Design Requirements for Recommendations in End-User User Interface Design

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Abstract. User interface design has become increasingly difficult due to the rise of new kinds of electronic devices and the emergence of the Internet of Things (IoT). Further, user interface (UI) designers struggle to adapt their UIs to evolving user needs and preferences. In order to address these issues, we want to support end users in designing their own user interfaces. However, end-user UI design represents a major challenge, given that end users often lack the necessary design skills. We investigated how design recommendations might be used to address the research question on *how to help end users during the UI design process?* A first step towards answering this question is the analysis of how end users should best get recommendations about potential design improvements. We therefore conducted a survey on how end users would like to get design recommendations, whether they trust user- or machine-generated recommendations, and whether they agree that their interactions are tracked and shared in order to improve the recommendations. Based on the results of our survey, we present a set of design requirements for the integration of recommendations in end-user UI design tools.

Keywords: end-user development · UID guidelines · design recommendations · artificial intelligence · trust.

1 Introduction and Related Work

Rapid technological advances make it increasingly difficult for designers and developers to create user interfaces that follow UI design trends, can adapt to different devices (e.g. tablets or smartwatches) and address evolving user needs and preferences. Therefore, a number of methods and techniques to simplify the UI design process for designers via dedicated authoring tools have been investigated. For instance, Meskens et. al. [9] presented a design environment for managing UI consistency across multiple devices. Focusing on the interaction across devices, Nebeling et al. [10] introduced XDStudio to support the interactive development of cross-device web interfaces. Considering the UI distribution across devices, Park et al. [12] optimised the allocations of UI elements through a designer-in-the-loop tool. Further, Kubitza and Schmidt [7] proposed meSchup,

a platform enabling programming by physical interaction with different devices and sensors in IoT settings. In addition to dealing with various devices and smart things, designers also need to cope with the widely varying and evolving user needs. Therefore, the end-user development (EUD) paradigm is paying attention to make systems *easy to develop* rather than only *easy to use* [1], and empowers end users to build their own solutions. Nevertheless, end-user UI design represents a major challenge given that end users are normally less skilled in developing their user interfaces than professional designers. An obvious question is therefore *"how to help end users during the UI design process in order to improve their UIs?"*

A rich body of work has been carried out to create *better* user interfaces complying to design guidelines for a given context. We focus on design tools helping users during the UI design process by either automatically generating parts of user interfaces or by suggesting design ideas. Lin and Landay [8] introduced Damask, a pattern-based design tool for early-stage design and prototyping of multi-device user interfaces. Damask includes a 'pattern sidebar' for browsing design patterns and applying them to specific designs. Following a rule-based approach, Henninger [5] presented the GUIDE methodology and tool for helping designers to create more usable interfaces.

More recently, Gajos et al. [4] introduced SUPPLE to automatically generate graphical UIs based on an optimisation algorithm. Quiroz et al. [13] use an interactive genetic algorithm combining UID style guideline metrics with subjective user input to evolve user interfaces. While these two approaches ask for little or no user input during the automated design process, other systems do not automate but rather assist designers during the design process. DesignScape [11] helps designers via interactive layout suggestions. *Refinement suggestions* help improve the current layout, while *brainstorming suggestions* propose major layout changes and different styles. A similar tool called Sketchplorer [16] uses different optimisation mechanisms to support interactive layouts and pays more attention to design aesthetics. Focusing on grid layouts, the GRIDS [2] wireframing tool allows designers to explore starting solutions, get suggestions for the completion of partial designs and search for alternatives. Paying attention to creativity Koch et al. [6] proposed an interactive design ideation tool that, based on machine learning, suggests visual inspirational materials.

Rather than helping designers and developers as in most existing work, Fernández-García et al. [3] introduced a recommendation system suggesting suitable components to end users in a sidebar. Approaches helping designers or users can also be found in commercial solutions such as Microsoft PowerPoint and its PowerPoint Designer, providing layout design ideas in an optional sidebar.

While many of the proposed solutions target developers and designers, parts of these solutions could also be applied in end-user UI development solutions. A major challenge is to find the best way to provide end users with the necessary recommendations and support them in creating their UIs. Given the different characteristics of the discussed systems, we conducted a survey to investigate what users find relevant with respect to recommendations in an EUD UID tool.

