ORIGINAL ARTICLE

User Interface on Smartphone for Elderly Users

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Abstract: Nowadays, Thai elderly have increasingly been using smartphones to communicate with their families. However, the elderly may have problems using smartphones because most of them normally have visual impairment which result in unclear perception of the screen. The test on how user interface (UI) design of the LINE application affects the elderly when using smartphones shows that the elderly spend more time and make more mistakes than the young adults. The analysis was conducted to find the major factors associated with such problems, and the results show that three components of UI; i.e., font, color, and level of brightness are the major factors that affect how the elderly use their smartphones. In order to confirm the test results, several combinations of font, color, and level of brightness were used to create UI of the simulated LINE application and each UI was used to test with a group of 38 elderly (the age of 60-69) who were told to perform eight different actions on the phone. After further research on UI, it is found that the most appropriate font for Thai elderly is Arial Unicode MS with the size of 16 pt., and the green tone of screen with 75% of brightness level is found to be the most appropriate for the elderly. The test results reveal that the elderly could perform seven actions faster and they made fewer mistakes in six actions. All in all, the test results indicate that the integration of the most appropriate three components can increase the effectiveness of smartphone usage among Thai elderly.

Keywords: elderly; smartphone; User Interface (UI); limitation in using smartphone

Introduction

There have been more elderly people in Thailand and we are on the verge of entering the aging society. In the past, the elderly spent time with their grandchildren without feeling alone [1]. However, nuclear families have been increasing [2] that make the elderly live their lives by themselves and feel lonely [3]. With the increasing use of smartphones to communicate in daily life, there is a need for them to adapt themselves to use smartphones to communicate with their families to feel less lonely and to reduce the gap between themselves and their grandchildren [4, 5]. Moreover, they can use smartphones to learn new things and to make their daily lives more convenient [6]. Nevertheless, the use of smartphones of the elderly is still less than that of the younger generations [7]. The reason is that the elderly have vision problems such as blurry vision, vision fading of colors and high sensitivity to light [8, 9] that lead to the difficulty in viewing contents on UI [10]. They also tend to waste their time pinching in and out the screen to see contents [11] or slowly type messages or make errors and wrong commands while using the phones [12, 13]. Some of them do not even understand some functions which can cause errors when sending commands to the phones [14]. As a result, UI should be improved for better vision of the elderly, especially the content structure of the screen,

color filter, contrast, and clear fonts [15, 16, 17].

The aforementioned information is the research results from abroad. However, Thai elderly have the same problems excluding language barrier. The main objective of this paper is to find the most appropriate UI design for social network applications on smartphones for Thai elderly, such that the elderly would feel more comfortable using the phones and make fewer errors.

Notion

Elderly

According to the Elderly Act B.E. 2546 of Thailand, the elderly are divided into 3 age groups based on their physical condition and reliance [18].

- Group1: This group of elderly refers to the elderly who are physically able to live and take care of themselves with the ages between 60 and 69.

- Group 2: This group of elderly refers to the elderly who can still help themselves but start to rely on family and society if there are underlying diseases. Their ages are between 70 and 79 years.

- Group3: This group refers to the elderly who require assistance from a helper in daily life and should be supervised by a physician. Their ages are from 80 years and up.

This research has selected the elderly from Group 1 because the elderly in this group are still self-dependable as well as being able to use smartphones by themselves.

Limitation on using smartphone of the elderly

Because the elderly encounter physical and capability changes [19] which cause major problems on the use of smartphones; therefore, the focus of this research is on the vision problems that affect the use of smartphones.

From an interview with an ophthalmologist from the hospital in Bangkok, most of the elderly feel like having a shade pulled down or across their vision, weaken eye muscles, dry eyes and some of them may have cataract, glaucoma and macular degeneration. Many elderly see unclear color, have amblyopia symptoms and are sensitive to light.

