Integration of Augmented Reality into Professional Care Processes

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Abstract

In this paper we present work done in a project that uses AR technology in intensive care. Our work shows how an advanced technology like AR can be established into professional care by pointing at aspects of our work that contributed to the identification of meaningful use cases and the acceptance of the technology among care staff. We also show what kind of challenges the introduction of AR in a domain like intensive home care causes and how we dealt with them. The aim of the paper is to peal out factors that may help in similar endeavours and lead to interesting discussions at the workshop.

1 Introduction: AR support for intensive home care

Professional home care is based on standards and associate workflows that ensure a certain quality of care provided. While professional caregivers in healthcare are trained in these skills, standards may vary from one institution to the other, and caregivers also have to comply to time limits and documentation needs. In addition, care needs to be personalized in that care activities include individual preferences and needs of a patient. This multitude of influencing factors on care make it hard for professional caregivers to fulfil all requirements of quality care, let alone informal caregivers like relatives of patients.

Intensive home care is a specific field of care, in which some of the requirements mentioned above are amplified. In intensive care, patients that would otherwise stay in hospitals or special care home wards (e.g. because they need ventilation aid during the day) are being care for at their homes. This includes complex care tasks that are potential harmful for the patient such as changing ventilation tubes, and therefore caregivers need special (additional) training for intensive care.

The challenges caused by the complexity of care are accompanied by a situation (in Germany and many other countries) in which there are less and less people working as care givers while

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the number of people receiving care is steadily growing. This results in a lot of pressure on those working in care and the education of new caregivers, and it can result in mistakes or lacking quality of care provided.

The work presented here describes an approach of tackling these challenges with the help of Augmented Reality (AR) technology. AR provides users with digital information superimposed on their real field of view (Azuma 1997), which allows users to work in a "mixed reality" that combines digital and real world information (Milgram & Kishino 1994). AR allows caregivers to execute care tasks while getting additional digital information about the task or the patient without losing sight of them, which cannot be achieved by other technologies like Virtual Reality. AR is available on different devices such as tablets, mobile phones and head-mounted devices ("glasses"). The latter can provide information while leaving the user in full operation of their hands (as opposed to holding a tablet or phone), which is needed in care. Head-mounted AR devices have therefore been identified to hold potential for supporting care (Kopetz et al. 2018; Prilla et al. 2016; Zhu et al. 2014).

In the project "Pflegebrille" (English: care glasses), we use head mounted devices (HMD) for AR to provide support for the conduction of care workflows to train and execute expert standards of care tasks, and to ease other care tasks by providing information on the patient and devices used by the patient. On top of that, we use AR to recognize and document care tasks. This is supposed to raise the quality of care while reducing efforts for documentation, and it aims to improve the wellbeing of all stakeholders in home care (caregivers, relatives, patients).

While the assumption of the project is that AR can bring benefits into care, there is only little work on the actual use of AR in care tasks (let alone intensive home care). Therefore, one of the main goals of the work presented here was to include stakeholders from the beginning of the project and to find ways to integrate the potentials of AR into intensive home care work. This includes work done in exploring the domains to find use cases that provide benefits for caregivers and patients, and that can be offered practically and from an economic perspective. In this paper, we will illustrate work done in this respect and reflect on potential methods to integrate AR-technology into care.

2 Related Work

AR technology has been used in multiple ways in healthcare. We can find approaches in which head mounted AR devices support surgery (Armstrong et al. 2014), in which these devices support patients suffering from Alzheimer's disease (McNaney et al. 2014), and in which they support rehab from neurological problems (Hondori et al. 2013). In the context of (home) care, there are studies showing the applicability and potential impact of AR technology for the acquisition of knowledge relevant for care. Among these, Albrecht et al. (2013) show the benefit of AR for learning over other media such as books, and Zhu et al. (2014) show in a literature survey that can provide benefits for multiple areas of learning and training in healthcare. Despite this, they also show that many applications for this are only available as prototypes or lack solid foundations in learning theories. Kopetz et al. (2018) provide a study that looks at the potential of head mounted AR devices in care. They find that care staff sees a lot of potential in this technology, but also has concerns regarding practical use of the devices and their implementation in practice (including economic concerns). Their follow-up implementation of support uses monocular devices for the display of text and pictures that work as guides during the education of care givers, and shows benefits this can have (Kopetz et al. 2018). However, beyond this there are hardly any approaches available in which HMD are used in care contexts (Duerr et al. 2018), and no approaches in which HMD support care in practice (rather than support care education like most other approaches).

