JCBI
Journal of Computing & Biomedical Informatics
ISSN: 2710 - 1606
Volume 06 Issue 01
2023

Review Article
https://doi.org/10.56979/601/2023

Survey Improving Usability of The Smartphones For Elders

Alisha Farman[1], Hira Farman[2*], Qurat- ul-Ain Mastoi[3], and Zain Noreen[1]

[1]Department of Computer Science, Mohammad Ali Jinnah University ,Karachi, Pakistan.
[2]Department of Computer Science, Iqra University, Karachi, Pakistan.
[3]School of Computer Science and Creative Technologies ,University of the West of England.
[*]Corresponding Author: Hira Farman. Email: hira.farman@iqra.edu.pk

Received: November 11, 2023 **Accepted:** November 27, 2023 **Published:** December 05, 2023

Abstract: The focal point of this study is the usability of smartphones for elderly individuals. Notably, Android dominates the current smartphone market share at 72.72%. This prevalence is influenced by various factors, including affordability, a diverse array of manufacturers, and a multitude of options for users to choose from. The satisfaction of most Android users is underscored, and even in cases of dissatisfaction, the platform offers ample opportunities for easy customization of devices. The challenge lies in the reluctance of elderly individuals to embrace the latest technological trends, including social media platforms. It is evident that the elderly exhibit hesitancy in adopting new technologies such as smartphones and their features. This hesitation is attributed to a need for a user experience that is clearer and more understandable, especially when compared to younger users. Elderly individuals often find it challenging to independently navigate essential smartphone features, necessitating assistance from family members or friends who possess a better understanding of the device. This extends to basic tasks such as making calls, sending texts, setting up new devices, and various other functionalities. In this research, an effort is made to understand this barrier with the study of both user experiences and user interface design elements (text size, font, color, etc.) of Smartphones that affect the elderly population. Launchers have been made to overcome this problem but the aim of this research is to find the gap and analyze its solution. The research finds that the gap is because of the android operating system user experience & interface design, since android is developed and managed by google. The research shows how the operating system OS can be improved and make the elder user needs. The primary emphasis of this research is directed towards enhancing the comprehensive experience and interface across the entire operating system. Google's decision to make Android open-source, known as the Android Open-Source Project (AOSP), allows global developers to contribute improvements without the need for special licenses. The proposed idea within this research aims to elevate the AOSP to align with the distinct experience and design expectations of elderly users. This research details the customization of AOSP, resulting in a tailored version of the operating system that incorporates features such as a modified keyboard, audible feedback for actions, enhanced text and control elements, a simplified drag-and-drop experience, redesigned icons, and adjustments to the unlocking and welcome screens that will improves user experience and user interface for elders.

Keywords: Smartphones; Elders; AOSP; User experience; User interface; OS; Android.

1. Introduction

As telecommunication technology evolved, people started to use wireless phones. The production started with feature phones which have much less features than a normal personal computer. This was really not a big problem a decade back. But in the current era of internet and social media, it's really important to get connected with the world anytime. The gap between personal computers and telecommunication peripherals is almost vanished by the arrival of smartphones & tablets. Smartphones are now an essential part of almost everyone's daily life since they assist people in many ways to perform

needed tasks throughout the day. Smartphones have a wide variety of users from children to elderly people. Although smart phones are not difficult for young people to operate but for elderly people, this is not the case. This creates a whole new challenge for manufacturers and developers to get their product usable by any type of user. It is observed that the elderly hesitate to use new technology such as smartphones or its features. Since elderly people need clearer and more understandable user experience than youngsters. With the current smartphone's user experience, elderly people are not just unable to use basic features of smartphones but also access utilities like apps, settings, contacts etc. In this paper, an effort is made to overcome this barrier with the study of both user experiences and user interface design elements (text size, font, color, etc.) of Smartphones that affect the elderly population. And also, the study's findings will contribute to understanding the problems of elderly users in using smartphones and provide valuable feedback to manufacturers of smartphone's regarding improvements to the UI to better suit the elderly needs. This thesis will explore the recommendations needed for manufacturers to apply their skills successfully to a smartphone interface for elders. From the previous study it is concluded that there is a big gap between smartphone manufacturers and elders' mental models [2]. Because of this gap, manufacturers didn't fulfill elderly needs. They developed the same interface with some changes and updates the phone with some features and of course that changes make smartphones more difficult for elders. According to the research, the questionnaire surveys (electronic, online) and interviews were held to gather the reviews of elders using smartphones and to evaluate the usability of smartphones for elders. Questionnaires consist of some questions like their experience of using smartphones and its features (e.g. making calls, texting, making emergency calls, using emails, etc.) and UI.

Previously, work on launchers has been done. Launchers were made according to the elders' needs and also evaluated to test the usability [10][11][12][13][14]. Launcher defines the home screen of an android device primarily as the most usable screen in the smartphone. It is also found that many launchers are available at a Google or Apple play store like Necta, Big Launcher, GoLivePhone etc. for elders. But this work made manufacturers do more work than a launcher. There are different approaches related to elderly people's accessibility of smartphones. One of the common approaches is launchers. The main problem with launchers is that they cover only the home screen rather than improving experience throughout the operating system of a smartphone. This includes settings app, welcome screen & many other UI elements that cannot be improved by just installing launcher. The other thing is that there are tons of launchers on Google Play store so it's difficult to find the one compatible with people's needs. Since the solution is for elderly people, it makes the process more complicated for them.

The focus of this work is to make a better user experience and user interface for elders so that they can use smartphones more easily and get connected with their family and friends and also feel comfortable by using smartphones in the gatherings. So to make this possible, in this research apart from launchers we will work on enhancing the google operating system i.e AOSP (Android Open Source Project) according to the elders' needs to improve usability and the user experience throughout the operating system. Since the operating system can also enforce rules and design guidelines to developers more comfortably rather than improving specific applications. AOSP is suggested for improving elderly people's usability issues which are addressed in the previous studied questionnaires

1.1. Objectives of Research

The main objective of this work is to:

1. Understands the developing needs of smartphones that fulfills elderly needs and makes smartphone interface easy and understandable according to the elderly population needs.
2. Compare and contrast different applications usability criteria.

3. How can the OS be customized?

1.2. What is AOSP (Android Open-Source Project)?

First, understanding the operating system of smartphones is important. There are two major stakeholders in the market, Google & Apple. Google provides Android OS which is open source & customizable by any manufacturer & developer maintaining its core. On the other hand, Apple with iOS which isn't open source and can only be modified by Apple itself. Google android is open source and because of that it's cheap to use and launch. Like there are around 1,300 android smartphone manufacturers around the world with a wide range of pricing segments. This is the main reason why android has a greater market share.

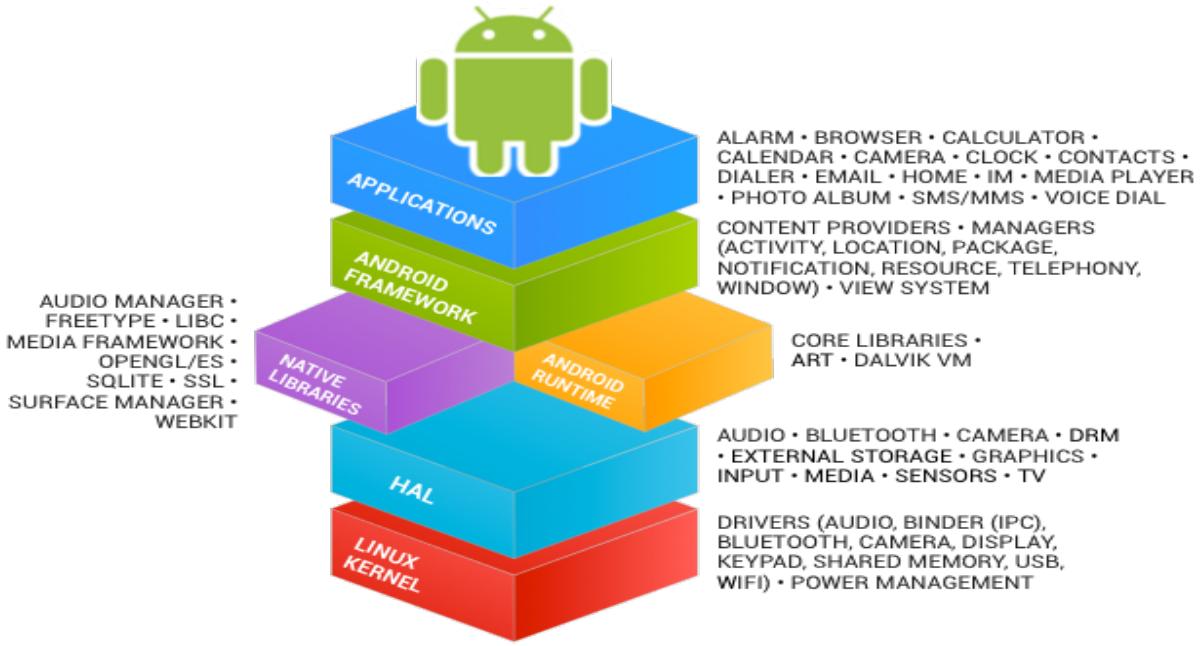

Figure 1. AOSP Basic architecture

Figure. 1, [22] Describes the basic architecture of AOSP i.e. how the AOSP works and what are its main components that will be focused.

