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Towards an AI-Driven User Interface Design for Web Applications

André Costa[a]*, Firmino Silva[ab], José Joaquim Moreira[ab]

[a] *ISLA - Polytechnic Institute of Management and Technology, Research Center, Rua Diogo Macedo 192, 4400-107 Vila Nova de Gaia, Portugal*
[b] *COPELABS – Cognitive and People-Centric Computing Research Unit*

Abstract

The increasing exploitation of Artificial Intelligence (AI) technologies has enabled the design of user interfaces in a way that integrating artificial intelligence capabilities has become crucial in the modern digital landscape. Exploring the main features and best practices for designing user interfaces for Web applications, which effectively support and leverage AI functionalities, is currently one of the relevant topics in this context. This research work discusses the fundamental principles of user interface (UI) design, and the challenges posed by the integration of AI into web applications. It emphasizes the need to strike a balance between the AI advanced capabilities and the users' ability to understand and control the system. Furthermore, the paper highlights the importance of creating intuitive and engaging UI designs that empower users to interact with AI-driven features effortlessly. The study presents a comprehensive analysis of various UI design techniques specifically tailored for AI-enabled web applications user interfaces. Additionally, the paper explores the incorporation of AI-driven recommendation systems, personalized interfaces, and adaptive designs, which dynamically adapt to users' preferences and behavior. To validate the proposed user interface design principles, the study presents a proposal for a guidelines structure that promotes empirical evaluations through user studies and usability testing. Results collected via a survey based on measuring the effectiveness and user satisfaction of AI-enabled Web interfaces. User interfaces in real-life scenarios are presented and provides information on the impact of UI design decisions on user interaction and overall experience. The outcomes of this research work contribute to a deeper understanding of UI design for AI-supported Web applications user interfaces and offer practical guidelines for designers and developers. By embracing the suggested principles, organizations and designers can create Web interfaces that effectively harness the power of AI while prioritizing user-centricity, accessibility, and ethical considerations.

Keywords: User interface design, Artificial Intelligence-enabled Web applications, Natural Language Processing, Machine Learning, Personalized interfaces, Adaptive designs

* André Costa *E-mail address:* p7118@islagaia.pt

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1. Introduction

The rapid advancement of artificial intelligence (AI) technologies has revolutionized various domains, including Web applications. AI-enabled Web applications hold tremendous potential for enhancing user experiences by delivering personalized and intelligent interactions [1]. However, designing user interfaces for such applications poses unique challenges and requires careful consideration of the intricate interplay between AI capabilities and user interactions [2]. AI-driven innovation accelerates human-computer interaction, posing challenges in dealing with autonomous AI systems. Interaction methods evolve with AI's diverse forms like Robots, Natural Language Processing, Virtual and Augmented Reality. Interaction design (IxD), in its five dimensions (words (1D), visual representations (2D), physical objects/space (3D), time (4D), and behavior (5D) [14] [15]. Surrounding digital and physical domains, plays a critical role in understanding and utilizing AI [16].

This paper presents a guideline proposal for designing user interfaces specifically tailored to AI-enabled Web applications. By addressing the nuances of incorporating AI into the User Interface (UI) design process, this approach aims to guide designers in creating intuitive, efficient, and trustworthy interfaces that leverage the power of AI while remaining user-centric [3].

The core motivation behind this structure lies in the need to bridge the gap between AI technologies and user expectations. AI algorithms often operate behind the scenes, making complex decisions and generating outputs that may not always be transparent to users. Consequently, users may feel detached, confused, or skeptical when interacting with AI-driven features [4]. We have therefore identified three objectives of this research work that are based on the development of a UI design method: crucial to build trust; provide clarity; and empower users in their interactions with AI-enabled Web applications.

