inactivity is triggered, which means that the user has been inactive for 30 minutes, then the music will start. If the user still does not move when there is music, the system will then start the voice prompt so that the user can follow the beat with the directed movement. During the duration of the voice prompt, the music's volume will be lowered to help the user hear the voice prompt. The movement that the voice prompt is instructing will also be shown on the screen. At the end of the music, the system will ask if the user wants some more music, or if the user wants the system to stop. The speech recognition recognises the word "yes" or "no" from the spoken word of the user. After the user said their intention, then the user will continue with encouraging feedback if the user did any exercise.

Figure 11 Final Prototype

Evaluation

In this section, the realisation of this project is evaluated. The user evaluation was conducted, and the goal, method and findings will be discussed in this section.

Goal

The goal of this user evaluation is to find out the reaction of a user when the user interacts with the system. The effectivity of the system in getting the desired reaction out of the user needs to be tested and observed. There is also a concern about the comfortability of the user when in the presence of the system, therefore the comfortability of the user around the system will also be observed.

Method

The target audience of the system is elderly hip fracture patients. For the purpose of the test, the requirements of the participant are being elderly, specified by age 55 and older. The user test was done on five elderly people, with age ranging from 58 to 72. They have no hearing deficiencies and are not disabled, however, all of them do have vision deficiencies, which makes glasses a necessity in viewing a close object clearly.

A simulation of what will be happening in the real world will be done to the participant, with a bit of modification. The system is to start playing right away after touching the screen, because otherwise, waiting for the 30 minutes threshold will be too long. For this test, all voice prompt will be played, regardless of whether the user has moved before the instructions. This is done by not introducing the active state during the music. The simulation will be done twice, first without any instructions, and the second one after an explanation about the purpose of the system. There will be music and voice prompt during the test, the participant can respond freely to the system in any way they like.

During the test, the participant will be observed on how they react to the system, the main points that will be observed will be comfortability around the system, ease of use of the system, reaction of the participant to the music, reaction of the participant to the voice, reaction of the participant to the display. Before the start of the test, all participants are briefed according to the information brochure and are required to sign a consent form. Information brochure and consent form can be found in Appendix B and Appendix C respectively.

Results

The participant reacts comfortably around the system, their reaction to the question of would the participant be okay with having this system in their bedroom is positive. this might be since all these elderlies are used to smart devices, such as smartphones, on them and therefore this device is not something new.

The music brings some movement to the participants, without any instructions and introductions. On the first test 3 out of the 5 participants immediately starts nodding their head towards the music, with one more person soon follows after a few seconds. Some of them have reactions towards the music, some start moving their hands, knocking their finger rhythmically, and even two out of the 5 participants move their legs according to the beat of the music before the voice prompt starts. The first instruction voice prompt, which asks them to follow the beat with their legs, caught them by surprise, however, on the second repetition, everyone except for one managed to get the instruction and do it. The last one managed to follow on the third repetition. The video shown on the screen helps as they try to look at the movement on the video, however, it might be a bit too small as they try to adjust their eyeglasses to see clearly there.

The second test went smoothly for all participant, they were able to follow the instructions within the second try or less. This shows that with a proper introduction to the system, the elderly are more aware of what to expect out of the system. From observation, the participants sometimes are confused about what to do with only the voice prompt and they had to take a look at the screen to verify what they need to do. This shows the importance of the screen in the system, to make sure that the user is doing the movement correctly.

The user all managed to answer the voice prompt within three tries. The participants were caught unprepared on the first test where they are not properly introduced to the system, therefore one participant needs the third voice prompt to respond to the system properly. On the second test, however, three out of five participants manages to respond to the system on the first voice prompt and the rest on the second voice prompt. This test shows that the voice prompt and speech recognition are an understandable method of interaction for the elderly.

Some more interesting things from the observation of the participants, they follow the beat well, with four out of five of them have no problem following the beat of the music. The other one does not follow the beat of the music, however, she has no problem with doing the movement. One of the participants even expresses the desire to dance to the music, which is entirely up to them on the real-world usage, as that would be considered as an activity and the system will not have to suggest an activity to do. Some of the participants also ask for a personalised playlist because they have personal favourite music. They expressed that they feel like moving when they hear their songs being played.

In conclusion, the results are positive to the user evaluation conducted. The participant responds positively to the music, and they can do the interaction with the system. However, although they are enthusiastic in their movement, the movement sometimes needs to be directed to have the desired effects for the rehabilitation purpose. Those participants that only moved their hand or does not move at all needs to have some instruction so that they can know the type of movement that can help them get better while enjoying their music.

