cARe: An Augmented Reality Support System for Dementia Patients

Dennis Wolf
Ulm University
Ulm, Germany
dennis.wolf@uni-ulm.de

Daniel Besserer
Ulm University
Ulm, Germany
daniel.besserer@uni-ulm.de

Karolina Sejunaite
Ulm University
Ulm, Germany
karolina.sejunaite@uni-ulm.de

Matthias W. Riepe
Ulm University
Ulm, Germany
matthias.riepe@uni-ulm.de

Enrico Rukzio
Ulm University
Ulm, Germany
enrico.rukzio@uni-ulm.de

Figure 1. a) Using pinch gestures, caregivers can place key-areas for instructions on the room model generated by the HoloLens. (b) After each key-area has been defined, instructions are displayed at their corresponding position (c).

ABSTRACT

Symptoms of progressing dementia like memory loss, impaired executive function and decreasing motivation can gradually undermine instrumental activities of daily living (IADL) such as cooking. Assisting technologies in form of augmented reality (AR) have previously been applied to support cognitively impaired users during IADLs. In most cases, instructions were provided locally via projection or a head-mounted display (HMD) but lacked an incentive mechanism and the flexibility to support a broad range of use-cases. To provide users and therapists with a holistic solution, we propose *cARe*, a framework that can be easily adapted by therapists to various use-cases without any programming knowledge. Users are then guided through manual processes with localized visual and auditory cues that are rendered by an HMD. Our ongoing user study indicates that users are more comfortable and successful in cooking with *cARe* as compared to a printed recipe, which promises a more dignified and autonomous living for dementia patients.

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INTRODUCTION

AR support of manual tasks such as maintenance [4], assembly [12] or surgery [3] has been widely researched over the course of the last five decades. These setups usually consist of four key features: registration of objects and spaces via maker-based or marker-less tracking [12], object-fixed or world-fixed virtual content [6], step-by-step instructions [5], and navigation between points of interest [1]. With the development of the Microsoft HoloLens and its inside-out-tracking approach, AR applications for HMDs have found their way into non-instrumented environments such as private homes. The ability to augment every-day objects with visual and acoustic information opened a new path to assist dementia therapists and patients. However, while related work focused on target groups such as doctors and industrial workers, usability requirements for cognitively impaired users are still being explored. This work describes the design and implementation of an AR support system for dementia patients and presents insights into challenges during the iterative development process. Additionally, our ongoing user evaluation with dementia patients aims to evaluate the benefit of *cARe* support for a cooking task.

MOTIVATION

As to this day, dementia is a not fully explored condition that affected about 47 million people worldwide in 2015 and is expected to reach 75 millions by 2030 [10]. Consequently, the treatment costs for dementia are expected to double from 1 trillion U.S. dollars in 2018 up to 2 trillion dollars in 2030 [9]. With a worldwide lack of caregivers, researchers are looking for ways to alleviate the burden on both, patients and caregivers via interventions [11] and assistive technologies [7]. As a contribution to this effort, we developed a generic AR framework that can be set-up by caregivers without any programming knowledge to assist dementia patients in various manual tasks. With cooking being one of the first IADLs that is affected by dementia, we chose cooking as the primary use-case for our system [8, 2].

FRAMEWORK

Designing and implementing *cARe* was an iterative process that included repeated pilot studies with dementia patients and discussions with caregivers to meet the requirements of both user groups. The resulting framework consists of the following components: a desktop and AR application for caregivers to configure IADL support and a navigation and incentive mechanism for patients.

Caregiver Application

Instructions for dementia patients are in general more detailed than for regular users, meaning that the input of individual instruction steps has to be fast and efficient. Therefore, instructions and their respective locations are defined in a desktop application to utilize the speed of mouse and keyboard input. Each instruction can be accompanied by a media file and tagged with the location it should appear at. The resulting list of instructions is then imported into the caregiver AR application where each key-location can be positioned at its real-world counterpart (see figure 1). This way, an existing set of instructions can be easily set up in a new room.

Patient Application

Inside the application, patients are navigated via animated arrows from one instruction step to the next (see figure 2). By saying 'next'. patients can finish an instruction step and continue with the next one. Since dementia patients require more motivation and incentives than regular users, each completed step is accompanied by a random voice recording of the caregiver praising the patient. Should patients trigger the 'next' voice command by mistake, they can navigate to the previous step by saying 'back'. Pilot studies have shown that patients tend to forget about their current task and get lost in thoughts. For this situation, we implemented a time-out that is triggered during an absence of head movement after which the patient is asked by a voice recording to continue the current step. Additionally, arrows navigate the patient back to the current instruction.

USER STUDY

In an ongoing user study, dementia patients are asked to cook with two conditions, with a regular paper-based recipe and *cARe*. In both cases, we measure the time the patient can perform independently before asking the caregiver for help. First results indicate that patients that were not able to produce a complete meal in the paper recipe condition, performed better in the conditions (i.e. could perform longer without asking for help.)

Figure 2. When a new instruction step is displayed, users are navigated with animated arrows from their current gaze direction (a) towards the new location (b) until the gaze pointer enters the next instruction (c). Saying 'help' or staying idle for a certain amount of time will trigger the navigation to the last instruction from the current field of view (d).

LIMITATIONS

Although *cARe* can support any manual task that can be described by localized instruction steps, there is no sophisticated process management system that could support parallel processes such as cooking pasta while preparing the sauce at the same time. Furthermore, patients tended to skip instructions or jump several steps ahead to return later to where they left off. This kind of navigation between instructions is not supported yet. Some voice commands were not recognized properly when the environment was too loud, so that a remote control had to be implemented to trigger the next instruction in these cases and thereby reduce frustration on patient side. Steam seems to be problematic for the spatial tracking cameras of the HoloLens which sometimes led to a loss of tracking while hovering over a steaming pot.

CONCLUSION

We have presented *cARe*, an AR framework that can support caregivers in dementia treatment by outsourcing task support and training for IADLs to an AR companion system. Our prototype was carefully designed in collaboration with experts, caregivers, and patients to meet all the necessary requirements for a support system that allows dementia patients to regain the ability to perform IADLs autonomously. In an ongoing user experiment we evaluate paper-based cooking against cooking with *cARe* support and strive to prove the efficacy and efficiency of our concept.

FUTURE WORK

To reduce the cognitive demand on the patiens, future version of *cARe* should include context recognition and thereby implicit navigation between instructions upon completion. This could be realized via object detection for 'take' and 'place' instructions and sensors for devices involved, e.g. a scale that communicates the current weight to the AR application.

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