Simulating a bonding experience with digital animals for people with dementia

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ABSTRACT

In 2015 the installation, 'Closer to Nature', was developed which aims to offer a richer living environment to people with dementia by suggesting a connection with nature achieved through a simple tactile interaction: a water pump that pumps real water connected to a high definition screen that continuously sends a live feed of a rural location (farm) which shows video feed of animals (goats) being fed while interacted with it. The project described in this report elaborates further on the installation, making it more interactive by integrating learning algorithms. The project specifically aims to reduce the loneliness of people with dementia struggle from when they need to live in care facilities. A design-oriented approach was taken to design a system that recognizes the user, enables a bonding experience between the animal (dog) and the user, and makes a tactile interaction possible with the user. The learning algorithm used is the 'systematic sampling with unequal probabilities' algorithm, which adapts the likelihood for a video to be shown according to the preferences of the user whose attention span and happiness is analyzed by the Omron Face Detection Sensor and saved for the specific user. Next to that an interactive prototype, a fetching ball dispenser mechanism in which a ball can be put whereafter a virtual ball is thrown on the screen, was created to simulate the 'fetching' game between the user and the digital dog of the system. Currently, the effectiveness of system on reducing the feeling of loneliness by simulating a bonding experience between elderly people with dementia and the system cannot be proven right or wrong, since the system has not been tested yet.

1. INTRODUCTION

"Dementia is a serious degenerative neurological condition that affects cognition and memory. Depression and anxiety often accompany Dementia. As their explicit memory deteriorates, implicit memory remains, so tactile interaction becomes increasingly important to people with Dementia." [1]

In 2015 an installation, called "Closer to Nature" has been built with " the aim to offer a richer living environment to people with dementia living in a care facility, through suggesting a connection with nature. This is achieved through a simple tactile interaction: a water pump that pumps real water. The concept consists of a high definition screen that continuously sends a live feed of a rural location. This allows the residents of the care home to gain implicit information about the weather, time of day and season of the year. Once the system detects that a resident of the care home is interacting with the pump, it sends a video feed of the animals being fed. This interaction suggests a kind of caring action or fulfillment of responsibility which might give a resident a positive self image. Due to the low engaging threshold and the simple interaction this installation should be attractive in several stages of dementia."[1]

In the Master course DBM140 Embodying Intelligent Behavior in Social Contexts offered by the faculty Industrial Design at the Eindhoven University of Technology, students are asked to embody learning algorithms in meaningful everyday-life applications [2]. Until now, learning algorithms are not used in the "Closer to Nature"-system as described. Therefore a concept was developed as an expansion to the "Closer to Nature" concept using such learning algorithms. The aim is to create a personalized interaction between the elderly living in a care facility and technology using learning algorithms to improve the quality of the interaction and function of the technology.

As a result a system was created which aims to enhance the bonding experience between the elderly and digital animal through recognition and a personalized reaction from the digital animal. In this case a dog was chosen to be the animal to interact with. Right now the system recognizes the users who are interacting with the system by asking the 'researcher' who the user is. Via the Omron

Face Detection sensor the attention and happiness of the user is recognized. Videos of the dog with several categories are shown to the user via the high definition screen. The learning algorithm 'systematic sampling with unequal probabilities' is used to learn the preferences (which video categories are liked or disliked) of each specific user and save it for use in follow up interactions. At last a physical playful interaction is added with a ball mechanism: the user can put a ball in a hole and subsequently a digital ball (video) will be thrown for the dog to fetch and bring back, after which the ball will be released by the mechanism again.

1.1 Vision

The memory of embodied intelligence is endless, but it needs a learning algorithm and training from humans in order to understand and interpret the given data correctly. Especially concerning social intelligence, as this can be complex and has many forms of sensory in- and output.

"*From both theoretical and technological perspectives, social computing technologies will move beyond social information processing toward emphasizing social intelligence*." [3]

It can store more data and therefore experiences, thus will outpace the experience of a human being. This can bring the embodied intelligence in the position of being better equipped for social interaction and decision making based on previous experiences than humans. However, as circumstances change, it should always be adaptive to the environment and thus continuously use a learning algorithm.

