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Image Based User Experience (UX) Factor Analysis- Mobile Phone Perspective

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***Abstract*—**This paper mainly assesses original image used within a mobile application to understand the differences and comparing them with the standard size. The purpose is to predict success rate of mobile applications prior availability to its customer. To do so, we considered sizes of Android based application which can be improved for the ease of user friendliness. In android package kit *(.apk)* the buttons are usually *(.png)* files where the size may differ based on various screen perspective. An application is developed to find and compare the existing button size found in a mobile application to the respective standard in terms of User Experience *(UX)* factor. Initially, the result in this work will produce a statistic for developers to compare button standard with the original standard and finally produce a generic overview to get a probable success rate with other products in the market. The main finding of this work are, consider an agile based approach during development including revising the developed applications if required before the final release to their user and to overcome the standard of the design issue in terms of standard button measurements with similar products.

***Keywords*—User Experience Factor; Button Size; Android Package Kit; PPI; DPI**

I. INTRODUCTION

Use of smart devices is continuously evolving a significant number of users. In the contemporary time, the smartphone is becoming the important devices for us in the post-PC era, which aid in our daily tasks with the useful functionalities[1]. The smartphone comes at the very first position in terms its availability and sort of handiness. Making a mobile device user-friendly to its user are assured by *UX* factors which is one of the most important parameters in product development. *UX* factor is a recent term come from human-computer interaction field which extends the vast concept of interaction design[2] User experience is a factor that describes, how well and easily it works, how they feel while they use and how well it fits into the entire context of its purposes. However, the companies and its developers need to understand the user expectations to produce expected products.

Nowadays, companies are racing to develop applications by fulfilling user demands and targeting the maximum market. Meanwhile, many of them do not have the right analytic to adequately measure their applications effectiveness before the product comes to the user. User experience design in the industry is to improve customer satisfaction and loyalty through the utility, ease of use, and pleasure provided in the interaction with a product [3]. User experience points such factors that enable the companies to work on user requirements, friendliness, usefulness, need and availability of desired functionality that attracts the user to own the product. On the other hand, the production companies need to keep track of new requirements by the user which is one of the major properties of *UX* factor.

Once a mobile application is launched to the market, it collects the statistics on *UX* factors that aim a certain level of success for new products. There are companies such as App Annie [4] used to make products by analyzing different users metrics in terms of *UX* factor. Application performance metrics is always helpful information for the developer and companies as they cannot really predict how the product is going to be evaluated by the user. There are many parameters to make an app successful such as usefulness, friendliness, affordability, responsiveness, usability, attractive design and

so on besides its brand value. The developer and company must consider the strategy that makes sure to achieve the business objectives by fulfilling user needs. Due to that, the visual design, metrics, and *analytics* need a complete concentration by the developing agent for their future designs. This work focuses a major *UX* factor that literally aims a higher success rate. We selected button images as our test case to get their analytic and compare Google provided standard in terms of *UX* factor [5]. Android is so popular in contemporary time. The global market share of Android is over 80% [6]. Google has its own development platform for Android-based application specifically on button architecture where they have provided the standards in terms of their design, platform, architecture, *UI*, Sensor, connectivity, storage, administration etc.

During the design and development of this work, we followed agile development strategy [7] due to its dynamic and feature-driven development method. Application developers who will follow the proposed approach in this work are also highly recommended to practice the agile strategy as it directly involves iterative, incremental and rapid application development method [8]. Rest of the work in this paper is divided into the following chapters. Few related works are cited in chapter II, Screen resolution, *PPI, DPI* are explained in chapter III. Chapter IV is about button collection and evaluation. A statistical evaluation of the result took place in chapter V. Finally, discussion and conclusion are drawn in chapter VI and VII respectively.

II. RELATED WORK

At the time of application development, few things are usually considered such as the presence of a specific feature, an appropriate system for running the application, adequate support of hardware, fully functioning devices and such relevant things those are required. But, during the launch of the application, the measurement of product's success rate is not calculated especially in terms of its acceptability to the users. Even there are not so much done in prior evaluating and predicting the success of an application before the commencement of the product to the market. Meanwhile, there is research on user-friendliness, *comfortability*, behavior, user perspective on different viewpoint depending on various age groups and so on. Another important designing issue is a seamless experience that allows the user to have a pleasure of continuity in using an application. The analysis of the User Experience and User Interface design took place in many dimensions which came out in many forms of research. We will see, how the researcher has thought and presented their ideas in this specific area.

