CoFaçade: A Customizable Assistive Approach for Elders and Their Helpers

Jason Chen Zhao[1], Richard C. Davis[2], Pin Sym Foong[1], and Shengdong Zhao[1]

[1]NUS-HCI Lab, National University of Singapore
13 Computing Drive, Singapore 117417
zhaoch21@gmail.com, {pinsym, zhaosd}@comp.nus.edu.sg

[2]SIS, Singapore Management University
80 Stamford Road, Singapore 178902
rcdavis@smu.edu.sg

ABSTRACT

We present *CoFaçade,* a novel approach to helping elders reach their goals with IT products by working collaboratively with helpers. In this approach, the elder uses an interface with a small number of *triggers*, where each trigger is a single button (or card) that can execute a *procedure*. The helper uses a *customization interface* to link triggers to procedures that accomplish frequently-recurring high-level goals with IT products. Customization can be done either locally or remotely. We conducted an experiment to compare the CoFaçade approach with a baseline approach where helpers taught elders to perform IT tasks. Our results showed that CoFaçade can reduce helpers' time and effort, reduce elders' frustration, and improve elders' success rate in completing IT tasks.

Author Keywords

Silver Computing, Accessibility design, CoFaçade, Collaboration

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

Silver computing, which provides technological solutions to help senior citizens better utilize information technology (IT), has become increasingly important in today's aging society. Though recent studies indicate increasing IT usage among elders, many find computerized technologies too challenging to use [13]. Elders often have difficulty facing the complexity of modern technology and need simpler solutions. For example, many elders are still challenged by procedures like starting Skype conversations with their children or finding a TV station among dozens of options.

We see four approaches to making IT products accessible to elders. One approach is to design products especially for them [14]. This can be helpful, but elders' needs are varied and changing over time, making it unlikely to find a universal design that fits all elders' needs [16]. Another approach is to make systems that can adapt to the needs of individual elders [29], but few products have been designed with such adaptation in mind. A third approach is to support customization of existing products (e.g., [10], [11], [19]) but the customization process itself can be too complex for elders. Since even simple procedures can be complex for some elders, we advocate a fourth approach where a third party works with an elder to help them accomplish their goals with IT products.

Consider situations like the following. Chye is 78 and lives alone. He has a domestic helper Kim, who visits twice a week. Chye is a fan of music from the 50's, but there is no FM station near him that plays this music. When Kim is around, she will tune into 50's music using Spotify on the computer Chye's children gave him. Also, Chye's son gave him an AppleTV so he can watch his favorite shows. He loves shows from the History Channel and the Discovery Channel. However, Chye has trouble finding them from AppleTV's on-screen menu and often asks Kim for help. Both Chye and Kim wish that Chye could enjoy his favorite music and shows even when Kim is not around. Kim spends lots of time teaching Chye how to do these things by himself, but Chye is often unable to do so.

Using *CoFaçade*, elders can accomplish frequently-recurring, high-level goals through a few customizable triggers on a simple interface, such as the physical remote control shown in Figure 1. Helpers use a familiar

Figure 1. Elders' trigger interface in our *CoFaçade* prototype, with five programmable button triggers on top and a reader for RFID card triggers on the

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customization interface to map triggers to procedures, which perform a sequence of subtasks on both software applications and consumer electronics. This customization can be done either locally or remotely.

The contributions of this paper are three-fold.

- We present the *CoFaçade* approach and the background research that led to it.
- We describe a prototype artifact we developed that implements this approach.
- We present an empirical evaluation that shows how the *CoFaçade* approach reduces helpers' workload while empowering elders to achieve their goals through IT products.

RELATED WORK

In this section, we discuss existing strategies for making IT products more accessible to elders.

Design for elders

"Universal Usability" has the goal of making interfaces usable by all people [25], and this has led to design guidelines for various groups. In "Designing for Older Adults," Fisk et al. provided a list of guidelines for elders [13]. These guidelines emphasize interface changes that respond to age-related changes in perception and cognition: larger displays, fonts, buttons, accessibility improvements in specific contexts (navigation [13], web [20], email [10], etc.), and fewer options. While these guidelines are very useful, adopting them requires dedicated effort in the design and implementation phases, thus excluding many currently existing applications. In addition, it is difficult to come up with a universal solution that caters to needs of elders, as their needs can differ among individuals and change over time [16].

Adapt to elders

To cater to elders' varied and changing needs, researchers have considered adaptive solutions. Wobbrock et al. define this shift as an ability-based design, in which "we move away from assisting human users to conform to inflexible computer systems, and instead consider how systems can be made to fit the abilities of whoever uses them" [29]. Adaptive interfaces can be configured according to individual user profiles [26], with some work done in making these profiles portable [4]. Since determining a user's profile can be difficult, systems may adapt based on automatically collected health information, and this poses a serious privacy risk [1]. Also, adaptive solutions require dedicated efforts to include them before releasing a product, while the majority of today's products or applications have not included such solutions.