So, this research work is focusing on Android OS to target a greater market share and ease of access to end consumers as well as manufacturers. The android OS is named as AOSP (Android Open-Source Project) for the developers & manufacturers. Every hardware manufacturer has to clone it when a new android version is released and customize it according to their hardware and software requirements. This includes adding custom hardware drivers for e.g. SPEN in Samsung or folding displays. Other than hardware implementations, they also make software & UI customization according to their UI design kits like One UI in Samsung or MIUI in XIAOMI.

1.2.1. Purpose of AOSP In this work:

The purpose is to suggest how to improve the AOSP UI/UX according to elderly usability so google can make this official with their manufacturers to launch elderly specific devices with the optimized proposed OS so consumers can get the experience out of the box without having to do any extra efforts. Study will create a elderly version of AOSP which manufacturers will follow to launch special Smartphone editions or specific devices for elderly people. This can also help Google android team to launch a elderly version of AOSP from their side so manufacturers can easily get the latest updates on the operating system along with the customization for elderly people. The improvements include the basic UI enhancements like high contrast text and font scaling, consistent navigation & improved input mechanisms for elderly people. This will also include a re-designed welcome navigation flow so anyone can set up the device easily.

In addition to AOSP improvements, improvement of the home screen also called launcher to accommodate more precise controls on the device and its capabilities. These controls include, basic priority apps, reduced drag & drop experiences, audible feedback with talkback etc. This also includes an improved feature phone style navigation buttons to accommodate easy navigation of the text field cursor. These customizations will also include, Android first time welcome screen setup UI as well as Notification bar, launcher and basic settings accessibility for elderly people

1.2.2. Benefits:

There are many other solutions for elderly people in the market but the issue is that all of them need to be re-configured manually on each device. The main benefit of the proposed solution is to make it an out of the box experience for the target market. This research is to guide the team at Google to launch an elderly version of AOSP to be adapted by manufacturers.

1.2.3. Limitations of the proposed approach:

The Limitation of the proposed approach is that this cannot be done manually by the average user. It has to be adopted by manufacturers & the Google AOSP team to create a separate flavor for it.

2. Literature Review

In this section, discussion of the work that has been done previously related to our work. How in the previous work the researchers identify the usability issues, what technique they used, their contributions in solving usability issues, solutions they proposed etc. has been discussed. This [1] is devoted to elderly people and their interaction with smartphones. The aim of this article is to conduct preliminary research in the field of interaction of elderly people with mobile devices. This research is for the Polish market but the obtained results can be used, among others, when designing applications and devices for seniors. In this study, the author conducted an electronic questionnaire consisting of 11 questions about how elders interact with their smartphones. The responses of the question show that elders need clearer and more understandable user experience and user interface. They can't even send short messages or use cameras or generate SOS signals or more basic functionalities. The author also shows the responses of the elders in the form of colored figures that divide the responses of groups with a percentage. In this [2] attempt to understand the major usability issues faced by elderly while interacting with smartphone UI. The objective of this research is to Find how elders use smartphones, and to find the gap between Elders and developers' mental models. The author conducted the electronic questionnaire to analyze the feedback of a random sample of elderly smartphone users. This study revealed the usability issues regarding the elders as smartphone users. The result shows that 70.6% of the participants were not impressed with the UI design. 64.7% were not happy with the general experience of using a smartphone. Around 47% elders faced difficulties in the setting up or customization of their smartphones The questionnaire's results also identified different users' trends when using smartphones, and assessed the users' experience of their smartphones. It is identified as the elders faced the usability issues in using the smartphones because of the gap between developers and users' mental models. In this study [3] the author finds the issues that how elders interact with their smartphones and mobile applications. In this research the mixed methods have been used by the author to study the mobile-user interaction. 4 tasks were defined for elders to perform by using a specific smartphone in order to get the results to better understand their user experience. effectiveness and time were focused in the study. and to calculate these performance metrics criteria was also defined. Author defines the result showing 83.44% success of making calls, 70.16% success of phonebook tasks, 63.13% success of initiating applications, and 60.42% success in using whatsapp. During the survey, the elders also showed their experience using smartphones as boring, fun,

enjoyable. It is also identified that Elders don't have technical knowledge so they ask their children and grandchildren to solve their issues, and sometimes elders have to visit nearby mobile shops in order to get the solution of their problem. In this study it is identified that WhatsApp's call and Phone's call icons make the elders confused. They do not know the difference between the two of them and have afraid to use it.The objective of this research[4] is to analyze the characteristics and assesses the usability of launchers with an adapted user interface (UI) for older adults, and also present a study in which the author compared a set of commercialized smartphone launchers with an adapted UI and ATs for older adults by means of heuristic evaluation. The heuristic evaluation was performed following the general guidelines suggested by Nielsen (1994) and Galitz (2013) as well as the procedures adapted for the analysis of smartphones for older adults. The author conducted a heuristic evaluation of the design requirements of launchers with an adapted UI for older adults. The study is focused on smartphone launchers with an adapted UI for older adults that support at least four features and one AT that the author was able to retrieve from online mobile app stores at a particular point in time. The result of this research shows that there are a few launchers having adapted UI for older adults with basic features and facilities and also a wide usability of AT's are available. Author claims that launchers that are age friendly are valuable for aged people. It means the age factor involves a lot. To Find the problems in the UI/UX [5]of smartphones for elderly people. And to provide valuable feedback to designers of smartphone technology regarding improvements to the UI to better suit the elderly. Another objective is recommending improvements of smartphone UI designs; specifically, for elderly users. The author claimed that Smartphones UI/UX is not according to elderly people's understanding. The researcher uses the Formative Heuristic evaluation technique in this study. Heuristic evaluation consists of: briefing session, evaluation period, and debriefing session. The study was conducted on an Android-based smartphone device, specifically a Samsung Device Galaxy J7 running with Marshmallow Android is used in the evaluation. The tasks were defined for the 8 older participants like they have to unlock the screen, they have to make a phone call, they have to send messages etc., and app management tasks like search, sort and modify smartphone settings like change ringtone, add a new input language etc. 27 usability problems and 27 heuristic violations were identified on the UI. The result of the research study shows that it is not only a UI design problem but also elders have to face difficulties in performing the hand gestures while doing the tasks, specially they have problems in "drag and drop", and "tap and hold" gestures. So, these problems should be focused during the design of the UI.one limitation of the research was that it lacked an iOS evaluation.

The main objective of this [6] is to highlight the issues faced by elders in understanding and using smartphones in Pakistan and also identify the specific features or functions that older people prefer to use so that this can facilitate the design of smartphones for elderly people. The authors used two methods in this study: focus group discussion (FGD) and questionnaire survey. In FGD, there are 8 older smartphone user participants who are 45+ old. These participants were directed by the debater. He started debate by presenting the topic and helped the elders to participate in the debate. He helped the participants to contribute to the discussion naturally the usage patterns, advantages and problems identified that are encountered by the older's. The discussion duration is 3 hours. The questionnaire was made to identify the smartphone functions that are important for elders. In this survey there were 200 participants including 94 females and 134 males who are over 45+ years. In this survey participants were allowed to choose one function among 23 smartphones that are designed by different manufacturers but have the same common functions. 23 basic functions were selected (to make a phone call, to set date and time, to display emergency button, Phone address book, to use camera, to use calculator, to set alarm, messaging, calendar, mini games, contact pictures, speed dialing, Bluetooth, WI-FI internet, radio, MP3 ringtones, playing videos, notepad,

email, global positioning system, sound recording, torch and MP3 songs).By FGD, the authors examined the perceptions, mentalities, interest point and issues facing by elders using smartphones. Author highlighted: Elders use mobile phones for calling purposes. They receive calls more than making calls. Elders rarely use additional functionalities like texting or Bluetooth etc. Elders have issues in Interface design. They responded that some mobile screens are small and uneasy to hold, and some have a shorter battery problem and mobile phones are also easy to break. Some icons on a screen are also small and not easy to pursue. There are also uncommon functions in smartphones. Elders don't know how to use that function. They only want to use easy functions that they are familiar with. Elders also have fear of incidental calling because of lack of locking keyboard knowledge. Elders rarely use text message service because they don't know how to input from the keyboard and find it difficult to learn. Elders also have cost issues in using mobile phones related services. By Questionnaire survey, the author examined that among 23 chosen functions, 11 functions (Calling, display date and time, Address book, emergency button, alarm, camera, calculator, calendar, contact pictures, torch and wi-fi internet) are used most frequently by elders while the remaining others are used rarely. Through a questionnaire the author highlighted: Usage of smartphones helps elders to improve their quality of life. Elders feel uncomfortable using Radio, Bluetooth, Mini games, Text messaging, MP3 Ringtones, speed dialing, Playing MP3 Ringtones, Playing Video, Notepad, Global positioning system, sound recording, Email etc. they only use smartphones for limited purposes. From the chosen functionalities the author asked the elders what functionality they would prefer to have on their smartphones? And provide the response chart to show the most frequent use functions based on priority. Out of 200 elder people 195 use smartphones for calling, 176 use camera, 170 use WIFI internet, 169 use address book, 132 use torch, 131 use contact pictures, 127 use display date and time, 101 use calendar, 97 use emergency button, 96 use alarm, and 87 use a smartphone calculator. The authors claim that the design and interface must be understandable and custom made for older people. The manufacturers must have to focus on psychological, perceptual and unique needs of older. Mobile phones must have good interface design with large size buttons, high volume, easy to understand and memorize menu etc. Mobile phones that have only helpful functions and are easy to operate may help older to accept and understand them. The objective of this study [7] is to evaluate the usability of smartphones for elders and their satisfaction level. Also, the objective of this study is to highlight that during designing new technologies elder's needs should be considered. In this study, the authors conducted a Face-to-Face conversation and an experiment in Tehran, in order to evaluate the usability and user-experience (UX) of older in using smartphones. The author selected the participants on inclusion and exclusion criteria. The inclusion criteria were based on 3 things: elders have good health so that they can grip smartphones. Elders don't have any Musculoskeletal Disorders and elders must have the ability to do their daily routine task on their own. The exclusion criteria were based on 3 things: elders have diplopia, elders have color blindness issues, elders have previous psychological diseases.5 tasks were designed for 30 elders to perform in an experiment using Sony Xperia M5, 5 inches touch screen wide, 142.5 gr used in the experiment because every participant used it before. Stopwatch and voice recorder are used to record the experiment. The experiment was held in a quiet room. In the end of the experiment the participants were asked to fill the SUS questionnaire that was in Persian language and score their satisfaction on using a smartphone based on VAS. SPSS Statistics software Version 24.0 is used to calculate statistical analysis of this study. The result of the study shows that elders took 45.6 sec in unlocking the phone. The elders took 79.4 sec in finding a specific contact and call.119.5 sec were required by elders for adding a new contact number and saving it. Elders took 113.5 sec in sending a text message to recently add contact. Setting an alarm task was challenging for the elders. since most of them didn't usually set an alarm, and whenever

