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Narjes Bessghaier
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Saudi Electronic University
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Towards Usability Evaluation of Hybrid Mobile User Interfaces

Narjess Bessghaier
COSMOS-SOIE lab
Higher Institute of Computer science and Multimedia
Sfax, Tunisia
e-mail: Bessghaier.narjess@gmail.com

Makram Soui
Department of computer science
Higher Institute of Management
Gabes, Tunisia
e-mail: souii_makram@yahoo.fr

***Abstract*—Hybrid mobile applications are in an ongoing debate about their usability comparing with native mobile applications. Despite the cross-platform compatibility offered by hybrid apps, many developers tend to go native. This choice is due to some issues in hybrid apps like performance, usability, and security. As web technologies improvements take hold, many developers and technology executives find HTML5 usable for building mobile apps. In this context, we choose to work on assessing the usability of Hybrid User Interfaces (HUI). This study shows the results of an experiment conducted over four hybrid apps to identify their usability defects. A predefined list of 13 structural usability defects selected from literature has been used. Our aim is to create a usability defects base of examples of hybrid applications.**

Keywords-component; usability defects; hybrid mobile applications; base of examples

I. INTRODUCTION

Companies are incorporating mobile applications as a main corporate IT service for their business to gain more competitive advantages. We find mobile services in E-health, E-commerce, E-learning, E-banking [2] [16] [17]. The increasing number of smartphone customers has led to a tremendous growth in the number of apps. The Apple App Store has approximately 2.2 million apps while Google play store has over 2.8 million Apps in 2017 [1]. Applications developers have become more interested in creating apps for different operating systems. The problem was that applications were mainly native (i.e. an Android application code can not run on an iOS device). To adapt the app for various operating systems, the hybrid applications were proposed. It is an HTML based-technology, which allows running a single code on several mobile platforms. In fact, developers were delighted by hybrid platforms to enlarge their customers' base [3]. However, hybrid applications need to deal with the smartphone devices' constraints above desktop such as Mobile infrastructure (e.g. limited bandwidth, low network coverage), Mobile Ergonomic context (e.g. Display size, Low resolution) [18]. These mobile-context issues have led to some usability issues that must be solved.

Usability is a crucial dimension in the successfulness and maintainability of mobile apps [4]. Therefore, it is critical to evaluate the usability of hybrid applications before they're being wrapped in a native container. Evaluating hybrid apps UI usability is an important phase of the design process to guarantee a consistent usability rate of the application on the different intendant platforms.

Our contribution consists on detecting structural usability defects of hybrid mobile applications which are related to interface properties problems and not functional defects that can exist due to implementation problems. Our final goal is to create a base of examples containing structural usability defects of four hybrid applications.

The remainder of this paper is structured as follows. Section 2, provides a definition of hybrid applications. In Section 3, we present the usability of hybrid applications. Section 4, describes the usability defects. In section 5, we describe our experimentation. Section 6 analysis and discusses the obtained results. While in Section 7, we conclude and suggest future research directions.

II. HYBRID APPLICATIONS

Hybrid applications aim to afford mobile-platforms compatibility, based on web-technologies (HTML, CSS, JavaScript) [3]. There exist many hybrid platforms which, allow web applications to get access to native platform features (e.g. camera, filesystem, sensor) [6]. These platforms such as PhoneGap, Cross-platform, Worklight take as input a web-application and generate as output an adaptive application that can run on different mobile operating systems (Android, iOS, WindowsPhone). Hybrid apps benefit from the versatility of both native and web approaches. This technology aims to exclude the dependency on device specific code and look at providing a single multi-platform code [3]. In fact, adopting hybrid mobile applications has some benefits over native apps: faster time to market, lower cost of products, addressing wide customer base [7]. Nevertheless, they present some limitations about performance, UI testing, security [8]. Some developers believe that there would be a massive concentration on hybrid programming if these limitations are overawed [6]. The big challenge against mobile hybrid developers is to produce applications that behave and look as a native one. To this end, hybrid apps involve the adoption of some JS libraries such as (SwipeJS, iScroll) to handle touch, gestures and transitions events [21]. As well, designers tend to use some frameworks such as (JQuery Mobile, Ionic, Bootstrap) to conceive their UI elements rather than HTML5.

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These frameworks have great impact on the structure and flexibility of an UI.

