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Towards a Reference Model of Guidelines for the Elderly Based on Technology Adoption Factors

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ABSTRACT

The number of older people in the EU (65 years and older) will increase to 149 million by 2050 compared to the current 101. A large percentage of this population has not followed the transition to the world of ICT. Even for application specially aimed at the elderly, the adoption is low. This suggests that despite numerous design guidelines published for designing interfaces for elderly, there is still work to be done. In this paper, we look at existing Technology Adoption Models, especially that of Lee et al. that focuses on elderly, and investigate whether current user interface design guidelines cover the adoption factors. For this, we did a literature survey on user interface design guidelines for elderly and found a rather heavy focus on the Usability factor while the others adoption factors were hardly covered. We propose to augment the set of existing user interface guidelines with guidelines that also support the other adoption facts of Lee. For this purpose, we present a first version of a reference model that could be used to organize guidelines, but also as a guide to uncover new ones.

CCS CONCEPTS

• **Social and professional topics** → **Seniors**; • **General and reference** → **Design**; • **Human-centered computing** → *User centered design*; *Usability testing*.

KEYWORDS

web design guidelines, technology adoption, elderly users

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1 INTRODUCTION

According to the European ageing report, in 2019, 20.3% of the EU population was aged 65 years or over [17]. Additionally, according to the same report it is estimated that the total number of older people (people aged 65 years or older) will rise from 101 million

(2018 figure) to 149 millions by 2050, with the number of people aged 75-84 years increasing by 60.5%, and the population of very old (85 years or more) is projected to more than double to 31.8 million. These estimates are not news in themselves as they have been noted in numerous research articles over the past years.

Over the years the use of Internet has exploded, but despite numerous tools and applications designed specifically for elderly a significant number have not embraced the new "digital time": "In 2017, almost half (48 %) of the EU-28 population aged 65-74 years did not use the Internet during the three months preceding the Community survey on ICT usage"[17]. This can have different causes. Therefore, we looked at the current literature on design guidelines for creating such applications. Despite most papers acknowledging a number of adoption factors, they mostly focus on usability guidelines, such as: ensuring larger fonts, short and to the point text, clear color contrast, etc. However, the EU ageing report's figures strongly suggest that this alone is not enough for elderly to adopt Internet-based technology. It could be time for looking at the bigger adoption patterns and attempt to augment existing user interface guidelines to also take adoption factors into account. Lee et al. [22] have made a similar remark "...Thus, the current state of research on older adults' adoption and use of technology calls for a broadening of perspective, an integration of insights for general application and practical implementation, and an effort toward building a theoretical framework" and they presented ten factors of "older adults technology adoption" converged from a literature survey.

The goal of this paper is to report on our research to come up with an augmented set of User Interface Design (UID) guidelines for elderly that takes technology adoption factors into account. The first step of the research is to create a Reference Model for these guidelines that should allow us to structure and categorize the UID guidelines, but also to uncover new ones. For this purpose, we started by taking a look at existing Technology Adoption Models, as well as to the model given by Lee et al., which is specific for elderly. These models are discussed in section 2. Next, we investigated existing usability guidelines for elderly as well as the User Centered Design approach for developing software (section 3 and section 4 respectively). We then present our literature study focusing on how design guidelines for Web-based services for the elderly relate to Lee's ten adoption factors (section 5). Based on the collected information and the research performed, we present in section 6 the first version of our Reference Model. Lastly, in section 7 we draw conclusions and discuss further work.

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2 TECHNOLOGY ADOPTION MODELS

Among the more popular and well known models for technology adoption models are the rather aged **Technology Acceptance Model** (TAM) [15] and its would be successors **Unified Theory of Acceptance and Use of Technology** (UTAUT)[42]. UTAUT was designed mainly with organizations in mind, but was later updated to cover consumer technology acceptance with UTAUT2[43]. UTAUT2 has eight factors that facilitate the acceptance of technology (i.e. Performance expectancy, Effort expectancy, Social influence, Facilitating condition, Hedonic Motivation, Price value, Habit, Behavioral intention), where as TAM uses only two factors: "perceived ease of use" and "perceived usefulness". How these two work in TAM, is quite straightforward: A person perceiving a technology too difficult and not very useful, will not likely try to use it, where as a user on the opposite side of the spectrum would very likely do the opposite. In UTAUT however, "Behavioral Intention" (i.e. willingness to use a technology) is affected by a number of different factors. The factors used by TAM explain roughly 40% of an individual's intention to use a technology, whereas UTAUT is capable of explaining 70% [30]. Despite their evident efficiency, the two models have also received criticism for disregarding the potential fluctuation of technology acceptance overtime and the fact that the acceptance levels tend to vary between experiencing technology for a first time and after using it [30].