We believe that the ability to store endless amounts of data can bring the embodied intelligence in the unique position of memorizing every person it interacts with. This enables the embodied intelligence to learn to understand user-specific social cues and adapt its interaction to the personal needs and preferences of the user. Storing the user's preferences and using this in the interaction can facilitate in a meaningful experience and better collaboration between user and embodied intelligence. With this vision on embodied intelligence in mind, we want to enable personalization of the interaction between the system and the user, as our hypothesis is that this will lead to more interaction and a bonding experience between user and system.

1.2 The problem statement

The core problem that motivated the development of the first concept of the Closer to Nature system is the limited mobility of elderly people suffering from dementia, living in a closed facility of an elderly care home. The existing Closer to Nature system was designed to provide a view of the outside world and stimulate a virtual way of interaction with animals. The goal of this project is to explore and expand the possibilities for a closer interaction between the elderly and nature.
The points of improvement that were formulated, based on the existing design, are to:

- Enable multiple distinct types of interaction;
- Allow more than one person to interact with the system;
- Enable the development of a bond between the user and the animals/system;
- Allow interaction between the user and the system in both ways.

The main goal of the improved design is to better facilitate interaction between elderly with dementia in care homes and nature through personal bonding to decrease loneliness. From these points, an improved design was proposed, using the screen-based interface from the original design, as well as two new sensory input functionalities. It is assumed that offering an increased variety of options for interaction with the system, will appeal to a broader group of users.

Firstly, the system is equipped with an Omron Face Detection Sensor, which can distinguish individuals, their preferred type of interaction, as well as their emotional response to these interactions. The technical specifications will be discussed later on. The development of a bond between the user and the system is considered to be important for the reason that this mimics the natural relation between humans and domesticated animals.

To allow for a more reciprocal way of interaction, a fetching ball dispenser mechanism was added. 'Throwing' a ball into the dispenser triggers a response on the screen, in the form of a video showing a dog fetching a ball. Linking the physical interaction with the virtual videos, provides the users with more elaborate feedback on their actions.

These interventions give the elderly a wider range of interaction possibilities, catered to their interests, physical conditions, mood, etcetera. In a broader perspective, the impact on the emotional health of the elderly can be significant, as it lessens their feeling of being restricted to the walls of the care home.

1.3 Related work

As researched by Banks, Willoughby & Banks (2008)[4], the interaction with a robotic or living pet can significantly reduce loneliness amongst elderly in long term care houses. When comparing the use of robotic versus living dogs in long-term care facilities, living dogs score higher on 'animal rights/animal welfare', but they scored the same on 'general attachment' and 'people replacement'. Therefore, it was concluded that robotic dogs can have the ability to combat loneliness amongst elderly in long term care houses by focusing on attachment and bonding.

The research on the effect of animal-assisted therapy (AAT) on loneliness among elderly in long-term care homes by Banks and Banks (2002)[5] shows a clear relation between the level of loneliness that the elderly experience and the frequency of contact with pets. The questionnaire-based research on these effects can also be applied in this project to evaluate the impact of the design presented in this paper. Determining the UCLA-LS loneliness scale

developed by the University of California Los Angeles (UCLA) both before and after using the Closer to Nature system provides an insight in whether and how users' social behaviour and feeling develop over a prolonged period of time.

2. Background information

In this section of the report the approach, primary social behaviors and learning algorithm are described.

2.1 Approach

A design-oriented approach was taken to design the system. To change the emotional state of the user and the attitude towards an animal 'behind a window' the in this paper described system was designed. The animal used is a dog due to the fact that the dog is one of the most common pets in Dutch households [6] and because of the intensity of the emotional connection which many dog owners experience. [7] The system uses an interesting technological solution, namely a gaze sensor. This sensor determines the happiness of a user and if the user is interested in / looking at the window. Furthermore the system should in the future recognize the user, now this is done by a researcher. The system uses the data from the sensor and determines the interest of the user in the animal. And as the animal is showing various behaviors, actually the interest in the way the animal is behaving is measured. This way the system learns to recognize the behaviours of the dog that the particular user likes. The system uses this knowledge to make certain behaviors appear more often. This is similar to how a dog learns (conditioning) in real life situations - positive reinforcement. [8] As the user can not touch the animal behind the 'window' the positive reinforcement does not consist of petting or feeding the dog but rather it consists of smiling and showing interest in the dog's behavior. In real life the dog reacting to a human creates a bond, especially if the dog shows positive behavior (behavior that the human likes). [7] To increase the bonding and interaction with the dog a physical ball can be thrown / rolled into a doggy door, the ball continues it's way digitally on the screen and the dog brings it back.