Discussion

Project Review

The research was started due to the high amount of elderly hip fracture patient in the Netherlands. The condition of rehabilitation for these elderly hip fracture patients are not ideal. The elderly patient receives at most half an hour of exercise time with physiotherapists every day, which is not sufficient for a good recovery. Therefore, the project goal was to design and develop a persuasive technology to help the elderly hip fracture patients self-manage themselves better. With this self-management technology, the elderly patient will hopefully be able to do exercise on their own free time, therefore maximising the rehabilitation period.

Through iteration, the realisation of this goal was in the form of a smart music box that asks the user to dance when the user has been inactive. The function of the final prototype was reviewed to verify the function of the system according to the project goals and design requirements. to start this evaluation, the display and sound will be evaluated. This component is a high priority in this project as it is responsible for engaging and interacting with the user. The display and sound in this system work fine. Based on the user evaluation, the sound from the speaker is loud and clear enough for the purpose of the system. The display, however, although functionally it works well and there is no problem with it, a 3.5-inch display is not suitable for real world usage with the elderly as it is a bit too small.

The voice prompt and speech recognition functionally work fine in this system. The voice prompt which utilizes text to speech engine from P5.speech library works with the music still playing in the background. However, the language is still in English, however, this can be easily changed by modifying the sentence that needs to be spoken to Dutch language and having a line of code setting(nl-NL) in the setup. The speech recognition was reviewed during the realisation as it previously showed signs of interference with music sounds. The microphone previously could have been too close to the speaker, and therefore the user's voice got drowned with the music. With the final design, the speaker and microphone are separated properly. On user evaluation, sometimes, there is still an error on voice recognition, where the system does not recognise the user's command, however, this might also be due to the participant's low voice.

The behaviour change techniques are implemented well on the user experience designs. It allows the user to connect the music by moving their body. However, there is still a need for a further review on the effectivity of this feature on the user evaluation as well as on long term evaluation.

The activity tracker is replaced with a manual input in this setup. The system uses the touch screen to indicate the inactiveness of the patient. This is just a setup for the final prototype as the project has no access to the activity tracker which are used in the nursing facilities. However, there is an advantage to this setup, the user could make use of the touch screen to start the music. If the user taps the screen, the system is notified of inactive state, this will then start the music. This feature could be taken into further iteration as a way for the user to start the music by themselves if they want to hear music and exercise. This feature could also be changed to speech recognition, however, to do that, the system must be always listening, this is something that will have to be discussed in the ethical review of the system.

The lid-opening mechanism ends up not implemented as it does not provide any added value to the interaction, especially in this development stage of the system. It is a cherry-on-top, something that would be pretty to look at, but otherwise does not necessarily affect the integrity of the system.

The user evaluation has a positive result with some feedback to further iterate the prototype. However, in this evaluation the demographics of the participants differs to the target user. First off, the participants of this evaluation are not hip fracture patients, and then the age is lower than the target user, the elderly hip fracture patient in the nursing home. This point might result in a different condition when the system is applied to the target user. With the gap of age, the elderly patient in the nursing facilities might face more physical deterioration compared to the participant of the user evaluation. The instruction acceptance of the elderly patient also needs to be further reviewed as due to the age gap, there might be different level of instruction acceptance and learning capability.

Difficulties and Limitation of the Studies

This project was an open-ended project where the possible implementation to find the solution of the project is endless, thus the background research done on this project is too broad. This is not effective as there is too little relevant knowledge that ends up being used at the realisation of the project compared to the amount that is written in the state of the art. If the background research is to be redone, then it might be better to focus specifically on what helps motivate a person to move.

In this project, one of the most difficult situations for the research is a language and culture gap that exists between the researcher and the targeted user. In order to design properly for the target user, the researcher needs to have an understanding of the user group. In this case, there are supervisor and friends that have supported in translating, as well as providing and filling in information that may otherwise be unknown to the researcher. However, the condition is still not ideal, as for example, to do the user testing to the elderly patient in the nursing home, then the Dutch communication skill is required. Due to this reason, the participant of the user evaluation in this project differs a bit to the target user.

Due to the limited time and resource of this project, research has been focused on the way of motivating the user and helping the user self-manage themselves. The other aspect of the system is discarded for efficiency. The activity tracker, for example, has been done manually which does not represent the real-world situation at all. However, this project also has no access to the activity tracker used in the nursing facility. To integrate an activity tracker to the system, taking an example of Fitbit, then there is a web API that can be used to get the activity data out of the Fitbit of a user. The maximum request rate for this API is 150 times per hour, which is enough to be used in this system, however, to get access to this API, the application that is going to feature the web API has to be submitted for registration at the Fitbit developer page.