2.1 Technology Adoption Models for elderly

In their study, Lee et al. [22] looked at existing literature on "older adults", "technology adoption" and "technology acceptance" with the aim to consolidate adaptation factors for elderly. The ten factors Lee ended up with are all supported by at least five or more studies from the 170 reviewed papers. These factors are summarized in table 1. They also went through some other models that had been already created, such as: Acceptability of Assistive Technology [25], CREATE model [32], and ADOPT model [44].

Additionally, Lee et al. note that besides these ten factors, there could be additional factors, of which they intermittently identified four: System reliability, Service trust, Lifestyle fit, and Conceptual fit.

3 USABILITY GUIDELINES

With the increasing interest in creating myriad of services for older users, the number of design guidelines intended for applications for older users has gradually increased, as is also noted by [28]. Despite the need of not just focusing on User Interface usability, they remain essential for a good design.

3.1 Web Content Accessibility Guidelines (WCAG)

WCAG is an official guideline from the World Wide Web Consortium (W3C). It is a comprehensive guideline that is set around four guiding principles: *Web content must be Perceivable, Operable, Understandable and Robust (POUR)*.

Since the original WCAG 1.0, the guideline has had to change with the times, as accessing website shifted largely to mobile platforms. The WCAG 2.0 became the official W3C recommendation in 2008. However, soon afterwards, some problems were identified

especially for guaranteeing accessibility for people with disabilities [33]. The latest version, WCAG 2.1¹ released in 2018, focuses on mobile accessibility, people with low vision, people with cognitive and learning disabilities, fixing some of the grievances.

3.2 Other Guidelines for elderly

There are a number of guidelines for elderly created over time (before WCAG 2.0 was released), such as the SilverWeb Guidelines created via extensive literature review in Human Computer Interaction and Ageing [47]. The final version presents 38 guidelines grouped within 11 distinct categories. There are also many "Check lists" making attempts to either condense or clarify the somewhat "heavy" WCAG list (see footnotes^{2 3 4}). Additional "senior friendly" website design guidelines are provided in [2], and some additional guidelines are also listed in Wilkinson & Cornish's paper on product interaction for older people [1].

3.3 Touchscreen Design Guidelines

It goes without saying that app on touchscreen devices are not websites, but in the same breath it is easy to see a good amount of overlap. Because websites and web applications are accessed daily from millions of mobile devices, the majority being touchscreen devices [16], user interface design for the Web is now also considering the characteristics of mobile, touch-based devices, mostly by using a so-called responsive design, which adapts the interface to the device and screen size used. Nurgalieva et al. [28] identified from 52 research articles focusing on older adults, a whopping 434 research-derived design guidelines for seniors, made available on their website with some simple filtering mechanism⁵. Despite several of the guidelines being mobile & touchscreen specific, such as multi-finger touching & zooming, several of the guidelines overlap with generic website guidelines, such as: "consistency", "simple feedback", "compliment images with text", "keep the interface clean and easy to read", etc. Out of all the guidelines, only one (stating effective question types in a questionnaire) could be (partially) placed within the Technical Support Adoption factor of Lee; the remaining 432 guidelines all fall under the factor Usability.

