Usability Analysis of Android and iOS Operating Systems

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Abstract — *An operating system is a code that interfaces with the end-user and executes the end-user or applications' commands on their behalf. Conventionally, operating systems were used in desktop computers to facilitate end-users. During the past few years, tremendous advancements have been made in the domain of mobile operating systems. Many operating systems have evolved, such as Android, iOS, SymbianOS, Firefox OS, etc. This paper discusses Android and IOS operating systems. The paper provides quantitative comparisons between them based on a comprehensive survey. The paper analyzes the data using association rules mining and k-mode clustering. It was found that the user interface of the phone heavily influences the satisfaction and adoption of a mobile phone.*

Keywords — *Android, iOS, comparison, user experience, usability analysis*

I. INTRODUCTION

A mobile application is a piece of software running on a mobile phone. It could be a framework or a naïve application that performs various functionalities besides making a phone call, and consequently, these capabilities vary from games to therapeutic capacities. The term application alludes to a programming framework that clients may install onto their cell phones. Over the past few years, we have seen the emergence of two popular mobile phone systems, i.e., Android and iOS. Both iOS and android mobile contain applications ranging from games, books, calculators, and provide options for diverse application gadgets. Each iPhone and Android contain several application alternatives like mike, GPS, or movement sensors to provide various innovative applications like guides for area help and GPS to discover cars [42]. Apple's iPhone and Google's Android do not exclusively contain all the essential features. Every cell phones have several improvement possibilities through plugins and apps. Regardless of the ordinary decisions shared by each iPhone and Android phones, there are still assortments inside the two phones' usage. The iPhone was launched in 2007, and by Sept 2012, the Apple store contains approximately 700,000 iOS applications that are altogether downloaded thirty billion times. Normally, iPhone OS is the iPhone's default operating system and comprises four layers that include the services layer, the OS layer, the Cocoa bit layer, and the Media layer. Android and iOS are based on cutting edge technology and has lead to the sudden spikes in demand for the UNIX Kernel. Android is programmed in Java language. It is open-sourced and allowed programmers to write programs inside the Java language freely. These codes employ the SDK provide by Google-enabled Java libraries. It is noteworthy to mention that the operating system's flexibility also opens for abuse of the system, such as stack overflow, session hijacking, etc.

II. INTRODUCTION TO ANDROID

Android is an OS for cell phones that keeps the UNIX framework, and Google owns it. Android is easier to download and provides the source code of the software with a mobile phone design. It includes an OS, middleware, and the UNIX kernel. Google bought the Android in 2005, and then Android was officially launched in 2007. [1]. From there, it is kept by the organization with the improvement in code that is up to now been themed like desserts, running in sequential order request [2]. Fig 1 provides a summary of various android versions.

During the early days, several initial versions of Android were launched. Android authorized open presentation, which is popular in 2008 through Android 1.0. It was an organization so old it didn't have an amiable nickname. [3] Then comes the cupcake. The Android 1.5 cake stage presents a few new choices for clients and designers. It includes user interface refinements, performance enhancements, new options, and new APIs and manifest components [22]. The Android 1.6 stage presents new decisions on behalf of clients and originators. Improvements include new user decisions, Google performance fill in, and original standard tools [23].

Android 2.1 (Éclair) remains an insignificant stage-discharge deployable on android-controlled handsets beginning in January 2010. This also proposes different API variations and virus repairs. For architects, the Android 2.1 platform is reachable as a downloadable part for the Android SDK. The downloadable point integrates no outer libraries. [24]

The next inline was 1.1.1   Android 2.2 (Froyo). It focuses on five major aspects, specifically performance and speed, new undertaking abilities, faster, a ton of ground-breaking programs, arranged most recent APIs and administrations and additions to android market [25]

Gingerbread was launched as the next eversion that sophisticated the UI, improves quality, the sensitive reassure and replica/stick options, and additional assistance

for close to field communication [1]. Android 3.0 (Honeycomb) provisions greater shelter and presents a couple of new PC program choices, and provisions multicore mainframes and hardware accelerator. [1].

