GuideMe: A Mobile Augmented Reality System to Display User Manuals for Home Appliances

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Abstract. In this paper we present GuideMe, a mobile augmented reality application that provides assistance in using appliances. In order to explore how users perceive GuideMe, as a design of an interactive and digital manual, we conducted two user studies. We compared GuideMe first with paper-based manuals and then with video-based manuals. Our results indicate that the paper-based manuals were superior regarding typical usability measures (i.e. error rates and completion times). However, participants reported a significantly higher perceived task load when using paper-based manuals. Due to a better user experience, GuideMe was preferred by 9 of 10 participants over paper-based manuals. We present our design in detail and discuss broader implications of designing digital manuals. Furthermore, we introduce a custom format to define manual structures for mobile augmented reality enabled manuals.

1 Introduction

Many of today's challenges in designing interfaces relate to the spread of technology to our homes and everyday lives with a shift from a rather narrow task-orientation to qualities of everyday experiences [3,2]. For example, ten years ago a baking oven would be operated by choosing temperature and mode. Today, an oven can be programmed to start at a predefined time with a predefined temperature and several operation modes. Interfaces of everyday products in our homes have gained in complexity. Getting familiar with all the features that such a product provides is challenging. In order to assist users, to handle their appliances and consumer electronics, manuals are created by technical writers and illustrators, who carefully describe the operation of the product. However, very few people enjoy interacting with a manual; i.e., going through a book consisting of technical writings and illustrations to find out how to operate a system or to solve an existing problem. Off the shelf mobile devices could be used as digital manuals and thereby performance and the user experience of interacting with manuals could be improved. However, designing a digital manual based on inspirations taken from physical manuals can be a cumbersome task.

In this paper we present GuideMe, a design that aims at exploring alternatives to traditional paper-based manuals. GuideMe is an interactive "digital"

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manual informed by properties of mobile devices and augmented reality technology. Hereby, our intention was to make use of people's familiarity with mobile devices and create a design that would be timelier and exciting to use.

This paper is structured as follows. In the next section we provide the background on mobile augmented reality and current practices for user manuals. Then we discuss in more general how GuideMe fits into current concepts and notions in interaction design. Building on these fundamentals we present details of the technical implementation of the prototype. Hereby, we introduce a custom format to define manual structures, which we refer to as User Manual Markup Language (UMML): an XML based format to define user manuals and especially technical illustrations. The GuideMe prototype is evaluated using manuals for two ovens and compared to a video tutorial and excerpts from the original printed manual. The results are summarized and discussed.

2 Background

The development of GuideMe builds on knowledge from traditional user manual design and the technical progress in the field of augmented reality (AR).

2.1 User Manuals

User manuals are a part of the technical documentation of a product. The SecureDoc guideline [18] states, "Products are not complete without documentation." The guideline interprets, an important standard in technical documentation, the IEC 62079:2001 on "Preparation of instructions. Structuring, content and presentation" [10] and helps designing the technical documentation of a product. It outlines the requirements that are induced by European law, such as to enable customers to use all features of a product and to protect customers of potential hazards. The guideline relates to factors that are often ignored when a product is accompanied by a user manual of poor quality. For instance, "High quality documentation helps reduce customer support costs," because with the right information at hand it enables customers to solve many problems without further assistance. Furthermore, "High quality documentation enhances customer satisfaction," because a poorly designed user manual can prevent customers from exploring the full potential of a product. Another factor is that customers relate the quality of the product to the quality of its documentation. Therefore, the need for high quality user manuals is given and the exploration of emerging technologies, such as augmented reality, to improve their usability is worthwhile.

Although other formats are available, the standard format for user manuals is still the printed handbook. Typically it offers an index that lists all functionalities or use cases of a product. Each one of them is then described in a step-by-step manner. Technical illustrations improve understandability by "expressive images that effectively convey certain information via the visual channel to the human observer" [20]. Mainly for cost reasons comprehensive user manuals are often included as digital PDF documents on CD or for download. Although the content is normally taken one-to-one from the printed version, it improves the aspects of information retrieval concerning finding the user manual itself (if available for download) and finding the relevant information in it by searching the document.