These kinds of vision problems in the elderly obstruct the use of smartphones. Therefore, UI of mobile applications should be carefully designed to suit their physical abilities. According to the survey, more than 50% of the elderly have trouble using the phones. Such problems can be solved by designing and developing new UI for mobile applications which can reduce the problems by 25% or else conducting the training which can reduce the problems by 28% [20]. Accordingly, the design and development of UI should be based on the effective use of the elderly [21]. This research determines the effective use of the elderly by measuring the duration and the errors while using the phones.

User Interface (UI) Patterns for Smartphone Apps

According to the entire forms of UI for applications on smartphones by Nail (2014) [22], 10 groups of the basic UI are summarized as follows:

1. Navigation: The creation of forms helps users to surf on smartphones better. The better design of Navigation form, the easier for users to use an application.

2. Forms: When using an application, information runs through forms. Registering to the system, multi-steps of work, calculation form, searching form and long form are the main forms to run an application.

3. Tables: A table is a great way to present information on a small screen.

4. Search, Sort, and Filter: They are the main tools to use in each application.

5. Tools: Tools mean to use body expressions to interact with the screen, there is no need to have a command button which is easier and more effective.

6. Charts: These figures are for presenting charts on mobile devices. It is a challenge in designing and presenting information in different forms. Charts must present the information and its relations.

7. Tutorials and Invitations: Users usually skip or ignore interactive messages or tutorial pop-up videos, which mean that it may not be convenient for them to see

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the videos at that moment or the videos may disturb them. Therefore, further research should be conduct to develop more interesting tutorials and invitations.

8. Social Patterns: These patterns show forms of UI that connect users to social media through mobile devices.

9. Feedback and Affordance: A form of UI that responds to user's actions on mobile devices. It consists of error messages, confirmation and system status. Users can respond to an application on a touchscreen.

10. Help: Users can see how to use an application or get help from here. This function consists of how to use, suggestions for users or frequently asked questions, tutorials for features, guide for use, specific helps, and response of defection.

Touchscreen Interface

From the collection of all interactive forms with users on a touchscreen, it can be categorized into 12 forms [23]; i.e., Tap to Open/Activate, Tap to Select, Drag to Move Object, Slide to Scroll, Spin to Scroll, Slide and Hold for Continuous Scroll, Flick to Nudge, Fling to Scroll, Tap to Stop, Pinch to Shrink and Spread to Enlarge, Two Fingers to Scroll, and Ghost Finger (still under experiment).

Literature Review

Recently, several literatures on user interface design for the elderly have been presented. Hölzl *et al.* [29] proposed that if UI on mobile devices is designed suitably for elderly, it can reduce usage errors and make smartphones easier to use. They suggested that the size of the icons and the size of the messages should be larger [29]. Darroch *et al.* [30] conducted the research on the effect of font size on reading text by testing the reading capability with two groups of users: the elderly and the young adults. The results reveal that both groups have the same reading capability; however, it is suggested that the font size for the elderly should be larger for better vision. Another research on mobile phone interface for older adults was proposed by Sulaiman *et al.* [31]. They concluded that the size of screen, icon, and font are the main concern in designing interface for the elderly. On the other hand, Abdulrazak *et al.* [32] researched on various styles of icons and how they affect the use of smartphones in elderly. They concluded that the icons should be designed such that they are easy to see by using contrasting colors between the icons and the background and the colors of the icons should be red, green, and blue.

It can be noticed that most of the researches focused on individual component of UI for a certain activity and no research is focused on an integration of components yet. Thus, this paper proposes another interesting research topic that focuses on the effect of the overall UI design for smartphone usage among Thai elderly. In this research we chose to simulate LINE application as our tool for the testing because it is one of the most popular social media applications among Thai people. Our simulated LINE application consists of all the functions provided by LINE. We conducted our research on the assumption that the integration of the most appropriate UI components can improve the use of smartphones among elderly. Therefore, this research is focused on finding what are the main components that affect the smartphone usage of Thai elderly, what are the best selections of the main components, and what is the best integration of UI design for Thai elderly.