Steve *et al.* pointed to the *uncomfortability* of a user can have in terms of user experience [9]. Frank and Edward emphasis on the design part and claimed that the design should be based on user experience [10]. *Bederson, et al.* priorities early evaluation of the design before the development [11]. Peter *Morville* identified the facets of user experience are useful, usable, findable, desirable, valuable, accessible and credible [12]. J. *Meyerson* mentioned regarding certain users are having difficulties in searching and navigating the digital culture [13]. Brewster, S.A. pointed to the lack of screen space in terms of allocating resources [14]. Pekka *et al*. [15] worked on thumb use of a user to work in a discrete manner for radio buttons, checkboxes etc. and other sequential work like writing into a text box and so on [16]. A good amount of research work carried out to understand the user need and implemented later to overcome the raised issues, but prior evaluation of an application from user analytic is quite rare. Our work will mainly focus this issue to predict a certain level of success by determining the existing button sizes varying from the Google provided a standard for Android-based applications.

III. SCREEN RESOLUTION AND PPI, DPI

A mobile application is not just made to fit in one fixed size screen rather it becomes available to support various screen size according to the pixel per inch *(PPI)* and dot per inch *(DPI)*. Screen size, button size, and its contextual location are prime issues during the development phases of any mobile applications. Different users have different thumb using pattern [17] or difficulties in operating a mobile screen. Therefore, if the buttons have an average size, it may become a problem for a person who has comparatively thicker thumb size. In this case, the most user application can be annoying for such a person. Thus, the acceptability of an application according to the standard may differ from user to user depending on various screen size.

Table 1. Variant screen resolution

DPI range	Screen range	DPI count
LDPI	0.75X	0 to 120
MDPI	1.0X	120 to 160
TVDPI	-	160 to 213
HDPI/HiDPI	1.5X	213 to 240
XHDPI	2.0X	240 to 320
XXHDPI	3.0X	320 to 480
XXXHDPI	4.0X	480 to 640

Android has developed their algorithms that *resize* the application layout according to the screen size [18]. Still,

problems may arise in allocating spaces for more elements in various screen size devices. The size of Mobile phones has changed time to time in terms of the screen area, mostly they got bigger with higher resolutions. Table 1 compares the ratios on the screen size and the pixel count. It ranged from low dots per inch *(ldpi)* to extra extra extra high dots per inch *(xxxhdpi)* so far to support various screens.

PPI and DPI

Pixels are the basic unit of a programmable color in a digital image and so the density of the pixel can be calculated by the amount of *PPI* [19]. According to modern science, the concept of *PPI* and *DPI* is considered as same [20]. *DPI* only refers to the application of *PPI* in printing an image. It prints the same amount of *PPI* on a printing paper. The more pixels an image contains, the more dots are printed by the printers on paper for both colorful and black and white images. As every pixel is equal in horizontally and vertically, so the density is also the same in each pixel.

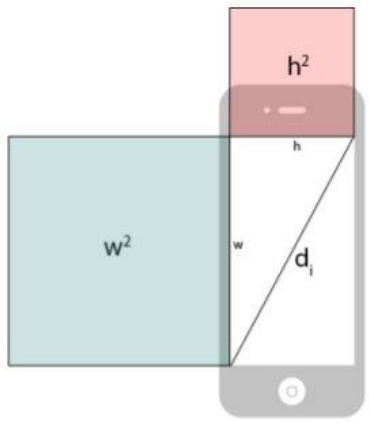

Figure 1. PPI calculation

The most renowned process to calculate the pixel density is to calculate it diagonally with screen (figure 1). We can use the height and width of the screen to calculate the resolution. We can calculate the resolution (diagonally) using the Pythagorean theorem:

$$a^2 + b^2 = c^2. \quad (1)$$

If we assume the width of the screen by *w* and the height of screen with *h* then according to the theorem the diagonal resolution in a pixel should be denoted by:

$$d_p = \sqrt{w^2 + h^2}. \quad (2)$$

As we have found the diagonal pixel, we can calculate the resolution with the respect of screen size in inches by using the following mathematical expression:

$$PPI = \frac{d_p}{d_i}. \quad (3)$$

where d_i is the screen size.