Third-party customization tools

To make existing applications accessible to individual needs, researchers have proposed approaches that enable third-parties to modify the interface or behavior of existing applications. These customization tools could be used to make applications more accessible to elders. These approaches typically operate either on the surface-level of the interface, intercepting input events and/or manipulating views before they are delivered to the application (e.g., Prefab [11], CoScripter [15], Chickenfoot [6]) or via a toolkit, which integrates the system with the toolkit to gain access to the internal program structures (e.g., Scotty [12], OldGen [21], WADE [19]). However, using these solutions to create elderly-friendly interfaces can still be tedious and complex, making it difficult for elders to use.

In summary, while designing for and adapting to elders are effective strategies, these strategies need to be incorporated during design time, and may not work with many existing IT products. Third-party customization tools can make existing products accessible to elders, but the customization process can be too complex and tedious for elders to handle. On the positive side, elders are not alone. They often have technologically capable social contacts who are willing to offer assistance, which offers an opportunity for a fourth approach which considers both stakeholders together, alleviating some of the design constraints.

Assisting elders

Researchers have investigated making IT products more accessible to elders through collaboration with helpers. Some of these researchers have studied the nature of such help and how to do it effectively.

For example, training takes significantly more time for elders compared to younger learners, and elders commit more errors in post-training evaluations [5] [8]. This highlights the need to design instruction to compensate for elders' slower cognitive performance, limited processing resources, lack of inhibition, and sensory deficits. Fisk et al. provided detailed guidelines on how to design training and instructional programs to teach the elders more effectively in Chapter 7 of their book [13].

In addition to teaching elders, another common form of assistance is to perform tasks for elders. Research has found that significant help comes from both household members as well as external social circles, such as volunteers [2] [23], [24]. Within the household, Grinter et al. [17] found that one person typically becomes a guru, routinely helping other household members who are less technically inclined. Outside the house, non-profit organizations often send volunteers to elders' homes to help them with various tasks, including computer tasks[1].

Since some elders have cognitive impairments, we also mention research that investigates helpers creating reminders for people with cognitive disabilities. Carmien, for example, proposes the use of a dual-interfaces approach for caregivers to create memory-aid scripts for people with cognitive disabilities [7]. Legion:AR collected crowd-sourced labels for images of a disabled person's

[1] www.newyorkcares.org; www.sgcares.org

environment to keep them on track while performing daily activities [28].

While we are investigating situations where a helper works together with an elder, our approach differs from all the previously mentioned approaches. We envision situations where the helper seeks neither to teach an elder how to accomplish a task, nor does it for them, nor reminds them how to do it. Rather we enable helpers to create customized procedures that help elders to accomplish tasks and link these procedures to simple triggers.

EXPLORATORY INTERVIEWS

To better understand how elders interact with IT products, we conducted three sets of interviews. The first were in-depth, semi-structured interviews[2] with 8 elders to help identify a productive design strategy. Since we saw many elders getting help from others, we conducted a second set of interviews with 40 adults below 50 years old who help elders. We later realized that elders' difficulties with IT products are not limited to computer applications. We therefore conducted a final round of interviews with 10 elders to know more about their experiences with consumer electronics.

Elders using Computer Applications

For our initial interviews, we found participants through a social worker at a community center for elders in Singapore. We asked to meet people over 50 years old with some computer experience and were introduced to 5 men and 2 women, ranging in age from 51 to 76. Another woman (Chinese residing in Canada, age 68) was later recruited through an author's social connection. Four participants had tertiary education, and six were retired. Participants reported using email, Skype, watching videos, and playing games on their computers. Some also used various work-related applications such as customer relationship management software or word processors.

Interview questions aimed to elicit elders' experience with computer usage, in particular focusing on difficulties encountered in usage. If difficulties were reported, there were follow-up questions on the nature of the difficulty and how the elders attempted to resolve the issue. In addition, interviewees were asked to demonstrate their usage of applications that they reported using. Their behavior was observed and noted. Interviews were transcribed and analyzed against the background information of the older users experience with computers.

Overall, our participants all demonstrated difficulties with eye and neck strain after using computers, some despite verbally claiming they have no difficulties. Some coped by enlarging the text on the screen, others by taking more breaks or working for shorter periods of time.

Participants with lower educational attainment tended to report difficulties with English and with 'learning'. One participant (P8) attributed his difficulty with dialog boxes to an "education issue".

Interviewees seemed to prefer interfaces that did not change. This theme occurred regardless of educational attainment or usage of computers at work. P7, despite claiming he has no difficulties with computers, indicated that he would like to be informed of web interface updates, stating that "Older people are more resistant to changes". He would like more time to "learn" new interfaces as they are updated. P6 described it as "old people like to use old thing (sic)". As indicated by [18], constantly updating interfaces can be a challenge to older users because of the ongoing learning needed. Even P5, who reported over forty years of computer usage, said she "did not like too much change" when discussing changing interfaces.