Research Methodology

This research is to design UI that is the most appropriate for Thai elderly with the procedure shown in Figure 1.

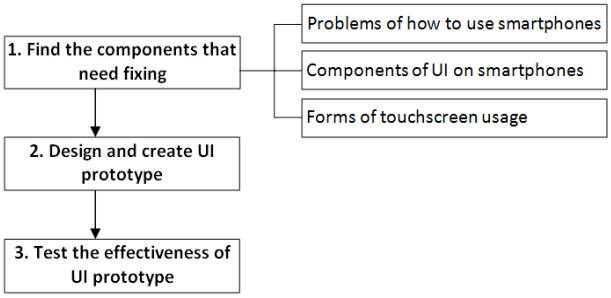


Figure 1. The UI design for elderly procedure.

1. **Find the components that need fixing:** The first step is to find the problems of using 5.5-inch iPhones by a group of 38 Thai elderly people age 60-69 years. Each of them are asked to use the simulated LINE application on a smartphone. They are told to do the specific activities and are observed for the incurring errors during the use and are timed. After that, the results of the test are analyzed to determine the effect of UI on the use of smartphones to the elderly. The test has already been morally approved. Before the test is conducted, the participants are given the instructions on how to do the test with picture illustrations for each step that are easy to understand and feel less tense and more confident when doing the test.

2. **Design UI to solve the problems of usage:** When UI components that cause usage errors for the elderly are determined, the UI design process begins and the prototype of UI in the form of the simulated LINE application is created.

3. **Test the efficiency of the UI prototype:** The UI prototype is tested by the same group of participants to determine the efficiency of the new UI. After that, the test

results of the new UI are compared to the test results of the old UI using statistical Paired t-test with the assumption that when the elderly use smartphones on the new UI, they should spend less time and make fewer errors.

Results

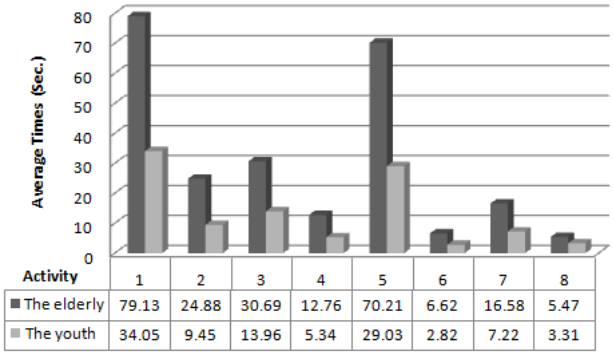
1. *Find the components of UI that need fixing.*

It is found that most of the elderly use smartphones to communicate via LINE because it contains complete social features [24]. Therefore, LINE was simulated and used as a sample application because it consists of several forms of touchscreen usage. All the activities that are designed for testing the effectiveness of touchscreen are shown in Table 1.

Table 1.Testing Activities.

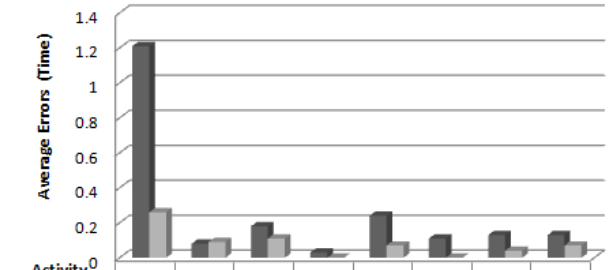
Activity	*Process of Activities*
1. Chat	- Swipe the screen to select a friend - Enter the Chat room - Type the Chat text as required
2. Add Friend	- Choose add friends with ID/ telephone number - Type defined friend's ID
3.Forward	- Select text to be forwarded as defined - Select Forward command - Select friends to be forwarded
4.Copy	- Select text to be copied as defined - Select Copy command - Paste the copied text and send texts
5. Edit Name and Profile Photo	- Select setting and select Profile - Edit name - Search for photos - Enlarge and select a photo to be displayed - Change photo
6.Free Call	- Select Free Call from Chat page - Press End Call
7. Sending Photo	- Select Photo Menu - Search for photos and send photos
8.Sending Sticker	- Sliding Menu to Send Sticker - Scroll to a sticker required and send sticker