The approach starting with a design goal related to changing behaviors and attitudes, and a technology related approach later on in the project of using learning algorithms and sensors to create this bond is optimal as this personal bond can only be created by getting to know the specific user's preferences and behaviors and reacting to these. To get to know these preferences learning is necessary and learning algorithms are key.

2.2 Primary social behaviors

The system mainly supports interaction between user and agent. However, the system will probably trigger interaction between users as well. For example through joint attention the users could exchange feelings on the bond established with the dog or show their intention to each other to start playing with the dog. It could be that they share memories with each other from the past about emotional connections they may have had throughout their lives with a dog.
Next to joint attention, the concept includes several primary social behaviors, such as eye contact, turn taking, actions towards common goal, reading and responding to mental states and emotions.

Eye contact
There is no initiative from the system to make eye contact with the user. However, the dog looks at certain moments in the camera, for example while waiting for a ball. If the user is looking at the screen during those moments, it can be interpreted as eye contact between the subject of the system, which is the dog, and the user.

Joint attention
The system recognises when there is joint attention of two or more individuals. The system then plays the movie categories that are enjoyed best in the state, where there are multiple individuals present, in order to hold their attention as long as possible.

Turn taking
Taking turns is slightly part of the system in a way that if there are multiple individuals present that want to throw the ball for the dog, they need to wait for the dog to bring back the ball. If the ball is brought back, someone else can play 'fetch' with the dog. In real life dogs can take the ball to the person they want to play with. However, the dog of this system cannot determine whose turn it is to throw the ball, as the door through which the ball is brought back has a fixed location.

Action towards common goal
The goal of the subject of the system, in this case the dog, is to befriend the patients whom are living in the care home. When the patients start interacting with the system, they will hopefully have a good time when seeing and playing with the dog. The result could be that that they start bonding with the dog and see the dog as their friend.

The system also embodies some complex social skills, like collaboration and provoking emotion.

Collaboration
When someone throws the ball, the dog needs to fetch it first in order to enable the possibility to throw the ball again. This can be seen as some kind of collaboration between user and system to complete the game 'fetch'.

Provoking emotion
The dog shows behaviors that are meant to provoke happiness among the viewers. It learns by positive reinforcement, which is based on the user having attention or even smiling, which behaviors provoke happiness by that particular user. The behaviors, provoking happiness, can vary per user.

2.3 Learning algorithm

An important requirement for the algorithm is that it facilitates personalization. The concept consists of multiple movie categories of a dog and the aim is to find the categories for each specific user which it prefers to play.

The gaze and smile are used as input to determine if a user likes the video, but how much they affect the preference of a movie category is up to the system to learn. Since preferences for a movie category can change according to the elderly's moods and the social setting (e.g. whether he or she is accompanied by other people), the system needs to continuously learn from the user. To ensure that the movies are not fully predictable, it is essential to offer the movies in a randomised order and include this in the algorithm. However, the chance of a movie category being chosen should not be random, but adapted to the user's preferences. To keep variety in the interaction, the algorithm should not allow for movie categories to disappear completely.

Extensive research has been done on a wide range of deep learning algorithms, these cannot fulfil the steps necessary to realise an automatic learning process for choosing movies and link this to user behaviour and responses. There are three main branches in machine learning; supervised learning, unsupervised learning and reinforcement learning.

In unsupervised learning data is freely structured by the algorithm into a summarized version of the data, by finding relationships within the data itself. The algorithm can for example divide a large group of people using their height, clothes or sex and all outcomes will be equally as good as there is no supervisor present to judge it. Unsupervised learning algorithms is not applicable to our system, as there is no labeling needed in a the incoming data.

In supervised learning the algorithms extracts information from already labeled data sets, so that it can label new data sets on its own. For example, the algorithm knows from provided labeled data sets what a banana looks like on an image and what an apple looks like, so when it receives a new image of a banana, it can classify that image as banana by itself. There is no example data set present to train the system of this concept and no new classification needed, therefore the unsupervised learning algorithms are not applicable.

