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Lorena Parra Boronat, Universitat Politecnica de Valencia, Spain

AMBIENT 2022

Forward

The Twelfth International Conference on Ambient Computing, Applications, Services and Technologies (AMBIENT 2022), held between November 13 and November 17, 2022, continued a series of events devoted to a global view on ambient computing, services, applications, technologies and their integration.

On the way for a full digital society, ambient, sentient and ubiquitous paradigms lead the torch. There is a need for behavioral changes for users to understand, accept, handle, and feel helped within the surrounding digital environments. Ambient comes as a digital storm bringing new facets of computing, services and applications. Smart phones and sentient offices, wearable devices, domotics, and ambient interfaces are only a few of such personalized aspects. The advent of social and mobile networks along with context-driven tracking and localization paved the way for ambient assisted living, intelligent homes, social games, and telemedicine.

We take here the opportunity to warmly thank all the members of the AMBIENT 2022 technical program committee, as well as all the reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and effort to contribute to AMBIENT 2022. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

We also gratefully thank the members of the AMBIENT 2022 organizing committee for their help in handling the logistics and for their work that made this professional meeting a success.

We hope that AMBIENT 2022 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the field of ambient computing, applications, services and technologies. We hope that Valencia provided a pleasant environment during the conference and everyone saved some time to enjoy the charm of the city.

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Customizability in Preventing Loss of Interest in Ambient Displays for Behavior Change

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***Abstract*—Ambient displays are effective for behavior change; however, their prolonged use may cause users to lose interest in the content and fail to change to desirable behavior. We investigate two methods of presentation customization to address loss of interest caused primarily by habituation to the system: 1) incremental and ad hoc customization and 2) initial and goal customization. These methods were incorporated into a prototype system designed to avoid a sedentary lifestyle at home. A 36-day user study revealed that effective methods varied depending on users' motivation for using the system. Issues related to customization and user feedback and directions to improve the loss of interest caused by distrust of the system were identified.**

Keywords—ambient display; behavior change; customization.

I. INTRODUCTION

People are encouraged to change their behaviors in everyday situations, such as behaviors to prevent the spread of CoVID-19, promote health (e.g., dieting and smoking cessation), and save resources to avoid global warming. To positively change their behavior, they must be appropriately motivated according to their current situation. Target behaviors can be quantitatively monitored using sensors installed in wearable devices and the environment. However, this information must be easily accessible, and motivating factors should be communicated for effective behavior change.

Several studies on ambient displays exist [1], intuitively making information understandable by mapping it onto virtual creature illustrations, light and sound patterns, and physical form changes, rather than numerical values or graphs. An ambient display is recognized as a part of an environment, such as an object or a painting, which is always activated as an independent system, rather than being used as an application that is activated each time information is checked. Ambient displays are widely used in behavior change because they can convey information without interrupting other daily tasks, and users can receive information positively through a pleasing design [2]–[6]. Ambient displays' novelty may attract users initially; however, they may gradually lose interest and stop paying attention to the display [2] because of the calm manner of information presentation, causing a reduction in the effectiveness of persuasion [3]. Furthermore, system malfunctions can present results that fail user expectations, resulting in loss of interest and abandonment of the system [4] [7]. To our knowledge, few studies have aimed to solve these problems in the context of behavior change. Studies on user interest estimation and its applications have used eye gaze information [8], head pose [9], user personality [10], and speech information [11]. These studies have dealt with users' temporary interests and preferences. However, ambient displays must handle long-term user interests, which is challenging. Here, based on a model of losing interest over a long period, we investigate two methods of customizing persuasive ambient displays to avoid losing interest in displays' content. The methods were implemented in a persuasive ambient display system that aims to encourage the user to be active at home and were evaluated in a 36-day test.

The remainder of the paper is organized as follows. Section II presents a model of losing interest. A customizable persuasive ambient display is designed and implemented in Section III. Section IV presents a user study, and Section V concludes the paper.

II. A MODEL OF LOSING INTEREST

Referring to previous study that modeled the mental states of children playing with robots [12], we proposed a model that adds the two states of habituation and distrust that occur with the long-term use of ambient displays (Figure 1) [13].