2.2 Augmented Reality

Initially research in AR-based user manuals has been conducted using head-mounted displays (HMD) to provide information while having two free hands. The KARMA project uses such an HMD to convey step-by-step instructions and superimposed instructions to specialized mechanics [4]. Henderson et al. [9] built an advanced HMD-based AR interface and showed that their system improves the current documentation of mechanics. However, AR research currently explores new platforms. An increasing number of AR applications uses the mobile phone to display virtual objects [7,5,13]. Furthermore, mobile projectors provide new means to augmented objects with information by projecting the interface directly on the surface of the object [11].

As early as 2001, the AR-PDA prototype [5] mentioned mobile AR manuals as one possible application domain. Since this time, researchers have explored different technical implementations and hardware platforms. Hakkarainen et al. [7] actually applied mobile AR to user manuals to showcase their developed system that still relied on a server infrastructure to calculate the positioning of superimposed instructions. Liu et al. [13] evaluated a new mobile AR approach in the domain of user manuals. They show that "real-time AR feedback on physical actions in the real world" is beneficial regarding usability and task load of users. The test was based on an adapted MIDI station that could provide such a feedback channel.

The technology to build AR-based manuals is developing rapidly. First applications are already available, e.g. an app to explain a new car model[1] or a prototype of Aurasma that uses augmented reality to explain how to connect cables of a router[2]. These approaches cannot be generalized to other home appliances. They are impressive technology demonstrations, and showcase state of the art marker-less object recognition of 3D objects. However, they require highly textured user interfaces and are tied to a specific car or appliance.

The research focus shifts from the technological feasibility to the design of such applications. Several companies offer mobile AR SDKs that support the development of AR applications for example Qualcomm[3] and Metaio[4].

3 Designing Digital Manuals for and with Mobile Devices

From the beginning mobile devices have been recognized as personal digital assistants, which help to manage personal information. Later mobile devices

[1] Audi A1 user manual
`http://itunes.apple.com/de/app/audi-a1-ekurzinfo/id436341817?mt=8`

[2] Aurasma Visual Browser `http://www.aurasma.com/`

[3] Vuforia SDK `http://www.qualcomm.com/solutions/augmented-reality`

[4] Metaio `http://www.metaio.com/`

were also perceived as a tool that can manage contextual information. They have pervaded our everyday life, and the number of mobile applications is growing.

> As computational things become everyday things, what we design for can not be restricted to how to enable people to become more productive. Thus, there is a need for complementary design philosophies. [14]

Redström herby, refers to how HCI researchers used to focus on performance and supporting people in accomplishing tasks. In the last decade many researchers started to focus on creating new experiences enabled by mobile devices. De Sa and Churchill [16] argue that the new affordances offered by mobile augmented reality have potential to enhance users‘ experiences. More specifically they discuss how this can be achieved through the provision of digital information which is relevant for the user context. With mobile devices information that is digitally stored can be processed anywhere anytime. Consequently, more and more information is presented in digital form as and through mobile media.

> One experiences the world through the technology, and the technology inevitably becomes part of the way one relates to the world. While many technologies appear in between the user and the world, not all are embodied. For a technology to hold an embodiment relation it must be technically transparent, it must allow its user to "see through" it. [3]

Based on philosopher Don Ihde‘s non-neutrality of technology-mediated experience, Fallman hereby points out that for technology to be embodied it needs to recede into the background of experience. One could argue that this is true for mobile devices and mobile augmented reality applications. Similar to how one does not feel the weight of glasses after carrying them for a while, a mobile device, although heavier, recedes into the background of experience during interaction with the real world. However, this real world becomes augmented with digital information.

Different lines of research within HCI have recognized the increasing blur between the digital and the physical in today's designs. Efforts to improve the understanding of those kinds of designs exist. For example, Vallgårda et al. discuss how knowledge of materials has been essential to design practice and how computers share important characteristics with other materials that are used in, for example, industrial design or architecture. They introduced computational composites as a new type of composite material [19]. They argued that computational properties of a computer are difficult to exploit, but through combining it with other material can come to use.

In mobile augmented reality applications, mobile devices are used to augment real-world objects and materials. One could regard mobile augmented reality as a computational property of a mobile device. Through augmenting a specific real world object (e.g. an oven); i.e. combining a mobile device with the real world object, augmented reality as a computational property comes to use.