necessary, it was done for them by a member of their family. 8 of participants declined to do this task since they thought that it might cause the phone to malfunction. Completing this task took, on average, 54s for the rest of the participants. 27 participants avoided doing the task of finding a bank using the application of a map installed in their smartphone. They believed they couldn't complete it and felt challenged and annoyed. Only 3 men agreed to do this job but failed after 48sec. They said the job could demotivate them and make them feel lower. As a result, no one completed the project. The average score of the System Usability Scale (SUS) questionnaire was 59.13 (min 37.50 and max 83). Additionally, participants rated their satisfaction related to the smartphone on average 62.5. This study concludes that there is no relationship between age and the type of task required in a smartphone. Unlocking the phone is considered the simplest task but it can also be concluded that most of the older users didn't know how to use a new phone and didn't understand the meaning of "Swipe to unlock". Also, most of the older users preferred to use messenger instead of calling. According to this study, the use of new technology must be learned by the elders to keep in touch with their family and friends. Participants were afraid of setting the alarm and using the map application. Participants feel at ease doing familiar tasks and feeling comfortable using their own smartphones. Participants blame themselves for not being able to tap correctly because of their weak eyesight or big fingers. This research study had some limitations. Some people are afraid to use a smartphone instead of their own phone and feel anxious and depressed, sometimes causing withdrawal from the study, and possibly disrupting their performance. Also, all participants were talking, and sometimes talking about their experiences on their phone, while completing the required work for them, and this could affect the time it took to complete the task.

The objective of this study[8] is to evaluate features of design and User-Interface of smartphones specially designed for aged people like 65 or more. Feature set contains size, visibility, text-to-speech and SOS tool. This study was carried out using Five smartphones which are claimed to be aging-friendly by their manufacturers. These smartphones include: Jitterbug Smart 2, Moto G5 Plus, ZTE Blade ZMax, Mitashi Play Senior Friend AP103, The Doro 8035. Devices are considered to have below five features of smartphone making at more aging-friendly by design and User-Interface: Design, Visibility, Menu & Navigation, Text-Speech and SOS Feature. When society is aging with fast speed, current smartphones need to be improved with their ability to fulfill requirements of all ages specially above 65. These devices were specially created to fulfill the requirements of elderly people who face difficulty in all aspects. The result of this study shows that:

- All devices have large displays and their body structure is also made of metal.
- All devices have a more simplified navigation method, easy-to-understand and very user-friendly.
- All devices have dedicated emergency help center service services for handling SOS/emergency.
- All devices have Text-to-speech feature which reduces typing effort

The limitation found in this study is that a metal body makes weight a little heavier as compared to common smartphones.

The objective of this study[9] aims to study the boundaries and motivations that Spanish adults face over phones and tablets. The research was done in Madrid. In this research, Semi structured interviews and participant observation methods have been used as a methodology. In Semi structured interviews the elders were allowed to speak freely but bound in a mobile technology topic. The interviews were taken in quiet places or a neutral place like cafeteria, hospital etc. and if the participant knew the interviewer so his/her interview could be conducted in their house. Spanish language has been used in the interviews, thus the quotes cited in this article have been translated into English. Consent forms were signed by the

older participants and voice recordings were made to transcript the interview. The data collected in the interview was in the form of a transcript, pictures and notes.

The authors coded the collected data by NVivo, its function helps to generate a map of codes for frame an investigation. Coding the data has been performed by doing a thematic analysis. This is the European investigation in Spain that happened at the Hospital Universitario de Getafe.15 participants were interviewed in total. The mean age of the participants is 78.5, being 65 the youngest and 90 the oldest. 10 interviewees were women and 5 men. 11 participants have ordinary jobs (taxi driver, cleaner etc.) and the others have a skillful job (engineer etc). 12 participants were perfectly fine physically, while 3 looked weak. 8 seniors remarked not to participate in public activities with other elderly people while 7 seniors reported participating in social activities. 6 participants learned the phone on their own whereas 9 took help from their close relatives. In this research study, the author described the motivations and barriers that elders faced while using smartphones.

In the study, the result of the experiment helped the author to identify the motivations to use phones for elders.

1. Seniors feel safe using mobile phones. It helps them in contacting their relatives or friends in an emergency. They said they were asked by children to carry mobile phones with them when they are going out.
2. Seniors can call their sons or daughters using smartphones.
3. Users of smartphones can also book taxis or read newspapers.
4. Senior couple felt good taking pictures using their phones.
5. Educated seniors prefer to have a phone to contact their friends and want to learn new technology because now landline phones are not in use.

Some Senior couples prefer landline over smartphones, they said that remembering numbers was easy because they have to dial numbers in landline phones. Comparison between Holders of Alcatel 2008G, Sendo S330 and Samsung Galaxy S3 the most used phones was also identified in the study by authors. Muting, dialing, unlocking and taking a call was easy in Alcatel 2008G. This phone had big buttons and clear visible functions. The senior who uses a Sendo S330 mentioned that they didn't have problems while charging a phone, refiling balance, turning off or turning in or making or receiving a call. The Owner of a Samsung Galaxy S3 mentioned that the screen was well-sized and the device has a proper interface quality. Only one participant i.e. no. eleven uses the tablet. Barriers When using Mobile Technologies:

Through this study the researchers perceive that

1. Some elders have memory recall issues so that they forgot the steps to get the task done or recall phone numbers.
2. Some seniors have a low vision so that they can't see the screen clearly or have a problem in locating the things on a screen.
3. Some seniors have poor thumb performance because of that they can't press the functions accurately.
4. Some participants have problems with deafness so they can't hear the call or listen to the caller's voice.
5. Some elders claim that the phones have a small keyboard e.g Samsung galaxy S3.

In the experiment the participants also shared their worst experiences like the participant who used Sony XA1 ULTRA made a mistake by giving the wrong direction that made the journey expensive. The same participant started recording voice in a what's app but forgot to stop so that private conversations were also sent. Participants who own Sendo S330 and Alcatel 2008G also had great difficulty in texting. They also mentioned that finding the number in a contact list was also difficult. Sometimes the torch turns on accidentally but the seniors can't turn it off.In this research [10], the author does the Heuristics extraction

and Structured Interview (questionnaire analysis). A new set of heuristics were proposed in this study to test the usability of touch screen mobile phone launchers for elders. The author firstly conducted the interview then proposed a launcher that fulfilled the need of elders that were identified in the interview and evaluation.

The author defines the three sections of heuristics: look and feel, interaction and functionality. These 3 classified heuristics elaborated into a list of questions. The evaluation procedure followed the 3 sessions: Heuristics Orientation session, Heuristics Orientation session, Heuristics debriefing session. The interview consisted of 3 groups:

1. Interviewer asked informative questions about their age, education, occupations, etc to the Arab elderly.
2. The interviewer asked the question to elder user about using mobile phones, their user experience and which smartphone they are using currently
3. Lastly the interviewer asked the user satisfaction about their mobile phones

The author defines the educational background of Arab elders: 41% illiterate, 12% literacy, 6% primary, 12% intermediate, 6% diploma, 24% bachelor. The result of the structured interview concluded that: Elders of Arab mostly used Samsung galaxy because of its larger screen and easy call making function. Nokia phones were also used by elders for a longer period but older prefers to use Samsung phones over it. The results show that the elders of Arab wanted to accept new technology, especially touch devices and use it. Elders were also asked to choose the functions that they use mostly in the mobile phone and provided a list: to answer incoming calls, to call someone, to type a text message and send, to display date and time on screen, speed dial of contact number, using address book to get address, to use camera, to use calculator for calculation, to set alarm and to send an email. Text messaging was a difficult task for elders. Elders wish they have a simple and better interface in their language. It is concluded that developers have to meet the elders' requirement during design of smartphones for elders of Arab and reduce the useless functions for elders. Searching the launchers and evaluating it and having a structured interview helped the authors make informed design decisions for launchers. The author in the study proposed the launcher called SAHL for Arab elderly population. This launcher included a better icon design and Arabic soft keyboard for Arab people. The objective of this research study is to develop a launcher and evaluate its usability according to elders' needs. SAHL launcher also included basic functions like alarm that can be helpful for setting time for prayer or fasting, calendar that is added in Hijri so that they can celebrate their Muslim festivals, and calculators that can be beneficial in daily life calculation. Sahl launcher designed the icons in 3 versions. In the first version ,the user interface came after many iterations and testing processes. The interface has available function icons with no label on it to test whether the elderly people can recognize the icon. As a result, it was difficult for them. Elders suggested making icons similar to the Nokia interface. In the second version, the icons on the interface were similar to the icons Elders were familiar with. Author also added social network icons in the interface. As a result, elders said that they use some of the social networks and after testing the second version , it has found that elders icon identification improved. In the third version, some icons were changed and the background color of buttons turned to white while the icon shapes are colored and the launcher color were selected according to the previous history. After getting the feedback from elderly it is stated that the design was improved from previous interface design (from first to second). The author claimed that In the touch screen devices, soft keyboards lack the look of portable keyboards because of their limited space available on screen. They said that the soft keyboard layout design must be changed that attracts the users and fulfills their needs. To identify the user-experience the Eye tracker was used. 4 market available launcher keyboards were selected for the experiment i.e Flex key, Swype, Big

keyboard, Go. This experiment will help to add a soft keyboard in the launcher that meets the proper design. The Experiment includes 25 participants who use touch screen mobile phones on a daily basis.