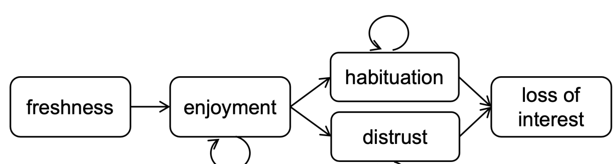


Figure 1. A model of losing interest

In the *fresh* state, the system is unknown to the user. Therefore, the interest level and use frequency are high. Users find their own way of using the system and thus *enjoy* the changes in information at their own pace. This period increases depending on the functionality and variations of the system. With system usage, a state of *habituation* occurs wherein the users gradually lose interest in the system because they feel that all the functions and patterns have been explored. If the system continues to present similar information for an extended period, users will perceive it as "background" information. Thus, users will eventually ignore it. This phenomenon has been often noted in previous studies that conducted long-term user evaluation experiments (e.g., Bauer et al. [14]). Additionally, a state of distrust emerges when users feel that the system does not follow their wishes or information and its representation methods are inaccurate. This occurs, for example, when the user's activity information is not accurately reflected on the display [4] [7], or the design is not to the user's liking. We believe that distrust increases the tendency to intentionally avoid using the system. Consequently, the user finally reaches a state of loss of interest and ignores the display. Therefore, we detect the emergence of habituation or distrust as a sign of loss of interest and intervene by returning the user to the enjoyment state. Here, we mainly dealt with the habituation issue.

III. Customizable Ambient Display for Active Living in the Home

A. Overview

A prototype system that motivates the user to be active, for example, moving around and performing exercises to prevent excessive sitting while working at home, and incorporates the above intervention concepts, was developed. The system employs a growth metaphor in which a virtual tree grows when the non-sedentary time per hour exceeds a certain ratio. This is aimed at improving behavior through the aspiration to increase tree growth. Two types of active involvement strategies were introduced to facilitate long-term engagement with the system: 1) incremental and ad hoc customization and 2) initial and goal customization.

B. Major components

Figure 2 illustrates the major functional components of the system, which consist of 1) home activeness calculation, 2) basic feedback, 3) interest level estimation, and 4) customization. The system ran on a Raspberry Pi 4 (RP4) with a 7-inch touch display. An OMRON Human Vision Components (HVC)-P2 [15] was connected to RP4 as a gaze detector to estimate the level of interest. Home activeness is judged by integrating the information from Fitbit Charge 4 worn by the user and a smartphone connected to a WiFi Access Point (AP) in their home.

1) Home activeness calculation: Home Activeness (HA) is defined as the ratio of the active time at home to the time spent at home, which is calculated every hour and is represented by (1). The active time at home in the past hour from time h was obtained as the difference between the time spent at home ($t_{home,h}$) and the inactive time at home ($t_{inactive,h}$). The value of t_{home} is measured by accumulating the duration of the user's smartphone being connected to a home WiFi AP, while we retrieved values using an activity type of "sedentary" in the Fitbit API for $t_{inactive}$. Note that the value of $t_{home,h}$ is 60 min unless the user leaves home between times h and $h+1$.

$$HA_h = \frac{t_{home,h} - t_{inactive,h}}{t_{home,h}} \quad (1)$$

2) Basic feedback: A tree growth metaphor was used. The tree begins to grow from a seed, and HA_h (1) is evaluated every hour (h). *Positive feedback* is when the tree grows by one stage if the value exceeds a certain threshold value (Figure 2 (b1)). In our earlier prototype system [13], the frequency of evaluation was set to once per day; however, the study participants were unmotivated by the lack of changes in the feedback. Thus, we chose once per hour as the evaluation frequency for the new system. Furthermore, to ensure that the growth was not easily completed during the experimental period of 12 days per condition (Section IV-A), images of the grown trees were prepared for approximately 100 stages. Contrarily, the tree becomes thinner by one stage if the evaluated value of HA does not exceed the threshold value, and the tree breaks at the fourth stage (Figure 2 (b2)), which we call *negative feedback*. An early prototype system did not employ negative feedback to ensure that the users did not quit using the system because of sympathy for the weakening virtual creature [16]; however, we found that the motivational elements were not enough with only positive feedback [13]. Thus, we decided to introduce both positive and negative feedback while taking care to ensure that the degree of negative feedback was not too strong; for example, the tree did not suddenly break but gradually thinned before breaking, and the update interval was set to 12 h instead of 1 h.

The threshold for positive/negative feedback was set to 3/60, which assumes at least 1–2 min of movement every 30 min based on the recommendation for interrupting long periods of sedentary behavior every 30 min by light movement [17]. Note that in a full-scale operation for health promotion, the target value should be set appropriately.

3) Interest level estimation: We hypothesized that the frequency of screen viewing would decrease as the level of interest decreased and attempted to model the correlation. In our previous work, we simply used the distance between the user and the display obtained from an infrared distance sensor [13]; however, this method caused frequent misdetections. Thus, we opted to use the frequency of eye gaze falling within the display area using the gaze detector HVC-P2 (Figure 2 (c)). A preliminary experiment, which is briefly described below, was conducted to test this hypothesis.