3 Approach: Co-Development of Solutions

While the usage of AR in intensive home care bears a lot of potential for care, there is hardly any work available on its usage in (intensive) home care, which would be mandatory for creating proper support for everyday care. Therefore, a major task in our work was to observe caregivers doing care. In an ethnographic phase, we conducted visits at the homes of ten patients and stayed for one or more shifts, and we interviewed 21 care givers and four relatives. This approach enabled us to (later) generate ideas of where AR can be used during care by experiencing different situations of care from the point of view that care staff have, and thus getting a feeling of what influences care, what kind of stress it means and many other aspects. This phase provided us with insights on how everyday home care that we could not have gathered otherwise.

We complemented visits and observations with interviews done with caregivers and relatives of patients in order to get to know their own opinion and assessments of the situations we witnessed. Problems, ideas and wishes derived from these interviews were then used as the foundation of what the later AR support would look like.

Based on this foundation, our work took an iterative approach that includes users more and more and brings the solutions developed closer and closer to real care situations. Development is done in participatory loops that consist of building prototypes and evaluating those prototypes with potential users. Each of the loops produces prototypes that we identified as relevant for home care. This support is then taken to potential users (predominately care givers) in steps towards real care situation: In the first loop, we conducted focus groups with care givers, in the second and third loop we work with care givers in empty patient rooms (simulating care), and in the fourth loop we will take the solutions into real care settings. The last loop will also produce a final evaluation of the AR support in a long-time test in practice.

At the time of writing this paper, the second loop evaluation has just been completed. Therefore, below we report on results from ethnography and the first loop evaluation. At the workshop, we will add results of the second loop.

4 Lessons Learned

Our approach revealed a lot of insights into intensive home care and specifically into needs and opportunities to provide support for it. Below we describe the most important one with respect to design and the integration of AR into everyday care.

One important aspect we observed for home care is that there are neither standard home care situations that can be found everywhere nor standard procedures for such care. Every patient is different, has another medical history and another familiar background that has to be taken into account during care. The spatial settings of intensive home care differ too. This causes problems at finding necessary care utilities like bandages, medicine or further medical consumables for caregivers who are not familiar enough with the care setting at the patient's home. Another problem is caused by the variety of medical consumables and different medical technologies at the patient's home. For example, there is a broad variety of ventilation machines used in home care, which cannot be known by heart by care givers. Different machines use different units to measure parameters, and so that operating one particular machine needs training and experience. Additionally, caregivers are often on their own at the patient`s home, because there is often no chance to get help of other caregivers at settling in the situation with the new patient in the unknown location. So, the caregivers often have to fight uncertainties. This is one of the areas in which support offered by AR becomes obvious: Providing caregivers with information about the patient, the setting and the devices used enables them to use this information while working with the patient.

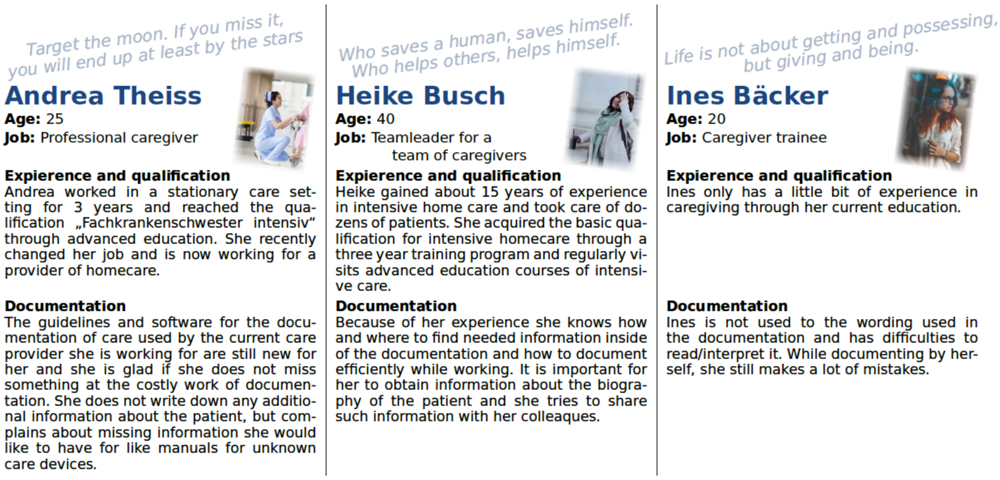

Figure 1: Sample of persona descriptions used in the project.

Another insight we gathered from observing the first prototype evaluation loop is that caregivers with different experiences in care need different kinds of assistance at their care tasks. For example, in workflows of everyday care tasks less experienced caregiver will need more details on the execution of the workflow and information about how the execution shall look like.