Result of experiment shows:

- There is no keyboard that is better than one another so the combination of results can provide better design recommendations for a soft keyboard.
- The question is also raised, if any other keyboard can provide better typing except standard QWERTY.
- Result also highlighted that user are not scared of new layouts, they can use new one without any fear.
- If more good features such as auto correction of word or a next word prediction is provided in a new layout, the user can feel more convenient.
- After the experiment some recommendations were defined for making the Keyboard for SAHL launcher.
- There needs to be a balanced system, the keyboard and the text input field.
- Size of keys must be appropriate that prevents users to type wrong keys or making mistakes
- In the keyboard, the size of keys must be balanced, they don't take keyboard space
- Provide a clear keyboard response, including some more features.
- to improve user interaction a new keyboard layout must be tried.

The Researcher designed the Keyboard for Sahl Launcher that consists of an alphabetic keyboard, a Numeric keyboard and the keyboard is in Arabic language. As in the above experiment, the evaluators raised the question for elders who have a low level of education or barely read or write. The letter sequence in the enhanced keyboard had already taught them in their preliminary education so they will not have problems using it.

The design of a soft keyboard in a Sahl launcher hopefully helps the Aran elders to use the smartphone keyboard comfortably without facing any problem. A/c to the previous studies it is found that using a multi-sensory response works better than a non-sensory response in older people. The author used 3 evaluation approaches to evaluate the launcher: Accessibility evaluation, Usability evaluation, eye tracking evaluation. Accessibility evaluation was performed on 4 launchers. In this study the Result of Accessibility evaluation shows:

- Big launcher and Sahl launcher have high accessibility compared to Wiser launcher.
- Arab elder users are not familiar with the icon of SOS that is used in Big launcher for emergencies. And also the icon in Big launcher is not labeled. Sahl launcher uses the WDG-UG criteria that's why it is better.
- Eventually Sahl launcher received points which means that this proposed launcher can be compared to any other applications available in the market made for older.

The results of usability evaluation were based on 3 usability criteria i.e effectiveness, efficiency and satisfaction. The outcomes are shown as midpoints for both the time and the mistake rate.

1. Efficiency: between 10 to 175 sec task ranges were calculated, during the task of typing a text message. between 10 sec to 40 sec considered a reasonable time for doing the major tasks on a launcher.
2. Effectiveness: Except for tasks 3 and 8, all the tasks were completed with ease. Participants make errors in task no. 2, 7 and 8. Less than 0.5% of the errors indicate that the job has been completed successfully.
3. Satisfaction: SUS (System Usability Scale) questionnaire was used for measuring the satisfaction. 86.5 was average scored SUS for all the participants which is acceptable as compared to the previous study where it is 68. Above 80 was scored by all participants except the participant 5 who scored above 68. It means the Sahl launcher is easy and convenient by all participants to use.

In the eye tracking the movement of eyes during typing and using the soft keyboard of the launcher is also shown. Eye movement and focus while typing was understood with the help of a gaze sequence. This evaluation indicates the quality of the opinions of the participants, which suggests that the participants will need to spend more time on it, look for a button to press, but the order in which the focus is the same for all members, having regard to the fact that the keyboard layout has been sorted alphabetically

The objective of this study [11] is to evaluate the usability of 3 launchers developed for elders and compare it with existing launchers. In this study, the authors use the usability testing by which the performance of the existing launcher and developed launcher can be evaluated. The aims of testing usability are:

1. To evaluate usability of Big, Necta and Wiser.
2. To increase the product's quality and usability based on test results.

A list of 6 tasks were defined for elders to perform. the usability criteria defined in this study as: Efficiency, Effectiveness, Satisfaction, Learnability, usefulness. The result of evaluation was collected in quantitative and qualitative form of data. Camera recorder was used to record the evaluation that was performed by 6 participants having each 6 launchers in a sequence. After evaluation the participants were asked about their impression about the launcher and also asked to comment about it and also, they were asked to describe the likes and dislikes.

The result in Quantitative data shows:

Task time was achieved first. The achieved task time is then compared with the average standard time. Average percentage of participants' success to complete the tasks under the standard time of Big is 1.85%, Necta is 1.85%, and Wiser is 11.1%.

Percentage of participant success:

For Big launcher: Task 1: 56%, Task 2: 0%, Task 3: 11%, Task 4: 33%, Task 5: 33%, Task 6: 0%

Average percentage of participant's success: 22%

For Necta launcher: Task 1: 67%, Task 2: 0%, Task 3: 33%, Task 4: 22%, Task 5: 11%, Task 6: 33%

Average percentage of participant's success: 28%

For Wiser Launcher: Task 1:11%, Task 2: 0%, Task 3: 33%, Task 4: 67%, Task 5:33%, Task 6: 0%

Average percentage of participant's success: 24%

Average number of errors for each task for each launcher is also presented in the result.

For Big launcher: Task 1: 0,33, Task 2: 1,56, Task 3: 2,11, Task 4: 0,89, Task 5: 1,11, Task 6: 2,22

For Necta launcher: Task 1: 0,33, Task 2: 2,22, Task 3: 1,22, Task 4: 1,44, Task 5: 1,56, Task 6: 1,44

For Wiser Launcher: Task 1: 0,11, Task 2: 2,56, Task 3: 0,89, Task 4: 0,56, Task 5: 1,00, Task 6: 2,11

The last quantitative data is SUS score. SUS score for Big is 49,72, Necta is 66,38 and Wiser is 51,11.

The result of qualitative data:

The author arranged the interview before and after the usability test to get qualitative data from comments, difficulties and type of errors and also found the user needs and problems about launchers. The author defines 24 user needs about launcher: Have a simple interface, Can be used to video call, Easy to learn, Need a SOS feature, The icons are understandable, Every icon has a name, Separate add contacts, dialer and contact list, Make special feature to add contacts, Make a simple and usable add contact feature, Icon name should be easy to understand, SMS feature easy to use, Make a simple and usable SOS feature , Consistent feature naming, Simple call feature, Bigger icon, Every icon has a name, Simple camera feature, Put an alarm feature outside the menu, Simple alarm feature, Colorful, Using English, There's a feature about personal information, Icon name using universal term, Menu interface. Based on the results of usability testing, the author developed the launcher for elder people that accommodates all their needs.

The developed launcher has 8 features: My Contacts, Dialer, SMS, My Number, SOS, Camera, My Apps, All Menu. The new launcher was designed colorfully in such a way that it can help elderly people to identify every icon and feature easily. In this study, The author defines the work of every feature for the launcher. The author shows the comparison result as:

Efficiency: Big: 1,85%, Necta: 1,85%, Wiser: 11,1%, New: 46%,Conclusion: increased

Effectiveness: Big: 22%, Necta: 28%, Wiser: 24%, New: 65%,Conclusion: increased

Satisfaction/ learnability/ usefulness: Big: 49,72, Necta: 66,38, Wiser: 51,11, New: 69,17, Conclusion: increased

The main objective of this [12] is to examine the older adult user interface guidance of smartphones and evaluating the usability of Android launchers for older by exploring the heuristics and also research study on the Android launcher developed for older adults. The two previous studies that were discussed in this study: study of Al-Ragan et al. from king Saud university and koala phone launcher. The author discussed the brief background of older adults and their age-related physical and cognitive changes and their mobile phone usage. Author describes the age-related changes of older users that can be physical and cognitive with the references of previous studies. These physical changes include: Vision, Motor control, hearing and the cognitive changes come with age like memory loss or take a long time for completion of task. Also, the author provides the background study of usage of mobile phones by older's. This study shows the need of older to use mobile phones. In this study, the author discussed the android launchers for elders. They discussed the age-related physical and cognitive changes in the elders and also explored what reasons and needs they use smartphones for. From the previous studies, the author also discussed the Ui design guidelines for touch screen for the elders and also heuristics for the evaluation of android launchers. The authors also discussed the research study that developed and evaluated the android launcher for elders. The authors suggest that while developing the smartphones, elderly need also need to be considered.

The objective of this study[13] is to test the usability of age friendly launchers and standard Android launchers to check whose performance is better and also to find the relationship between the user interface complexity and usability performance of launchers. The author answered the two Research questions in this study. The comparison between GolivePhone launcher and android launcher is discussed in the study.