Icecream Sandwich remains a variation of the Android adaptable programming group made by Google. Launched on October 19th, 2011 [1], Jelly Bean is the name given to a couple of significant reasons having some execution upgrades intended to permit the bundle an electric sander and extra responsive feel with activity catches and diverse interior changes [1].

KitKat is a type of the Android adaptable programming structure made by Google [1]. Lollipop is a version of the Android with a convenient working system made by Google, with adjustments in the scope of 5.0 and 5.1.1. Uncovered on June 25th, 2014, all through the Google I/O conference [1]. Marshmallow can principally represent considerable authority in rising the client expertise and brought two or three alternatives like an overhauled authorization model inside which applications are no longer consequently conceded the entirety of their nominative consents at establishment time, Doze power topic for broadened battery life once the client doesn't control an apparatus, and local help for unique mark acknowledgment. [1].

Google's 2016 Android Nougat and Oreo are intended to appeal to as wide a partner degree crowd as possible [3, 26]. Android 9.0 (Pie) is the next in line. Android 10 denoted a move for Google. Google reported a rebranding of the product framework, getting rid of the naming topic, and rather protrusive with rendition numbers exclusively [28].

Android 1.0 and earlier versions
Cupcake
Donut
Éclair
Froyo
Gingerbread
Honeycomb
Icecream sandwich
Jelly Bean
Kitkat
Lollipop
Marshmallow
Nougat
Oreo
Pie

Fig 1: A summary of Android versions

III. INTRODUCTION TO IOS

iOS is the name of the operating system running in iPhone, iPod contact, and iPad. The inside code is stacked on all devices to empower them to run and support various applications. While Apple doesn't utilize open code names for iOS in how the organization accomplishes OS X, it uses inside code names dependent on ski resorts. In general, they're not implied for people because, as it may, when a form of iOS opens up to the world, they're not hard to discover [29].

The first version of iOS was iOS 1[5]. One year later, when the iPhone transformed into an extensively more prominent hit than about anyone foreseen, Apple released iOS a 2.0 (by then known as iPhone OS 2.0) to orchestrate with the arrival of the iPhone 3G. The most significant alteration presented during this launch was the app store, and it helped local and outsider applications. Around 500 applications were offered inside the App Store at dispatch [4].

iOS 3 focused on the presentation of the iPhone 3GS. It has new features such as c**opy and pastes and** glue content from application to application. [6].

With iPhone 4's new Retina Display, iOS4 will naturally redraw content and controls for existing applications to make them get along with the new higher constituent thickness [7]. It was followed by iOS 5 [8]. iOS 6 has more than 200 new extra options and improvements to Siri [9]. iOS 7 and 8 were next in line [11, 12]. iOS 9 has several analysis features. [13]

Macintosh iOS 10 is a framework in its case. With stickers, movements, and outsider application reconciliations [14] iOS 11 update includes a great deal of adaptability with an overhauled focus, new App Store style, alongside greater availability choices [15]. iOS 12 concentrated a lot on making refinements to regularly used other options and including wrinkles that improve at any rate with which individuals use their gadgets [4,16]. iOS 13 is gigantic and garish. It has a smooth dull mode; hanging updates to applications like apple maps, photos, and even reminders; and long-late augmentations kind of a swiping console and UI improvements. [17]

IV. LITERATURE REVIEW

There has been a host of studies that analyzes the features of Android and iOS. A comparison of four mobile operating systems, i.e., Android, windows mobile phone, iOS, and Firefox OS, was performed in [35]. A usability analysis of instant messaging app on iOS and Android was performed in [37]. A qualitative analysis of the features of Android and iOS was performed in [38]. Another work that is based on qualitative comparison was done in [39]. [30] provided the mobile application development

experience on iOS and Android. [31] I also analyzed the two platforms from the developer's perspective. The authors analyzed to determine which one is better from teaching perspectives. [32] I analyzed the two operating systems from security and privacy perspectives. An exploratory study was performed with 700 German students, and directions for further research were provided. In another work, the security of the two platforms was analyzed [33]. [34] I also analyzed the two mobile os from a security perspective. Various factors, such as provenance, permissions, isolation, and encryption, are considered. In [40], a quantitative comparison of performance parameters of mobile app development strategies is performed. In a similar direction, mobile application development tools were analyzed in [41]. It was found that PhoneGap consumes less memory, CPU, and power. A comparison of users of iOS and Android in the context of smoking cessation app was performed in [36]. Having performed the extensive literature review, it is found that there is a shortage of quantitative studies on the usability of mobile phones.