Nine university students in their twenties used an ambient display set up in their homes, illustrating a tree. The fact that only the background color changed over time was not mentioned to the participants. They indicated the level of habituation and distrust on an 11-point scale from 0 to 10, with a frequency of once per hour. Lower values indicate lower levels of these states. The experiment continued until one of these levels reached the maximum value of 10. Although the individual completion times of the experiment ranged from 1 day to 2 weeks, the results of all nine participants showed the same tendency. Specifically, with the exception of one participant, a negative correlation with an average value of –0.60 and a standard deviation of 0.39 existed between the frequency of viewing and the level of habituation or distrust. The frequency of screen viewing was obtained by averaging

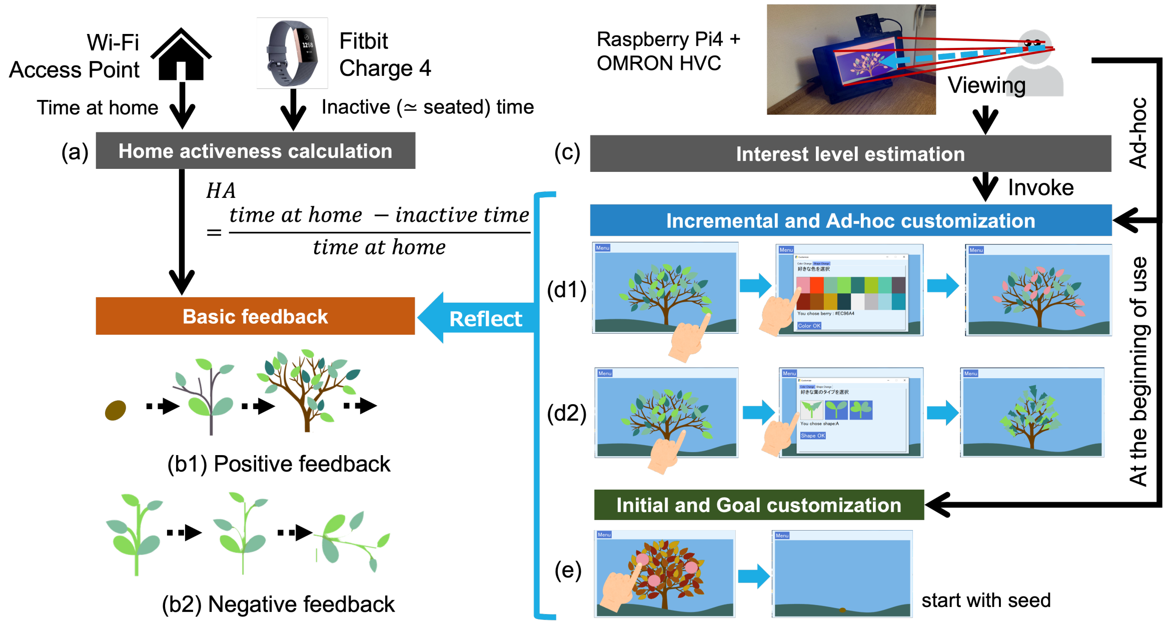


Figure 2. Major Functional Components of of the Prototype System

the number of times the participants viewed the screen at least once per hour over the time they spent in the room per day. For example, the value is 0.5 if a user spends 4 h at home and views the display twice, zero times, three times, and zero times each hour.

4) Customization: In our early prototype system, two types of involvement strategies were proposed: active and passive involvement [13]. Active involvement allows users to customize the appearance of the tree and change their daily goals, which is based on the self-determination theory that the users can be motivated in the long term by increasing their self-determination [18]. Conversely, passive involvement was designed to attract the user's eyes to the display [19] by animation, which changes the speed of swaying the tree according to the distance from the user. A comparative user study showed that active involvement tended to keep users' interests relatively high, whereas a monotonous system was not suitable for maintaining user interest over a long period, even with active involvement. Therefore, we implemented two types of active involvement approaches, which differ in the timing and target of customization.

First, the number of customizable parts increases as the tree grows to give the system an "unknown" element and create a sense of anticipation of what might happen next. For example, only the color and shape of leaves could be changed immediately after sprouting, while the colors of the trunk and fruit could be changed after some stages of growth. This is because the user will quickly become habituated to the functionality and lose interest if everything is customizable from the beginning. The user can change the color at any time by tapping any part of the presented image, such as the ground and background (Figure 2 (d1)). The shape of the leaves and the spread of branches can also be changed (Figure 2 (d2)). Additionally, the system prompts customization if the user's interest falls below a certain level and the user passes in front of the display. Such an approach from the system side is intended to make the user aware of the display even if the user's interest in it declines and to regain their interest by redecoration. The threshold for prompting customization was set to 0.516. The value was obtained as the ratio of the average frequency of viewing by nine participants when the level of either habituation or distrust reached 9 out of 10 to the frequency of viewing on the first day when the interest should be the highest. We call this type of customization *incremental* and *ad hoc customization*, or simply *ad hoc customization*.