4 USER CENTERED DESIGN (UCD)

It is quite common to use UCD when designing tools for the elderly. The idea is to involve the user in the design process. Interpretation on how to actually go about this is somewhat varied but the core principle is the same: evaluate often and keep the users in the loop [22]. It has been proven to be an efficient method in various design cases [7, 10, 24] but it also has notable caveats. Recruiting a representative group of users for evaluations and/or involvement in the design is not always straightforward, especially with older users [46]. Similarly, the evaluation becomes in itself more demanding as the researchers have to be more sensitive of potential limitations (e.g. of visual, auditory, cognitive or motor skills) that may influence the data collection [12, 46]. Lastly, gaining the

¹<https://www.w3.org/TR/WCAG21/>

²<https://webaim.org/standards/wcag/checklist>

³<https://www.w3.org/TR/2005/WD-WCAG20-20050630/checklist.html>

⁴<https://usability.yale.edu/web-accessibility/articles/wcag2-checklist>

⁵<http://design-review.mateine.org>

Table 1: Lee's Technology Adoption factors and their description

Name	Description
Value	The degree to which a technology is perceived as useful and communicated as potentially beneficial
Usability	The degree to which a technology and its interfaces are easy to learn, use, and interact with
Affordability	Perception of costs and expenses related to purchase and use of a technology in relation to potential benefits
Accessibility	Awareness and knowledge of a technology's existence and availability in the marketplace
Technical support	Availability and quality of professional support throughout learning, purchasing, using, and keeping a technology
Social support	Support and endorsement from family, peers, or social communities toward use of a technology
Emotion	Perception of a technology's potential roles for providing emotional benefits such as entertainment, enjoyment, and peace of mind
Independence	Expectations around how the use of a technology may or may not involve social stigmatization and stereotyping
Experience	The degree to which a technology's features and operations resemble user's prior experiences with relevant systems
Confidence	The degree to which a technology's features and designs prevent user from feeling anxious or intimidated

trust of the participants of evaluations is important, as well as receiving objective feedback. Older people may be more suspicious and more inclined to please the interrogator/developer. Clearly communicating that anything going wrong with the application is the developers fault and not theirs is important [10].

Additionally, outside events could force some common practices to be completely overhauled, as seen with the COVID-19 pandemic. On the one hand, as one of the worst hit and vulnerable groups the need to create and provide supporting technology for the elderly has increased during the outbreak, but on the other hand it also has compromised the traditional UCD process as it is downright dangerous to have physical contact with elderly and this will likely remain so for some time to come. Conducting evaluations via online or via the social network of the elder could be a viable alternative, but this does bring about entirely new challenges. Limiting these evaluations to only the group of people technologically savvy enough to communicate over the Internet could heavily bias the results and bring about wrong assumptions. So this should be avoided.

5 LITERATURE SURVEY METHODOLOGY

Given the focus of our research, website design guidelines for the elderly, we used the search word "web design" in conjunction with the many manifestations for elderly user, i.e. "aged/ageing/older/elderly/senior user". We conducted the survey on ACM Library, IEEEExplore and Google Scholar. Timeline was restricted to the last 10 years. In a first sweep we downloaded up to 10 papers with each combination, or until matches clearly became off topic. The next phase was to weed out all papers not specifically focusing on our

Table 2: Literature survey results

Name	Description
Usability	[1, 3–7, 11, 18, 24, 26, 27, 29, 31, 35–41, 45]
Social support	[24, 39, 41]
Emotion	[35]
Independence	[1]

topic; only papers that presented design guidelines in the context of web applications were kept. In case of two papers discussing the same topic, we would go with either the one presenting clear guidelines, or otherwise the latest publication. Lastly, we removed two duplicates that Lee et al. used in their survey as these were already discussed in their paper [14, 47]. Our final count was 21 out of 161 papers.

For these papers, we investigate whether they considered any of the factors listed by Lee et al.. The results are given in Table 2 where we list any paper that provides some sort of guideline fitting to a specific fact. Any factor left empty was removed from the table, as the full factor list is given in Table 1. These findings give weight to Lee et al.'s criticism on overly focusing on Usability. A number of factors are not covered at all by the papers we surveyed. For Value, Affordability, and Accessibility, this can be explained by the nature of most research projects, where there is little intention to bring the product on the market, at least not in that stage of the research. For other factors, a number of papers did discuss at least some of the factors, but failed to provide any guidelines for them.

We realize that by deciding to stick to "pure" website guidelines, we omit a significant amount of mobile & touchscreen focused studies. This limitation was taken to ensure that all the guidelines were indeed intended for web-based applications. In future work we will investigate the impact of also considering guidelines for touch screen devices.