While printed manuals are still the standard media for manuals, there is a need for digital manuals and interaction that is more timely and uses features of mobile devices that people have already become familiar with.

However the mobile device itself is a medium that supports through its properties (e.g. being mobile, lightweight, having a camera, having a screen etc.) interaction that is fundamentally different from paper. Finding out how to best interact with new media is in general a difficult task and requires exploration. This is particularly true for digital counter parts of physical designs. For example, Grasset et al. [6] try to answer the question if a mixed-reality book is still a book and explore the design and development process of visually augmented books. They argue that exploring design issues becomes more important as technology gets more mature; and that the development of prototypes requires time and very specialized experts.

The intention of this section was to reflect on what it means to exploit mobile devices for interaction in a broader sense and to remind the reader of current design notions and problems. A mobile device is a new medium and mobile augmented reality can provide rich sensory effects. The key challenge for AR-based user manuals lies in building on the aforementioned technological advances in AR and to connect the device and the required information in a manner that is intuitive to the user and if possible even fun to use. It is unclear how much of the knowledge on user manual design can be applied to mobile phones and which new challenges arise when user manuals are adapted to the mobile device.

In order to provide some insights we now move to a concrete implementation of a digital manual that is inspired by properties of a mobile device.

4 GuideMe Prototype

The GuideMe system identifies home appliances by using the camera and retrieves an interactive manual from a server. The interactive manual is specified in the User Manual Markup Language (UMML). The following sections outline the method used to recognize the device, the UMML specification and the resulting user interface.

4.1 Connect to the Physical User Interface

To use a mobile device to interact with an appliance a connection between those has to be established. Both components should become a single user interface to display the required information.

For this purpose, a marker-based object recognition similar to [15] was chosen because the preferred marker-less recognition of an appliance requires textured surfaces [17] and therefore cannot be applied properly to home appliances which often have monochromatic or reflecting user interfaces. Marker-less approaches struggle to distinguish two devices of similar color and form. If marker-less recognition is applied the reflective user interfaces, the reflections will become part of the calculated feature, thus making it difficult to recognize the same device with different reflections. In a marker-based recognition the marker becomes part of the user interface.

4.2 Definition of the Digital User Manual

Appliances differ in size, form and functionality. In result each user manual has to be customized. GuideMe aims at providing the best possible user manual for a specific appliance and a specific mobile device. Therefore, we decided to put the design of the user interface into the hands of the experts by providing them a simple format to author user manuals. In consequence designers can adapt existing manuals to a specific device and experiment with different layouts and structures. We developed a new format to define manuals and refer to it as User Manual Markup Language (UMML). UMML defines the layout of the recognized user interface. In comparison to existing formats like APRIL [12], UMML benefits from a clear focus on user manuals. APRIL aims at structuring narrative content and defines cast, interactions and behavior. This flexibility leads to complex definitions that require advanced knowledge.

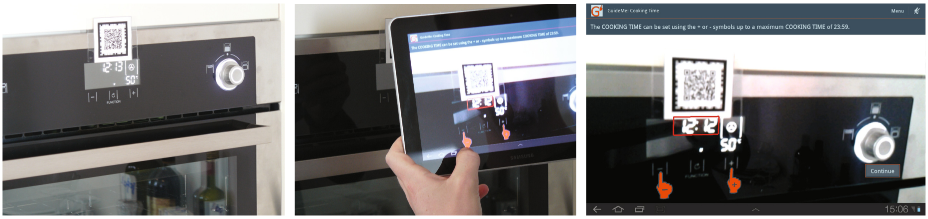
The resulting schema builds on a smaller set of XML statements to define the user manual. The user interface was split into the basic elements like text, arrows or any other graphical element. Custom elements can be defined and used as well. The grouping of these elements and the final structure of UMML was inspired by the design of current printed user manuals.

An UMML file consists of two parts: the menu description and the list of functionalities. Each functionality definition has a unique ID. The menu description organizes the available functionalities into a hierarchical structure of menus that can contain functionalities or submenus. Functionalities can be linked into a menu several times at several levels, if desired. Functionalities contain a title tag and consist of a number of steps. The steps are identified and linked by a unique ID. Each step definition contains a list of virtual objects and their position in relation to the frame marker, e.g. an arrow pointing to a button. Furthermore, images, videos and audio files can be linked into the manual.