For all activities in Table 1, we compared the duration and the number of errors when using smartphones to perform each activity between the elderly and the young adults ages between 18 – 45 years. From 46 participants, the graphs in Fig. 2 show that there are significant differences on duration and the numbers of errors between these two groups of participants. The elderly tended to spend more time and make more errors than the young adults. In order to reduce time and the number of errors on smartphone usage of the elderly, we analyzed the test results and we have found that the main causes of errors are the components of UI as shown in Table 3.



Activity	1	2	3	4	5	6	7	8
The elderly	79.13	24.88	30.69	12.76	70.21	6.62	16.58	5.47
The youth	34.05	9.45	13.96	5.34	29.03	2.82	7.22	3.31

(a)



Activity	1	2	3	4	5	6	7	8
The elderly	1.21	0.08	0.18	0.03	0.24	0.11	0.13	0.13
The youth	0.26	0.09	0.11	0	0.07	0	0.04	0.07

(b)

Figure2. Comparison of (a) times and (b) errors that occurred during smartphone usage between the elderly and the youth.

2. *Design UI that improves the usage.*

The new UI for elderly is designed by studying various researches in terms of fonts, colors, and brightness. The researches on fonts are from Phiriyapokanon (2011) [25], Linh (2013) [26], the design of colors are from Salman, et al. (2010) [27], and the level of brightness are from an application. Then the simulated LINE application with the new UI prototype was developed and tested on participants in order to find the most appropriate integration of components to create UI for the elderly as shown in Table 4.

From Table 4, we can summarize that the most appropriate UI for the elderly should consist of the integration of the following components:

Font: From using 29 fonts of MS offices to create several UI prototypes and test them on the elderly, we have found that Arial Unicode MS is the best apparent for them.

Size: Our UI prototypes were created by using five different font sizes: three font sizes from LINE application;

Table 3. The analysis of the components associated with the problems of using smartphones.

Activity	*Timing and Errors*	*Errors occurred*	*Touchscreen*	*Components that affect the usage*
1	- Take a long time - The most frequent errors	Swipe the screen mistakenly	Slide to Scroll Slide & Hold for Scroll Fling to Scroll Tap to Stop	Font, Color, Brightness, Space
		Typing error	Tap to Select	Font, Color, Brightness, Keyboard size
2	- Take a moderate time - Infrequent errors	Type wrong ID	Tap to Select	Font, Color, Brightness, Keyboard size
3	- Take a moderate time - Frequent errors	Select wrong command	Tap to Open	Font, Color, Brightness, Space
		Swipe the screen mistakenly	Slide to Scroll Slide & Hold for Scroll Fling to Scroll Tap to Stop	Font, Brightness, Space
4	- Take less time - Infrequent errors	Select wrong command	Tap to Open	Color, Brightness, Space
5	- Take a long time - Frequent errors	Select the wrong menu	Tap to Open	Font, Color, Brightness, Space
		Type wrong name	Tap to Select	Font, Color, Brightness, keyboard size
		Select wrong photo	Slide to Scroll Slide & Hold for Scroll Fling to Scroll Tap to Stop	Brightness, Size of the photo
6	- Take less time - Infrequent errors	Press wrong call	Tap to Open	Color, Brightness, Button size
7	- Take less time - Infrequent errors	Selecting wrong photo	Tap to Select	Brightness, Photo size
		Swiping wrongly	Slide to Scroll Slide & Hold for Scroll Fling to Scroll Tap to Stop	Brightness, Photo size
8	- Take less time - Infrequent errors	Select wrong button	Tap to Open	Color, Brightness, Button size
		Select wrong sticker	Slide to Scroll Slide & Hold for Scroll Fling to Scroll Tap to Stop	Brightness, Photo size

i.e., 9, 12, 16, and other two larger font sizes; i.e., 19 and 21 pts. The most appropriate font sizes for the elderly are 12 and 16 pts. Because large font sizes make UI to be too crowded and the elderly have to scroll the screen up and down to view the contents on the screen which is not convenient for them [33]. From this comment, we thus introduce an alternative design for the elderly by developing UI with font size equals to 12 pts but a user can enlarge it to 16 pts by touching and holding at the location of the contents where a user wants to enlarge.