All participants reported difficulties with computers. One participant (P1) reported difficulty with troubleshooting her computer network. Six participants reported difficulties with memory or vision. These difficulties were particularly obvious when participants were asked to demonstrate their usage of applications.

When asked how they deal with difficulties, two said they went to family members, four went to people in their social circle, one went to both family and friends, and one said he did not ask anyone for help. P5 and P8 said that they were reluctant to ask their children for help, because they were "impatient" or "too busy" to teach. It should be noted here that, since our participants were drawn from a socially active pool of elders in a volunteering group, the number calling friends for help (instead of family) may be inflated.

Helpers Working with Elders

As turning to people for help was prevalent in our first interview study, we then surveyed adults about their experiences when offering help to elders. We used snowball sampling (starting from the authors' social connections) to collect 43 responses from people aged from 25 to 49 (M=32). Most participants were from Southeast Asia, ten were from China, one was from Australia, and one was from Germany. There were 23 men and 18 women. Ten were students, and the remainder were working adults.

Participants were asked to relate an instance of offering IT help, specifying who was helped and the nature of that help. The majority of help instances (n=35) were with parents or grandparents, while the remainder (n=8) were with non-related elders or friends. Help instances fell into four (non-exclusive) categories: offering help from a remote location (n=15), repeated tutoring (n=13), helping only with setup (n=5) and helping by sourcing or preparing entertainment content such as videos or music (n=4).

More than half of the participants expressed some form of frustration with the helping process. Six participants specifically labeled the help instance as "difficult" or

[2] Link to detailed list of questions: http://www.nus-hci.org/?attachment_id=1357

"bothersome." For example, one participant complained about repeatedly needing to teach an elder how to perform a seemingly simple task: "I just feel frustrated to teach them to use web browser when the same problems happens again and again".

Distance was an important factor for many participants. For example, one participant reported, "I only have the opportunity to help my mother use Skype only when I went back to my country". Another participant shared: "I cannot guide my parents on computer troubleshooting through the mobile phone when I am working".

Some of our participants found creative workarounds to difficulties they encountered. For example, one participant gave her mother a video recording that showed how to perform a computer task. Another participant created a written tutorial: *"I write all the steps how to start the TV and change to my father's favorite channel on a paper."* Other participants try to setup elders' devices in a simple way that avoids confusion. One said, "*I bought an iPhone for my mom, and only install three applications on that. I told her 'If you want to call me, click the first application, if you have emergency, click the second […].'* Another said, "*I bought a computer for my father and put the most commonly used applications on the desktop.*"

Elders using Consumer Electronics

After conducting these interviews, we realized that we had not explored elders' use of consumer electronics. Since these can also be a source difficulty for some elders, we conducted a final round of interviews with 10 elders that focused specifically on consumer electronics. Again, participants were recruited through snowball sampling. Six were from Southeast Asia, three were from China, and one was from the United States. There were four men and six women, ranging in age from 55 to 87. Four had tertiary degrees, four had secondary degrees, and two had completed diploma programs. Participants varied in their comfort level and experience with computers much as our earlier interview participants did.

Regarding consumer electronics, participants felt comfortable with most electronics devices, but 7 of 10 participants complained about major difficulties when using TVs or DVD players. Problems ranged from navigating complex digital TV interfaces to switching channels on a conventional TV. Many experienced problems with remote controls. P3 reported difficulty turning on subtitles. P7 reported that her universal remote control would not turn on her TV properly. She then added, "…it does 50,000 things that are supposed to be so nifty. It's too complicated."

When participants experienced problems with electronics, all reported calling a friend or relative for help as our original interview participants did. If they could not find someone to help, they would simply give up using the device.

Discussion

In summary, while some elders we interviewed are quite technologically advanced, most encounter recurring difficulties with some IT products, and a few find all IT products complex and intimidating. We found no evidence that the level of difficulty encountered was tied to participants' education level or even experience with technology. Rather, elders find that keeping up with the rapid pace of change in modern IT products is simply too tiring.

Many elders turn to friends or relatives when they need help. When this happens, new technologies are often hard to avoid, because helpers often bring technologies that they are more familiar with. Therefore, when the current difficulty has passed, the elder may encounter new difficulties. But the helper often has limited time and is not always present when needed. Also, many helpers grow impatient when training elders to use new products. Some helpers customize elders' products to make them easier to use, but this is not always possible.

COFAÇADE APPROACH

Our exploratory interviews shed light on the nature of elders' problems with IT products, the role played by helpers, and the challenges encountered by helpers. Considering all of these insights together leads to a new approach to helping elders reach their goals with IT products, which we call CoFaçade. In software engineering, the term "façade" refers to a design pattern that provides a simplified interface to complex program procedures [3]. This name highlights the fact that the helper creates a simple trigger interface collaboratively with an elder.

