Tangible Virtual Kitchen for the Rehabilitation of Alzheimer's Patients

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ABSTRACT

We present a tangible virtual kitchen system for the rehabilitation of Alzheimer's patients. The system utilizes Sifteo cube, a commercially available product containing physical cubes with touch screen, accelerometers, and neighboring sensors. The system supports intuitive and natural user interactions to improve motor skill rehabilitation for everyday kitchen tasks.

Keywords: Alzheimer rehabilitation, tangible user interface.

Index Terms: H.5.2 [User Interfaces]: Interaction styles;

1 INTRODUCTION

Familiar everyday activities often requires the cognitive processes of task step ordering and object selection, and are routinely performed with subjective ease. However, brain damage or disease can cause frequent errors leading to failure to complete the task ([1]. One of the diagnostic criteria of Alzhimer's disease (AD) is everyday action impairment with serious consequences, including institutionalization, depression, and death [2].

Neuropsychologists commonly recommend learning or relearning instrumental activities of daily living that are potentially useful to dementia patients [3]. The intervention increases the patient's functional autonomy through extensive training and repetition of everyday activities, leading to improved performance on the trained tasks [4]. Error reduction approach, at a teaching technique preventing people from making mistakes during learning, is shown to be more effective than trial and error learning [5]. However, the training is time-consuming and not always feasible in typical clinical settings.

Our previous work proposed a virtual kitchen environment for rehabilitation for AD patients with regards to everyday tasks in the kitchen [6]. We present a tangible interactive rehabilitation system for AD patients that support motor interactions. We employed the usage of Sifteo cubes [7], which contain a touchscreen, accelerometers, and neighboring sensors, to assist the patients in performing physical movements in rehabilitation training tasks. The Sifteo cubes support a range of different interactions and easy reconfiguration to be suitable for training, despite its size limitation. The system simulates the motor skills required for everyday kitchen tasks by engaging the patients with tangible interactions on the physical cubes.

2 BACKGROUND

There are many previous research work into tangible user interfaces for rehabilitation. Leitner et al. [8] developed concept rehabilitation exercises targeted towards visual impairments and intellectual perception problem. Their study focused on table top systems using projection and pattern matching task. Therefore the system requires set up and has limited portability. PhysiCube [9] uses the same Sifteo Cube product and has proven appreciation from therapists. PhysiCube is used for upper limb rehabilitation for patients with physical disabilities dues to neurological disorder. The PhysicCube is a game-based system for rehabilitation. Our system is designed to simulate real world tasks.

3 SYSTEM

The system uses 8 Sifteo cubes and a base system. Each cube is approximately 4.3 x 4.3 x 1.2 cm in size, containing a 128x128 pixel touchscreen. The cube connects wirelessly to a small base station with a built-in speaker. Figure 1: shows the sample layout of the system for a coffee making task.

3.1 Tangible interactions

Figure 1: The layout of the Coffee Making task.

This section describes the sample rehabilitation task of making a coffee using a coffee machine. Upon starting the system, the base will speak out the instruction for the entire task: "Make a coffee with a traditional coffee machine, and serve in a cup with one sugar". The instruction contains the process of the task to assist the patient. Each cube will display an object associated with the task, including: a tap, a coffee machine, a cup, coffee and filter box, and a box of sugar. An *action cube* displays a hand as a tool to transfer objects between cubes during the task. The order of the objects are randomised among the cubes. The task is set up in the patients' own kitchen, where the cubes are laid out on a table or kitchen bench. Such settings provide contextual information for the kitchen rehabilitation tasks.

There are a range of tangible interactions the patients can perform with the cubes, including: touching the screen, tilt the cube, touch the cubes on the side (connecting the cube), and shake the cube. Each step in the task process was designed to maximise the intuitiveness of the steps simulating the actual interaction with physical objects in real life. Here are a few examples.

The patients touch on the screen to: open the cover of the coffee machine, turn on and run the coffee machine. They are required to reach out with their hand and use one finger to touch on the screen of the cube containing the coffee machine object. These actions in real life also involves moving their hands or finger to press or touch on physical objects.