6 REFERENCE MODEL

Our goal is to create an augmented set of guidelines usable during the user interface design phase of web-based applications for elderly that also takes technology adoption factors into account. From the previous sections it can be deduced that creating a coherent all encompassing set of design guidelines is a complex task and will result into a large amount of guidelines. To organize these guidelines, we will use a Reference Model, which is a generic conceptual model that formalise recommended practices for a certain domain [34]. To create this reference model, we start from the ten technology adoption factors developed by Lee et al. [22]. Some of these factors focus on the deployment and maintenance phases of the software life cycle and are therefore less relevant during the design phase or need to be considered in the earlier phases of the software development, such as during the requirement analysis. For instance, the choice for a particular operating system, which may influence a number of the adoption factors, should be part of the requirement analysis and will influence the actual design but it is not subject of the design decisions. The price of a product or the organization of the technical support are typical examples that are also out of the scope of the design. Therefore, we distinguish between three categories of factors. **UID irrelevant factors** are factors for which it is not possible to meet them by means of user interface design decisions. **UID partially relevant factors** are factors that can be met partially by user interface design decisions but for which, in general, also other actions are needed. **UID fully relevant factors** are factors that can be completely satisfied by user interface design decisions. In the following subsections, we discuss which factors belong to these different categories and give examples of how they can be supported by design guidelines.

6.1 UID Irrelevant Factors

Affordability & Accessibility are both valid concerns, especially for commercial products, but during design of the user interface these factors can be ignored. Of course, they should be considered at some point in the development of a product, as for instance the need to have a high-end smartphone to run an application will have a considerable impact on the affordability, as well as the limitation to a particular operating system, or the use of expensive software licenses. However, in general these decisions will be part of the requirements analysis. Once these decisions have been taken, the user interface design should follow them but the actual design will not influence these aspects anymore.

6.2 UID Partially Relevant Factors

Value as defined in Lee et al.'s work is the perceived usefulness of a product and how this is communicated. Ensuring that a product is useful is part of the requirement specifications, as requirements should be formulated that when satisfied will allow to satisfy the

needs of the users. However, there are different ways to satisfy a requirement and this is part of the design. Design guidelines should make sure that users indeed perceive products as useful. This can be achieved by means of a good usability, but also through communication inside the application, such as by indicating or highlighting the usefulness of functionalities and features.

Technical Support involves supporting users and potentially providing supplementary learning tools & materials to enhance the use of a product. At first side, this looks to be outside the scope of the user interface design. However, more and more we see that accessing technical support and learning material is incorporated into products. For instance, a person can shake with one's smartphone to reach technical support, or a step-by-step explanation is provided when a product is used for the first time. Incorporating an easy way to reach technical support or to find learning material is especially important for elderly, as they may not know how to do this. As such, guidelines are needed to ensure that certain aspects of technical support are incorporated into the design. Furthermore, it may be useful to consider that older people often prefer printed material [8]. Digital manuals do have multiple advantages that can be implemented, as Lee et al. also discusses, but they do have a caveat of them being additional thing that the user would need to learn to use. Paper manuals have the added benefit of being familiar to elderly. They of course have their own problems, such as the fact that mistakes cannot be simply corrected, nor can any additional information be added. Hence a hybrid solution would likely be optimal, with the paper manual only explaining the core functionalities and providing clear access method for supplementary information that is also easy to print.

Social Support can also be approached from two angles. If a friend, family member or acquaintance supports the use of technology by working as a "technical support" or as a "champion" [44], this can convince elderly to try and stick with a technology. However, social support can also be incorporated into the design. Especially in web-based technology, including social support is relatively easy to achieve. If the technology supports social interaction by design [39] or clearly helps the user to get in touch with "real people", this could be a significant boost.

Experience also affects the adoption. Ideally, technology should resemble the user's prior experience with other systems. However, in practice this can be difficult to achieve, especially when the users have diverse experiences. Compatibility with the style of a specific system can be formulated as a requirement, but it is also possible to realize this through personalization [9], which can for instance be achieved by means of using a profile or set of preferences which allow to adapt the interface either statically or dynamically to the user's preferences.