The proposed approach encompasses key considerations and guidelines that designers should incorporate throughout the UI design process [2][4-6]. It emphasizes understanding user needs, transparent communication of AI presence, maintaining user control, ensuring explain ability, and addressing ethical and legal implications. By integrating these elements, designers can create interfaces that seamlessly integrate AI functionalities while prioritizing usability, simplicity, and user satisfaction. Additionally, this study acknowledges the iterative nature of UI design, recognizing the importance of continuous testing, feedback gathering, and refinement. Given the evolving landscape of AI technologies and user expectations, this iterative approach ensures that the UI design remains adaptable and responsive to changing requirements and user preferences.

This paper aims to provide a comprehensive overview of the proposed guideline, supported by relevant research findings, industry best practices, and practical insights [7]. By examining the various components of the structure, we aim to shed light on the intricacies and challenges of designing user interfaces for AI-enabled Web applications. Furthermore, this research endeavors to serve as a valuable resource for designers, developers, and researchers seeking to create user-centric, AI-powered interfaces that deliver exceptional user experiences.

Based on the objectives defined above, the methodology of activities to achieve them is described:

1) Literature review: extensive search of the most relevant bibliography on Interaction Design rules and best practices [8-11], that were collected in previous work [7] in which 16 basic principles and guidelines for UI design were identified: Affordance; Discoverability; Reliability & Predictability; Feedback; Internal & External Consistency; Personalization & Shortcuts; Social and Cultural Context; Ease of use (access, dismissal); Error prevention and correction; Interactions history; Learning based on user interactions; Avoid major disruptive changes; Promote prompt feedback; Customize AI behavior; Ease of forgetting; and Help and Documentation.

2) A subset of these 16 principles was identified to be part of the design and implementation of a prototype.

3) The development of a survey was carried out to obtain results from the use of the prototype.

4) The results were evaluated and discussed, and conclusions were drawn.

The paper is structured as follows. Section 2 describes the basic principles and guidelines applied to the development of the prototype. The third section describes the subset of these guidelines used to implement the prototype. Section 4 presents the discussion of the results of the application of a questionnaire to a group of users and, finally, the fifth section presents the conclusions.

2. Design principles and guidelines applied to prototype

Based on [7], a previous work of the authors, a subset of design guidelines for AI system interfaces was identified and compiled. The guidelines that aligned most closely with the current state of the art were chosen to be demonstrated in an interactive prototype. This prototype artifact was developed and tested on usability factors. The objective of the testing was to assess whether the proposed principles could enable users to perform their desired tasks in a pleasant, efficient, and safe manner. The guidelines that are presented and tested in a prototype detailed in section 3, are resumed as follows:

- Affordance: is the quality or property of an object that defines its possible uses or clarifies how it can or should be used. For example, when we see a chair, it is quite evident that it is for us to sit in [12]. According to [13], it is a resource that the environment offers to an animal in which the animal must possess the capabilities to perceive and use it. In this case the object is the AI system, and the animal is the human being.

- Discoverability: the degree of ease with which users can discover all the elements and features of a system when they first experience it. An AI system should be learned quickly and effortlessly by new users. Example: Discoverability depends on many factors. Applying the main guidelines when designing an interface is likely to achieve the desired effect.

- Reliability & Predictability: an AI system must be reliable and predictable to ensure its implementation and use by users. In the developed prototype, the user can successfully predict the outcome of an interaction and all the interaction design factors set adequate anticipations about what will happen. Even before the user clicks on something, which means it is predictable.

- Feedback: proper communication must be done in both directions. Thus, feedback at all points of interaction is essential for usability.

- Internal & External Consistency: internal consistency (within the system itself) and external consistency (in accordance with the expectations and standards of the industry it belongs to) are very important in AI systems.

- Ease of forgetting: the complexity and dynamism with which we live our lives are such that patterns may not remain consistent over years, or even months. It is crucial to force the most used applications to forget the learning process and start learning again, aiming for better or simple more current results. In the case of advanced AI systems, a quick reset/stop may be considered, allowing the system to be restarted with factory settings, as well as running temporarily in safe mode (no AI).

- Help and Documentation: however well designed the systems are, they should always have useful, simple, and efficient documentation. If, on the one hand, we have the tasks of customization and advanced user customization, on the other hand, interoperability will be important in this type of system, as well as the possibility of integrating more functions, so documentation for the "programmers" should also be a reality to consider.