File Path	Original Image Size	Standard Size
/res/drawable-hdpi-v6/ic_menu_help.png	20	HDPI
/res/drawable-hdpi-v6/icon_breaking_link.png	04	HDPI
/res/drawable-hdpi-v6/btn_check_off_disable_focused.png	18	HDPI
/res/drawable-hdpi-v6/btn_check_label_background.9.png	16	HDPI
/res/drawable-hdpi-v6/btn_check_off_selected.png	18	HDPI
/res/drawable-hdpi-v6/icon_decreasetext_tool_default.png	18	HDPI
/res/drawable-mdpi-v4/btn_check_on_selected.png	46	MDPI
/res/drawable-mdpi-v4/icon_edit_focused.png	88	MDPI
/res/drawable-mdpi-v4/icon_refresh_disable.png	54	MDPI
/res/drawable-mdpi-v4/btn_check_on_pressed.png	11	MDPI
/res/drawable-mdpi-v4/plus_sign.png	18	MDPI

Figure 2. Comparing original image with standard image size

IV. COLLECTING AND EVALUATING BUTTONS

The main purpose was to collect different size images within an application to get the button *analytics*. To avail the opportunity we followed few simple steps, such as:

Decoding .apk file

We developed an Android package kit decoder to decode .apk files. We decoded few Android-based mobile applications with the owner consent to test our tool and verify the claim of this work.

Selecting button files

A web-based tool was developed to choose specific .png files which have button properties. Among all *.png* files, the specific button files can be found in respective *mdpi, hdpi* folders. Figure 2 shows some file *analytics* such as their current size compared to the standard size.

Comparing button file

We stored all the buttons in the database to be compared to the Google provided standard and produce the *analytics*. The *.apk* file eventually had too many images where some of them were buttons and some were other image files with different properties which were not considered. For our analysis, we have listed all of them in the database ranging from *ldpi* to *xxxhdpi*.

Table 2. Existing size compared to the original size

File types	Existing size (in pixel)	Expected size (in pixel)
~.png	20, 16, 7, 3, 19, 11, 10, 43, 39, 24, 46, 23, 4, 34, 29, 31, 25, 9, 6, 22, 30, 14, 40, 37, 33	hdpi (213 to 240)
~.png	8, 11, 12, 29, 22, 26, 14, 10, 25, 9, 16, 6, 15, 28, 20, 3, 19, 5, 17, 2	mdpi (120 to 160)

A set of image (.png) files is stored in table 2 from the extraction of an application to compare with the expected size. The first column is the file type *(the full path and file name have been avoided due to privacy issues)*, the second column contains actual button sizes found in the *.apk* file and the third column provides the expected range for different size screens. Such actual results may help the development team to verify their work compared with the standard measurements. The analytic contributes a great knowledge of their currently developed products to do the cost-benefit analysis before launching to market. However, if the applications are not developed to the standard, the success prediction cannot be made in advance which may lead to an unpleasant user acceptability. The next chapter could give a deeper insight of analysis of currently developed products with such limitations.

V. EVALUATION OF RESULTS

Table 2 has the *hdpi* and *mdpi* files *(.png files with button properties)* found with their actual size in pixel within an application. It gives a clear comparison that, the actual button sizes are much lower than the expected range. In this chapter, we decided to get analytic and produce a statistical overview of the button size of an application to evaluate our achieved results. According to the number of the testing sample we decided to analyses them with *One-Sample t-test* [21] which can be derived from the following equation:

$$t = \frac{\bar{x} - \mu}{S}\sqrt{n}\,. \tag{4}$$

We considered *hdpi* and *mdpi* as individual test cases.

Case 1: high dots per inch (hdpi)

$$H_0 : \mu = 226.5, H_1 : \mu \neq 226.5 \tag{5}$$

Table 3. One-Sample Statistics for *hdpi*

	N	Mean	Standard Deviation	Standard Error Mean
hdpi	25	23.00	12.936	2.587

Table 4. One-Sample t-Test for *hdpi*

	Test Value = 226.5					
					95% Confidence Interval Of The Differences	
	t	df	Sig.(2 tailed)	Mean Difference	Lower	Upper
hdpi	-78.658	24	1.789E-30	-203.500	-208.84	-198.16

In the first phase of analysis, the *mean* scored 23 for 25 *hdpi* samples table 3 which shows the difference from the population means which is *226.5*. Table 4 shows the mean comparison where the calculated value of *t-statistic* is *negative 78.658* with *24 degrees of freedom* (df) at *5%* level of significance. For 24 degrees of freedom, the tabulated value ranges from *negative 2.064 to positive 2.064* for *2-tailed test* [21]. If the test value scores within this range, the null hypothesis will be accepted otherwise rejected. Alternatively, if *Significance value* is lesser than the level of significance we can reject the null. The calculated value of *t-statistic* is much lower than the negative value of the tabulated value and the significance value is *1.789E-30* which is also lesser than the level of significance.