III. HYBRID APPLICATIONS USABILITY

ISO-9241-11 [5], defines usability as the degree to which a product can be used by specified users to achieve particular goals in a particular context of use in terms of effectiveness, efficiency, and satisfaction. Mobile systems manufacturers have proposed a number of UI guidelines in order to produce usable applications. Apple iOS states the platform characteristics and Human Interface guidelines that should be considered during development process [9]. Three primary themes differentiate iOS from other platforms: Clarity, Deference, and Depth. Google manufacturer published its own guidelines for Android User Interface [10]. This helps developers to elaborate a good GUI that satisfies the requirements such as touch gestures, contextual menus hierarchy, input controls and notification settings. However, these UI principles are specific to each platform. Thus, it is advocated to have a common set of guidelines for the target platforms [3]. Several scholars proposed a set of adapted usability principles to mobile context [11] [19] [20]. In the reference [12], the author matched between Nielson's 10 usability heuristics that are desktop-centered and (Android, iOS) UI principles. As a result, he obtained a unified checklist of mobile usability principles. Henceforth, designers ought to follow this kind of independent-platform heuristics to promise with some better usable applications.

IV. USABILITY DEFECTS

There is not a usability defects data set of hybrid mobile application. To this end, we started by identifying some validated usability problems from literature. We have selected a total number of 35 defects. However, we only kept 13 structural usability defects, that doesn't require a task to be modeled in order to be detected. The selection of these defects is done through a deep research and reading of usability related studies.

TABLE I. LIST OF STRUCTURAL USABILITY DEFECTS.

Defects	Description
Incorrect layout of widgets	This defect is concerned with the "alignment, dimension, orientation, depth and position" of layouts [13].
Incorrect appearance of widgets	It is concerned with the aesthetic aspect of a UI, including: font, color, icons, and labels [13].
Home page is too busy	Is related to the crowdedness of a UI with widgets that will distort user's perception of displayed data [14].
Deficient content inside the "about us" tab	Users check the "About us" tab to see information related to the development laboratory, version, and other related information of the application [22].
Information overload	It is the perception of more information than is necessary [4].
Screen clutter	It is related to the way of displaying a large amount of necessary information without careful choices of data visualization techniques [4].
Lack of task support	Task support must be provided to help users [4].
Expected information missing	The deficiency of some information will cause the user to go to another app [23].
Missing functionality	Functionality is declared as missing either because it is provided on similar applications or it would be useful to have to achieve a specific task [23].
Functionality Unclear	Specific functionality is expected since buttons are provided for it. However, the buttons work in a limited range of conditions that are not indicated [23].
Terminology unclear	Should not use complex wording to satisfy all user's educational levels [23].
Incomprehensible instructions	Tasks instructions must be clear and simple to comprehend. Unintelligible instructions will halt the user from performing his task [15].
Inconsistent spacing	Interaction element's layout should be well positioned, so that a user easily finds it to interact with the widgets [15].

V. EXPERIMENTATION

A. Studied Projects

The evaluation is conducted over 4 hybrid mobile applications: Fresh Food Finder [1], JustWatch: Films et Séries[2], Feedly Get Smarter[3], and Key chain[4].

Fresh Food Finder: This app helps its users to locate farmers' markets for grown food. It enables them to easily find markets near their current location.
JustWatch: Films et Séries: It's an application of videos streaming. It offers its users the possibility to watch movies, series from a variety of streaming engines. *Feedly - Get Smarter:* Helps users to organize, read, and share any information they need to keep by their hands. *Key chain:* This application helps users in coding their pin codes and passwords into multiple squares. Users shall need to remember which four squares contain their code.

TABLE II. PROPRETIES OF STUDIED MOBILE APPS

App Name	Version	Number of UI	User rating	Framework
Fresh Food Finder	v 1.3	7	3.7	JQuery
JustWatch: Films et Séries	V 0.15.9	14	3.8	Ionic
Feedly Get Smarter	V 37.2.0	7	4.5	HTML5
Key chain	V 1.7	7	4.2	Ionic

1/https://play.google.com/store/apps/details?id=com.tricedesigns.FreshFood&hl=fr
2/https://play.google.com/store/apps/details?id=com.justwatch.justwatch&hl=fr

3/https://play.google.com/store/apps/details?id=com.devhd.feedly&hl=fr
4/https://play.google.com/store/apps/details?id=com.dechdroid.keychain&hl=fr

B. Subjects

The study was conducted at the Higher Institute of Management in Gabes, Tunisia. 20 students were invited to this evaluation study (11 females, 9 males). 12 are bachelor degree students and 8 are master students. The data that were collected about the participants show that only subjects in master degree have an experience with software quality evaluation. However, all students have an experience in using mobile applications.