In conclusion, the specified design principles provide a substantial foundation for the development of an AI system interface artifact. In the next topic, examples of the identified guidelines will be presented, as we will delve into the specifics of the prototype.

3. Prototype development

Hevner et al. [19], March et al. [20], and Nunamaker et al. [21] provide additional explanations of what IT artifacts are, which are crucial outcomes of IS research. In this research, we connected the Design Science Research Process framework [22] with the themes of our study to produce an artifact. The goal was to illustrate the importance

of a specific set of guidelines, which was incorporated into a prototype conceived for this purpose. The selected principles where based on two primary objectives:

1. To exhibit the most coherent principles throughout the state of the art established in [7]:
   - Affordance
   - Discoverability
   - Reliability & Predictability
   - Feedback
   - Internal & External Consistency
2. As well as ascertain whether the application of a contemporary guideline for AI systems is feasible and contributes to improving the perceived reliability and safety of the system:
   - Ease of Forgetting

Both these goals were accomplished with the development of the “Vitamina AI” prototype (Figure 1). These were demonstrated throughout the user flow of a suggested AI system that suggests, orders, and sends the most suitable dietary supplements and vitamins based on users' biometric data, objectives, and lifestyle.

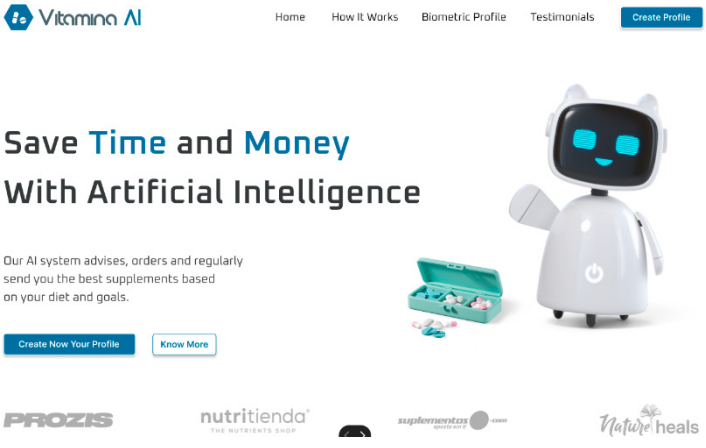

Fig. 1. VITAMINA AI prototype

The functionalities of the "Vitamina AI" prototype are directly aligned with the key guidelines we aim to highlight: the recommendation feature based on user biometric data and preferences enables adequate "Discoverability" and "Feedback," while the consistent interface and the ability to reset to factory settings indicate "Internal & External Consistency." Further, the programmed forgetting functionality delivers users the flexibility to try new options, adhering to the "Ease of Forgetting" guideline. Below is a brief example of how each guideline appears to the user when interacting with the prototype.

- Affordance example: Users can use this property through a slider that the user can instinctively slide and select the option he/she wants in a natural and logical way. Also visible in buttons, checkboxes, X-shaped icons to close messages, among others.