In CoFaçade, the *elder* is an older adult who has goals they wish to accomplish with IT products but has recurring difficulties and may even find technology intimidating. The *helper* is more comfortable with a technology that can help the elder realize their goals. Note that the helper may not be a technology expert.

Systems built with the CoFaçade approach have separate interfaces for elders and helpers. The elder uses an interface with a small number of *triggers*, where each trigger is a single button (or card) that can execute a *procedure*. The helper uses a *customization interface* to define procedures and map them to triggers.

The trigger interface should be embedded in a familiar artifact. Such artifacts are stable, comfortable, and part of the elder's everyday life. A physical remote control is an example of a familiar artifact, but a trigger interface could also be embedded into any other artifact ranging from a smartphone to a coffee cup, as long as the elder is familiar with it. Also, since our exploratory interviews showed that most elders wish to accomplish a fairly small number of frequently-recurring tasks, a small number of triggers is often sufficient.

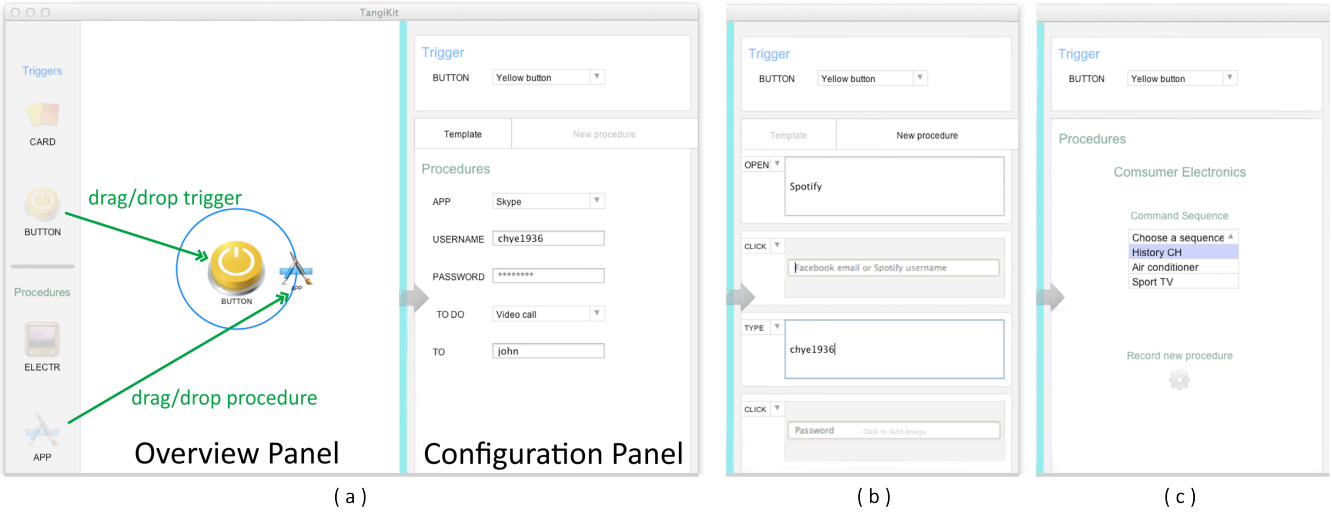

Figure 3. Helper's customization interface (a) Button trigger, Skype app template. (b) Configuration panel for button trigger, new computer application procedure (Spotify). (c) Configuration panel for button trigger, new consumer electronics procedure.

The customization interface is for defining procedures that accomplish frequently-recurring high-level goals with IT products. The procedure definition process needs to be fast and easy, because helpers often have limited time. Since there is a wide variety of products and new products are constantly begin created, the customization interface needs to work with any existing IT product. Also, the helper should be able to customize triggers and procedures either in the elder's presence or at a remote location.

The approach we have described has four key elements; all are necessary to address the problems revealed in our exploratory interviews:

1. Distinct roles for elders and helpers
2. Elders have a simple interface with small number of triggers embedded in a familiar artifact.
3. Triggers are mapped to procedures that accomplish high-level goals with any IT product.
4. Helpers have a simple interface for defining and modifying procedures either locally or remotely.

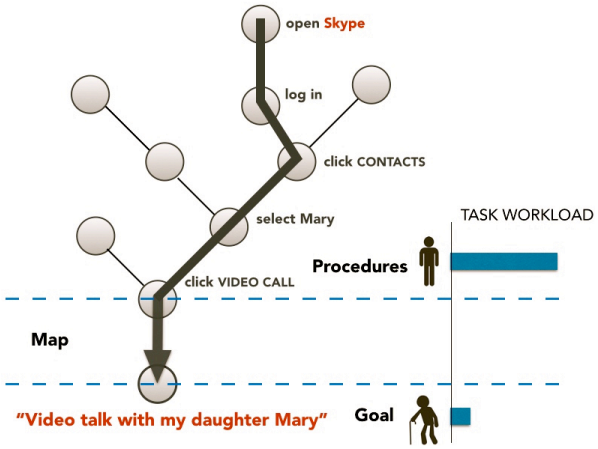

Figure 2. The CoFaçade approach: distinct roles for elders (goal) and helpers (sub-goals composition).