Summative usability testing sessions were used as a methodology to get the answers of research questions. Device for recording the testing: a document camera and Morae Usability Testing software. The evaluation of usability performance of the launcher was based on efficiency and effectiveness. Tasks are divided into 4 groups: Call and contact, SMS, Calendar.In this study the authors define the User Interface Complexity Matrix (UICM).In the study, the authors firstly find the answer of research question 1 by the comparison of usability performance of both android and GoLivePhone launcher. Secondly, they identify the answer of research question 2 of How the UICM is an important aspect of age-friendly design – of the two launchers is related to their usability performance. GoLivePhone was quicker in terms of successful execution of tasks that represented task efficiency. The comparison of the observed and expected outcomes of usability tests on the basis of the UICM suggests that higher user interface complexity leads to lower usability performance in terms of both task success and task efficiency. According to UICM, GoLivePhone has a less complex interface structure. The authors also mentioned that if the number of optimal paths are higher than success of task completion will increase. In this type of cases the task efficiency can also be decreased, same like GoLivePhone. GoLivePhone better follows design guidelines for age-friendly user interfaces on smartphones because it has a larger number of different screens through which the user passes while solving the task on the optimal path. A post-test inspection was conducted for GoLivePhone

and Android launcher showed a smaller number of actions on the same screen (according to the number of steps on the optimal path) on GoLivePhone than on Android conducted by users. GoLivePhone has higher efficiency for the tasks 'delete contact' and 'send SMS to number 'that is explained by a higher ratio between the average number of different screens on the optimal path divided by the number of actions required to successfully complete the task following the optimal path. The task of deleting an event reminder describes the last deviation between the observed and expected outcomes. Android was better than the GoLivePhone here instead of there is no difference expected according to the UICM. The author also mentioned the limitations of the study as the results of the study may not generalize to a population level because of the nonrandom selection of participants and the large sample of summative usability is used. The main objective of this research [14]is to improve the user experience of the smartphone messaging application for the senior citizens and low literate users. The study in this paper is based on messaging systems for low literate and elderly people. The study focused on increasing the usability of human and smartphone interaction to enhance the user experience of low literate and elderly people. The author compared the proposed system with the existing system. In this study, the authors focused on the requirements of senior citizens and low literate users from the perspective of "to read and write messages" from users "memory load", "navigation consistency", "consistency and standard", and "touch screen finger-based tapping". "Visual representation", "navigation" and "miss click avoidance" is developed in the study as a framework. Authors described the comparison of provided messaging applications and a proposed application in the study. Android platform is used in this research. Types of message apps used in the study: Google message, Raku-Raku, Big SMS, Large Launcher. These apps are specially designed for the Elderly, moreover none of these apps are designed for the Low-literate users. The study in this paper is based on messaging systems for low literate and elderly people. The study focused on increasing the usability of human and smartphone interaction to enhance the user experience of low literate and elderly people. The author compared the proposed system with the existing system. The author shows the COMPARISON OF MESSAGE SYSTEM CRITERIA in the study. In this study the author showed the issues in the UI of messaging applications and then proposed a solution to overcome the issue and make a better UI to get better user experience (UX). Algorithms used in this study: Inbox Display algorithm, Previous State Method algorithm., Action Register Method algorithm.

The objective of this research [15] is to make the user interface of touchscreen accessible for seniors who are active, and to compare the touchscreen interface with android user interface.

Koala Phone Launcher is evaluated by measuring error rate of the selected tasks performed on the launcher and then compares it by performing the same tasks on Android 4.4 UIs with large text features activated. 6 tasks were designed to evaluate: 1) Add a new phone number for Joseph. 2) Send an SMS "Hello" to Thomas. 3) Set the alarm clock to 14:37. 4) Take a photo of an arbitrary scene. 5) Find a picture of a castle and send it via email. 6) Open a map application.

The result of this study shows that:

Performance with the koala phone was better than the android for task 2: 86.67% with koala phone and 60.00% with android and also task 5: 93.33% with koala phone and 20.00% with android a completion rate.

In a given 99.98 time the participants complete tasks with a koala phone launcher than an android.

For all the 6 tasks are completion rate was: For koala phone launcher:40.00%, For android :6.67%

As a result, 98.44% chances are higher when using the koala phone launcher than android.

With koala phone launcher the average error rate was 14% and with android the average rate was 33%. The difference between the two UIs was statistically significant.

In the previous study[16],Device usability has been assessed using a particular assessment technique to monitor and analyze senior people's health and to make sure they are connected to the world socially .The authors conducted semi structured interviews with elders to understand their thinking about using the technology i.e smartphone or tablet. Authors then conducted tests and they found smartphones were preferred over the tablet. Result was found by SUS, a mean SUS score for Test 1 of 55 (± 22,3) and Test 2 of 53,5 (± 14,9).

Another study[17] was conducted for observing the needs and limitations of elders.The main objective of the study was to to improve the use of mobile phones for specific groups, such the elderly and vision-impaired. The usability test was conducted among 25 old people who have lost vision problems. For the system some recommendations were made for improving the size of the keyboard and color of icons. Multiple screens were shared with the elders having round rounded shape and square shape buttons and icons with light shaded backgrounds of some recommended size.The study shows that the user interfaces can also be designed keeping elderly needs in mind. A fuzzy model can be developed based on efficiency and effectiveness.

In order to create innovation that can be adapted to each user's needs, this study[18] set out to create a thorough assessment of the older population's proficiency with mobile user interfaces. The Elderly Mobile User Interface Ability Evaluation method (EMIRATES), a method that was developed, was used to examine 135 older persons in total. Based on the evaluation's results, the prediction of age and the impact of technology on senior citizens' use of mobile interfaces were examined. In this study[19], the author discussed the usability of modern mobile phones for elders who are 60 or above aged. They considered 4 major factors that affect people in their older age like listening sense , vision, cognition and mobility. The authors considered 21 studies to describe that elders' needs are ignored while designing Smartphones. Modern Mobile phones should minimize the load of memorization and should have the same icons as the real world. The Literature review was done in the study to highlight major needs to improve the usability of mobile phones for elders and the authors also suggested to designers to make launchers according to their study to overcome the problems faced by the old population.The purpose of the research [20]Understanding elders' and their carers' experiences was intended to aid in three ways: 1) studying the eldercare experience from the viewpoint of key stakeholders; 2) evaluating the significance of psychological and social factors in the eldercare experience; and 3) identifying implications for product, interface, and interaction design as well as opportunities for new technologies and products.

In order to: 1) study the eldercare experience from the perspective of primary stakeholders; 2) evaluate the significance of psychological and social factors in the eldercare experience; and 3) identify implications for product, interface, and interaction design as well as opportunities for new products and technologies, the research effort set out to understand the experiences of elders and their carers.Research results indicated that eldercare experiences and the adoption and use of new goods are significantly influenced by social, emotional, and environmental aspects [21].

In order to create a useful set of design principles, researchers in this study work[22] thoroughly analyzed the scientific literature that offered suggestions for the creation of mobile apps based on usability testing with senior citizens.The results of this study significantly advance the domains of gerontechnology and digital health.

In order to better understand the accessibility measures employed to enhance the senior population's digital health technology experience, a systematic review was carried out in this research[23]. Selected publications from the reliable databases Scopus and the Web of Science are included in this study. Four major themes emerged from the thematic analysis of data from 29 articles: i) effectiveness; i) efficiency; iii)

satisfaction; and iv) learnability.

3. Gap Analysis For Improving The Usability Of Smartphone For Elders

Some great work had already been done for making smartphones usable for elders. Our work is different from others in such a way that we are enhancing Google OS i.e AOSP(Android Open Source Project) for improving the usability of smartphones and making better user experience for elders.

3.1. Software/Systems table:

In the direction towards the quality of this thesis work, different research papers were read that presented the list of technologies that have been used in order to identify the usability of mobile phones for elders. Software/Systems TABLE describes different technologies that are taken out from the past works.

Table 1. Software/Systems used in previous work

#SS	Software/Systems name	Description
SS1	Launcher	It defines the home screen of an android device primarily as the most usable screen in the smartphone.
SS2	Smartphones	A mini personal computer contains its own chipset and OS to perform day to day task and telecommunication easily
SS3	Feature Phones	A telecommunication GSM based device mostly used for simple calls and text messages with most simple user interface & experience
SS4	User Interface (UI)	Describes how a software looks, mostly visual graphics and colors. Improving UI will automatically affect usability of the system.
SS5	User Experience (UX)	Defines how a user interface will behave. Mostly related to flow rather than interface. Its make the system usable in terms of behavior
SS6	SUS(SystemUsability Scale)	It is an attitude Likert scale for measuring usability of a smartphone for elders.
SS7	VAS	An analog scale that is used to measure usability, subjective characteristics or attitudes that cannot be directly measured.
SS8	eye tracker	The Eye tracker can be used to track the eye movement of users on a smartphone screen in order to identify the effectiveness and efficiency of the task. It makes the usability more robust in terms of scrolling and navigating
SS9	Tablet	A large form of smartphone mostly starts from 7″ screen size and onwards. Primarily usable as a portable personal computer.
SS10	NVivo	It is a computer software used to analyze qualitative data for smartphone users' usability.
SS11	SPSS Statistics software Version 24.0	It is a software using which interactive, or batched, statistical analysis of data can be done to increase usability

SS12	Assistive technology	A technology which can assist performing real world tasks to maximize usability of a smartphone device
SS13	Android	Is an open-source smartphone operating system acquired by Google to improve smartphones usability
SS14	IOS	It's a smartphone operating system developed by Apple for their smartphones.
SS15	AOSP	Android OS source code maintained by google represented as Android Open-Source Project. Usable for enhancing & improving an android smartphone OS
SS16	MoraeUs ability Testing software	Morae is used to test usability of systems.
SS17	ANOVA	ANOVA was used for error rate by participants for a given UI. This includes usability errors
SS18	McNemar Exact Test	For statistical analysis, McNemar Exact Test was used for completion rate of individual tasks and all tasks combined by participants for a given UI

3.2 Source Table:

Given source table 2 displays the beneficial research papers that have been read and detected before proposing our solution of improving usability of smartphones for elders.