- Discoverability example 1: We can highlight the importance of the "Hero" section, where proper organization of the information, well-designed copywriting, and the existence of a prominent primary call-to-action (CTA), as well as a secondary option, will have a positive impact on this goal. Example 2: In the footer, the user is likely to look for the help menu and contacts. Another relevant issue is to maintain the flow of movement in the footer, not allowing a page to simply end up in the footer without any option to allow for continued navigation.
- Reliability & Predictability Example 1: Clear and timely information helps the user know exactly what is happening and avoid the tension of the unknown. Example 2: The use of natural language in communicating with the user throughout the interaction. Example 3: For the system to be reliable, it is essential to specify not only what it does, but the degree of error with which it does it. It may even be appropriate to mention what it is unable to do. Something that may be more explicit or implicit in the messages presented to the user.
- Feedback example 1: In interactions with the prototype, feedback is complete and easy to understand. In addition to explaining to the user what is happening and the issues relevant to where they are, it provides options in the interaction itself that take the user directly to where they want to go. Example 2: Confirmation messages are also an important key. Critical and irreversible actions should have, in addition to textual and visual confirmation, ways to revert and continue navigating the platform.
- Internal & External Consistency example: Internal consistency is achieved by using fonts, colors, and illustrations on all pages. External consistency is achieved through futuristic 3D AI illustrations, along with easily recognizable industry illustrations, such as a doctor/nutritionist and a pillbox. It is also important to humanize the platforms through vectors or photographs of human beings. Creating interactions that are empathetic and easily recognizable. People tend to trust technology more when it is associated with something they recognize in the real world.
- Ease of forgetting example: It is possible to check the possibility of erasing data in one of the relevant areas in the prototype, without having to take several steps and searches to find the functionality. This increases the degree of control and the perception of safety.
- Help and Documentation example: On the platform's help page there is a search bar to facilitate the search for specific terms, but also task-oriented help menus and for the topics most used/searched by the users. All this with a clean and simple design that makes this task as practical and pleasant as possible.

4. Results discussion

In this research, a methodology known as "Empirical Evaluation with Questionnaire" was adopted, inspired by the structured data collection approach described by [17]. By combining closed-ended questions for quantitative analysis and open-ended questions for qualitative feedback, and involving both ordinary users and design professionals, the questionnaire provided a holistic understanding of user interactions with the prototype, ensuring a strong evaluation of its performance. This questionnaire was structured in three main parts:

- Demographic data: Demographic background and background of the participants.
- Platform usage: Completion of five tasks focused on the various aspects of navigation and operation.
- User experience: Focus on general evaluation and user experience.

The study had 41 participants ranging in age from 18 to 51, with 53.7% being regular users and 46.3% being interface design and user experience professionals. The participants had various levels of education with 61% having a college degree. The participants included Portuguese living in Portugal and abroad. As well as Portuguese speaking foreign citizens.

During the evaluation process, participants were instructed to complete a series of tasks to assess the functionality and usability of the prototype. These tasks were carefully designed to simulate real-world interactions with the platform. Here, we provide a summary of each task:

- Task 1 - Navigating the homepage
- Task 2 - Create a biometric profile
- Task 3 - Access the personal area
- Task 4 - Erase your data / biometric profile
- Task 5 - Return to the homepage from the Personal Area)

The results show alignment with the objectives of the study with more than 95% of the users performing all tasks without difficulty. Detailed results regarding the tasks performed are presented in Table 1.

Table 1. User questionnaires results.

Question	Results		
	Yes	No	Yes, with difficulty
After performing task 1, did you understand the objectives of the platform?	97,6%	0%	2,4%
Were you able to complete task 2?	95,1%	0%	4,9%
Were you able to complete task 3?	95,1%	0%	4,9%
Were you able to complete task 4?	97,6%	0%	2,4%
Were you able to complete task 5?	97,6%	0%	2,4%

A video tutorial was used to support the the questionnaire. This tutorial showed how to navigate the platform and complete the tasks. However, the majority of users - 90.2% - expressed they did not need visual aids to use the application. That seems to highlight the intuitiveness and user-friendliness of the prototype. Also, were also asked to select the attributes that, in their opinion, best illustrated their experience with the platform. The answers suggest that purposes of the guidelines were achieved in a large part.

1. **Safety**: 73.2% of users reported a feeling of safety during their interactions. This indicates that incorporating the design principles of reliability and predictability benefits the prototype in this crucial area.
2. **Intuitiveness**: 70.7% of the responses were aligned with the "ease of discovery" and "ease of use" guidelines. Users navigated the system naturally and carried out the suggested tasks.
3. **Simplicity**: 70.7% of users indicated that they perceived the system to be "simple". This suggests that "internal and external consistency" is noticed. The platform's simple interface, in line with industry standards and user expectations, contributes greatly to this aspect.
4. **Pleasantness**: 63.4% of users understood the platform's efforts to create a pleasant and enjoyable interaction environment.
5. **Functionality**: 58.5% of users recognized the platform's "functionality" as one of its main features. This shows its alignment with the concept of "affordance".