We define the user interface containing sets of triggers which can accomplish different high-level goals as *goal-oritiented interface*. In summary, CoFaçade enables elders to achieve frequently-recurring IT tasks with a simple goal-oriented interface and enables helpers to create related procedures seperately. Figure 2 illustrates the goal-tree structure of CoFaçade approach, where the decision-making path for creating procedures can be made by helpers with their preferred methods through composing each sub-goals. Therefore, we envision CoFaçade approach has three advantages: 1) Helpers have the freedom to choose their familiar methods to create procedures (e.g., use Skype rather than Google Hangouts for video calling task). 2) Elders can express their needs in a high-level (e.g., video talk to my daughter Mary). 3) Benefit both parties by seperating the task into goal and procedures, with respect to their distinct roles in this collaborative approach and thereby increasing the overall efficiency.

PROTOTYPE DESIGN AND IMPLEMENTATION

To help us evaluate the CoFaçade approach, we implemented a prototype system. Our trigger interface prototype is the remote control shown in Figure 1. To keep this interface as simple as possible, we included only five button triggers with different shapes and colors. The number of triggers can be expanded through RFID-tagged cards, which we describe later. This remote control also includes a Bluetooth network connection and infrared (IR) sensors and emitters for recording and playing back procedures that control consumer electronics.

The helper uses the customization interface shown in Figure 3 to define procedures that control the elder's computer applications and consumer electronics. This interface can be used in three ways requiring increasing levels of computer expertise. Using *templates* requires the least expertise, and we expect this to be the most common case. Templates give helpers simple customization interfaces with pre-defined

procedures for common applications and require average computer skills to operate. If no template is available for a desired application, the helper can define a *new procedure.* This requires slightly more skill than using a template, but it can be done fairly easily using the graphical user interface shown in Figure 3b. Creating new templates requires the most skill and will be explained later.

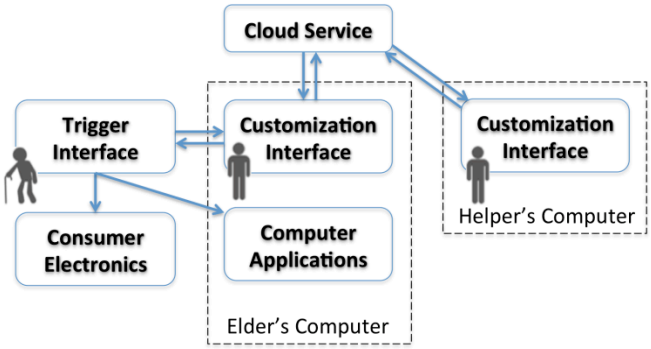

Figure 4. Overview of our CoFaçade prototype.

Figure 4 shows how the components of our prototype are connected. Triggers and procedures are loaded into the elder's trigger interface via the customization interface on the elders' computer. The elder can then use the trigger interface to control their computer applications or consumer electronics. The customization interface can also store triggers and procedures in a cloud service, giving the helper access to the customization interface even when they are not physically present.

Currently, our prototype supports two types of triggers: buttons and cards. We first explain how helpers can configure buttons to control two types of procedures: computer applications and consumer electronics. We then explain how to create new templates and explain why and how to use card triggers.

Computer Application Procedures

Our prototype uses Sikuli Script [30] to control applications on the elder's computer. This allows helpers to make procedures for any application on the elder's computer by capturing a series of screen shots. Since this can be cumbersome, however, we also provide templates that give helpers high-level control of commonly used applications. Currently, we have one fully functional template for placing calls with Skype.

Imagine that a helper wished to configure an elder's trigger interface to make the yellow button place a call to the elder's son. To do this, the helper would take these steps in the configuration interface (see Figure 3a):

1. Drag the *BUTTON* icon from the trigger palette to the overview panel.
2. Select *Yellow button* in the configuration panel.
3. Drag the *APP* icon from the procedure palette to the ring around the button in the overview panel.
4. Select the *Skype* app in the configuration panel, and enter the elder's Skype ID and password and the son's Skype ID.
5. Press the arrow button to send the configuration to the elder's trigger interface.