In Reinforcement learning there is no supervisor that tells the system whether something is good or bad, but a trial and error process with a reward signal at the end. Thus the feedback is not instantaneous. Most importantly, the agent gets to take actions and influences the environment, which affects the subsequent data it receives. Q-learning is a form of model-free reinforcement learning. It is task-oriented, in which every combination of state and action is assigned a value and based on using comparing two estimates of a Q -value to improve the estimate. Reinforcement algorithms do not fit our requirements perfectly, as our outcome is not a specific goal to work towards.

The algorithm that was considered most suitable, is the 'systematic sampling with unequal probabilities' algorithm. This is a statistical method rather than a learning algorithm. The algorithm randomly chooses a number of the total and can then identify to which movie category the number belongs. The amount of numbers within the movie category changes according to the user's preferences. The more the video is liked by the user, determined by the time the user watches and smiles, the more numbers the system assigns to the movie category, as can be seen in figure 1. The benefit of the systematic sampling algorithm is that it is able to dynamically determine which movie and movie category to show, learn from the emotional responses of the user and adapt the probability of displaying a certain movie category to this.

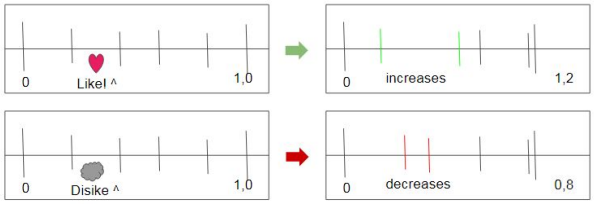

Fig. 1 A visualisation of the used algorithm

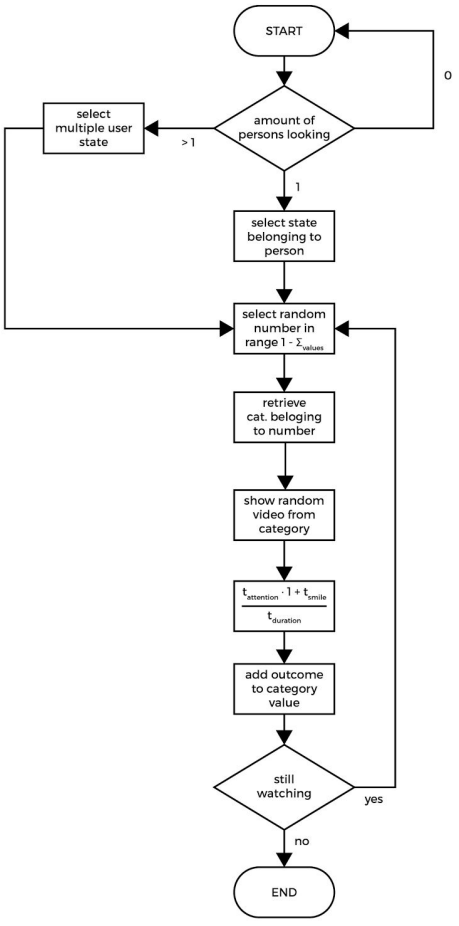

Fig. 2 A flow diagram of the used algorithm

3. The system

In this section of the report the social context in which the design is envisioned and the complete system (the program

and the complete prototype) are described.

3.1 Design of the interaction - the social context

The context of this project takes place in the elderly care facility called 'Vitalis', based in Eindhoven, NL. The previous version of the 'Closer to Nature'-system is installed in the facility. The system is placed in the living room a closed living environment for elderly with dementia. The elderly people can interact with the current system by themselves or with a caretaker.

In general, animal therapy provides a joyful experience for those elderly who live in the care homes because they usually respond positively to animals [9]. Some residential care facilities allow their residents to keep pets or provide animal therapy with help of outside organisations that bring farm animals and other animals to the care homes. However, people in dementia care facilities lose the ability to care for their animals as their dementia progresses. Furthermore, allowing animals in the care home might compromise the sanitation conditions or might burden care providers with the care of these animals.

The system 'Closer to Nature' aims to bring a connection with nature back to the facility, since nature and animals have a positive effect on the emotions of residents living in the care facility and it is complicated for care providers to facilitate interactions with animals or nature.