Future Work and Recommendation

The prototype shows promise for further development. In the future iteration of this device, something that would be nice to have is a graphical interface for the physiotherapists to choose the suitable exercise for the patient. This could be in the form of a hidden menu where the physiotherapists have easy access to the choice of exercise. The physiotherapists can then select the exercises that they deemed to be suitable for the patient's condition.

Another feature which might be interesting to see is the inclusion of a Spotify web API to have a playlist of the user and play the user's choice of music. This is in accordance with the user evaluation's participant's request of having personalised playlist so that aside from just listening to music for exercising, they could have a device that doubles as a music player.

The speech recognition can also be extended, in accordance with having the device double as a music player, the speech recognition can be used as a trigger to start the music. The user can say for example, "play music" and then the system will start playing music, or the user can call a nurse through the system by speaking to the system. However, before this is incorporated, there is a need to do the ethical review of an always listening device.

According to the target user, the language has to be further refined. As it was said above, the language at the moment is still in English and it needs to be changed to Dutch to accommodate the market. The activity tracker has to be implemented as well before the system is ready to go to the market if Fitbit is used in the nursing facilities than the system needs to be registered to Fitbit to gain access to their web API.

Conclusion

The research tries to answer the research question of how technology should be designed to help improve self-management rehabilitation capabilities of elderly patients. The result of the ideation is a music box that is automated depending on the user's activity, to play music and remind the user about the user's inactivity. This idea allows for a persuasive, non-forceful method of not only reminding the elderly patients to start moving their body but also motivates them to do so.

The final prototype was functionally doing well, it also fulfils the design requirements. It can play music, display video, has text to speech engine for voice prompt and speech recognition to take the user's answer verbally. However, it is still not yet ready for real-world usage as it does not yet connect to any real activity tracker. Moreover, the language still needs to be changed to the Dutch language as it is currently still in English.

The prototype has been user evaluated and the result has been positive, the participants which are of similar demographics to the target user responds to the music box well, and the music is found to encourage them to move their body, especially if they particularly like the music. The screen performed well for them, however, there might be a consideration for a bigger screen to accommodate them better.

Finally, it can be concluded from this research that although not perfect the music box has shown to be a valid proof of concept. Music has shown that it can be a persuasive way to motivate elderly people to move their body voluntarily. Technology has been combined to help the elderlies do self-management on themselves. The combination of music and technology shows the possibilities to solve the situation of the elderly lacking the capabilities to self-manage themselves.

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Appendices

Appendix A. Code

HTML Code

```
<!DOCTYPE html>

<html>

<head>

        <meta charset="UTF-8">


        <title>Motivation management system</title>


        <script type="text/javascript"
src="https://cdnjs.cloudflare.com/ajax/libs/p5.js/0.8.0/p5.min.js"></script>

        <script type="text/javascript"
src="https://cdnjs.cloudflare.com/ajax/libs/p5.js/0.8.0/addons/p5.dom.min.js"></script>

        <script type="text/javascript"
src="https://cdnjs.cloudflare.com/ajax/libs/p5.js/0.8.0/addons/p5.sound.min.js"></script>

        <script type="text/javascript" src="libraries/p5.speech.js"></script>

        <script type="text/javascript" src="sketch.js"></script>


        /* full screen on web browser */

        <style type="text/css">

      body {margin:0; padding:0;} /* remove top and left whitespace */

      canvas {display:block;}    /* remove scrollbars */

      canvas:focus {outline:0;} /* remove blue outline around canvas */

      .fs {position:fixed; bottom:20px; right:20px;}

      #enter {display:block;}

      #exit {display:none;}
```

```
    </style>
</head>
<body>
</body>
</html>
```