However, it was found that none of the studies analyzed the two operating systems quantitatively. So, the objective of the study was to analyze them. The next section discusses the survey and analysis performed.

V. ANALYSIS OF ANDROID AND IOS

A survey was conducted in which various questions were asked to smartphone users. The number of participants was 60. Table 1 shows the questionnaire and the questions asked to the participants. The first question was about the particular mobile brand they use. The second set of questions was about the convenience of the users in using the mobile phone. The third set asks questions about the affordability of the mobile phone. Then several questions were asked about the functionality and perceived quality of the mobile phone.

Table 1: Questionnaire for an end-users opinion regarding smartphone

1. Which smartphone are you currently using?

Convenience

2. Which smartphone is easier to use?
3. Which phone's user interface is interactive/friendly?
4. Which one has a better user experience?
5. Which phone works smoothly without any interruption?

Affordability
6. Which one is cost-effective and provide cutting edge technologies?
7. Which one is more suitable for the upper class?
8. Which one is more suitable for the upper-middle-class?

Functionality
9. Which one has the highest battery life?
10. Which one is more speedy (quick response)?
11. Which one provides Apps Security?
12. Which OS has sufficient Apps storage size?
13. Which one has low Apps loading time?
14. Which one provides better performance compatibility?
15. Which one provides Better maintainability?
16. Which one provides forget password recovery?

Perceived quality
17. Are you satisfied with your smartphone?
18. What are the factors that influence the purchase of your smartphone?
19. Which one provides a suitable better lifestyle?
20. Considering your complete experience with your smartphone, how likely would you be to recommend it to a friend or colleague?

Any comments: _____

The target population was all the users in Karachi. Convenience sampling was adopted. The following graphs represent the statistics of the responses from end-users.

A. Demography of the participants

Fig. 2 shows the details of the participants. Almost 70% of the participants were male users. Most of them were young, with age between 20 and 30. All the participants were residents of Karachi.
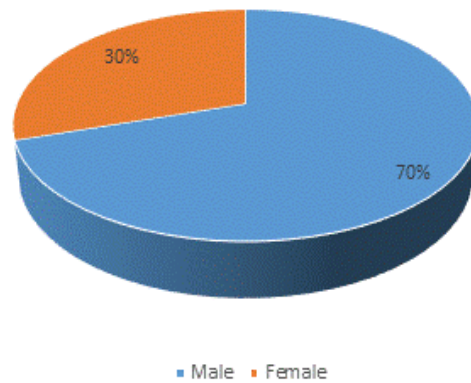

Fig 2: Gender of the participants

Amongst the participants, 45% uses Android, and 40% are users of iOS. A small percentage of the population was the users of both types of handsets.
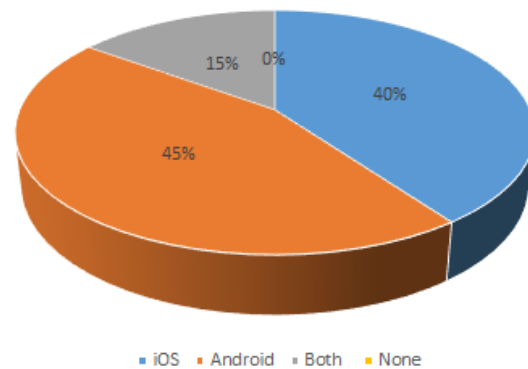