This project aims to not only bring nature to the elderly people in care facilities, but also add a bonding experience with the aim to reduce the feeling of loneliness by creating a bonding experience.

To stimulate the bonding experience, the new system makes use of a (digital) dog, as mentioned in section 2.1. The bonding experience is further enhanced by using recognition and personalized reaction. For example, after a period of time the dog (the system) will recognize the user and greet the person in such a way. Secondly, the dog (the system) will know whether the user likes a more active dog or a more quiet dog, and responds to the user in such a way.

More specific, there are four types of interaction possible with the system.

- Nobody is interacting
- A new person is interacting
- A familiar person is interacting
- Multiple people are interacting.

Right now the system cannot add a new person on its own and it cannot recognize who of the familiar users is interacting with the system. For this it needs to ask the 'researcher'.
To create a strong bonding experience for each of the interactions, these interactions are treated separately, which will be further described in the next section (3.2).

To further enhance the bonding experience, a more tangible interaction is added to the system, by means of including the possibility to play with the dog by throwing a ball. This interaction also allows for sensory stimulation, which has a positive effect on the people living with dementia, since their explicit memory deteriorates and implicit memory remains, so tactile interactions become more important [10]. This is explained further in section 3.2.

3.2 Intelligent behavior and embodiment.

The backend of the system
The arduino program reads serial data, received from the OMRON gaze sensor. The values that are received are interpreted by the Arduino program. By looking at the data received by the Arduino we found that the sensor recognizes a user when he/she looks at the screen; looking in another direction doesn't enable the sensor to determine the gaze of the user. The data, concerning where the user is exactly looking (up / down / left / right), is not necessary, as the user is either looking at the screen or not. If the user is not looking at the screen, the sensor doesn't recognize a gaze at all.
The other data, generated by the sensor that the Arduino interprets, is the level of emotion shown and which emotion is shown. As only happiness was determined quite accurately it was decided to use happiness as an extra indication to determine if the user is enjoying the video; this data is used on top of the data, which determines the attention of the user towards the screen (if the user gazes in the direction of the screen and, with that, has attention for what is happening on the screen).

To interpret if a user is showing happiness, the amount of emotion shown and the emotional value should be between certain values. To test which values, various people tested the sensor by making different happy faces (smile, big smile, laughing). The extremes of those values were taken to indicate the borders. Meaning that any indication of happiness is seen as happiness; this is because people standardly look more neutral (or angry or sad) than they look happy and if they are alone, smiles are less extreme, as smiling is a social indicator. [11]

Furthermore, the arduino checks if a ball is thrown in the doggy door (in the prototype this is the hole above the doggy door) by means of a pressure sensor. When the ball is thrown into the hole the ball is kept in the prototype by means of an electromagnet keeping the doggy door closed; the ball is kept inside the prototype until the dog has returned the ball in one of the movies.

The data in the arduino is sent as 3 integers. One integer states how many people have attention for the prototype, one integer states how many of these users are happy and the third integer indicates the presence of the ball. In Processing this data is used to determine what to do. When one person has attention for the prototype Processing indicates to another Processing (through OOCSI) that one person is looking and that it wants to know who. A question appears in this Processing screen.

The researcher can pick which user is watching, which is then sent back again through OOCSI.

In the meantime the Processing program, which is connected to the gaze sensor, started counting how long the user is watching and how much of that time he/she smiles. Per movie that is played of the dog, (the time the user has attention * 1 + how much of this time the user smiles) is divided through the duration of the clip. This means that smiling has a huge effect on how much the video is liked. The reason for this is because smiling doesn't happen that often and is less extreme, as explained before. The plus 1 is necessary because otherwise likability of the video will remain 0 if the user doesn't smile while attention also indicates interest. The value that follows from this calculation is between 0 and the duration of the video+1.

This value is saved for the person that is watching at the end of each movie (also if the person discontinued watching during the video). The value is added to the value that is in the .csv file this value describes how much the video category that the video is in, is liked by the user. If the user likes the video better the value increases more due to the longer watching time of the user and the amount of smiles. Then a new video is picked to be played. Which video is picked, is determined by the algorithm using the values that the program saved before. As the value of a video becomes bigger for one category of movies (could also be done for each movie individually) the likelihood of that category being picked becomes larger. This is done by means of chance. The likelihood of each category is divided by the total of all categories. Then an Array is filled with category numbers. The percentages of the category numbers in the Array and the likelihood of a certain category are interdependent. A random position in the Array is picked and the number at that position becomes the category of movies that should be played. The higher the appeal of the movie, the more often the category number repeats in the Array and the bigger the chance the category is picked.