Second, the appearance of the final stage was customized at the beginning (Figure 2 (e)). Some people may want to have a sense of "working toward a goal" through customization at the beginning. Once the goal appearance is set, the system starts with a "seed" view, and the user spends time at home toward a tree with the specified appearance. The second approach is designed to motivate the user to grow the tree toward the goal appearance, which we call *initial and goal customization* or simply *goal customization*. In this approach, no suggestions for customization were made by the system.

IV. Experiment

A. Methodology

A user study was conducted to investigate the effectiveness of the proposed behavioral feedback and customization methods with six university students in their 20s (two females and four males). They were each asked to use the system under three conditions for 12 days: 1) with ad hoc customization, 2) with goal customization, and 3) without customization as a baseline. The participants did not receive any specific instructions regarding their time at home, and the order effect was counterbalanced.

Home activeness and frequency of viewing the display were analyzed. As qualitative data, the participants were interviewed at the end of each system condition usage to collect the perceived interest in and distrust of the system. Furthermore, another interview aimed at comparing the three conditions was conducted at the end of the entire experiment.

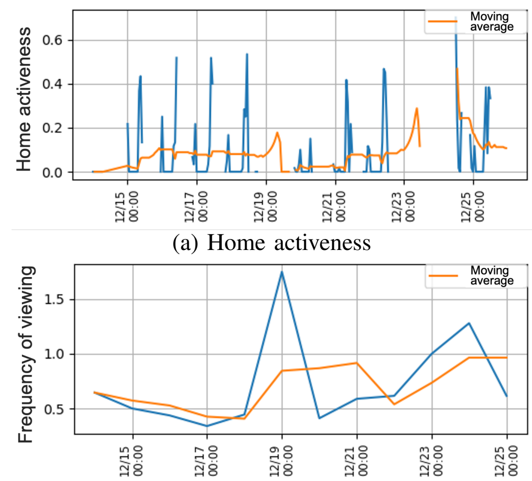
B. Results and Discussion

1) Feedback method: Some participants felt that the measure of activity was well reflected in the growth of the trees, whereas others did not. This contradiction might be because the tree growth rate depended on the participants' daily home time, as tree growth was determined once every hour. For example, if they stayed at home all day, the tree grew by about five stages in one day if the HA reached the threshold every 3 h. However, if they went out in the morning and returned home at 22:00, the tree grew by only about two stages, even if they were active after returning home. Hence, they felt that their efforts were not reflected, which is likely to increase distrust of the system. Thus, various scenarios should be handled by changing the speed of tree growth according to the user's daily rhythm and the amount of time spent at home. That is, the user's preferences and lifestyle and behavior should be considered for more effective feedback.

Negative feedback was invoked by three participants. One participant stated that negative feedback made her more aware of the need to improve her behavior, which we confirmed as an increase in HA. However, other two participants stated that they had already lost interest in the system and thus did not feel the need to improve their behaviors. This suggests that negative feedback is ineffective if the user reached the state of loss of interest. Negative feedback is invoked if an HA below a threshold is detected for half a day. Consequently, the user is likely to have lost interest in the system and may abandon the use thereof if the tree breaks under such conditions. Therefore, the use of negative feedback may not be effective, especially for users who lost interest in the system.

2) Effective customization method by user type: The participants used the three types of system conditions consecutively for more than one month, and the degree of loss (or continuation) of interest varied depending on individual characteristics. Therefore, we classified the participants into three types based on the interview results: 1) Highly Motivated (HM), 2) Gradually UnMotivated (GUM), and 3) Poorly Motivated from the beginning (PM).

Three participants fell into the HM type and continued to use the system throughout the experimental period without a significant decrease in the frequency of screen viewing or the duration of their activities, although some differences exist in their tendencies. Figures 3a and 3b present an example of the time trend in home activeness and frequency of viewing, An example of time trend in home activeness and frequency of viewing are shown in Figures 3a and 3b, respectively. All participants in this type preferred ad hoc customization followed by goal customization and then the baseline. They tended to be more motivated by the metaphor of tree growth, suggesting that the presence or absence of a goal did not affect the results. Additionally, because participants regularly checked the display, we considered it a good match with the customization method, allowing them to customize the visualization at any time. They would not use the system if they were not interested in it, because operations were required to customize the display. Therefore, the participants in this category were highly interested in the display, and the nature of the display being customizable at any time may have led to the continuation of their interest.