4.3 Magic Lens User Interface

The GuideMe application is an UMML interpreter that builds on the Vuforia SDK to implement a so called “magic lens” interface [1]. The fixed components of the user interface are minimal to leave the screen to the manual designer. Only a small tool bar at the top supports the navigation and shows the current progress. The remaining part of the screen can be used to display the augmented camera image. This design aims at providing a maximum of possibilities to the manual designer and restricts the design considerations to providing the appropriate components to use the available space in an easy and intuitive manner.

Figure 1 shows how the camera image of the physical user interface (figure a) is combined with instructions (figure b and c). Two hand icons point at the available buttons. A frame is used to highlight the part of the display that will change by pressing the buttons. The user sees a live image of the real oven. Therefore, the user does not need to compare a depicted oven in a manual with the real oven. Furthermore, if the participant moves the hand to press a button, the camera will display this action on the screen as well. The virtual



(a) Oven with Vuforia frame marker and enclosed QR code

(b) GuideMe highlights the corresponding operating elements

(c) GuideMe screenshot with highlighted operating elements

Fig. 1. GuideMe prototype in action

objects defined in the UMML file can be classified by their positioning on the screen. The user has to hold the tablet in front of the user interface to recognize the marker. GuideMe uses the size and position of the marker to adapt the coordinate plane. Texture components, symbols, arrows, frames and user defined graphics are placed relative to the recognized marker position. In general these components are placed in the same plane as the marker but a 3-dimensional placement is possible as well.

In some cases superimposed objects might not be sufficient to indicate the correct action. For example, if one button has to be held while pressing other buttons, an image of two arrows pointing to both buttons will not be enough. The instructions that are printed in a manual have to be conveyed to the user as well. Using UMML and GuideMe, they can be printed on the screen or played as an audio or video clip. All three methods are possible with the existing UMML elements. Videos, audio clips, Android webviews, buttons and option menus are placed at fixed positions on the screen. Android webviews can load HTML context into the Android application from a file or the Internet. Video and audio clips start automatically when the corresponding step is rendered. Textual descriptions are placed at the top of the screen. All components can be freely combined, although a full screen video overlaps other components.

Navigation between user manual steps is possible by pressing buttons or by selecting from an options menu. Options menus and buttons can be defined in the UMML file. Users can always return to the last step using the Android back button or return to the menu by using the navigation bar at the top.

5 Evaluation

We conducted two subsequent studies to obtain first insights on the user experience and task performance using GuideMe. The first study compared GuideMe based manuals against excerpts from the original printed user manual and the second against video tutorials.

We selected two state-of-the-art ovens, the *Stoves SEB900MFSe* and the *Bosch HBL78B7.1*. Both provide sufficient complexity to require a manual for first usage of advanced functionality and provide several user interface elements, such as knobs, buttons and displays that could be augmented. They are similar enough to allow a comparison but have different user interfaces to mitigate learning effects during the study.

5.1 User Manual Design

One simple and one complex task were selected from the original printed user manual. In a pre-test the two tasks were completed on both ovens with similar effort. However, the complexity of the selected task was reduced by one step after the pre-test. Participants needed more than 10 minutes to set the start of the cooking period using the original manual. Hence, the complex task in the study consisted of only four steps.

For the first study the relevant pages of the original manual were used as is. All unrelated pages were removed to limit the scope of the evaluation to the presentation of instruction. The original manual served as a basis for all other manuals. For the second study, video tutorials were needed. The authoring of the video tutorials was inspired by existing video tutorials. Each video tutorial was implemented as one continuous video. The video contained the text as spoken comment and as superimposed text on top of the screen. Furthermore, additional annotations in the video highlighted important user interface elements of the oven. Users can navigate the video by using the standard Android controls, e.g. jumping to any point of the video sequence by selecting it from the progress bar.