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For steps that require the patients holding a virtual object, the *action cube* is used. To take the container out of the machine, or the filter out of the filter box, and a sugar cube out of the sugar box, the patient picks up the action cube and touch the action cube to any side of the coffee machine, filter box, or sugar box cube, the *source cube*. A small animation on both cubes will show a transfer of the liquid container, filter, and a sugar cube from the corresponding object cube onto the action cube. The patient can then bring the action cube with the virtual object to touch on the sides of the *destination cube,* to drop the virtual object to the destination, such as bringing the container to the tap, or dropping the cube of sugar into the cup. This sequence of touching the action cube on the source cube to take a virtual object, then to drop onto the destination cube uses the neighboring sensors of the Sifteo cube to simulate the exact real world action.

Instead of simply touching the cubes on the side, the patient can also perform a *tilting action* on the cube. For the step of pouring coffee from the container into the cup, the patient picks up the virtual container by using the action cube. After touching the action cube to the cup cube to activate the pouring action, the patient is required to hold the action cube and slightly tilt it and hold for approximately 2 seconds to perform the pouring action. Figure 2: illustrates the pouring action. This interaction mimics very closely the real world counterpart, activating the patients' motor skill that is normally required in real life. During each of the step, there are sound effects emitted from the base unit to increase realism in simulation.

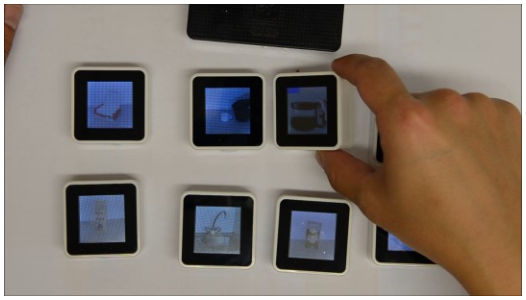

Figure 2: Pouring coffee from action cube to the cup cube

3.2 Reminder assistance

Our previous desktop based system supports multiple level of reminder cues to assist the patients in the execution of the task. Our new tangible virtual kitchen also implements similar reminder feature. The reminder is activated and escalated to the next level after a set interval. At any stage, the reminder level and interval counter is reset when the correct step has been performed.

The first level reminder is audio instruction from the base. The instructions are task-related, such as "Open the cover of the coffee machine". The second level reminder repeats the same audio instruction, but with a flashing animation on the relevant cube(s) to help the patients identify which cube(s) to interact with. The flashing animation includes a colored bar on the top and bottom of cube (shown in Figure 3: Top), flashing at set intervals. The third level reminder has a different audio instruction and a different flashing animation. The 3rd audio instruction will speak out the specific cube-related instructions, such as "Connect the two cubes". The flashing animation will display an instruction bar instead with the word: Touch, Tilt, or Connect, appropriate to the interaction for each step. The fourth reminder will perform the current step and proceed to the next step.

We have demonstrated the system to a number of Alzheimer's patients and the patients warmly received the new system. We are planning to perform formal experiments to evaluate the system in the near future.

4 Conclusion

We have implemented a tangible virtual kitchen rehabilitation system for Alzheimer's patients, as an improvement our previous desktop based virtual reality system. The new system utilizes Sifteo cube, which is a commercially available tangible user interface with touchscreen, accelerometers, and neighboring sensors. The system supports intuitive and natural interactions with physical cubes, such as touching, connecting, and tilting, which aims to improves motor skill rehabilitation.

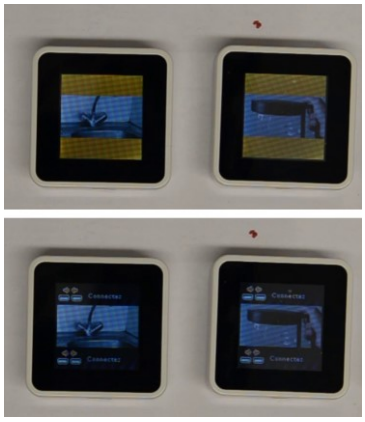

Figure 3: Level 2 (top) reminder with flashing colored bar and Level 3 (bottom) reminder with instruction bar

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