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

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

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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