2 Design Recommendation Survey

We designed an online questionnaire[3] to collect end users' opinions on how they would like to receive design recommendations, examine their level of trust in user- or machine-generated recommendations and to determine whether they are willing to be tracked to improve their recommendations. We collected a total of 82 fully filled-in questionnaires (49 males, 31 females and 2 'other') and the participants' mean age was 30 years ($SD_{age} = 6.7$). About half of the participants (42) described themselves as computer scientists. In order to check for differences between the group of computer scientists (CS) and non-computer scientists (NCS) we conducted a t-test for each closed-ended question, but no significant differences were found at the p-level of 0.05. Further note that we used a 4-point Likert scale with an additional 'N/A' option for all rating questions.

2.1 Presentation of Design Recommendations

In a first question in this category we asked participants whether they would see design recommendations as something positive or negative. 78 participants indicated that they see recommendations as something 'positive' (56) or 'very positive' (22), while only 4 participants answered with 'negative' (2) or 'N/A' (2). The reasons why participants see recommendations as something positive are to get some inspiration and new creative ideas (21), to get help during the design process making it easier to create improved designs (27), to save some time (7) or to simply not having to think about making a good design themselves (8).

In order to find out about the preferred placement of design recommendations, we presented participants three possible options. A first option was the placement of recommendations in a sidebar, as done in PowerPoint and related work [2, 3, 6, 8, 11, 16]. As a second option, we proposed recommendations given by a digital assistant, similar to virtual assistants on various existing websites. A third option consisted of showing recommendations as an overlay on top of the original UI design. Participants were asked to rate each of these three options separately. Recommendations provided in a sidebar was rated as best option, as illustrated in Figure 1. Further, less than half of the participants (33) liked recommendations from a digital assistant and only 25 participants considered recommendations using an overlay as a good idea. Participants liked the sidebar due to its clear overview of different recommendations. Moreover, 14 participants mentioned that they were already used to a sidebar layout. Regarding the digital assistant, some participants (6) directly thought of Microsoft Clippy and disregarded the idea, and a few (6) just mentioned it would bother or annoy them. Overlays were in general seen as too confusing, crowded and invasive (26).

We also asked participants whether they would prefer recommendations in textual or graphical form. In related work recommendations are often given in a graphical way [2, 4, 6, 11, 13, 16], but sometimes also in pure textual form [5] or a combination of both [8]. While many participants (59) expressed their interest

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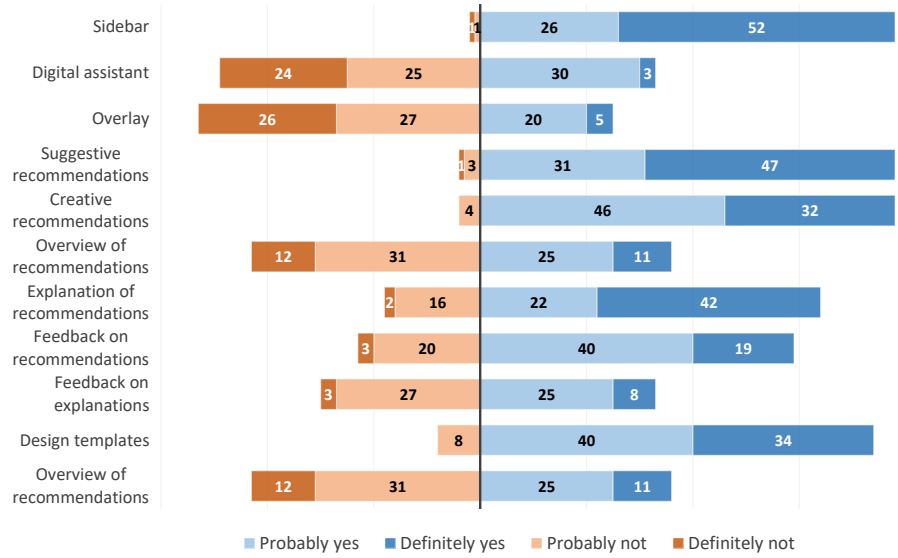

Fig. 1: Presentation of design recommendations

in graphical recommendations, 19 participants selected the 'other' option and 17 out of these mentioned they would like a mix (e.g. text on hover). We further asked whether they would like to get suggestive recommendations to improve their design or creative recommendations. Figure 1 shows that the same number of participants (78) favoured suggestive or creative recommendations.