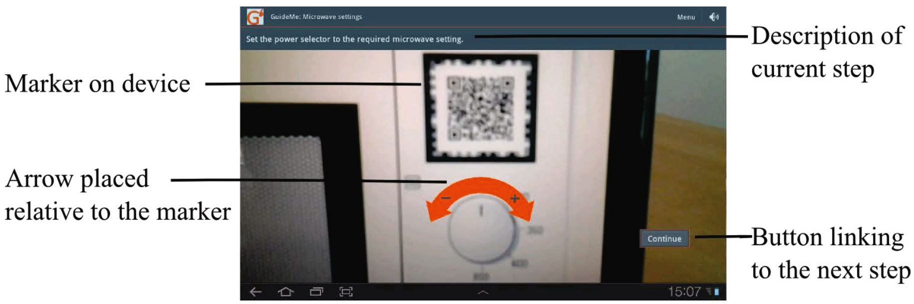


Fig. 2. GuideMe example manual: explaining a microwave oven

The GuideMe manual was structured according to the numbered steps in the manual. For each step, the corresponding explanation is shown at the top of the screen and the step is visualized on the screen as shown in figure 2. Arrows images and further markers are superimposed on the camera image to indicate relevant buttons and displays. Navigation between steps was realized by buttons.

5.2 Study Design

The first conducted study compares (a) the original printed version and (b) a manual based on GuideMe on a tablet. GuideMe ran on a Samsung Galaxy Tab

10.1 tablet with Android 3.1. We measured task completion times and used the NASA TLX [8] to measure the subjective task load of participants. Participants were asked to think aloud while completing the given tasks. Observers noted down their statements, the perceived body language and the operation of the appliance. A concluding questionnaire captured the subjective preferences of the user. The subsequent second study replicates the design of the first study, but compares (a) a video-based tutorial on a tablet and (b) GuideMe on a tablet. The participants in the second study did not overlap with participants from the first study.

During the user study, each participant performed overall 4 measured tasks, two on each oven: (a) 1 simple and 1 complex task using GuideMe for one oven and (b) 1 simple and 1 complex task using the printed original manual for the other oven. Switching between devices and reversing the order of technologies and devices aimed at mitigating learning effects of the oven's user interface. Participants could use as much time as necessary and should mention when they deemed the task to be completed or if they want to give up on it. There was no additional help offered except the manual to be tested. After each task participants completed the NASA TLX questionnaire. The concluding questionnaire collected overall feedback on both used technologies and the perceived complexity of the used ovens.

This data was evaluated in a within subjects design to mitigate the individual differences in performance and NASA TLX usage. The significance of quantitative data (NASA TLX and task completion times) was analyzed using a paired T-test and Cohen's d.

2 groups of 10 young technology-savvy participants (22-31, 4 female, 16 male) took part in the studies. All 20 participants used GuideMe and all of them operated both ovens. The majority of the users already knew similar ovens before the test (55 % Stoves, 70 % Bosch). 53 % agreed or strongly agreed when asked to state their familiarity with Android device on a 5 point Likert scale. 74% agreed or strongly agreed regarding their familiarity using tablet PCs. Only 10% had any experience with augmented reality applications. Albeit this user group does not represent the overall population, it represents the potential early adopters of mobile media based user manuals.

Each of the 20 participants performed 4 tasks, resulting in a total number of 80 measurements. 5 of these measurements were classified as outliers, because participants required exceptionally long to complete a given task. Participants were stuck because they entered unforeseen menus and got lost in the mismatch between instructions and available options. As we use a pairwise T-test the corresponding measurement using the second device was excluded from the analysis as well.

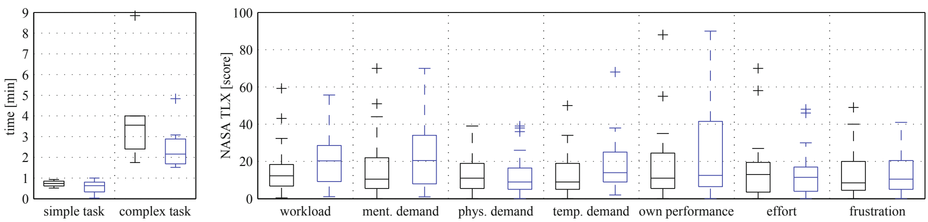
6 Results

All participants in both studies reported that the two provided user manuals were useful to complete the given tasks. Nevertheless, when asked if the oven was difficult to use the majority of users disagreed or strongly disagreed (65% Stoves, 85% Bosch). According to this question, the Stoves oven was experienced as more difficult.