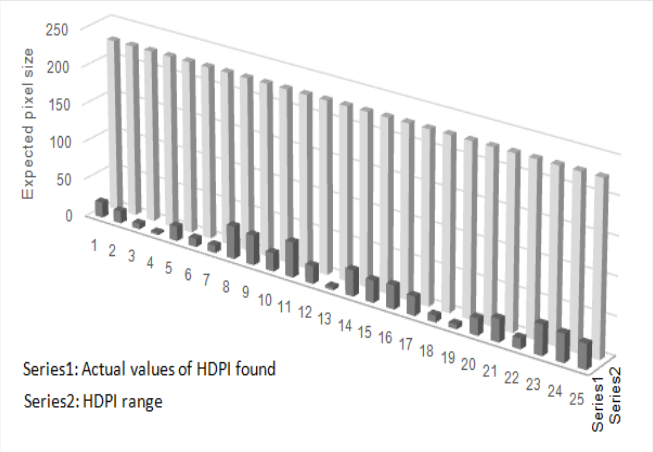

Figure 3. comparing hdpi with standard range

Both of these claims that we are rejecting the null hypothesis which means the actual button size does not meet the expected standard. Graphical representation of the claim is shown in figure 3.

Case 2: medium dots per inch (mdpi)

$$H_0 : \mu = 140, H_1 : \mu \neq 140 \quad (6)$$

Table 5. One-Sample Statistics for mdpi

	N	Mean	Standard Deviation	Standard Error Mean
mdpi	20	14.85	8.305	1.857

Table 6. One-Sample t-Test for *mdpi*

	Test Value = 140					
					95% Confidence Interval Of The Differences	
	t	df	Sig.(2 tailed)	Mean Difference	Lower	Upper
mdpi	-67.390	19	4.4186E-24	-125.150	-129.04	-121.26

We analyzed 20 *mdpi* samples where obtained mean is 14.85 table 5 that differs from the population mean *which is 140*. We ran the similar *One-Sample t-test* for *mdpi*. According to table 6, the calculated value of *t-statistic* is *negative 67.390* with *19 degrees of freedom* (df) at *5%* level of significance. In this case, the tabulated value ranges from *negative 2.093 to positive 2.093* for *2-tailed test* [21]. For *mdpi*, the value of *t-statistic* and the *significance value 4.4186E-24* reject the null hypothesis as both values are lesser than the tabulated and level of significance range respectively.

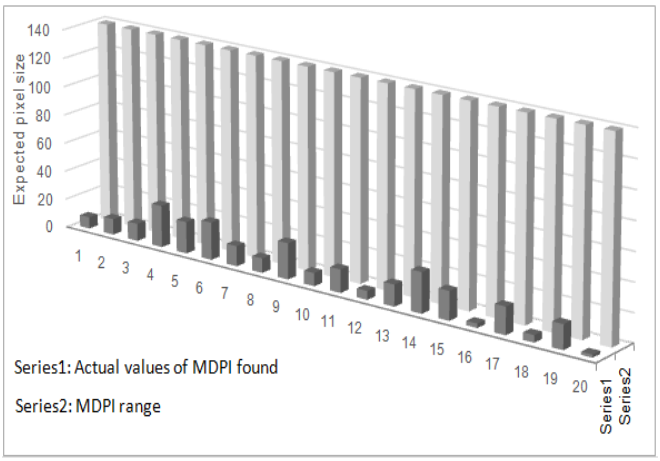

Figure 4. comparing mdpi with a standard range

Thus, it indicates the unacceptability of actual button size compared to their standard. Figure 4 gives a clear picture of the differences.

VI. DISCUSSION

Currently, there are many companies developing suitable applications for different purposes. The small and new companies are in a competition with the experts to market their new products. Many of them becoming unsuccessful in their future editions due to their limitations in designing in terms of *UX* factor. Prior evaluation is highly recommended for such companies and products that help them in estimating the possibility of success and their business. Calculating a success rate before product launching may help them into a closer prediction of their application marketing. This research work is targeted to assist these application development companies and their developers who probably need a prior evaluation that prevent them to take any risk for their products and their future user.

VII. CONCLUSION

In this paper, we presented a systematic approach to a solution for evaluating applications that could help companies and development teams in predicting their business. We have tested a good number of applications from the local markets with their permission where we found, most of the applications do not meet the standard requirements that discussed in previous chapters. The evaluation results show the faults in button sizes of applications which may lead to discomfort to the user in the

long run. As the computing trend is continuously changing, the using behavior of users are also changing that expects more fine-tuned product designing to take future challenges and make them useful. This work exactly focused on of the most sensitive issues of an application in terms of UX factor to assume a prior success. Continuity of this work will focus on the contextual location of the button on various size screens.

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