Koch et al.'s [6] ideation tool provides explanations why a certain recommendation has been given and we asked our participants whether they would like to have such explanations. As illustrated in Figure 1, many participants (64) were in favour of getting such an explanation. 54 participants preferred on-demand explanations and 13 out of those mentioned that this way they would *"stay in control and be able to ignore it when not needed"*. Another 11 participants expressed that they *"did not want to be annoyed by the explanation or have repetitive information being displayed"*. 18 participants further wanted to *"avoid clutter, being distracted or being overwhelmed"*.

In Koch et al.'s [6] tool, feedback can be given about recommendations with the options 'more like this', 'not this one' or 'surprise me' and a feedback mechanism is also present in the GUIDE methodology [5]. A majority of our participants (59) were interested in giving feedback on recommendations. In contrast to the previous question related to the explanation of recommendations, many participants answered with 'probably yes' rather than 'definitely yes'. This might indicate that feedback would be considered as a plus rather than a must have. We further asked the 64 participants interested in an explanation of recommendations whether they would also like to be able to give feedback on these explanations. The answers were mixed with almost half of the participants (30) not being interested in this feature. Further, as shown in Figure 1, 74 participants were in favour of getting recommended design templates to start with.

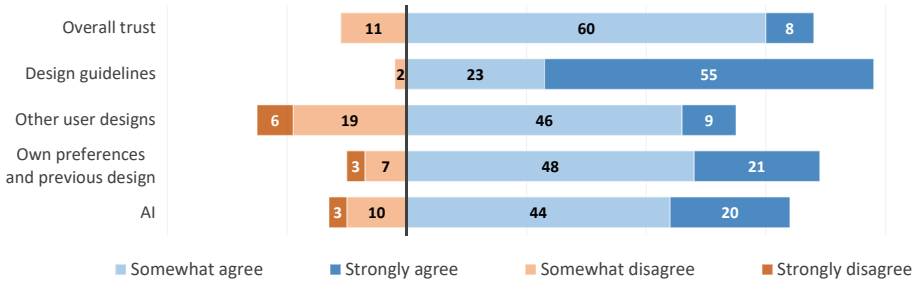

Fig. 2: Trust depending on recommendation source

Our final question in this category asked participants whether they would like an overview of all recommendations they received after finishing their UI design. This question was inspired by the timeline functionality in Sketchplore [16] and GRIDS [2], and the history panel of previous suggestions in [6]. The answers were mixed as 36 participants expressed interest in such overview, giving as reasons *"checking what has been selected from the recommendations"* (8) or for *"learning purposes"* (7) and *"traceability of why the UI design changed"* (3).

2.2 Trust in Design Recommendations

Since it is essential to know whether users would trust the recommendations of an end-user UID solution, we asked questions related to this subject. As shown in Figure 2, 66 participants trust design recommendations and only 11 participants mentioned that they would 'probably not' trust them. Participants mentioned that their trust in recommendations depends on the quality of the recommendations (5), the corresponding explanations (5) and the assumption that recommendations would be made by experts based on common design practices (32).

We assumed that some recommendations could be considered more reliable depending on their source. From related work we learned that recommendations could be based on design guidelines [5, 8, 11, 13, 16], other users' designs (user-base) [3], a user's own preferences [4, 13] and previous designs [3] as well as some AI components [3, 6]. As shown in Figure 2, almost all participants (78) believe that recommendations based on design guidelines are reliable, while 25 participants do not trust recommendations based on other users' designs. 69 participants would trust recommendations based on their own preferences and designs, and 64 would trust recommendations made by some AI.

2.3 Willingness to Share Personal Data

Given that design recommendations might be improved by tracking a user's interaction with the design environment, it is important to know whether users are willing to share such personal data. We asked participants whether they would accept their interactions to be tracked and shared. We offered participants three possible answers, including 'yes, but only for myself', 'yes, for everyone if

my data is anonymised' and 'no'. Only 10 participants selected 'no', with half of them explaining that they do not like to be tracked as they are private persons. A majority (49) selected the second answer and the remaining 23 participants the first option. These results are promising as it means that an end-user UID tool might rely on this type of information to improve its recommendations.