For multiple people having attention to the screen the same principle is used. The difference is that here the value is saved under 'multiple users'. This will eventually result in knowing which videos keep the attention of multiple users best.

When a user starts watching this is also saved under 'videos that attract users' this will eventually result in the system playing videos to attract users (using the same algorithm) This way users are invited to interact with the prototype.

By using the sensor in this manner, the data that is generated is properly handled by the system to fit the design goals.

Playful interaction

A tactile interaction was added to the system embodying 'retrieving' with the digital dog. A prototype (Figure 3) was built which included a hole where the user can put a ball into and a small 'doggy door' which can hold and release the ball. After a user has put a ball into the prototype and the system will show a video in which a ball is thrown for a dog to fetch. After the dog has brought it back the system will release the ball in the prototype by opening the doggy door.

The system uses an electromagnet to hold and release the doggy door. Secondly it uses a Force Sensitive Resistor to know whether a ball is put in the system or not. The files for laser cutting can be found in Appendix A.

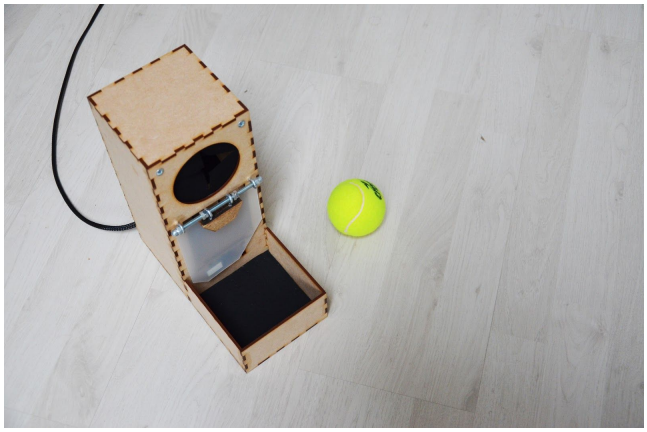

Figure 3: *Ball-mechanism*

3.3 Testing and analysis

The main goal of this design is to better facilitate interaction between elderly with dementia in care homes and nature through personal bonding to decrease loneliness. A second goal was to enable interaction between multiple people and the system. Three parts of the main goal are in need of testing:

- Does this design better facilitate the interaction between elderly with dementia in care homes and nature, compared to the original design?
- Does this system enable users to develop a personal bond with the system?
- Does this design decrease loneliness, with an emphasis on including personalised interaction?

The ideal, and the only realistic testing environment is the elderly care home that the concept was designed for. Especially when designing a system for a niche user group such as elderly with dementia, the user group cannot be substituted or simplified, as the symptoms related to dementia are diverse and differ from person to person. Regarding the timespan in which the system is tested, it is beneficial to observe the user's' interaction behaviour for several weeks or even months, to be able to conclude how their behaviour changes over time when using the system.

An aspect that requires attention when evaluating the implementation of the new design, is whether adding a broader spectrum of interaction possibilities better facilitates the interaction between nature and the user group, compared to the original design. Especially adding a two-way interaction. Better facilitating interaction is defined

as the system being more appealing for the user to use. The hypothesis is that the two-way interaction in combination with the other video categories appeals more to the user compared to the previous single, one-way interaction. This can be validated using two groups: 1 and 2. Group 1 starts with using the original system, which has only one type of interaction. Group 2 starts with using the updated system, including the playful interaction and other categories. Halfway during the test, the groups switch system. To limit cross-over effect, it was decided to make use of two groups and let them test the systems in opposite order. To determine how appealing a system is, a combination of amount of times a system is visited and duration of the visit is used.

The goal to facilitate personal bonding between the user and the system needs validation. The hypothesis is that the personalised interaction leads to a bonding experience. To personalise the interaction, the learning algorithm is used to determine which interaction category pleases and engages the user most. However, to verify that a personal bond is created, a questionnaire needs to be developed in collaboration with an expert on measuring user-product bonding experiences.