If no template is available, the helper can choose the *New procedure* tab in the configuration panel and enter a series of commands (Figure 3b). Our prototype supports five commands found in Sikuli Script. OPEN starts a named application. CLICK and DBLCLICK activate a button identified by a screen shot. TYPE enters text in a control identified by a screen shot, and WAIT pauses for a specified time. Currently, screen shots are chosen through a file chooser. A fully developed system might allow helpers to capture screenshots directly.

Consumer Electronics Procedures

Our current prototype does not provide templates for consumer electronics, but helpers can define new procedures for consumer electronics devices. To define a new procedure, a helper would begin with the same steps 1 and 2 used for a computer application procedure. The remaining steps are as follows (see Figure 3c and Figure 5).

3. Drag the *ELECTR* icon from the procedure palette to the ring around the button in the overview panel.
4. In the configuration panel, press Record new procedure. A pop-up window appears (see Figure 5).
5. Enter a name for the new command sequence and press the *Record* button (on the right).
6. Point the device vendor's remote control at the IR sensor at the top of the elder's trigger interface and press the desired sequence of buttons.
7. Press *Stop* (on the right) and close the pop-up window.
8. In the configuration panel, select the newly entered name from the command sequence menu.
9. Press the arrow button to send the configuration to the elder's trigger interface.

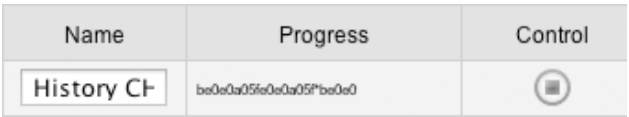

Figure 5. Recording a new command sequence. Point the device's remote at the trigger interface and press the desired buttons. *Progress* shows numbers as buttons are pressed.

Note that the helper may need to be physically present with the elder to capture a new sequence of commands from a device vendor's remote control. Once a sequence has been captured, however, the helper can configure the trigger interface from a remote location.

Creating New Templates

As stated earlier, we expect using templates to be the common case for helpers. Since devices and applications change frequently, our prototype makes it easy for people

with basic programming skill to define new templates. We expect that templates will be created and updated fairly quickly either by companies or by highly skilled helpers.

To make a computer application template, a creator begins by using a graphical user interface like the one shown in Figure 3b to define Sikuli scripts for typical use cases. These scripts continue to work if interface elements move, but need to be revised if elements change appearance. (Note that some apps allow control through web services or other programming interfaces that change less frequently than the visual interface. Highly skilled template creators can use these interfaces instead of Sikuli to create templates that will last longer.) After defining use case scripts, the creator then identifies steps that require user configuration (e.g. user name, password) and links these parameters to text fields or list boxes using a markup language.

This process requires only basic programming skill, allowing numerous programmers to create templates and share them through a common repository or marketplace. Also note that, while we currently support only computer application templates, our approach could be extended easily to support consumer electronics templates.

RFID Card Triggers

When elders require more than five triggers, our prototype allows helpers to create new triggers using numbered cards with RFID tags. We chose to expand the number of tasks through RFID cards, because physical cards are more familiar and easier to handle by people with no computer skill. Previous research [31] has shown that at least 25 cards can be organized effectively in a photo album by people with little computer expertise, and our exploratory interviews suggest that this is sufficient for most elders.

Elders can write descriptive labels on cards to help them remember which card accomplishes which goal. Helpers can then map cards to procedures in the customization interface by (1) dragging the card icon from the trigger palette into the overview panel and (2) choosing the card number in the configuration panel (see Figure 6). This simple method makes it easy to keep track of a large number of procedures, and it avoids overwhelming elders with a large array of buttons.

Figure 6. Choosing a card number in the trigger config. panel.

Our prototype captures the core ideas in the CoFaçade approach. Elders have a simple interface with small number of triggers that accomplish high-level goals with any computer application and any consumer electronics device with an IR remote control. Helpers have a simple interface for configuring procedures, and they can do this either locally or remotely.

EVALUATION

We are interested in whether the CoFaçade approach *improves helpers' experience* and *lowers barriers to elders using IT products*. To answer this question, we evaluated the CoFaçade approach in the context of helpers assisting elders with setting up Skype calls. Skype call is a task faced by many elders [27] and it has similar complexity to many other common tasks elders often want to perform, such as checking an email inbox or choosing a TV channel from dozens of options.

We evaluate the improvement in helpers' experience by measuring the time taken in the helping process. We evaluate the reduction of barriers to using IT products by elders by measuring: 1) the frustration level by the elders to learn to perform the task, and 2) their success rate in completing the task.

Our hypotheses are that the CoFaçade approach can reduce the time and effort involved in the helping process and improve the success rate for elders in completing the IT task and reduce their frustration.