Color: Regarding the vision fading of colors of the elderly, the best UI design is to use contrasting colors between the foreground and the background (screen) [27] because if their colors are of the same shades, it is too difficult for the elderly to separate texts or icons from the background. Therefore, our UI prototypes use light colors, such as white, or light gray for background and dark colors, such as green, pink, black, or blue for foreground. The test results reveal that the most visible colors for the elderly are green tone and pink tone.

Brightness: By using the built-in brightness adjustment function, we created UI prototype that provide 5 levels of brightness: 0%, 25%, 50%, 75%, and 100%. We have found that the most appropriate levels of brightness that the elderly can see are 75% and 50%.

After the most appropriate selections of the main UI components were found, we created several integrations of these components and tested them with the elderly once again in order to see whether the integrations of the most appropriate selections can improve the smartphone usage of the elderly or not. We analyzed the test results and have found that the most appropriate integration of three main components for Thai elderly is to use 12-pt Arial Unicode MS in green tone with 75% level of brightness. Moreover, the elderly also prefer to enlarge the size of font by touching and holding at the location of the contents.

3. Test the effectiveness of the UI prototype.

The effectiveness of the newly developed UI prototype was analyzed by comparing the results based on the assumption that the use of smartphones on the newly developed UI should result in less time spent and

fewer errors during the usage.

According to Table 5 and Table 6, it is found that almost every action on the new UI takes less time and causes fewer errors than that on the old one. Only action 4 (Copy) takes about the same time and causes the same number of errors as the old UI. According to the observation, the Copy command is quite difficult because the elderly has to touch and hold the screen to make the command pop up, which cannot be changed. Action 5 (Edit Name and Profile Photo) has the same number of errors as the old UI. According to the observation, there are too many steps to perform the command and there is a part for the participants to swipe the screen to select a picture or pinch out the specific picture, which needs the access to the photo album of a smartphone. These complicate steps cause the participants to select the wrong pictures or swipe the picture too fast or zoom out the picture too slow.

Table 4. The model of the interaction with the elderly users (Sakdulyatham, et al., 2016).

Component	*Prototype*	*Results*
Font	29 Thai fonts (20 pt.)	- Arial Unicode MS
	Font size: 9 pt., 12 pt., 16 pt., 19 pt., 21 pt.	- 12 pt. - 16 pt.
	Possibility ofenlarging character size	Agreed with the idea
Color	Green, pink, blue, yellow, white	- Green - Pink
Brightness	Screen brightness: 0%, 25%, 50%, 75%, 100%	- 75% - 50%
Combination	Combine each best prototype element in an interface design	- Arial Unicode MS - 12 pt -> 16 pt. - Green - brightness 75%

Table 7 shows the relationship between the activities and the integrations of components that can improve the smartphone usage of the elderly together with how much faster the elderly can perform the activities. It can be seen that the activities with the actions that use the new UIs created from the most appropriate integrations of components can reduce more time than those activities that do not depend on these main components. The actions that depend on the integrations of components are marked with ✓.

Table 7 also reveals that the actions on the new UIs with the most appropriate integrations of three main components can make the elderly accomplish their actions a lot faster than those actions on UIs that do not use the integration of all three components. Table 7 shows the improvement of each activity in ascending order as we can see that Chat activity contains the actions that depend on the integration of three main components and thus yields the best improvement.

Table 5. Comparison on duration and interactive use of the new UI and the old UI (*means the value that does not correspond to the assumption.).