Key to the success of the improved design is whether the Closer to Nature system reduces loneliness amongst elderly with dementia by personalising the interaction. Especially for validating this part of the concept, it is crucial to test the design over a prolonged period of time, since the system needs to be used on a regular basis to enable personalisation. Loneliness can be measured using the standard questionnaire UCLA [5]. Three groups are created for this test; 0, 1 and 2. Group 0 is the control group and will not interact with the system. Group 1 uses the system, but without the learning algorithm. Group 2 uses the system including the algorithm. First, the loneliness base line needs to be established, thus all participants need to fill in the questionnaire before the test begins. After the the participants interacted with the system accordingly over a longer period of time, the questionnaire will be filled in again, so differences can be measured. The hypothesis is that the system including the personal interaction reduces loneliness the most.

The multi-user interaction that was proposed at the start of the project is less pronounced in the final design. While this can therefore not be tested and validated, it is wise to observe whether users attempt to approach the system with multiple persons, or whether the interaction of one user triggers the curiosity of others.

4. Conclusions

Currently, the effectiveness of system on reducing the feeling of loneliness by simulating a bonding experience between elderly people with dementia and the system cannot be proven right or wrong, since the system has not been tested yet. It would be recommended to test the system further to generate enough data to analyse.

The system proposed in this research contains all features needed to perform valuable research and functions as a solid base for future research. It enables multiple distinct types of interaction, allows for more than one person to interact with the system, enables the development of a bond between the user and the digital animal (dog) and allows interaction between the user and the system in both ways. The Omron Face Detection Sensor ensures that the recognition of and the detection of the state of happiness of the user is possible. Secondly it detects how many users there are and their states of happiness. Subsequently, through a learning algorithm the preferences of the user(s) is altered and saved to user in future interactions, with the aim to simulate the bonding experience. Interaction in both ways is allowed by the prototype by giving the user the opportunity to 'throw' the ball for the dog to retrieve.

Also, the in class presentation session showed that the concept was experienced as enjoyable and understandable by the audience. This presentation has shown that the system in current state can create a positive environment.

5. Discussion

Our vision on embodied intelligence is that the ability to store endless amounts of data can bring the embodied intelligence in the unique position of memorizing every person it interacts with. This enables the embodied intelligence to learn to understand user-specific social cues and adapt its interaction to the personal needs and preferences of the user. Storing the user's preferences and using this in the interaction can facilitate a meaningful experience and better collaboration between user and embodied intelligence. Our goal was to enable personalization of the interaction between the system and the user, as our hypothesis is that this will lead to more interaction and a bonding experience between user and system.

The function of the current algorithm is to personalize interaction with the user by using their gaze and smile as input. This is a first step in developing social intelligence, but it can be taken much further in the future as there are many more social cues that need to be included to approach the level of social intelligence of a human being. Important forms of input that are needed to understand different emotions and better adapt interactions with a user, are for example facial and voice recognition, touch, and the user's posture. In the future it might even be possible to go beyond social cues and use heart rate and neurological input, such as dopamine in the system. Processing all the social cues and adapting the interaction requires a combination of multiple learning algorithms. When the system can gain a better understanding of the user, it can for example compare the user's preferences to those of others, and use this to give recommendations. Using such recommendation, algorithms can speed up the personalization process, as the system does not need to test all possible options.

Multiple types of interaction

One of the goals was to offer a variety of interactions with the system rather than one, so that the user can have its preferences. In the current system there is one interactive game that can be played and multiple movie categories that can be watched, thus there is a greater variety.

However, there is currently only one interactive game that can be played. This can be further elaborated if it is proven to be a success.

Developing a bond
Using background information we have the hypothesis that the system will facilitate a bonding experience. However, this claim has not yet been tested, therefore it is unknown if elderly will develop a bond with the dog.

Interacting with multiple people
At the moment the system does not respond to multiple people. It only opens a different algorithm, so it can determine which movie categories please multiple people the longest.

Visuals output improvements
The current videos have different start and end frames, which disrupts the flow when watching. To improve the flow between videos, they need to be remade using the same start and end frames.

Tactile experience improvements
In its current state, the prototype is relatively small as it is a first prototype to demonstrate how the system would work. The prototype worked well as demonstrator, although in the future it could benefit from the following improvements.