Table 2. Source Table

S#	Source Name
S1	"Initial survey on interaction of elderly people with smartphones",2020
S2	"Revisiting the Usability of Smartphone User Interface for Elderly Users",2017
S3	"Usability and Design Issues of Smartphone User Interface and Mobile Apps for Older Adults", 2018
S4	"Smart but not adapted enough: Heuristic evaluation of smartphone launchers with an adapted interface and assistive technologies for older adults",2018
S5	"Usability Evaluation of the Smartphone User Interface in Supporting Elderly Users from Experts' Perspective",2018
S6	"Usage of Mobile Phones Amongst Elderly People in Pakistan",2018
S7	"Survey of the Smartphones Usability Score and the Level of Satisfaction among Elderly Users ",2019
S8	"Aging-friendly smartphones: An analysis of design and user-interface to understand smartphone 'usability' for elderly citizens",2019
S9	"Use of Mobile Phones and Tablets amongst Spanish Seniors: Barriers and Motivations ".,2020

S10 "SAHL: A touch screen mobile launcher for Arab elderly",2017

S11 "Developing a Usable Android Launcher to Help Elderly People in Indonesia Use Smartphones", 2017

S12 "Touchscreen Smartphone User Interfaces for Older Adults" ,2017

S13 "A comparison of the usability of a standard and an age-friendly smartphone launcher: experimental evidence from usability testing with older adults",2018

S14 "Usability Study of Smart Phone Messaging for Elderly and Low-literate Users",2020

S15 "Koala Phone: touchscreen mobile phone UI for active seniors",2015

S16 "Digital technology for elders better living: a usability and user-experience assessment",2023

S17 "The Development of a Fuzzy Model and Usability Test of a Recommended Interface Design for Mobile Phones for Elderly Users ",2023

S18 "Designing mobile technology for elderly. A theoretical overview",2020

S19 "Optimizing Mobile User Interfaces to Improve Usability for the Elderly: A Literature Review",2022

S20 "Usability Barriers for Elderly Users in Smartphone App Usage: An Analytical Hierarchical Process-Based Prioritization"

S21 "The ELDer project: social, Design Guidelines of Mobile Apps for Older Adults: Systematic Review and Thematic Analysis, and environmental factors in the design of eldercare technologies", 2023

S22 "Usability measures used to enhance user experience in using digital health technology among elderly: a systematic review",2023

3.3 Sources And Software/Systems Table:

This Table displays the summarized results in tabular form of relationship between the research papers and technology discussed above. It also helps in finding what technology thesis work owns. It compares and gaps works with different technology of different research papers to show trends, patterns and relationship between achievements of different researches.

Table 3. Sources And Software/Systems Table

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**Current Study**
SS1	x	x	x	✓	x	x	x	x	x	✓	✓	✓	✓	✓	✓	x
SS2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
SS3	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x	x
SS4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
SS5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

SS6	x	x	x	x	x	x	✓	x	x	✓	✓	x	x	x	x	✓
SS7	x	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	✓
SS8	x	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x
SS9	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x	x
SS10	x	x	x	x	x	x	x	x	✓	x	x	x	x	x	x	x
SS11	x	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	x
SS12	x	x	x	✓	x	x	x	x	x	x	x	x	x	x	x	x
SS13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SS14	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SS15	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓
SS16	x	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x
SS17	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	✓	x
SS18	x	x	x	x	x	x	x	x	x	x	x	✓	x	x	x	x

3.4 Table of Techniques used for Identifying issues:

This table shows the techniques that were used in previous work in order to identify the usability issues faced by elders in using smartphones. In the table, a checkmark (✓) indicates the techniques employed for identifying issues in the prior research, specifying the corresponding technique utilized in this current study. Conversely, a cross (✗) denotes the techniques not utilized in the earlier work.

Table 4. Techniques used for Identifying issues

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**
Interview	x	x	✓	x	x	x	x	x	✓	✓	x	x	x	x	✓	✓	**x**
Questionnaire	✓	✓	✓	x	x	✓	✓	x	x	✓	x	x	✓	x	✓	**x**	**x**
Observations	x	x	✓	x	✓	x	x	x	✓	x	x	x	✓	x	x	✓	✓
Online survey	x	✓	x	x	x	✓	x	x	x	x	x	x	x	x	x	x	x
Heuristic evaluation	x	**x**	x	✓	✓	x	x	x	x	✓	x	x	✓	x	x	x	x
Face to face conversation	x	**x**	x	**x**	**x**	x	✓	x	x	x	x	x	x	x	x	x	x
Heuristic extraction	x	**x**	x	**x**	**x**	x	**x**	x	x	✓	x	x	x	x	x	x	x

3.5. Table of The methodology evaluation in papers:

This table shows the methodology or techniques used for evaluating usability of the proposed solutions. Mostly in previous work, launchers have been proposed according to the elders' needs and then evaluated. But our work is quite different from previous work. This work suggested enhancing the OS of smartphones that will fulfill the elderly population requirements.

In the table, a checkmark (✓) denotes the evaluation methodology utilized in the preceding research, along with the corresponding assessment technique employed in this study, while a cross (✗) indicates the methodologies not employed in the previous work.

Table 5. The methodology evaluation in papers

	S 1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**Current Study**
Expert Evaluation	x	x	x	x	x	x	x	x	x	✓	x	✓	x	x	x	x	X
High Fidelity Testing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	**x**	✓
Low fidelity testing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	✓	**x**	X
Paper prototype	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
Usability testing	x	x	x	x	x	x	x	x	x	✓	✓	x	✓	x	✓	✓	✓
Literature reviews	x	x	x	x	x	x	x	✓	x	x	x	✓	x	x	x	x	X
Eye tracking evaluation	x	x	x	x	x	x	x	x	x	✓	x	**x**	x	x	x	x	X
Accessibility evaluation	x	x	x	x	x	x	x	x	x	✓	x	**x**	x	x	✓	**x**	X

3.6. Table of identified issues:

The table shows the issues identified from the previous work with usability goals and user experience. Elder population face many issues while using smartphones. The elders are not impressed with the UI design. And they are not happy with the general experience of using a smartphone[2][19][20]. Elders don't have technical knowledge so they ask their children to help them in solving an issue. Sometimes the children are busy and have no time. So, the elders want to learn the skills on their own [2].

Table 6. identified issues

Functionality	Issues	Usability goals		User Goals
Keyboard	In [10], the author proposed the launcher for Arab elders. The Arab elderly complained about writing text messages so the author designed the Arabic keyboard for the elders with the alphabetical arrangement of keyboard in Arabic and also increased the size of keyboard .In [10], evaluation also shows the gaze distribution of the participants that tells that the participants have to spend more to look for a button to press,	Effectiveness Efficiency Learnability utility	x x x ✓	1. Useful 2. Satisfactory 3. Valuable 4. Helpful 5. Motivating
	In [1] the author claims after the survey that elders have issues in sending text messages. Elders expect voice dictation and simplicity in design.	Efficiency effectiveness memorability Learnability utility	x x x x x	1. Challenging 2. Annoying 3. Frustrated 4. Guilty 5. unhelpful
	In [7], the result of an experiment shows the Participants blame themselves for not being able to tap correctly because of their weak eyesight or big fingers., The results of this study confirmed the findings of Tsai and Van Biljon which show that typing is difficult for older users, and has taken many wrong taps to be able to select the right key, so they need smartphones with large touch screens and large buttons.	Efficiency effectiveness memorability Learnability utility	x x ✓ ✓ x	1.Frustrating 2. Annoying 3. challenging

	In [17], the experimental findings reveal that participants expressed satisfaction with the dial screen. This satisfaction is attributed to the larger size of the number buttons, which distinguishes them from the standard buttons typically found on smartphones..But the larger circular buttons on a dial keyboard were confusing the elders.	Efficiency effectiveness memorability Learnability utility	✓ x ✓ x ✓	1. Satisfied 2. confusing
Icon design	In [10], the author claims that elders have an issue in remembering the icons without text labels on them.so they proposed a launcher with the icons on the interface similar to the icons Elders were familiar with; it makes elders easy to memorize or remember. Elders suggested making icons similar to the Nokia interface. This design is only for the Arabic elderly population.	Effectiveness Efficiency Learnability utility Memorability	✓ ✓ ✓ ✓ ✓	1. Helpful 2. Motivating 3. Satisfying 4. engaging
	In [6], the author claims after having a discussion that Elders have issues in interface design. Elders have issues with smartphones small screens, small icons on a screen Elders only use familiar functions, fear of try new functions	Effectiveness Efficiency Learnability utility Memorability	x x x x x	1. Challenging 2. Unmotivating 3. Unpleasant
	In[17], the author asserts that, according to their claim, the menu screen should feature light-colored icons and text on a dark background. However, participants faced difficulties using this screen, with elderly individuals expressing that it led to a loss of sharpness during their interactions.	Effectiveness Efficiency Learnability Utility Memorability	x x x x x	1. Challenging 2. annoying 3. Unpleasant