Fig 3: Users statistics of the phone

B. Convenience

Fig. 4 compares the convenience of mobile phones. As can be seen, most users think that Android is easier to use and the user's friendly. Most of the users think that iOS has a better user experience and works smoothly without any interruption.
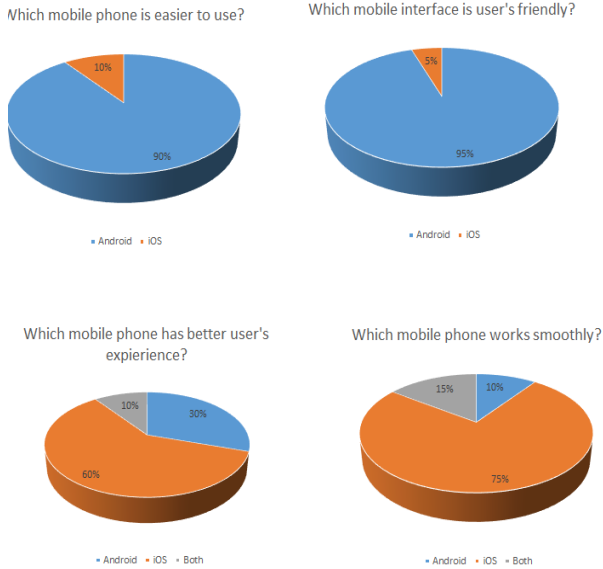

Fig 4: Convenience of mobile phones

C. Affordability

Fig 5 shows the affordability of mobile phones. It can be observed that Android phones are affordable compared to iOS and iOS and are considered a phone suitable for the upper class.
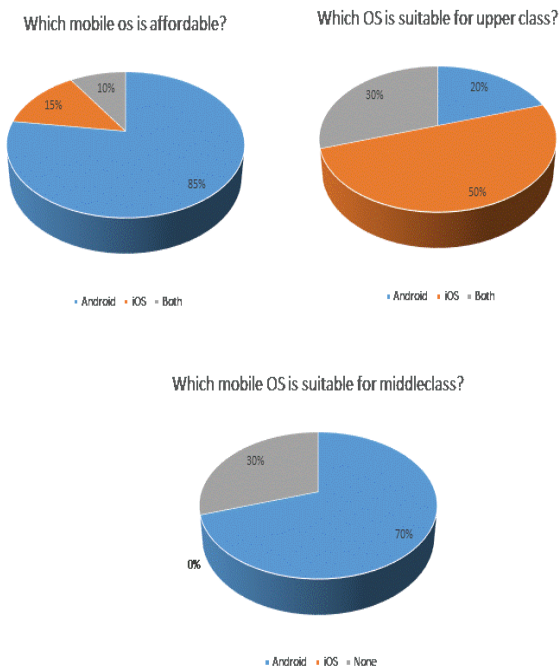

Fig 5: Affordability of mobile phones

D. Functionality

Fig 6 compares the functionality of the two mobile phones. It can be seen that iOS is better in most respects as far as functionalities are concerned. This includes battery life, response time, security, and password compatibility.
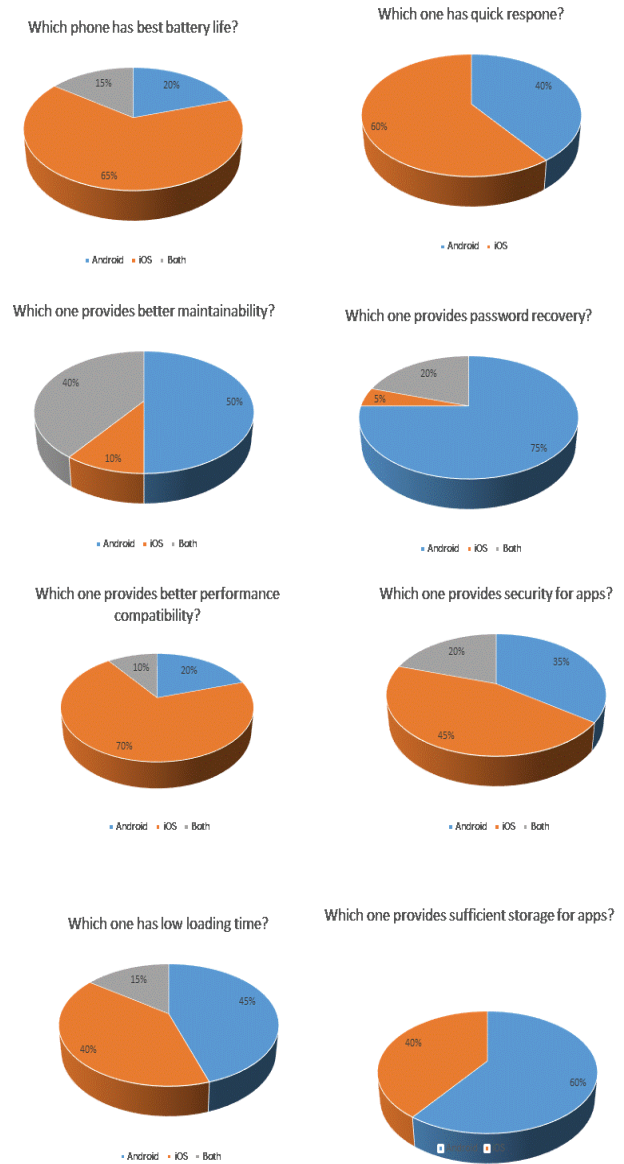