JavaScript Sketch

```
var active = true;
var musicTime = 0;
var musicEnded = false;



var elapsedTime = 0;
var lastMillis = 0;
var inactiveTime = 0;
var inactiveReminder = 5000;

var promptCounter = 0;

var vidPlay = false;
var ex1;

var music;

let lang = 'en-US';
var voice = new p5.Speech();
var listen = new p5.SpeechRec();

function preload(){
  music = loadSound('assets/music1.mp3');
}
```

```
function setup(){
  createCanvas(windowWidth, windowHeight);


  voice.setRate(0.7);


  ex1 = createVideo('assets/ex1.mov');
  ex1.hide();
  //listen.continuous = false;
  //listen.interimResults = false;
}


function draw(){
  background(0);
  elapsedTime = millis() - lastMillis;
  //print('test');
  if(active == false){
    if(music.isPlaying() == false){
      music.play();
    } else if (music.isPlaying() == true){
      exercise();
    }


    inactiveTime = inactiveTime + elapsedTime;
  }


  if(vidPlay){
```

```
    image(ex1,0,0);
  }

  lastMillis = millis();
}



function exercise(){

  if (promptCounter<3){
    if(inactiveTime>inactiveReminder){
      if(vidPlay){
        ex1.stop();
        vidPlay = false;
      }
      music.setVolume(0.7);
      voice.speak('can you move your leg according to the beat?');
      voice.onEnd = null;
      print('prompt');  //prompt for instructions and videos
      promptCounter++;
      inactiveTime = 0;
      inactiveReminder = 5000;
      if (!vidPlay){
        ex1.loop();
        vidPlay = true;
      }
```

```
    }
  } else if (promptCounter==3){
    if(inactiveTime>inactiveReminder){
      vidPlay = false;
      ex1.stop();
      music.stop();
      moreMusic();
      active = true;
      promptCounter = 0;
    }
  }
}

function moreMusic(){
  voice.speak('would you like some more music?');
  voice.onEnd = listening;
  print('moreMusic');//voiceprompt for more music
}

function listening(){
  print('listening');
  listen.start();
  listen.onResult = getResult;
}
```

```
function getResult() {
  var positiveString = "yes";
  var negativeString = "no";
  if (listen.resultValue == true) {
    var str = listen.resultString;
    var positive = str.includes(positiveString);
    var negative = str.includes(negativeString);
    if(positive && !negative){
      print('positive');
      active = false;
      inactiveTime = 0;
    } else if (negative && !positive){
      print('negative');
      //feedback
    } else {
      print('undecided');
      moreMusic();
    }
  }
  //print(listenResult);
}

function mousePressed(){
  active = !active;
  inactiveTime = 0;
  print(active);
```

```
  print(music.isPlaying());
  loop();
}
```

Appendix B. Information Brochure

Information Brochure

Project Background

Elderly people who have to rehabilitate after a hip fracture often end up in a nursing home. The motivation for rehabilitation is present, the patients want to go back home as quickly as possible. Yet, a large proportion of patients do not do exercises on their own, something that is essential for not only a quick, but also an effective recovery. Therefore, this project has developed a system that can be installed in a patient's environment with the goal of reminding the elderly and supporting them in doing the exercises.

The designed system will come in the form of a music box. The system can play music and has an automated voice prompt to give instructions to the user. There is also a display on the system which will make the instruction easier to understand.

Goal

The goal of this test is to find out the reaction of a user when the user interacts with the system. The effectivity of the system in getting the desired reaction out of the user needs to be tested and observed. There is also a concern about the comfortability of the user when in presence of the system, therefore the comfortability of the user around the system will also be observed.

Target Audience

The target audience of the system is elderly hip fractured patients. For the purpose of the test, the requirements of the participant are being elderly, specified by age 50 and older. All visions and hearing deficiencies will be noted down.

Job Description

A simulation of what will be happening in the real world will be done to the participant. The simulation will be done twice, first without any instructions, and the second one after explanation about the purpose of the system. There will be music and voice prompt during the test, the participant can respond freely to the system in anyway they like.

Observation

During the test, the participant will be observed on how they react to the system, the main points that will be observed will be:

- Comfortability around the system
- Ease of use of the system
- Reaction of the participant to the music
- Reaction of the participant to the voice
- Reaction of the participant to the display

Information

If you have any further question or enquiry, you can obtain more information about the test or the project in the future by contacting the person below:

Kevin Rafael Indrawijaya
kevinrafaelindrawijaya@student.utwente.nl

Appendix C. Consent Form

Statement of Consent Form

Test Administrator : ______________________

The aim of this test is to evaluate the functional prototype that is used for improving self-management capabilities of older adults with a hip fracture.

During the test the system is observed to find potential shortcomings and improvements. The information gathered during the test session may be used in the research of this topic. Your name and personal details will remain anonymous.

You are allowed to stop participation of the test at all times. There is a test administrator next to you if you have any questions.

Statement of Informed Consent
I hereby declare that I have read the description of the test and my rights as a participant. I agree to voluntarily participate in the test.

Date : ______________________

Name : ______________________

Signature :

____