TABLE III. PROPRETIES OF PARTICIPANTS

Characteristics	Measures	Numbers
Gender	Male	9
	Female	11
Age	[20-25]	20
Field study	Management and computer science	8
	Systems information	4
	Decision-making and management	8
UX in software quality	No experience	12
	With experience	8

C. Scenario

Candidates were primarily requested to fill out a user profile questionnaire. After answering the first part, subjects were invited to evaluate 3 mobile UIs of 4 hybrid applications. The UIs were selected as the most ones having usability defects. This primary check was done by the authors. Participants interact with a HUI to identify all possible defects. Two observers and an expert in mobile user interface design controlled the experiment. Before the beginning of the experimentation, the expert explained the usability defects. A link to our data set is provided in the footnotes[4]. Fig. 1 presents an example of the evaluated HUIs and its correspondent detected defects of one of the participants.

4/https://drive.google.com/open?id=0B0s2DqmVB5fBZGRNVWZYbE85VzQ

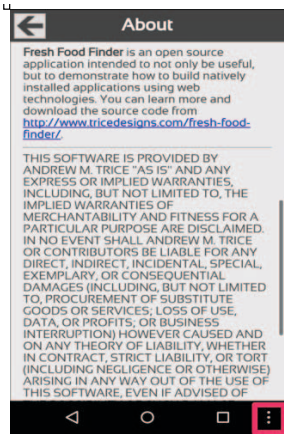

Figure. 1. Example of an adaptive UI "About".

Age	Sex	UX	Education Level	Problem	Interface
low	low	MEDUIM	High	information overload	about
low	low	MEDUIM	High	screen clutter	about
low	low	MEDUIM	High	incorrect layout of widgets	about
low	low	MEDUIM	High	missing functionnality	about
low	low	MEDUIM	High	incorrect appearance of widgets	about

Figure. 2. Example of structural usability defects of "About" UI.

VI. DISCUSSION

In this section, analysis and discussion of the obtained results of each application 's UIs are addressed.

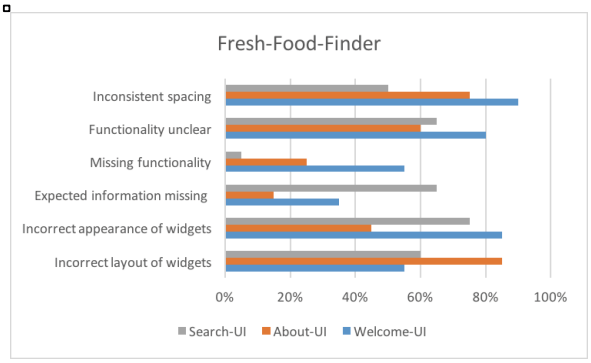

Figure. 3. The detected defects for Fresh-food-finder app.

Fig. 3 shows the detected defects for the 3 UIs of the application "Fresh-food-finder". The results show that the majority of detected defects for each UI are identified by more than 50% of evaluators. This proves the existence of these defects in the evaluated UIs.

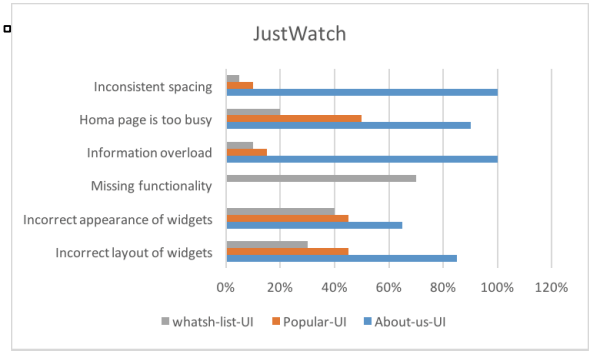

Figure. 4. The detected defects for JustWatch app.

Fig. 4 shows the identified structural usability defects for the project "JustWatch". The findings show that most of the evaluators have found problems with the "About-us" UI. For instance, 100% have identified the Inconsistent spacing, and Information overload defects. This proves that this UI suffers some layout structuring problems.