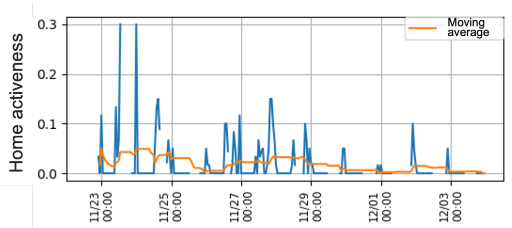
(a) Home activeness

(b) Frequency of viewing

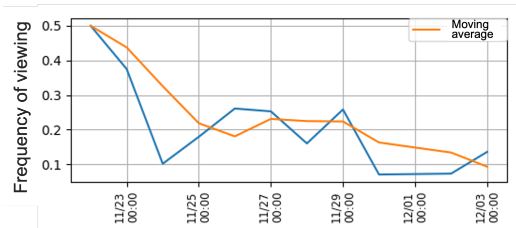
Figure 3. Time trends of a participant in the HM type who used the system without customization (baseline) for the third option.

Two participants belonged to the GUM type, showing a gradual weakening of their motivation. Figures 4a and 4b show the time trends in the home activeness and frequency of viewing of a participant who first used goal customization. The frequency of viewing gradually declined as days progress 4b, indicating that the level of interest was decreasing. Moreover, home activeness was not as high as in the case of HM. The other participant showed a similar tendency. All GUM-type participants used the ad hoc customization type as the second or third option; however, they never used the customization functionality because they had already lost interest in the system or did not see any tree growth, according to the interview results. Interestingly, they agree that they preferred goal customization, allowing them to set a goal tree first. That is, we consider that GUM-type participants had difficulty maintaining their motivation with only the metaphor of tree growth and customization of visual elements. However, they were facilitated to make efforts to reach the goal since their goals were made more concrete. Therefore, we believe that an approach that encourages voluntary operation is not effective for participants who show a strong tendency to lose interest. Any functionality might be utilized after a complete loss of interest; therefore, this issue should be addressed at an earlier stage.

One participant was classified as the PM type, who had



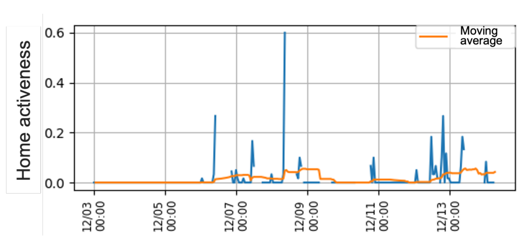
(a) Home activeness



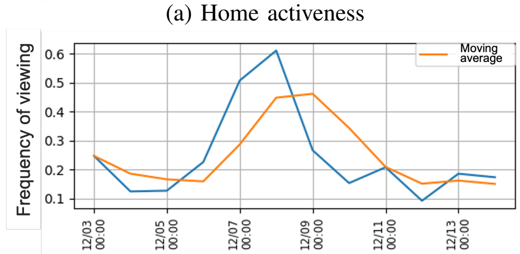
(b) Frequency of viewing

Figure 4. Time trends of a participant in the GUM type who used the system with goal customization as the first option.

low interest in the system and low awareness of behavior change from the beginning and tended not to utilize the system continuously. Figures 5a and 5b show the time trends of home activeness and frequency of viewing for this participant using goal customization as the second option. According to the participant, the confirmation of tree growth did not inspire him to change his behavior, nor did he notice any particular difference between the systems. The possible reason is that the participant was unaware of the risk of being sedentary at home and was not conscious enough to change his behavior through an ambient approach. Thus, for participants who are not interested in changing their activity level, their consciousness are challenging to change through customization, and a stronger approach or information other than activeness is considered necessary. For example, indirectly activating participants' interests by simultaneously displaying their interests and information may be effective.



(a) Home activeness



(b) Frequency of viewing

Figure 5. Time trends of a participant in the PM type who used the system with goal customization as the second option.

Thus, we consider that effective approaches differ depending on the level of motivation that users have to use the system, which is in line with [20] [21]. Previously, our research group has attempted to estimate the stages of behavior change in the transtheoretical model [22] as levels of motivation. We wanted to change motivational strategies according to these stages and apply them to a system for promoting energy-saving behavior [23]. The motivational stages were estimated by a decision tree classifier that used the data on electricity consumption and usage status of an information presentation system as inputs. The results suggest the possibility of a motivation-aware behavior-changing system. If behavioral features representing motivation level and a sufficient number of correct labels are obtained, the motivation level can be estimated through machine learning, and users of GUM and PM can be covered for the type of activity time considered in this study.

3) Customization method: As discussed in Section IV-B2, the ad hoc customization feature tended to be effective in maintaining users' interest who were mainly motivated to increase their activity level. Although the method could prompt users to customize the tree visualization if a decrease in interest was detected, the functionality was only invoked once for one participant during the experiment, making it difficult to evaluate the effectiveness of the recovery process. The determination of the reference value for invoking this process was based on viewing the display on the first day of the ad hoc customization. Users who did not start with the ad hoc customization started with a certain degree of loss of interest initially. Thus, the threshold is quite small, and we consider that HA rarely falls within the thresholds. Therefore, the threshold should be determined based on data from the first day of using any of the systems.