Participants

A total of 18 elder-helper pairs (36 participants) were recruited. The 18 elders were recruited from a local organization (13 female; age range from 55 to 80; M = 64.83, SD= 7.20). All elders had taken part in local senior computer classes and had basic computer skills and Internet experience. The 18 helpers were young adults recruited from the university community. They are students majoring in a variety of disciplines including design, chemical engineering, business, and computer science. All of them reported at least 5 years of using computers and were comfortable with technology. The matching between the

Simple task (6 steps)	Intermediate task (9 steps)
Start a video call to a designate person from three candidates.	Start a new group call to two designate people from three candidates and adjust to the suitable volume.
1) *Click the Skype icon from desktop;* 2) *Input username and password;* 3) *Click "login";* 4) *Click "contact list";* 5) *Choose the designated person from a list of three candidates;* 6) *Click "video call".*	1) *Click the Skype icon from desktop;* 2) *Input username and password;* 3) *Click "login";* 4) *Click "file";* 5) *Click "new conversation";* 6) *Click the "add" button;* 7) *Find two designated people in a list;* 8) *Click "video call";* 9) *Adjust volumes.*

Table 1: Task description

elder and helper was based on their availability for the experiment schedule. Task and Stimuli

As previously mentioned, we choose Skype as our testing environment as we believe it represents a typical task an elder would like to perform and want to seek help with. For the task design, we wanted to simulate realistic scenarios. The baseline condition simulates the common situation in which a helpers teaches an elder to use an IT product so that the elder can use it on their own when the helper is not available. The baseline is compared with the CoFaçade condition in which the helper first configures the elder's trigger interface, and then the elder completes the task independently using the trigger interface. We designed two level of complexity for both methods: one simple task and one intermediate task (Table 1).

Apparatus

Participants in both conditions used a MacBook Pro laptop computer with 2.5GHz dual-core i5 processor, 4GB RAM, and 13' display, running OS X Mountain Lion. The software in the laptop included both our prototype's customization interface for the helper and Skype 6.4 for OS X. In the baseline condition, helpers also used the Skype tutorial available at support.skype.com to teach the elders. In the CoFaçade condition, elders also used the physical trigger interface described earlier in the Prototype Design and Implementation section.

Experimental Design

We used a within subjects experimental design with two independent variables, each with two levels: approach (baseline vs. CoFaçade) and task complexity (simple vs. intermediate). Approach was counterbalanced among participant pairs while task complexity was presented in a sequential order from simple to intermediate. This is because we were not interested in comparing the performance between levels of difficulties.

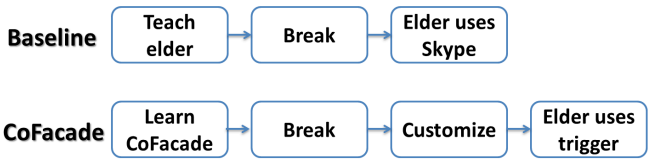

Figure 7. The workflow of the experiment

The workflow of the experiments is described in Figure 7. At the beginning of the experiment, the helper was introduced to the elder and both were given 10 minutes to acquaint themselves with each other.

Then, in the baseline condition, the helpers taught the elders how to achieve the task goal by using a standard printed tutorial from the official Skype website and also by offering guidance until the elders informed the helper that they felt well-prepared. Following a three minute break, the elder performed the task with no help apart from the availability of the printed tutorial. If the elders failed to accomplish the task, they were asked to try again with the aid of the helper.

In the CoFaçade condition, the experimenters taught the helper how to use the CoFaçade customization interface. Following a three minute break, the helper used the customization interface to define procedures for the elder's trigger interface. Next, the helper was asked to introduce the trigger interface to elder and let them use it to complete the task.

All participants (both elders and helpers) ended the experiment by filling in a questionnaire and going through a post experimental interview. In summary, we had 18 pairs of participants x 2 approaches (baseline vs CoFaçade) x 2 task difficulties (simple vs. intermediate) = 72 collaborative help/teaching tasks total.

Results and Discussion

The main quantitative measures for the study were the overall time to complete each task and elders' frustration rate when performing the task. Overall time included all aspects of the task, as shown in the following formulas:

$$T_{baseline} = t_{teach\_elder} + t_{elder\_uses\_Skype}$$

$$T_{CoFaçade} = t_{learn\_CoFaçade} + t_{customize} + t_{elder\_uses\_trigger}$$

To measure frustration rate, we computed the ratio of elders' self-reported perceived time to the actual time they spent performing tasks. This is an established method for measuring frustration implicitly [22]. Research has shown that more frustration tends to be overestimated (ratio>1) while less frustration is underestimated (ratio<1) [9].

		Baseline		CoFaçade	
		M	*SD*	*M*	*SD*
Overall Time					
	Simple	8.33	5.11	3.02	0.69
	Intermediate	10.07	6.10	3.36	0.77
Frustration Rate					
	Simple	1.46	0.82	0.49	0.64
	Intermediate	0.90	0.48	0.63	0.60

Table 2: Results of overall time spent on the collaborative task (in minutes), and elder's frustration rate.