Fig 6: Functionality of mobile phone

E. Perceived quality

Fig 7 shows the perceived quality of the mobile phone. As can be seen, most people prefer the size and feature of the mobile phone before purchase. Hence, people who use Android are satisfied with it and recommend Android to other users.
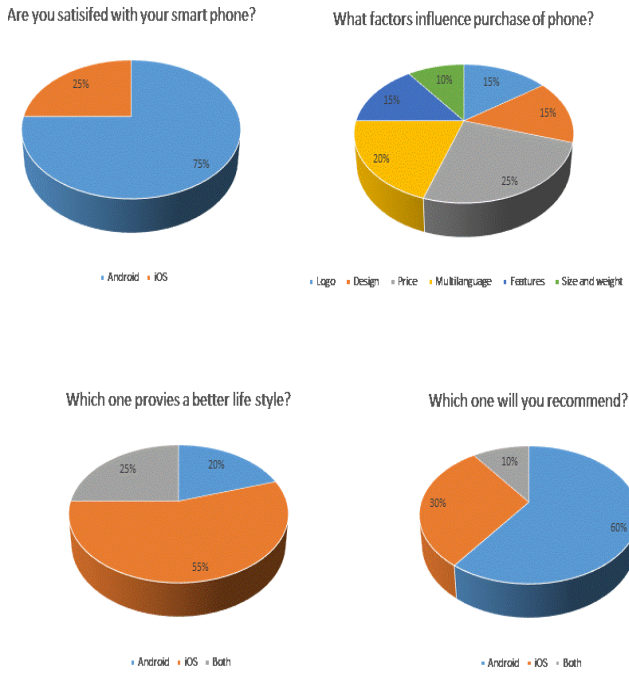
Are you satisfied with your smart phone?

What factors influence purchase of phone?

Which one provies a better life style?

Which one will you recommend?

Fig 7: Perceived quality of the mobile phone

VI. ANALYSIS USING ASSOCIATION RULES MINING AND CLUSTERING

To analyze the data further, association rules mining and clustering were performed on the data. Fig. 8 and 9 show the association rules and clustering code. The code has been implemented in Python using the Anaconda platform.

Table 2: Implementation details	
Association rules mining Algorithm	FP-Tree
Clustering algorithm	k-modes
Support	0.5
Confidence	0.9
Library	I extend, k-modes
Language	Python
Number of clusters	2