6.1 GuideMe vs. Printed Manual

A first group of 10 participants completed a simple and a complex task using GuideMe on one oven and a similar task using the original paper manual on another oven. 90% of them stated in the concluding questionnaire that they preferred GuideMe over printed manuals. As shown in figure 3(a), they needed significantly more time ($p < 0.0003, d = 1.46$) to complete both tasks using GuideMe than by using the printed manual. Although all 10 participants deemed each task completed, the final result of the complex task included errors for the majority of participants. One specific error stood out. Users of the Stoves oven ignored the icon indicating the selected mode and ended up setting a timer instead of setting the cooking time. In many of the observed cases this was due to the timeout of the user interface after 5 seconds. After changing from main menu to the timer menu, participants looked at the manual. They did not notice when the oven display changed and subsequently showed the main menu again. Pressing the next button, as advised in the manual, switched again from the main menu to the time menu instead of from the timer menu to the cooking time menu. The error was very common for GuideMe users (70%), while none of the users of the paper manual made this mistake. A similar problem with a timeout of menu occurred at the Bosch oven. However, the changes in the display of the Bosch are more apparent so users recognized the problem and could avoid a mistake.

In the original manual all steps of the desired functionality were printed on the same page. Participants could scan all steps at once and quickly jump between the different steps. Therefore, they could often perform several steps at once. Afterwards they had to look at the device to synchronize their expectations with the current behavior of the device in front of them. GuideMe users could only see one step at a time. If users wanted to look at another step they had to



(a) Task completion time

(b) NASA TLX score

Fig. 3. GuideMe (black, left columns) compared to the original printed manual (blue, right columns)

press the forward/back button or return to the manual overview. It appeared to be counterintuitive for participants to go one step back in the manual because of the timeout in user interface.

Nevertheless, the NASA TLX scores depicted in figure 3(b), are significantly lower ($p < 0.046, d = 1.4$) for GuideMe. The NASA TLX subscales show the reasons. Participants felt that printed manuals induced an increased mental and temporal demand as well as higher concerns about performance compared to GuideMe. Participants stated in the concluding questionnaire that GuideMe makes it easier to associate instruction symbols with user interface elements. Using GuideMe, it was easier to follow the defined steps, e.g. *"It shows an easier way to act"* or *"You get only the relevant information"*. The main drawback of GuideMe was seen in the weight of the tablet (565 g) that had to be held with the camera pointed at the marker. The detailed analysis of the NASA TLX dimensions in figure 3 shows how users of the printed user manual underestimated their performance. Although, the observed results show a flawless and swift operation of the device, they did not feel as confident in their performance using the original manual. p No matter which technology was used, there was always a disruption between gathering information from the manual and applying the new knowledge by operating the oven. Participants using GuideMe did rarely manipulate the oven controls while looking at the camera image on the tablet screen. On the one hand, this behavior was induced by marker recognition problems, e.g. when the marker was no longer in the cameras field of view because of the attempt to operate the oven. On the other hand, participants had problems to operate a control in 3-dimensional space, e.g. pressing a button, while looking at a 2-dimensional image of their hand movement. Furthermore, one user said, *"The tablet blocked operation of the oven because it had to be pointed at the marker."*.

6.2 GuideMe vs. Mobile Video Tutorial

The remaining 10 participants used GuideMe in comparison to the video tutorial. There was not a clear preference of one technology as 6 out of 10 preferred the video tutorial over GuideMe. The task completion time depicted in 4 was significantly faster ($p < 0.0056, d = 1.26$) using the video than using GuideMe. The video tutorial received a significantly lower NASA TLX score ($p < 0.0108, d = 0.9$). Participants said again that the weight of the tablet and the need to point the tablet at the user interface are the main obstacles when using GuideMe *"You don't have to hold the tablet in front of the QR Code."* The NASA TLX subscales in figure 4 show a difference in the physical and mental demand, because users had to point the tablet at the marker. However, this difference did not occur in the first study when GuideMe was compared to the original printed manual.