In contrast, experienced caregivers may not need as much assistance at the execution but a faster workflow that helps to sustain quality in documentation. Care givers new to patients (no matter whether they are experienced or not) may need additional information on the way the patient prefers the task to be conducted. To support this variety, we created four personas for the types of caregivers we encountered that we supposed to guide the adaptation of workflows. Samples of the persona descriptions are shown in *Figure 1*.

The personas can be used to develop different process support for different levels of experience and documentations needs by asking questions such as “Which support does Andrea need” or “Would Ines need this information?”.

Another insight brought forward by observations and the initial evaluation loop is a set of support features that match the potential and advantages of head mounted AR devices with needs occurring during care. We found that caregivers would be more willing to accept this technology if they could see the immediate benefit and quality it brings to their care work.

Figure 2: Field of view of a user wearing the care glasses to walk through the workflow for pain management while simultaneously interacting with the patient.

Among these matches we found that supporting information on workflows containing information on and assisting people in the correct execution of certain tasks (e.g., considering expert standards) can ensure the correct execution during those tasks and offers an automatically documentation while executing the task while leaving the hands of the caregiver free to provide the care task to the patients. Workflows we identified include standard procedures like (chronic) pain management (see *Figure 2*) or wound management as well as advanced procedures like changing ventilation tubes of patients. Similar to this, a feature translating the values shown on a ventilation machine to the parameters set up by the physician in charge of the patient demonstrates the same value: While checking and probably adapting ventilation parameters, the correct parameters are shown on the devices, thus easing the task and securing proper conditions.

As described above, AR devices can share the stream of cameras attached to the devices and let others annotate it to provide remote (expert) support. This was chosen to be another supportive feature that enables the caregiver to call care experts directly in order to achieve help or advise in certain situations. The expert can add virtual pointers into the field of view of the calling caregiver and sees the situation in situ, just like the caregiver from his perspective.

Moreover, caregivers are in general complaining about the extent of the demanded documentation, and in many cases documentation is not properly done. The concept for the Pflegebrille consist of an automatic contextual tracking that recognizes a task done by the caregiver (e.g., by using barcodes on medical devices used for that task) and – besides offering support that fits to the situation – also automatically documents the task after it was executed. Likewise, organisational tasks like ordering medical consumables can be shaped efficiently with this concept. When the devices recognize an item in hand of the caregiver, they offer fitting workflows that include making orders for the consumables (e.g., recognizing wound tape and ordering it). In comparison to ordering items with a form (as done usually), the Pflegebrille scans the item, asks for or suggests an amount of new items, waits for a short approval of the caregiver and sends the order to the provider.

Figure 3: The EPSON Moverio BT 300 HMD used in the project (left) and the Pflegebrille worn by a care giver performing the pain management workflow.

5 Implementation

Typical patients in intensive care are not used to technology like Augmented Reality. In addition, care is a domain in which contact with patients and empathy are very important. Therefore, we needed a lightweight device technology that would not scare away patients or make them loose their connection to the caregiver. We decided to use the EPSON Moverio BT 300 (see *Figure 3*), which is a small yet powerful HMD but does not have the techy views and large sizes of other HMDs such as the Microsoft HoloLens. In addition, it is lightweight and can therefore be worn for longer periods of time by users, and its price is relatively low compared to other HMDs – an aspect that is important in a domain like care.

Nonetheless, as the market for AR HMDs is constantly changing and as there are different operating systems running on these devices, we implemented the Pflegebrille on a software-platform called Simplifier[1], which enabled us to create features and processes for Pflegebrille that run on most available HMDs in the same way and without changes. The Simplifier empowers also eases the development of features, as it is built of re-usable blocks for interaction and on templates for workflows. This also allows us to adapt workflows according to the processes/standards of certain care providers.

6 Conclusion

Concerning the meaningful introduction of AR technology into care we found it helpful to develop and implement use cases closely together with the stakeholders. As IT support for intensive care is a under researched area, we explored the domain before we started to work on technical solutions. This enables us to identify needs and conditions under which they need to be supported. Our solutions include features that provide information about the patients and tasks to be done for them when and where needed, saving time and increasing quality for care tasks and their documentation, as well as providing security at task execution. Even though the digitization in homecare is not proceeded that far and although care staff is often sceptic on technical solutions added to their workplace, the Pflegebrille received good acceptance during our first evaluations. We attribute this to letting them participate closely in the process.

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[1] For more information on the Simplifier, please refer to https://www.simplifier.io/.

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