6. **Reliability**: 48.8% recognize that "reliability" signifies the principles of "feedback" and "reliability and predictability" have produced results. With a potential for improvement in this aspect.

The users' perceptions validate the effectiveness of the guidelines integrated into the prototype, corroborating their relevance and positive impact on the user experience. In addition, it was used The Net Promoter Score, an indicator of loyalty and satisfaction [18].

Based on these quantitative results, we will analyze the qualitative open answers in the next section. These can help us understand these positive results, as well as the less positive ones.

4.1 Analysis of user feedback

The specific comments received from the users invited to test the prototype were characterised by a variety of impressions and suggestions that made it possible to understand the various aspects of its functionality, design and usability.

A considerable number of users expressed enthusiasm and interest in the prototype, describing it as an innovative and interesting project. The uniqueness of the idea was highlighted. These impressions highlight the prototype's ability to capture users' attention and elicit positive reactions.

Participants recognized the prototype's potential for AI-assisted medical recommendations and the use of this type of system in the AI sector. Specifically pointing out the relevance of these recommendations for people with health problems. This recognition demonstrates the prototype's potential to respond to needs even in a sector as critical and sensitive as health. Several users commented on the usability and design of the solution. Some comments praised its functionality and intuitive nature, while others pointed out that some people without a technical background or familiarity with technology might still experience some discomfort or difficulty.

A recurring comment identified the lack of an option to view the menu while navigating the different sections of the prototype, which implies the need to better apply the "System visibility" guideline to improve the overall user experience. As for aesthetic and conceptual associations, one comment worth noting compared the design of the prototype to a futuristic scenario depicted in films. This analogy draws parallels with a population dependent on synthetic foods to maintain health. While this association reflects the potential futuristic appeal of the prototype, it also highlights the need to balance aesthetics with the functional aspects of the technology, especially in the context of a health-focused application.

5. Conclusions

The diverse range of comments received provides relevant information about the strengths of the prototype, as well as the areas that still deserve attention. The perspectives presented denote the aesthetic effect, usability, and potential applications of the prototype. At the same time, they highlight concrete areas for improvement. The constructive nature of the feedback demonstrates the potential of usability testing to make user-centered improvements. And how these can optimize the functionality, usability, and design of the prototype, thus contributing to its effectiveness as an AI-assisted healthcare technology solution.

Based on the questionnaire results, it was recognized that the application of the established guidelines was both effective and valued by users, specifically guidelines 2, 3, and 4 of the developed structure. The significance of these guidelines is observed through users' comments, even though they may not explicitly be aware of the guideline’s concrete application.

General comments corroborate the results obtained in the User Experience (UX) portions of the questionnaire. There is a marked interest and enthusiasm among users for this type of platform, indicating a willingness to recommend and potentially use the system in the future. Such a positive reaction is contingent upon the platform meeting user expectations and ensuring a user interface/experience (UI/UX) that prioritizes their interests.

The feedback further underscores the importance of guideline 3 emphasizing the necessity for reliability in such interfaces. This reliability can be achieved through continual optimization based on UX Research findings. Users naturally exhibit a level of self-protective behavior when interacting with these systems, which was considered during the structure's development.

The user feedback also highlighted the significance of both internal and external consistency in interface design, particularly due to the prototype's innovative system. Further enhancements of the interface will be considered to improve consistency, as delineated in guideline 4, and achieve better results overall.

All users have different experiences and different backgrounds. In this sense, it can be difficult to obtain a result that pleases everyone.

Even so, the application of these guidelines in the user interface design of a website or a web application provides, according to the results obtained, added value for developers as well as users. Ensuring a safe, intuitive, simple, pleasant, and efficient experience by integrating them into the interface design process of the new independent and intelligent systems that are to come.

As future work, it's intended to develop a website based on the implementation of all the guidelines identified to heuristically cover all the aspects of a website.

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