Confidence is very important for elderly as they easily feel vulnerable and become apprehensive when they are unsure of (possible threats caused by) technology. So, the fact that the product can be trusted should be guaranteed by external organizations, but it should also be supported by the design. For instance, the information asked (like personal information or an image of the user) and the way this is done should not create suspicion. In addition, despite not being completely against trial-and-error [23], older users do prefer to have a clear understanding of the consequences of each action, because they are afraid that any misstep can be

detrimental to it. It is also paramount to carefully formulate any feedback message to not scare or stigmatize the user.

6.3 UID Fully Relevant Factors

Usability remains a core factor for the adoption of any product. As we have seen in the previous sections, this has been researched extensively and numerous design guidelines have been formulated to enhance usability for various user groups. WCAG 2.1 provides without doubt the core guidelines to use when developing a Web-based application, most of them falling under the factor Usability. To bring about full WCAG adherence can however be a daunting task. Luckily WCAG also offers a checklist of their own⁶. The more popular front end frameworks, such as React⁷ and Angular⁸ have also supporting materials available. Additionally help plugins for the developing process are available⁹. However, focusing on achieving 100% might not yet guarantee user satisfaction [20, 22, 33].

Emotion deals with the potential role for providing emotional benefits such as entertainment and enjoyment. More and more, this is recognized as an important aspect: using a product should be pleasant, not a tricky chore. The notable attention to gamification [19] is an example of this, but emotional benefits can also be realized in other ways, for instance by providing playful interfaces [21]. In any case, it is important to keep the balance between pleasure and the actual functionality.

Independence is an important concern for many older people. In principle, technology that is intended for assistance of some sort will support this independency, however care should be given on how this is presented to the elderly. For instance, the language used in an application should avoid stigmatizing the user. Older people who feel vulnerable or dependent on others may easily perceive an application as a threat to their independence or feel being patronized by the application.

7 DISCUSSION

Asides these presented factors, there are number of additional variables that very likely affect the adoption process as also acknowledged by Lee et al., such as age, gender, educational background, and culture. There exist many guidelines related to these issues; usually they are usable when the technology in question is intended for a specific group of people. Most of these guidelines can reside under the Usability factor. It will be much harder to formulate general guidelines related to these issues as they are all related to the characteristics of the users. If a broad audience is targeted, the best option is to use some kind of personalization, which we also consider to be part of Usability.

We also want to highlight the need for simple but flexible guidelines to start from within the design process. This to reduce the risk of misinterpret guidelines or of taking an interpretation which is too strict, as was shown by evaluations of some websites that had followed UI guidelines to the letter. The result was not perfect. One study focused on what could be arguably misidentified in

the context of how to force the use of novel functions that users ignored [45].

Lastly, it should also be noted that as technology advances, some of the existing guidelines could very well become outdated. For instance, research in computer vision based analysis [13] or the emergence of speech-to-text and text-to-speech services could have a big impact on user interface design guidelines. Voice commanded web applications are undoubtedly among one venue of future interests [26], which will require new guidelines. Using an additional classification based on technology in our reference model could be one way to more easily deal with such advances.

8 CONCLUSION

The need to support elderly with ICT tools has become obvious during the COVID-19 pandemic. However, the adoption of these tools by elderly is still an issue. One way to tackle this is to create ICT tools that are better attuned to the characteristics of the elderly. In the past, developers mostly rely on user interface design guidelines to achieve this, but apparently this is not sufficient. In parallel, different technology adoption factors were identified in the literature with the work of Lee et al. specifically targeting the elderly. We first investigated how well these factors are covered by existing user interface guidelines. It turns out that most of the existing guidelines focus on only one of the adoption factors, i.e. Usability. We then took a look at all adoption factors to see how they could be used in creating a better set of user interface guidelines for elderly. In this paper the focus is on web-based applications. As a first step in achieving this, we created a Reference Model for User Interface guidelines based on the Technology Adoption Model of Lee et al. This work can be used as a stepping-stone to collect, classify and, more importantly, extend existing User Interface Design guidelines. For this the Reference Model needs to be refined, e.g. to allow for finer grained classification. This is the subject of our future work.

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