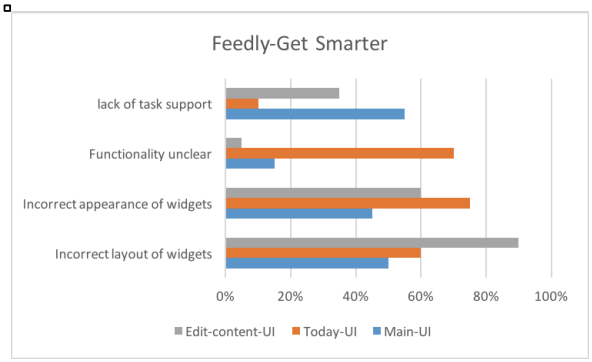

Figure. 5. The detected defects for Feedly app.

Fig. 5 indicates the identified defects for the project "Feedly: Get Smarter". The app is the most one having few number of usability problems. However, the results show that the "Today" UI is the most one having problems as it is identified by more than 60% of users. "Edit-content" has the Incorrect appearance of widgets, and incorrect layout of widgets defects as they are detected by 60% and 90% of users respectively.

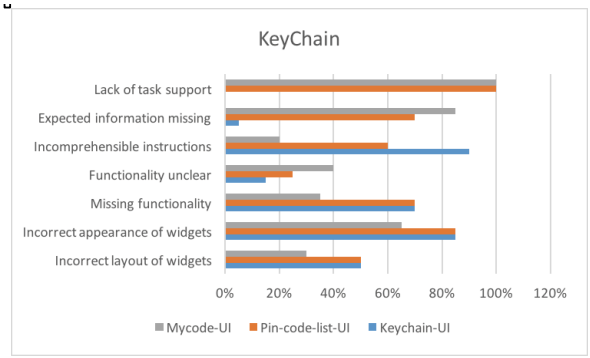

Figure. 6. The detected defects for Key Chain app

Fig. 6 presents the results for the "Key Chain" project. The findings indicate that this project suffers the most from usability problems with 7 identified defects. 100% of users have identified the "Lack of task support" problem for both "My-code" and "Pin-code-list" UIs. This emphasizes the importance of providing help instructions. The "Pin-code-list" and "Keychain" UIs have approximately same usability defects with 4 major problems. Approximately 82%,50%,70%, and more than 60% have detected the "Incorrect appearance of widgets, incorrect layout of widgets, missing functionality, and incomprehensible instructions" respectively.

The identification of these usability problems reflects the user rating about the usability of HUIs. Moreover, the diversity of identified problems depends firstly on the different user profiles "Age, Experience level", and secondly on the structural characteristics of the interfaces. To check the reliability of these results, the expert has examined and validated the findings based on his experience.

After the evaluation of the UIs, we asked the participants points of view regarding these structural defects and how they can negatively impact the successfulness of an application. The majority of users agreed with us on evaluating the applications layout appearance before the evaluation of the app's functionality. Evaluators insisted on the importance of having a good layout structure and widgets appearance as they are the most detected defects. One of the users declared: "*I'll be using the app till I find a more appealing alternate*". Another said: "*The application functionalities are what we are looking for. However, I'll be always searching for a better-looking one*".

These points of view position the UI in a high rank, which encourage our work on improving hybrid application UIs as they are not made directly through a mobile app development platform.

VII. THREATS TO VALIDITY

In this section we report threats to validity to our experiment. As an internal validity, we have used state of the art usability defects. These defects are known to be GUI usability related defects, and we relied on their prior validation by scholars. As a construct validity, we have relied on the expert own experience to validate our conceived base of examples. As an external threat, we have only used 4 hybrid apps, that might not be enough to construct a consistent base of examples. For this reason, we are planning to extend the number of evaluated projects.

VIII. CONCLUSION

This paper has presented an empirical evaluation of 4 Hybrid applications. To this end, an experiment has been conducted by inviting 20 subjects to evaluate three HUIs for each app. The aim was to identify and to highlight the usability defects when interacting with the hybrid apps using their mobile devices. In this experiment, usability issues of each evaluated hybrid interface have been collected via a questionnaire. The The obtained results were analyzed, interpreted and validated by an expert. This evaluation is very expensive and time-consuming. In our future work, we will propose an automatic evaluation tool based on a set of quantitative metrics to assess the usability of 41 HTML based apps and detects related usability defects based on a set of rules. These detection rules will be generated via the use of the genetic programming. As our evaluation tackles only the structural defects of HUI, we plan to work on the detection of functional defects via code smells analysis.

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