Activity	*Times(sec)*			
	UI		t	p-value
	Old $\bar{X}$ *(SD)*	*New* $\bar{X}$ *(SD)*		
1	79.13 (26.61)	59.96 (17.52)	5.83	0.000
2	24.88 (6.95)	19.44 (6.12)	5.05	0.000
3	30.69 (12.06)	21.08 (6.62)	5.95	0.000
4	12.76 (3.34)	11.82 (4.00)	1.34	0.094*
5	70.21 (14.29)	56.22 (13.63)	6.99	0.000
6	6.62 (3.71)	4.19 (1.42)	4.18	0.000
7	16.58 (5.10)	14.64 (6.38)	2.16	0.018
8	5.47 (3.40)	3.86 (2.14)	2.42	0.010

*SD = Standard Deviation.

Table 6. Comparison on the number of errors and interactive use of the new UI and the old UI (*means the value that does not correspond to the assumption.).

Activity	*Average Errors*			
	UI		t	p-value
	Old $\bar{X}$ *(SD)*	*New* $\bar{X}$ *(SD)*		
1	1.21 (1.14)	0.50 (0.79)	3.50	0.000
2	0.08 (0.27)	0.00 (0.00)	1.78	0.041
3	0.18 (0.46)	0.03 (0.16)	2.23	0.016
4	0.03 (0.16)	0.03 (0.16)	0.00	0.500*
5	0.24 (0.49)	0.16 (0.55)	0.68	0.249*
6	0.11 (0.39)	0.00 (0.00)	1.67	0.050
7	0.13 (0.41)	0.00 (0.00)	1.96	0.029
8	0.13 (0.34)	0.03 (0.16)	1.67	0.050

*SD = Standard Deviation.

Conclusion and Recommendation

Smartphones help the elderly to feel less lonely

Table 7. Relation between different uses of touchscreen in each action and related components of UI.

No.	Times Reduced (Old UI – New UI) Sorted	Activity	Touch screen + UI components																				
			1. Tap to Select			2. Tap to Open			3. Slide to Scroll			4. Slide & Hold for Scroll			5. Fling to Scroll			6. Tap to Stop			7. Pinch to Shrink & Spread to Enlarge		
			Font	Color	Brightness	Font	Color	Brightness	Font	Color	Brightness	Font	Color	Brightness	Font	Color	Brightness	Font	Color	Brightness	Font	Color	Brightness
1	19.17	1. Chat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
2	13.99	5. Edit Name and Profile Photo	✓	✓	✓	✓	✓	✓			✓			✓			✓			✓			✓
3	9.88	3. Forward				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
4	5.44	2. Add Friend		✓	✓	✓	✓	✓															
5	2.43	6. Free Call					✓	✓															
6	1.94	7. Sending Photo			✓		✓	✓			✓			✓			✓			✓			
7	1.61	8. Sending Sticker					✓	✓		✓	✓		✓	✓		✓	✓		✓	✓			
8	0.94	4. Copy					✓	✓															

=The integration of all three components.

because they can communicate with their family members and friends. However, the elderly whose physical health are impaired, especially for those who have loss of visual acuity, photophobia, diplopia, and visual distortion, they have hard time viewing contents on the screen which result in longer duration on the phone and making more errors when using applications than the younger generations. The test results reveal that the main components of UI that are important to the elderly are brightness, color and font. It is found that UI with Arial Unicode MS font with the size of 12-16 pts. on the green tone of screen and level of brightness at 75% is the most appropriate integration for the elderly. The comparison in the use of smartphone application with newly developed UI and the old UI reveals that the elderly take less times and create fewer errors on the new UI than on the old one. As a conclusion, we can summarize that new UIs can reduce the time the elderly use to accomplish most of the activities. The main three components that affect the smartphone usage of the elderly are font, color, and brightness. The new UIs with the integration of the most appropriate three main components can reduce more time that those with the integrations of only one or two main components. Therefore, the UI of smartphone applications for the elderly should be designed by using the most appropriate integration of components so that the elderly can use their smartphones more effectively and more comfortably.

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