A. Implementation

There are two popular association rules mining algorithms widely used. These are Apriori and FP-Tree algorithms. Because of their simplicity, the paper has used the Apriori algorithm. The code has been written in Python, and the pandas' library has been used to extract the data. The external library extension has been installed. The values of support and confidence were set to 0.5 and 0.9. To perform clustering, the kmodes library was used. The data is clustered into two groups. Table 2 provides the implementation details.

```python
import pandas as pd
from mlxtend.preprocessing import TransactionEncoder
from mlxtend.frequent_patterns import apriori
from mlxtend.frequent_patterns import association_rules

data = pd.read_csv('data.csv', engine='python')
transactions = []
for index, row in data.iterrows():
    l=[]
    for j in range(0,18):
        l.append(str(row[j])+str(data.columns[j]))

data.iloc[index][j]=str(data.iloc[index][j])+str(data.columns[j])
    transactions.append(l)
print(data)
te = TransactionEncoder()
te_ary = te.fit(transactions).transform(transactions)
df = pd.DataFrame(te_ary, columns=te.columns_)
frequent_itemsets    =    apriori(df,    min_support=0.5,
use_colnames=True)

frequent_itemsets.to_csv("test.csv")
association_rules(frequent_itemsets,    metric="confidence",
min_threshold=0.9)
```

Fig 8: Association Rules on the dataset

```python
import pandas as pd
data = pd.read_csv('data.csv', engine='python')
from kmodes.kmodes import KModes

km = KModes(n_clusters=2, init='Huang', n_init=5, verbose=1)

clusters = km.fit_predict(data)

# Print the cluster centroids
print(km.cluster_centroids_)
```

Fig 9: Code for clustering on the data set

Table 3: Results of association rules mining

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction
0	(Android1)	(Android2)	0.661017	0.610169	0.542373	0.820513	1.344729	0.139041	2.171913
1	(Android2)	(Android1)	0.610169	0.661017	0.542373	0.888889	1.344729	0.139041	3.050847
2	(Android1)	(Android3)	0.661017	0.644068	0.559322	0.846154	1.313765	0.133582	2.313559
3	(Android3)	(Android1)	0.644068	0.661017	0.559322	0.868421	1.313765	0.133582	2.576271
4	(Android1)	(Android4)	0.661017	0.525424	0.508475	0.769231	1.464020	0.161161	2.056497
5	(Android4)	(Android1)	0.525424	0.661017	0.508475	0.967742	1.464020	0.161161	10.508475
6	(Android2)	(Android3)	0.610169	0.644068	0.559322	0.916667	1.423246	0.166332	4.271186
7	(Android3)	(Android2)	0.644068	0.610169	0.559322	0.868421	1.423246	0.166332	2.962712
8	(Android1, Android2)	(Android3)	0.542373	0.644068	0.525424	0.968750	1.504112	0.176099	11.389831
9	(Android1, Android3)	(Android2)	0.559322	0.610169	0.525424	0.939394	1.539562	0.184142	6.432203
10	(Android2, Android3)	(Android1)	0.559322	0.661017	0.525424	0.939394	1.421134	0.155702	5.593220
11	(Android1)	(Android2, Android3)	0.661017	0.559322	0.525424	0.794872	1.421134	0.155702	2.148305
12	(Android2)	(Android1, Android3)	0.610169	0.559322	0.525424	0.861111	1.539562	0.184142	3.172881
13	(Android3)	(Android1, Android2)	0.644068	0.542373	0.525424	0.815789	1.504112	0.176099	2.484262

```
[['Android1' 'Android2' 'Android6' 'Android3' 'Android5' 'Android4'
  'Android17' 'Android9' 'Android10' 'IOS11' 'Android12' 'Android13'          Cluster 1
  'Android14' 'IOS7' 'Android8' 'Android15' 'Android16' 'Android19']
 ['Apple1' 'Apple2' 'IOS6' 'IOS3' 'IOS5' 'IOS4' 'IOS17' 'IOS9' 'IOS10'
  'IOS11' 'IOS12' 'IOS13' 'IOS14' 'IOS7' 'Both8' 'IOS15' 'Both16' 'IOS19']]
                                                                             Cluster 2
```

Fig 10: Clustering results

VII. CONCLUSION

This research's main objective was to analyze which mobile application is better, and as indicated by the exploration, both iOs and Android provides basic features. Some people are used to a particular operating system and have not tried the alternative. People think that iOS is more secure than android. Android is affordable and provides good features, and is recommended by middle-class people. However, iOS provides a good response and a set of easy to use features and is recommended by the upper class.

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