Regarding goal customization, some participants insisted that they would like to see the gap between their current situations and their goals. Others wanted to confirm the goals that were initially set whenever they wanted. These functionalities would be useful because forgetting the goal appearance throughout long-term use is reasonable.

4) Distrust in the system: From the interview results, we confirmed the occurrence of distrust of the system owing to the failure in retrieving data from Fitbit. This is because the data on the Fitbit cloud service sometimes failed to synchronize with the measurement data on the Fitbit wearable device, resulting in delayed or no update of the feedback. However, distrust, to some extent, can be addressed by making the internal status of the system (e.g., communication status and data freshness) naturally transparent on the feedback screen.

V. Conclusion

We investigated two methods of display content customization to prevent loss of interest caused mainly by habituation during prolonged use of ambient displays. A prototype system aiming to motivate people to be active at home was implemented and evaluated in a 36-day user study with six participants. The implications of this study are as follows:

- The negative feedback in the tree growth metaphor did not work effectively, especially for those who lost interest in the system. Negative feedback's timing or degree should be reconsidered.
- The effective customization methods varied depending on the motivation level of users for the use of the system: highly motivated users preferred ad-hoc customization; goal customization seemed to work for moderately motivated users, but they gradually became unmotivated; and poorly motivated users needed an approach other than customization.
- Although a function for prompting users to customize the display was implemented based on a preliminary experiment, it worked only once because of the inappropriate setting of a threshold value. Thus, the threshold must be redesigned.
- Distrust of the system was found in terms of the feedback rule (i.e., tree growth is only for time spent in the house) and system malfunction (i.e., failure in synchronizing between devices). These issues should be addressed to prevent loss of interest.

We will address these issues with a special focus on the functionalities of prompting the user based on the frequency of display viewing and relaxing distrust.

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An Overview of Technology-Driven Care Solutions for Seniors in Aging Societies

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***Abstract*—Aging populations are putting a strain on professional care facilities. Technology can ease this strain while at the same time improving the quality of life for senior citizens. Using robotic home companions and utilising sensors to monitor and improve the life of seniors, it is possible to help caregivers target their efforts to be more effective. It is important to observe privacy concerns while developing these technologies to ensure acceptance by the end users. In this work, we provide an overview of such technologies already in place and discuss their limitations. This is done by surveying relevant literature. Findings show that the available technologies are still far from solving the current challenges.**

Keywords-quality of life; senior citizens; ambient assisted living; companionship.

I. INTRODUCTION

According to researchers like Prince et al. [1], it is estimated that 5-7% of the elderly population (≥60 years) of each world region has dementia. In 2021, more than 55 million people suffered from this disease, with an expected increase to 78 million in 2030 and 139 million in 2050. In addition to these findings, Alzheimer Nederland [2] estimates that around 290,000 people have dementia in the Netherlands, 95% of whom are above 65 years of age.

The increasing number of elderly caused by the aging population will only increase the number of elderly patients according to Wan et al. [3] and the Alzheimer's report [4]. Research done by Daviglus and Bell [5] found a link between the cognitive decline of ageing and an increase in the number of cases of depression or dementia. This means that, in a few short years, caring facilities will overflow with the number of patients needing care which the seniors cannot provide by themselves.

Much research has been trying to counter the problem of overfull care facilities and the reluctance of elderly patients to move out of their homes. Studies that investigate the Quality of Life (QoL) and technological possibilities that make life easier for the dementia patients and their caregivers are an important asset.

Currently, there are projects that help to make living with dementia tolerable. These projects try to recognise the signs and symptoms of patients with dementia. Once analysed, the data will support the improvement of the help that dementia patients receive, and it can also slow down the progression of the disease. These inventions mainly focus on the use of sensors and collection of data of their patients to improve their living situations [6][7].

Data collection is also an important part of these projects. The collection of data gives insight, information and is an essential function for the healthcare sector. Through data collection and analysis, caregivers can understand situations better. Research has been conducted into what kind of sensors can be useful to collect data of dementia patients.

This article is an overview of the challenges dementia patients and care facilities will have in the near future, the developing technological solutions trying to solve these challenges and the privacy concerns these solutions may raise. The rest of this paper is structured as follows. In Section II, we explore assessing QoL using a list of indicators. Then, in Section III, we see what technologies are currently available that can manage the mentioned challenges. Finally, we discuss the most relevant privacy concerns in Section IV before summarizing with the conclusions in Section V.

II. QUALITY-OF-LIFE INDICATORS

Quality of Life (QoL) has become a major topic of study within dementia research. Alzheimer's disease or a related state of dementia can affect the lives of patients and their families.