In this study 50% of GuideMe users made again the same mistake while operating the Stoves oven as in the first study. Moreover, 60% users of the video tutorial made the same mistake. The mobile video tutorial does not provide a visible separation into steps. Users had to use the standard video navigation

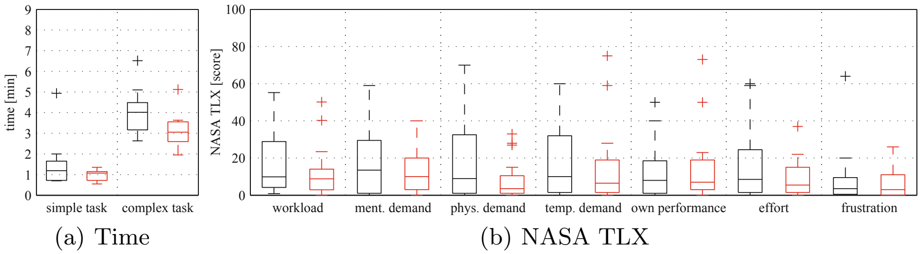


Fig. 4. GuideMe (black, left columns) compared to a video tutorial on a tablet (red, right columns)

to go forward and backward. However, it was difficult for participants to scan through the video, and go to one specific step. When GuideMe manuals were read and applied in a step-by-step manner, the video tutorials were watched as a whole, before operating the oven. Participants rarely stopped the video. They rather watched the whole video again and aimed at memorizing the whole procedure to perform it afterwards. The users that preferred video said *"It's faster"* or *"Description is more detailed and easier to watch"*. 4 user preferred GuideMe because they felt that the video induced *"time pressure"* and they like the *"step-by-step"* approach of GuideMe because the *"steps are better separated"*.

The body language in this study differed from the participants using the paper manual in the first study. In the first study participants held the paper manual only while reading and put it aside while operating the oven. Some users put the manual on top of the oven while reading from it. Body language suggested that participant were focused scanning the printed manual to extract relevant information. In the second study, participants using the video tutorial or GuideMe were looking expectantly at the tablet screen. They kept on holding the tablet in their hands. For instance, even when operating the oven, one hand was still holding the tablet. In the first study this behavior was attributed to the need to point the camera at the oven, but the same behavior was now observed for users of the mobile video tutorial.

7 Discussion

The two studies and the design of the GuideMe prototype provide insights into the usage of different user manual formats, the developed prototype and the design challenges when creating user manuals for and with mobile devices that combine physical user interface elements and digital information.

7.1 User Manual Formats

Three different formats of user manuals were used in the two studies. The average task completion time for the printed user manuals is the fastest and the number of errors was the lowest among all technologies. Nevertheless, our technology-savvy participants preferred the two technology based solutions. On the one hand, this might be due to the nature of our user group. It appears that video as well as GuideMe provide a special positive experience to this group. While the paper was treated like a tool, the participants did not put the tablet away during the study. The used platform, the interactive nature of the presentation or the ongoing animation on the screen, contribute to this effect. On the other hand, participants felt, although wrongly, more efficient when using video or GuideMe as reflected in the performance scale of the NASA TLX. Video and GuideMe allow users to simply imitate actions or follow detailed advice. The paper manual had to be understood and mapped to the ovens' user interface. The participants have to decide more in the mapping process and each small decision adds to their uncertainty.

Although GuideMe learned from the printed manual, some design aspects became only clear by comparing both media in the study. For instance, the step structure of GuideMe was copied from the original manual but not the arrangement of steps on a single page. Each augmented image requires the whole screen of the mobile device. Hence, content that is printed on one page in the manual is split into a sequence of screens. This split is a critical point as users can no longer scan through all steps on a page to recognize the current state of the device. Future implementations should aim at supporting this type of scanning, e.g. by employing similar methods as in mobile image browsing. Furthermore, GuideMe could combine benefits of printed paper and digital augmented objects by combining both media as explored by Grasset et al. [6].

A user manual does not only contain a series of steps, but aims at teaching the user interface of the device. Hence, task descriptions contain additional information such as warnings on possible errors, the impact on other functionality and a method to revert or abort the current task. Video tutorials often select a simple subset of steps and neglect this additional information for the sake of a shorter and clearer presentation. However, this background information is essential to actually create an understanding of a new device. Albeit we included all this information in the video, the video was praised for the clarity of the explained steps. However, participants criticized the perceived "time pressure". Participants did not use the available controls to stop the video. Splitting the instructions into a linked set of small videos may eliminate this behavior. Such manuals can be realized using the current functionality of GuideMe.