Unlocking screen	In [7], the author performed an experiment and asked the elder participant to unlock the phone so the experiment result shows that Unlocking the phone is considered the simplest task but the elders didn't understand the meaning of "Swipe to unlock".	Effectiveness	x	1.Frustrating 2. Annoying 3. challenging
		Efficiency	x	
		Learnability	x	
		utility	**x**	
		Memorability	**x**	
Reduce drag and drop experience	In [5], the author claims that it is not only a UI design problem but also elders have to face difficulties in performing the hand gestures while doing the tasks, specially they have problems in "drag and drop", and "tap and hold" gestures. So, these problems should be focused during the design of the UI.	Effectiveness	x	1. Frustrating 2. Annoying 3. Unpleasant
		Efficiency	x	
		Learnability	x	
		utility	**x**	
		Memorability	**x**	
Welcome screen with Audible Feedback on actions	All the researchers worked on the devices that were already in use. So, elders don't have to set up the phone before using it. But when they buy a new phone they have to take help from their children or relatives and sometimes they feel demotivated using a smartphone.	Effectiveness	x	1. Frustrating 2. Annoying 3. Unpleasant
		Efficiency	x	
		Learnability	x	
		utility	**x**	
		Memorability	**x**	
Text And Controls	In [14], the author shows that button navigation is important. They claim that the user must have a clear vision of the button. They proposed a solution that increases the button radius to 5px.	Effectiveness	**x**	1. Helpful 2. satisfactory 3. childish
		Efficiency	**x**	
		Learnability	✓	
		utility	✓	
		Memorability	✓	

In [17], the experimental findings reveal that participants expressed satisfaction with the dial screen. This satisfaction is attributed to the larger size of the number buttons, which distinguishes them from the standard buttons typically found on smartphones..But the larger circular buttons on a dial keyboard were confusing the elders.	Effectiveness	x	1. challenging 2. unsatisfied
	Efficiency	x	
	Learnability	x	
	Utility	x	
	Memorability	x	

4. Proposed Methodology

The primary goal is to investigate and enhance smartphone usability for elderly individuals, focusing on the Android operating system. This involves a comprehensive study of user experiences and user interface design elements.Collaboration with developers to customize the Android Open-Source Project (AOSP) based on the identified needs of elderly users. This may involve adjusting text size, fonts, colors, and other interface elements. The research methodology shows how Aosp will help to customize the OS and fulfill the elderly needs.

4.1. Research Path

Smartphone usability for elderly people is in-focus for this research. The main goal is to improve the usability of the operating system overall, not just specific sections like home screen or app drawer. This affects the usability aspects for elderly whether they are setting up the device or using it for day to day tasks. Approach is to tweak the user interface & experience for elderly people as they can get familiar with smartphone operating systems. Most of the elderly people are more comfortable with feature phones as compared to smartphones, this makes the path clearer so the gap must be removed between feature phone controls and user interface.

The solution consists of customizing the android operating system since its open source and can be customized without any special license. The main reason why Apple's iOS is not in focus is that it is not available for public customization since it's proprietary to Apple & not available for open-source contributions. Another reason for choosing android is that it contains over 70% share of overall smartphone market as well as has a large variety of price range from lower-end to the higher-end flagship devices. In this context, the rate of effectiveness will be much higher for the smartphone market.

4.2. Analysis

The problem analysis is performed by analyzing the previous research papers which are focused on the usability problems mostly by launchers. The performed analysis covers different aspects like usability goals like performing calls, sending texts etc. Some of the research covers the data gathered by survey & questionnaire. The Data gathered clearly shows that the elders want to learn and discover features of smartphones but they are unable to get it done without any help from youngsters. The elders are even not able to do simple tasks like setup the device for the first time, setting up SOS, using social media apps, using cameras etc.The main problem with previous research is that they are focused on specific apps or mainly home screen, some of them providing design guides to developers or improving it on a small scale. This makes the issue that every app developer and OS designer have to follow these guidelines manually and thing before they are developing something. This approach has accessibility problems to developers

since the platform is not integrating these guidelines by itself. In this context, Platform has to be capable enough to enforce developers to follow the patterns.

4.3. The technical aspect

Since the research is based on customizing the operating system, the target is Android. Android is an open-source operating system acquired by google. Since google is maintaining and developing the android operating system and distributing its releases to multiple manufacturers throughout the globe, its public access to developers are available via AOSP (Android open source project) repository which is also maintained by google and always up to date to the latest version of android OS. Since android is open source, there are lots of custom operating systems built on top of it such as cyanogen mod, Lineages, Omni ROM etc. These custom operating systems are generally referred to as Custom ROMs. The way these custom ROMs are built is to improve the features and experience of the base AOSP version so the target audience can install it into their specific devices. Some of these Custom ROMs become the mainstream OS for specific brands like OPPO is now using cyanogen mod as their operating system. Now this research is going to implement a custom ROM in the same way that the previous ROMs are built. The main difference of the implementation is that the research is focused on improving the UI & UX for elderly people so this implementation is going to be on the UI layer side rather than the core layer of the OS. The final customized version of the operating system is going to be open source so custom ROM developers can also use it as their base OS as well as it will be submitted to Google AOSP as a proposal to launch a elderly version of the operating system so manufacturers can adopt it more easily and it get the support from Google AOSP team.

4.4. Methodology

The enhancements this research is intending to do in AOSP for elderly are primarily focused on the UI or Presentation layer of the operating system. This contains many UI enhancements like Keyboard, Icon design, Unlocking screen, Welcome screen and some other elements of the operating system.

4.4.1 Proposed Functionalities:

The customized version of the operating system will propose many features to improve usability for elderly people. Some of the functionalities are listed below.

Table 7. Proposed Functionalities

FT#	Functionality	Descriptions
FT1	Keyboard	• Feature phone style keyboard with navigation buttons • Keyboard keypress feedback in letter voice • Qwerty
FT3	Audible Feedback on actions	• This feature will help send audible feedback on every action to increase understandability.
FT4	Text And Controls	• By default the enhanced AOSP will provide scaled (i.e enlarged, big font) text & controls (i.e buttons). This also includes restructuring the buttons used to perform important actions such as making a call that will make the interface user friendly.
FT5	Reduce drag and drop experience	• Reduce drag and drop experiences by structuring a layout in a way where it is no longer needed.

FT6	Icon design	• Increase icon size with text labels and familiar images to make the user interface friendly .
FT7	Unlocking screen	• Adding a simple unlock button to make the user experience better rather than swiping. • Highlighted notifications for chats & calls
FT8	Welcome screen	• Simple & easy step by step navigation process with classic UI rather than a modern small scaled interface.

4.4.2. Low-Fidelity Prototype:

This prototype will contain initial wireframes that are going to be achieved in the final version of the customized operating system. This will contain the structure and basic icons for understanding the changes and to help with the next version of prototype.

4.4.3. Designing of Prototype:

This phase will consist of designing the UI & UX of the prototype which is prepared in the low-fidelity phase. This design will contain colors, icons, & structures which are going to be used in the high-fidelity prototype.

4.4.4. High-Fidelity Prototype:

The high-fidelity prototype or interactable prototype will contain a working prototype which can be interacted with touch input on mobile devices as well as on desktop devices preview editors like Adobe XD. This prototype will help to understand the flow and correct any flow errors or interface glitches which can lead to failure in the final prototype.

4.4.5. Final Prototype:

This will contain a working & installable prototype which can be used as a working version of the design implemented in previous phases. This will lead the design and experience to the working model on real android devices.

4.4.6 Evaluation:

The Final version will be evaluated by a group of elderly people who will evaluate the implementation on their devices to test if they can use it easily or if things have to be corrected.

5. Discussion of Gap Analysis And It's Solution

Smartphones, after all, are a really essential part of our daily life. The elderly people are the ones who suffer from the current smartphone experience in their day to day tasks. Smartphones are really useful when you get the way to operate them and generally this is not a problem for youngsters. But there is a fair fraction of elderly people who need assistance to use most features of smartphones. The purpose of this research is to improve the smartphone operating system according to the elderly people's needs. Research also targeted the android OS for the customization since Android OS has a large market share that is over 70%. Android is also very cheap and a variety of options available across smartphone manufacturers. This includes from lower-end smartphones to the flagship level smartphones, and android has covered the market. Covering this wide range of markets is also boosted by its open-source nature. Since developers from all around the world can improve and build on top of it, it really helps the OS add new features faster as well as reduce bugs too.

From the previous research, the major point is noted that almost all of the researchers are focusing on improving the specific part of the OS by developing custom launchers (Which are represented as home

screens). This approach has a major drawback that it has to be done manually on each device and needs a slight technical assistance to help elderly people operate it. Most of the elderly people prefer to use feature phones rather than smartphones because of the simpler user interface & design. The research idea is to reduce the gap between feature phones and smartphones for elderly people. There are multiple steps to achieve usability, effectiveness & learnability. The research has started to begin from low-fidelity prototype to high-fidelity prototype. Low-fidelity prototype was designed as an initial wireframe or structural design which will help to develop the high-fidelity prototype. Part two was referred to as the High-Feasibility prototype, in this phase design will be prepared according to user-interface for elderly people which will be followed in the final prototype. Part three will be referred to as the final prototype which will allow users to interact on real devices. This will be the implementation of the UI & UX built in the previous steps. Finally, the evaluation will be performed to make sure that elderly people's needs are matched and to mark improvements which affect the usage of smartphones for them.