Detailed results for both overall time and frustration rate are shown in Table 2. We conducted a two-way repeated-measures ANOVA and found a significant main effect of approach on overall time ($F_{1,17} = 25.25$, $p < 0.001$), but no significant main effect of complexity on overall time. Averaging across complexities, overall time was 9.20 minutes in the baseline condition and 3.19 minutes in the

CoFaçade condition, which shows that the CoFaçade saves considerable time when compared to the baseline approach. In the baseline condition, elders spent 70% of the overall time learning and 30% performing tasks. In the CoFaçade condition, helpers spent 56% of the overall time learning to use our prototype and 27% customizing the elder's trigger interface, while elders spent the remaining 17% of the time using the trigger interface. Note that since the intermediate task was always performed after the simple task, it is likely that participants spent more time learning in the simple task. This may explain why the overall time for the intermediate task was not much longer than the simple task.

On frustration rate, we found significant main effects from both approach ($F_{1, 17} = 7.73$, $p < 0.05$) and complexity ($F_{1, 17} = 15.4$, $p < 0.05$). Pairwise t-tests with bonferroni correction showed that frustration rate decreased significantly in the CoFaçade condition for both complexity levels when compared to the baseline condition ($p < .05$ for both complexity levels).

We also found a significant approach and complexity interaction effect on frustration rate ($F_{1, 17} = 15.57$, $p < 0.01$). Pairwise t-tests with bonferroni correction showed that the difference in frustration rate between complexity conditions is significant for the baseline condition ($p < .05$), but not significant for the CoFaçade condition. In the baseline condition, the decrease in elder's frustration from the simple task (M=1.46) to the intermediate task (M=0.9) is largely due to learning effects. The intermediate task shared several common steps with the simple task, and it was always performed second in this study. Under more realistic conditions, there would be more time between tasks, and elders would be much more likely to forget what the helper taught them. This is supported by our exploratory interviews, where many helpers reported teaching elders the same procedure repeatedly.

In addition to improvements in overall time and frustration rate, we also noticed that elders' task completion rate improved when using the CoFaçade approach. All elders were able to complete both tasks in their first attempt when using our prototype's physical trigger interface. In the baseline condition, 4 of 18 elders failed their first attempt to complete the simple task, and 2 other elders failed their first attempt to complete the intermediate task.

We also discovered that several helpers were concerned about the need to see elders' passwords. P20 and P27 suggested adding features to capture elders' passwords without making them visible to helpers. Elders were less concerned about privacy, especially when giving passwords to family members. As P3 said, "*My son helps me set up all these computer things, I cannot remember these accounts.*"

Finally, we note that using university students as helpers is a limitation of our study. Many of the university students we recruited came from fields like design and business and fit into the criteria we expect for a typical helper: comfortable with technology, but not necessarily experts. Most elders we interviewed had at least one person in their social circle with this level of comfort with technology. However, some of our helpers had more experience with technology. The usability of CoFaçade could be further evaluated with helpers outside a university setting, and we leave this for future work.

In conclusion, the significant reduction in frustration rate and the improved task completion rate for first attempts indicates that the CoFaçade approach is both easier and more effective for elders. This is shown in P11's comments, for example: "*I am very happy to let them help me in this way. This method is much easier for me to use computer [sic].*" Furthermore, the significant reduction in overall time shows that the CoFaçade approach reduces helpers' burden when working with elders. As P33 explained, "*I would prefer this method rather than guiding them time and time again.*"

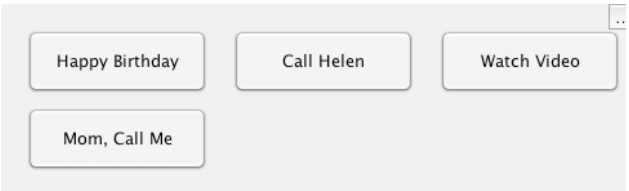

Figure 8. A virtual trigger interface for elders.

Our current implementation supports buttons and RFID card triggers. However, other types of triggers are possible. For example, Figure 8 shows a software interface we developed for elders. Elders can trigger computer tasks by clicking the corresponding buttons on their computers.

CONCLUSION AND FUTURE WORK

This paper introduces the *CoFaçade* approach to helping elders realize their goals using IT products. To demonstrate the effectiveness of this approach, we implemented a prototype using a handheld physical trigger interface and a desktop customization interface for defining procedures for both computer applications and consumer electronics.

We conducted an evaluation where 18 helpers either taught elders to perform a computer task or customized the trigger interface to perform that task. Our experimental results showed that the CoFaçade approach reduces helpers' workload, reduces elders' frustration, and improves elders' task completion rates. Another main advantage of CoFaçade is that it can provide elders a stable interface, even as user interfaces rapidly evolve.

Further research should investigate uses in the household setting as well as the feasibility of additional types of input such as voice input, gesture input, etc. These should be intuitive and provide convenience for elders.

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