The speed of the reaction system when a ball is put into the prototype could be improved. At the moment there is a small delay between the moment when the ball is put into the prototype and the ball being virtually thrown on the screen.

Secondly, the prototype could benefit from an improved continuation of the physical ball throwing to the digital movement by means of making the ball digitally be thrown away from about the same spot as the ball is put into.

Also, the throwing movement could be improved by making the prototype in such a way the user can really throw the ball instead of putting it into a hole.

Digital experience improvements
The change of movies should go fluently. This way the chance that the change in movies is noticed by the user is reduced to a minimum.

Learning algorithm improvements
At the moment, during long movies, the value indicating how appealing the movie is considered by the user, can be relatively higher than during short movies, if the user is smiling constantly. This is caused by the multiplier. Such a difference between long and short movies is not desired and should be improved in the future. However, as the chance is quite small that the user is smiling constantly, this is not a big problem when testing the workings of the algorithm and determination of how appealing the movie is.

Future vision
Multiple animals
In its current state only one dog is shown. The system might benefit from using multiple animals for the elderly to choose from to bond with, as this gives more room for personalization of the interaction.

More advanced interaction
Next to that more interaction might be created by adding the possibility to train your own animal. A dog can learn tricks, which also might enhance the bonding experience.

Multimodal feedback
The system at the moment only shows videos with no sound. The experience of the system could be improved by involving sound and maybe even smell.

Tactile experiences
At the moment only a ball is used to give the opportunity to the elderly to interact with the system. More toys could be added to enhance the tactile experience of the system. For example, a squeaking toy can be included to get the attention from the digital dog.

6. REFERENCES

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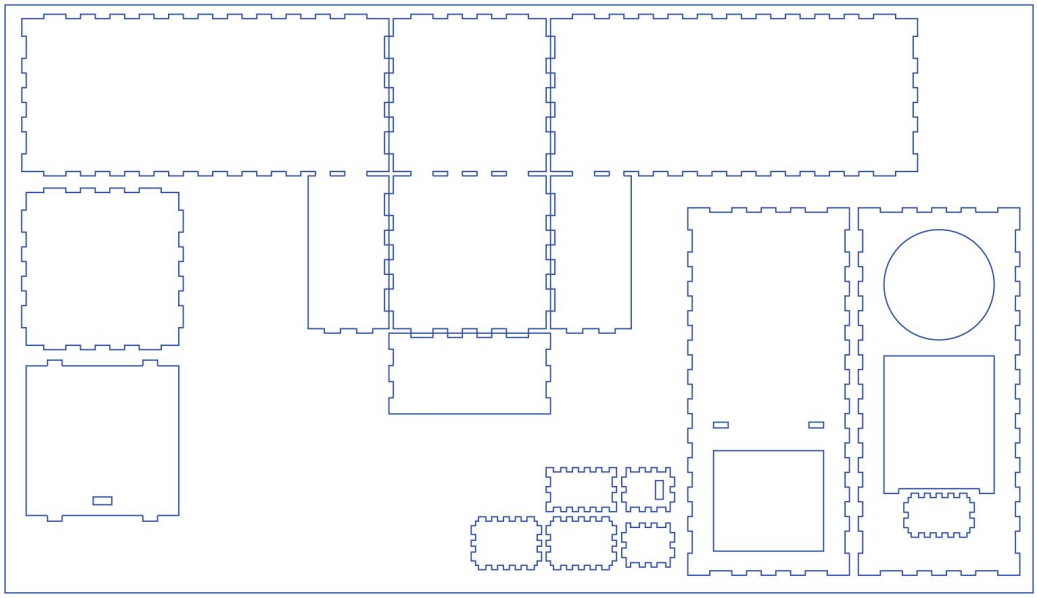
7. Appendix

[A] Improved lasercut model of interactive ball mechanism



Scale: 400mm x 700mm

[B] Processing Code OOCSI

Look in team8_code_appendix.zip file

[C] Processing Code Algorithm

Look in code_appendix.zip file

Main code
Look in team8_code_appendix.zip file

Data class
Look in team8_code_appendix.zip file

[D] Arduino Code

Look in team8_code_appendix.zip file

[E] Data Used For Processing

Look for the data, which includes all used movies and a CSV file in team8_data_code_appendix.zip file