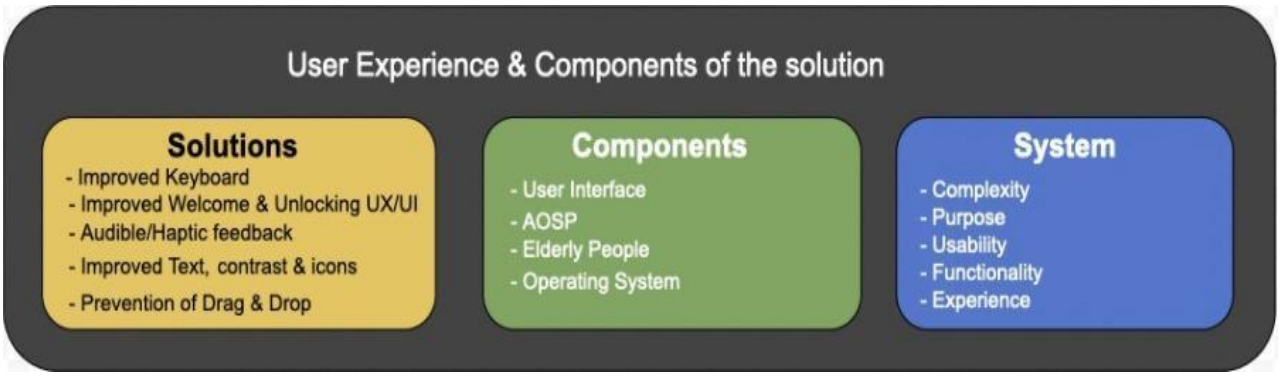

Figure 2. User experience & Components of the solution

The Figure 2, demonstrates the important components, Solutions & the system research is going to cover. Components are the entities part of the research such as AOSP, Elderly people etc. Solutions are the proposed solutions for improving the elderly people's smartphone usability. The table 8 describes the summary of functionalities that have issues, identified from the previous work with the proposed solution.

6. Conclusions

The research aimed to pinpoint the challenges encountered by elderly individuals in utilizing smartphones. Mobile phones represent a widely adopted technology across both younger and older demographics globally. Designers must address specific requirements to enhance accessibility and comprehensibility, facilitating smoother social interaction. The findings of the study indicate that the needs of the elderly are often overlooked. The interface design of smartphones falls short in catering to the requirements of older users, impacting the overall usability of smartphones for this demographic. The study outlines five primary usability objectives: effectiveness, efficiency, learnability, utility, and memorability. Attainment of these goals by elderly users signifies successful usability in smartphone usage. Certain functionalities must be specifically designed to meet the needs of older individuals in order to enhance the overall user experience (UX). This research survey focused on identifying the functionalities of smartphones that contribute to achieving or falling short of usability goals. Additionally, the survey explored the user experience and gauged how elderly individuals perceive their interactions with these functionalities while using smartphones.

The purpose of this research is to improve the smartphone operating system according to the elderly people' needs. The major drawback found in previous research is that almost all of the researchers are focusing on improving the specific part of the OS by developing custom launchers (Which are represented

as home screens). This approach has a major drawback that it has to be done manually on each device and needs a slight technical assistance to help elderly people operate it.

An effort is made to overcome this barrier with the study of both user experiences and user interface design elements (text size, font, color, etc.) of Smartphones that affect the elderly population. This gap is because of the android operating system user experience & interface design, since android is developed and managed by google.

In future, research must be conducted to implement the recommendation of functionalities in smartphone Operating systems. The research should demonstrate that improving the operating system is beneficial for long term usage like customizing the areas which are not accessible by apps like welcome screen, Keyboard navigation buttons etc. Implement the customized AOSP on smartphones and conduct testing sessions with a sample of elderly participants. Gather feedback on the prototype's effectiveness in addressing their usability needs.

References

1. A. Kapczyński and M. Lawnik, "Initial survey on interaction of elderly people with smartphones," Sci. Pap. Silesian Univ. Technol. Organ. Manag. Ser., vol. 2020, no. 149, pp. 303–313, 2020, doi: 10.29119/1641-3466.2020.149.26.
2. H. M. Salman, W. F. Wan Ahmad, and S. Sulaiman, "Revisiting the usability of smartphone user interface for elderly users," in Lecture Notes on Data Engineering and Communications Technologies, vol. 5, Springer Science and Business Media Deutschland GmbH, 2018, pp. 155–162.
3. C. Y. Wong, R. Ibrahim, T. A. Hamid, and E. I. Mansor, "Usability and design issues of smartphone user interface and mobile apps for older adults," in Communications in Computer and Information Science, 2018, vol. 886, pp. 93–104, doi: 10.1007/978-981-13-1628-9_9.
4. A. Petrovčič, A. Rogelj, and V. Dolničar, "Smart but not adapted enough: Heuristic evaluation of smartphone launchers with an adapted interface and assistive technologies for older adults," Comput. Human Behav., vol. 79, pp. 123–136, Feb. 2018, doi: 10.1016/j.chb.2017.10.021.
5. H. M. Salman, W. F. Wan Ahmad, and S. Sulaiman, "Usability Evaluation of the Smartphone User Interface in Supporting Elderly Users from Experts' Perspective," IEEE Access, vol. 6, no. c, pp. 22578–22591, 2018, doi: 10.1109/ACCESS.2018.2827358.
6. Z. I. Bhutta, J. A. Sheikh, and A. Yousaf, "Usage of mobile phones amongst elderly people in Pakistan," in Advances in Intelligent Systems and Computing, 2018, vol. 588, pp. 621–630, doi: 10.1007/978-3-319-60582-1_62.
7. Z. Vahedi, M. Fateminia, and L. Hajizadeh, "IJOH INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE Survey of the Smartphones Usability Score and the Level of Satisfaction among Elderly Users," 2008. [Online]. Available: http://ijoh.tums.ac.ir.
8. A. Zain, "Ageing-friendly Smartphones Ageing-friendly smartphones: An analysis of design and user-interface to understand smartphone 'usability' for elderly citizens Senex: III. Congress of Aging Studies for Graduate Students Ageing-friendly Smartphones," 2019.
9. M. Gomez-Hernandez, E. Villalba-Mora, and X. Ferre, "Use of mobile phones and tablets amongst Spanish seniors: Barriers and motivations," in ICT4AWE 2020 - Proceedings of the 6th International Conference on Information and Communication Technologies for Ageing Well and e-Health, 2020, pp. 44–52, doi: 10.5220/0009570400500058.
10. M. Al-Razgan and H. S. Al-Khalifa, "SAHL: A TOUCHSCREEN MOBILE LAUNCHER FOR ARAB ELDERLY," 2017.
11. J. Renny Octavia Johanna and M. Putri Anindita, "Developing a Usable Android Launcher to Help Elderly People in Indonesia Use Smartphones."
12. A. Sano, "Touchscreen Smartphone User Interfaces for Older Adults." 2017.
13. A. Petrovčič, M. Šetinc, T. Burnik, and V. Dolničar, "A comparison of the usability of a standard and an age-friendly smartphone launcher: Experimental evidence from usability testing with older adults," Int. J. Rehabil. Res., vol. 41, no. 4, pp. 337–342, Dec. 2018, doi: 10.1097/MRR.0000000000000307.
14. R. Anam and A. Abid, "Usability Study of Smart Phone Messaging for Elderly and Low-literate Users," 2020. [Online]. Available: www.ijacsa.thesai.org.
15. J. Balata, Z. Mikovec, and T. Slavicek, "KoalaPhone: touchscreen mobile phone UI for active seniors," J. Multimodal User Interfaces, vol. 9, no. 4, pp. 263–273, Dec. 2015, doi: 10.1007/s12193-015-0188-1.
16. PETRA '23: Proceedings of the 16th International Conference on PErvasive Technologies Related to Assistive EnvironmentsJuly 2023 Pages 123–130 https://doi.org/10.1145/3594806.3594846"Digital technology for elders better living: a usability and user-experience assessment",
17. Weerapong Polnigongit,Waiwit Chanwimalueng,Sandey Fitzgerald,"Development of a Fuzzy Model and Usability Test of a Recommended Interface Design for Mobile Phones for Elderly Users",January 2023 ,International Journal of Interactive Mobile Technologies (iJIM) 17(02):118-136,DOI:10.3991/ijim.v17i02.33877

18. Chiuhsiang Joe Lin, Sui-Hua Ho,"Designing mobile technology for elderly. A theoretical overview",Applied Ergonomics,Volume 89, November 2020,
19. Harun Easwaran Karthikkeyan, "Optimizing Mobile User Interfaces to Improve Usability for the Elderly",Human-Computer Interaction,Usability January 2022,DOI:10.13140/RG.2.2.30328.52481
20. Mujtaba Awan,1Sikandar Ali,2Mushtaq Ali,1Muhammad Faisal Abrar,3Hamid Ullah,4and Dawar Khan,"Usability Barriers for Elderly Users in Smartphone App Usage: An Analytical Hierarchical Process-Based Prioritization",Volume 2021 | Article ID 2780257 | https://doi.org/10.1155/2021/2780257
21. Miguel Gomez-Hernandez Xavier Ferre , Cristian Moral, Elena Villalba-Mora,"Design Guidelines of Mobile Apps for Older Adults: Systematic Review and Thematic Analysis",JMIR Mhealth Uhealth 2023;11:e43186 ,doi:10.2196/43186
22. Azaliza Zainal, Nur Farhanum Abdul Aziz, Nahdatul Akma Ahmad, Fariza Hanis Abdul Razak, Fadia Razali, Noor Hidayah Azmi, Haily Liduin Koyou,"Usability measures used to enhance user experience in using digital health technology among elderly: a systematic review",June 2023 Bulletin of Electrical Engineering and Informatics 12(3):1825-1832,DOI:10.11591/eei.v12i3.4773
23. Porting Android to the PowerPC architecture. (https://www.embedded.com/porting-android-to-the-powerpc-architecture/?fbclid=IwAR2Jawpa1IO-8_0HTH512Zl1EmpdP9IUu8F-2X4 yhFA2Vg_R9gjMS5fh)