3 Design Requirements

After identifying end users' needs through our analysis of the survey responses, we translated their opinions, attitudes and beliefs into a set of design requirements (DRs). Two authors independently analysed the answers, generated their set of design requirements and cross-checked these design requirements. While some design requirements such as DR1 and DR4 are rather evident, other requirements shed a new light on the design of UID recommendation systems.

DR1: Recommendations should best be shown in a sidebar Given the large number of participants (78) favouring recommendations in a sidebar, we advise to do so in an end-user UID authoring tool. Participants' familiarity with sidebars in PowerPoint and other applications gives it precedence over other presentation types. As proposed by some participants, an optional overlay showing more detailed recommendations might be added on top of the UI design.

DR2: Recommendations should be shown graphically The majority of participants (59) expressed a preference for graphical recommendations. However, given that many (19) also suggested a combination of both textual and graphical recommendations, we advocate for a graphical representation of recommendations with a textual description of a recommendation on hover over.

DR3: Recommendations should cover simple improvements as well as creative aspects Many participants (78) liked the idea of having simple and creative recommendations as realised by Donovan et al. [11]. While an end-user UID authoring tool should definitely provide recommendations for simple UI improvements, users will also appreciate receiving more creative recommendations, which is one of their motivations for using a design recommendation system.

DR4: The visibility of recommendations should be controllable Given that 50 participants preferred to have on-demand recommendations and the fact that 15 participants mentioned (in comments) the need to control the visibility of recommendations, it is important that an end-user UID authoring tool provides a way to show or hide recommendations. This feature is present in commercial solutions but often not in related academic work.

DR5: Explanations should be provided on demand only For a majority of participants (54), automatic explanations of recommendations would be considered annoying. However, explanations are seen as an opportunity for learning and they seem to increase the credibility of design recommendations. Given that a total of 64 participants were in favour of showing explanations, they should be provided on demand in order to not distract users during the UI design process.

DR6: Users should be able to provide ratings/feedback on recommendations Giving feedback on recommendations is useful to improve the quality of the recommendations since poorly rated recommendations would less likely be shown. Further, feedback on recommendations might help in improving the recommendations in the long term [5] and a large number of participants (59) expressed interest in giving feedback on recommendations.

DR7: Users should be able to provide ratings/feedback on explanations Explanations increase the trust and credibility of design recommendations. End users might consult explanations when they want to learn more about certain design guidelines or are simply curious about a design recommendation. Even though participants had mixed opinions about rating explanations, we believe that it can make low-quality explanations more understandable, useful and clear.

DR8: An overview of received recommendations should be available While participants had mixed opinions about an overview over the received recommendations, various reasons have been given by participants in favour of having such an overview. Therefore, an end-user UID authoring tool should preferably provide an optional overview of the recommendations users applied as well as the ones they did not apply.

DR9: Design templates should be offered as optional starting point Given that 74 participants expressed interest in having design templates to start the design process, an end-user UID authoring tool should provide the choice between starting from a blank design or some pre-defined design templates. Providing such an option can save participants time which is one of their main motivations for using recommendations in the first place.

DR10: The source of recommendations should be selectable Most participants (68) tend to trust recommendations. While almost all participants would trust recommendations based on design guidelines, this is not the case for recommendations based on other users' designs. Therefore, the recommendation system should allow users to define the source of recommendations, such as design guidelines, a user's previous designs, other user's designs or some AI component.

These ten design requirements and guidelines summarise the outcome of our survey and provide an answer to our main research question on "how to help end users during the UI design process?" Design recommendations are a good way to help end users during the design process as they are seen as something positive and trustworthy. By following the presented design requirements, a developer can create a UID recommendation system based on users' expectations and needs.

4 Conclusion

The findings of the presented survey serve as a foundation for helping end users during the UI design process. Overall, the results of our survey show that users would like to get design recommendations, that they are likely going to trust

them and that they are willing to share some personal data about their interactions to improve these recommendations. We presented a number of design requirements summarising users' needs regarding a design recommendation system. The presented design requirements can be used by the research community to improve, extend or create new end-user UID authoring solutions with recommender systems that best fit their users and enable them to become better at designing their own user interfaces. Based on the presented design requirements, we are currently developing a design recommendation extension for the eSPACE end-user UID authoring tool [14, 15] and plan to evaluate the efficiency and effectiveness of the resulting design recommendations in an in-situ user study.

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