Both studies were influenced by the weight and size of the used tablet. The weight increased the physical demand. The size of the tablet was perceived as a barrier between user and the oven. Further evaluations using smaller devices can research the resulting trade-off between screen size and weight for this application domain.

7.2 GuideMe Prototype

The marker-based object recognition did highlight the challenges induced by the properties of the appliance and the employed tablet. The camera on the tablet is located on the top of the tablet thus creating a shift of the image that can be confusing. The camera is expected to be in the middle of the tablet. Completely different devices like wearable displays[5] or personal projection devices [11] would better align movements of the device and the created image.

The ovens' user interface in our study was too wide for the used tablet camera. Ovens were identified by a single marker in the middle of the user interface that had to be within the cameras' field of sight all the time. On the Stoves oven for example, the knob to change the temperature is more than 20 cm away from the marker. Participants often held the tablet too close to the user interface to see marker and knob in the magic lens. Multiple markers or a new kind of distributed markers could provide a solution. Another option would be to decorate the user interface in a manner to enable marker-less object recognition. The participants themselves came up with a third simple solution. They missed a button to freeze the current state of the screen. This approach would combine augmented reality and image based user manuals.

UMML enables GuideMe to be flexible and abstracts from the required programming. Technical documentation experts can design augmented reality user manuals by writing UMML. However, we did not evaluate the modeling capabilities of UMML in this paper.

7.3 Digital Manuals for Mobile Devices

Future user manuals should emphasize the playful exploration of the functionality provided by mobile devices. The two conducted studies have provided first evidence that video and AR-based manuals can support this change. Users felt more secure using these manuals. Moreover, their body language indicated a positive attitude towards this new medium. This preference was confirmed in the concluding questionnaire.

However, the initial positive attitude may change, if the design of such user manuals does not account for the specific properties of the mobile devices, e.g. the position of the camera. Designers and technical documentation experts are needed to facilitate this change. Until now technology has dominated the development. UMML is a first approach to simplify development and include the experts. The notion of computational composites as suggested by Vallgårda [19] can help to bridge the gap between designers and technology driven developers.

In AR-based manuals the appliance becomes part of the user interface. For instance, the color of superimposed graphics has to to blend into the camera picture of the device. The design of the appliance is linked to the design of the manual. Properties of both components influence each other and create the final design. Therefore, GuideMe aims at a maximizing the flexibility of the design.

A further integration on the technical level was proposed by Liu et al. [13]. They compared AR manual implementations and concluded that "the conventional AR approach performs almost as well as pictures" but feedback from the device would "significantly improve task performance and user experience". A

[5] Project Glass `http://plus.google.com/+projectglass/`

direct feedback from the home appliance to GuideMe would prevent possible discrepancies between the actual state of a device and the state that GuideMe is assuming and thus significantly lowering error rates and frustration. Although standardized methods for device feedback would be beneficial to applications like GuideMe such a standardization of feedback mechanisms across appliances and manufacturers is not foreseeable.

8 Conclusion

We described GuideMe a mobile design for AR-based user manuals, discussed the underlying combination of mobile media and physical user interfaces and presented the results of two small scale studies. Both studies compared GuideMe manuals to current alternatives, the printed manual and mobile video tutorials, with young users and real home appliances. The printed manual resulted in the fastest task completion times and the lowest error rates. However, these classic usability metrics were not decisive arguments for the participants; they preferred video tutorials and GuideMe on the tablet. Both are interactive formats that allow users to imitate actions. In result participants enjoyed using these manuals on the tablet.

Augmented Reality and video provide starting points to new user manuals that are fun to use. Both manual types can be designed, combined and tested using UMML and GuideMe. A mobile application for consumers to adapt and create simple UMML manuals by drag and drop is currently in development. Applications like GuideMe and a simple editor would open the explored design space for a broader audience. The current progress in mobile media has the potential to transform the user manual but requires more research on the manual design.

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