One of the most important aspects that can determine the stage of dementia is the QoL. Several studies used developed methods to measure the QoL. Examples of methods are Dementia Quality of Life Instrument (DEMQOL) (which is conducted by those with dementia themselves) and DEMQOL-proxy (which is conducted by the caregivers) [8].

Sensors can be used to measure the emotional, social and physical well-being of a senior citizen, and their ability to function in daily life (the QoL). McCaffrey et al. [9] created the DEMQOL to gather information from dementia patients through the caretakers and the patients themselves. This information would be passed through 8 generic measurements and 6 dementia-specific measurements added by Ettema, Dröes and Lange [10] to create an indicator of the QoL. After reviewing this model and its addition, researchers

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like Ann and Gene concluded that this method can be used across the different subtypes and stages of dementia [11].

Furthermore, several studies have been done on which technologies can help to identify dementia or to support people with dementia. According to Hoffmeyer [12], dementia can be identified by using mobile sensors (such as an accelerometer). This research achieved an accuracy of 81%.

Currently, most anomaly detection systems are often data or application specific, but anomaly detection can be useful in many situations. Anomaly detection methods are explored to monitor the QoL of senior citizens. This method is a seemingly natural tool to automatically detect anomalies in any possible sensor data that can represent time series [13].

According to researchers like Wang and Zeng [14], results show that people with early dementia have more alternations of sleep-wake cycles. The quantity and quality of sleep may reflect their dementia condition and can affect the QoL for people with dementia. Sleeping patterns can be detected continuously and transformed into data and visualised in a dashboard where a caretaker could see the quality of overall sleep. The caretaker could then decide who to visit when making the rounds.

In conclusion, it may be possible to combine the idea of the DEMQOL questionnaire and sensors to track the condition of the senior citizens. Deciding which indicators should be measured to track the QoL should be decided by experts that currently do such assessments face to face with the senior citizens. By automating this process using the sensor data and visualising it on dashboards to be monitored by caretakers, they can gain insights in how their patients are progressing in real time all the time. Caretakers can use this information to provide targeted and timely care to their patients.

III. DEVELOPING TECHNOLOGICAL SOLUTION

The increasing number of elderly people has not gone unnoticed for long. Their placement in care homes and wellbeing has been researched, and technological advancements are being developed to support their QoL.

A. Home companion

A current trend with caretakers is the introduction of home companions to their patients. Home companions are pet-like toys which simulate the having of and caring for a pet. These toys often look like dogs or cats which can move parts of their body to simulate the interactions the patient can have with an actual pet. Developers are using these toys to provide the seniors with companionship and thereby raising their QoL.

Examples of such interactive companions include Paro, a robotic home companion who had the appearance of a seal [15]. Paro was used to reduce stress and loneliness inside care facilities. It encouraged communication between residents and to the robot itself, which concluded in psychological improvement and even reduced stress levels. Other robotic companions, like the Oleo and ifbot [16], would also help improve the overall QoL but are too expensive for civilian everyday use. These robots do show the potential and effectiveness of increasing the QoL for elderly patients living alone.

B. Sensors and monitoring

1) Home automation

Smart homes also have the potential for making the life of people in general and senior citizens in particular easier. In their research exploring using smart homes to support seniors, Demiris and Hensel found that most of them cover monitoring or automation [17]. In case of automation, these systems can do that in multiple ways. One example is XBee [25] where seniors can operate home appliances from an app. By doing this, the elderly do not have to deal with the complicated dials which are on home appliances, such as washing machines or dryers. However, a commonly found disadvantage to these systems is their cost of installation. Also, there are still manual activities that have to be done in order to complete these day-to-day activities. For example, the wash still has to be put into the machine in order to turn it on from an app.

A different example is allowing relatives or caretakers to help seniors manage their home, even from remote distances. This way unexpected visitors or unsupervised trips by the seniors could be detected and stopped when needed. Even though the feedback for these types of systems is largely positive, some elderly expressed concerns about the intrusion on their privacy. Also, a more unexpected conclusion from this particular research was that elderly tended to turn more indolent. For example, instead of normally checking for the door being closed and in case of forgetfulness asking the system, elderly did not even bother checking for it themselves but relying on the system in the first case.

2) Fall prevention and detection

The European Union has been funding projects that help prevent falls for seniors for many years now as it is a common cause of severe injury. Falling accounts for approximately 40% of all injury deaths among the elderly. As a result, these European Union funded projects are aimed towards prevention and protection of commonly falling elderly.

Preventing a fall can be done for example by having sensors detecting when seniors might be about to get up with a lower blood pressure. Having a system that would sound an alarm in such a situation can advise the elderly that they should not exert themselves and thereby keep them safe [28].

The main goal is that by detecting a fall, an automated system can proceed to call for assistance. This can be essential when, for example, a senior has passed out or is for any reason unable to call for assistance themselves. A unique approach to this problem is using vibration detection [27], which measures vibrations in the ground and can identify when someone has fallen. Practical studies found this technology quite promising. However, its performance can vary depending on floor type.

3) Other research

There is also different research done with the aim to help elderly live at home for longer, such as research regarding day-to-day planning [26]. This research proposes an activity

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schedule generator, where stable schedules can be generated. The generator can even keep into account what the layout of the house is and what smart devices the patient has. Such a system can help an elderly person organise the work they have to do in a normal day-to-day planning. Moreover, by being able to generate daily scenarios for the life of a senior at home, it can also help developers of smart devices to further improve their systems, as it can also be used to mimic the life of an elderly person. Difficulties with this system is that it can be abstract and there is not a ready to download version available at the time of writing.

Such mimicking of daily activity was also used to learn the normal behaviour of a specific elderly person in other monitoring related research [29]. This research shows that learning the normal behaviour of a specific individual allows us to spot changes in behaviour. These changes, although sometimes benevolent, can be indicators of mental or physical problems. Whilst the system learns these behavioural changes, it can determine whether or not to act upon this, or at least communicate it via the interface it is attached to. This system is still undergoing a lot of development, as it is far from perfect. The system would during practical tests not always notice behavioural changes in time. Furthermore, privacy is still a large issue, because there are cameras and other sensors required for the system to work.

IV. PRIVACY

A recurring trend with many of the above-mentioned interventions is that they rely on the collection of data. This data is needed not only to monitor the patient, but also to improve the product itself. It is important to carefully scrutinise what data can be collected, because collecting data can be harmful if not done correctly according to research by Melander-Wikman et al. [18], Boise et al. [19] and Townsend et al. [20].

A lot of research has already been done about monitoring elderly patients. It would then come to no surprise that a lot of issues with data collection methods have appeared. For instance, Fukuda et al. [21] found that by monitoring patients, the caretakers are invading their personal space. Surprisingly, Melander-Wikman, Fälthom and Gard [18] found that the elderly tend to react positively towards the collection of data, if the data is used for the right purposes and if there is enough transparency [18]. The reluctance towards being monitored can differ based on individual opinions and does not seem to be a consensus among the patients.

Research by Schulz et al. [21] and Holone et al. [22] shows that monitoring elderly patients without their knowledge or approval could lead to aversion or reluctance to the inventions, to the point patients would even show "privacy enhancing behaviour [23]. In such a situation, patients actively avoid the sensors installed in their homes, thereby defeating the purpose of installing the sensors in the first place [30]. This shows that the elderly patients should be made aware of the situation and the monitoring so they could negotiate their privacy if necessary.

Care facilities already use devices that collect data, for instance a fall detection device by Melander-Wikman, Fälthom and Ghard [18]. The reaction of the elderly towards the up-and-coming monitoring devices was either positive or indifferent, stating they are already being surveyed anyway. Their only concern was the possible misuse of their data, found by Boise [19]. Research by Townsend, Knoefel and Goebran [20] shows that most elderly patients disregard their privacy when it would mean they could live autonomously longer.

V. CONCLUSION

To conclude this article, it shows that the increasing amount of elderly people with dementia due to cognitive decline and the ageing of the population will be a serious issue in the next 20 years.

Developers are working hard to create new ways to stimulate patients, decrease their stress and increase their well-being. There are multiple ways to do this, such as by the use of home companions or Smart Homes. Development in this area is fast and new research is continuously being done.

There have been multiple findings throughout our report, which can be summarised into a few key points. The first point is that, in order for the elderly to stay at home longer, they rely on having tasks automated. This can be quite easily explained as day-to-day tasks can be tiresome, which was even shown in research where the life of elderly was simulated.

Continuing with the tiresome factor, the second key element seemed to be the focus on elderly and them being prone to falling. The elderly seem to fall more often and be more vulnerable to injuries as well. There is a lot of research done on this subject, some of it supported by European funding. However, most research seems to primarily aim at detecting falls or acting upon results of falling. This focus should shift towards avoiding falling and preventing injuries when the elderly fall. As more and more research is being done, this shift in priority should be taken into account.

However, the developing technological solutions also come with a price. Not only financially, but also the privacy the elderly need to give up in order to be able to live at home longer. Privacy among the elderly is a sensitive issue. Though some are less concerned about it, it should still be managed correctly, ethically and legally. Research performed by previous groups shows what technology can be used without legal or social repercussions, as well as data collection methods which can intrude on the privacy of the patients.

With increasing numbers of elderly people with dementia world-wide, the coming inventions will help control the overflow of patients and help relieve stress for the patients, families and care facilities.

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