Emergency Related Mobile Applications: Usability Framework and Proposed Implementation

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ABSTRACT

There are a variety of mobile applications that provide convenience to mobile device users and emergency related applications are one of them. The number of these emergency related applications has been increasing as people see the need for these applications. Many existing usability frameworks are meant for mobile applications in general. Applications of different functionalities especially emergency related applications might be evaluated differently when it comes to what factors are needed in it to be considered usable. Therefore, this research proposes a new usability framework that caters specifically for emergency related mobile applications according to the priority of usability factors needed in the application. Finally, an emergency facilities locator mobile application is proposed where the user interface design uses the guidelines derived from the new usability framework.

KEYWORDS

Usability framework, guidelines, emergency, mobile application, user interface design

1 INTRODUCTION

Research in user interface has been increasing due to the advancement of technology that has brought in numerous applications which have now shifted towards mobility. Mobile phones evolved greatly since its introduction in the mid 1980s [1][2]. The smart phone era started in the year 2002 with touch screen introduced in 2007 by Apple with the revolutionary iPhone. The perception of mobile phones changed especially with the rapid increase of mobile applications to suit those smart phones [2]. It produced a different and brand new way to use mobile phones and interact with them [3].

Aside from the operating system, mobile applications can be considered the heart of smart phones as without these applications, the smart phone does not contribute much in the lives of the people. As technology progress, mobile applications developed have increased in usefulness for many different areas in life. However, this has caused a decrease in usability where users find themselves facing small screen sizes, cognitive overload, high power consumption and limited connectivity [4]. These factors also pose a challenge to developers as these are the factors they have to consider when designing user interfaces for the mobile application. Usability is definitely important as it is a condition for survival. When an application fails to show its functions and purpose right from the beginning, users tend to abandon it [5].

Most researches on user interface and usability such as Nielsen’s [6] rules on interface design gives a general guideline on how the interface of an application should be designed. However, with the increase in areas of usage for mobile application [4], more specific guidelines are needed along with their priorities for these applications. Different types of mobile applications might need to increase their focus on specific rules and usability qualities in their user interface to produce a better Human-Computer Interaction (HCI) and also to ensure that the main purpose of the application is fulfilled.

The main idea of this research is to analyze usability models and determine the factors that determine the usability of an application. From there, further analyze how those factors can be applied to an emergency related application. Therefore, the goal of this research would be to come up with a new usability framework and
propose a set of guidelines that would be used to design the user interface of an emergency related mobile application. This research would also show the priority of the usability factors in the context of emergency applications. The results of this research can be used to improve on the current applications available in the market and also serve as guidance for any future development of emergency related mobile applications.

2 BACKGROUND AND RELATED WORKS

An emergency is events that affect people, property or the environment negatively or a situation where things do not go as planned [7]. During an emergency situation, the two essential factors are the help needed to overcome that situation and the time taken for the needed help to arrive on site.

The rise of technology has changed the way people respond in an emergency. Previously, people would save the emergency contact number and call the emergency personnel when an emergency arises. In this case, reminders had to be given out to people to save the emergency contacts and many people still do not do it and are unable to contact emergency personnel in time. Nowadays, with the help of the Internet, people are able to locate emergency facilities and their contact numbers online and this enables people to respond more rapidly in event of an emergency. To add to that, mobile applications are getting more and more popular and there are applications with all sorts of functionalities, emergency applications included.

2.1 Rules for Interface Design

ACM’s code of ethics [8] states that every individual in society regardless of race, sex, religion, age, disability, national origin and other similar factors should have equal opportunity to benefit from computer resources. This code of ethics reinforced the importance of the usability of a mobile application, which indirectly comes from its user interface design. Schneiderman [8] brought up a problem where computing technology has yet to reach the level of universal usability due to the difficulty of device usage where users waste 5.1 hours a week trying to use computers. Therefore, Jakob Nielsen [6] defined ten broad rules of thumb on an interactive user interface design, which are:

a) Visibility of system status: users should always be kept inform by the system through feedback.

b) Match between the system and the real world: the system should follow real-world conventions to make it more natural to the users.

c) User control and freedom: the system should support redo and undo actions.

d) Consistency and standards: unambiguous interpretation of each word, situation or action in the system.

e) Error prevention: avoid error-prone conditions, remove them effectively and provide confirmation for the user’s actions to remove the possibility for errors.

f) Recognition rather than recall: information about the system should be visible and obtainable whenever needed so the user does not need to remember those information.

g) Flexibility and efficiency of use: a system that caters to both experienced and novice users.

h) Aesthetic and minimalistic design: each dialogue contains only needed information.

i) Help users recognize, diagnose and recover from errors: error messages should be put in simple language, indicate the exact problem and provide a solution to the error.

j) Help and documentation: steps on how to carry out the user’s task should be provided.

2.2 Usability Challenges

Adipat and Zhang [9] and Anam et al. [10] pointed out the problems faced by mobile users from their devices:

a) Information overload: too much information in one screen at a time.

b) Limited memory of mobile devices: users need to remember the meaning of a command or action.
c) Navigation loss: trouble reaching the desired page.

d) Cumbersome input methods: small keyboards which require high concentration.

These problems pose a challenge to mobile users and may cause them to lose interest in using their mobile devices.

2.3 Existing Usability Models

There are many usability models in the literature. The usability models of Nielson, ISO and People at the Centre for Mobile Application Development (PACMAD) model are reviewed and compared in the following subsections.

2.3.1 Nielsen usability models

Nielsen [5] and Zhang and Adipat [11] defined usability as a quality attribute that evaluates the ease-of-use of user interfaces. Usability is then defined through 5 components, which are:

a) Learnability: the level of difficulty for first time users when it comes to completing basic tasks of the system

b) Efficiency: speed of performing tasks once users become familiar with the system

c) Memorability: how much users can remember about how to use the system after a period of absence

d) Errors: the number of errors, the level of severity and the ease of error recovery

e) Satisfaction: the experience users obtain when using the system

2.3.2 ISO’s Usability Model

Organization for Standardization (ISO) [12] defines the ISO 9241 process-oriented standards as the extent to which a product can be used by users to achieve specified goals effectively, efficiently and also be satisfied with the product. Therefore, the three components used to measure usability are:

a) Effectiveness: the degree of goal achievement users get from the system

b) Efficiency: the resources needed by the system to achieve the user’s goals

c) Satisfaction: physical emotions felt by the user after using the system

This ISO standard requires a human-centered design approach to produce a usable and interactive system. However, measurements of usability is not limited having these characteristics in the system but also requires an evaluation of the performance and satisfaction of the users which creates a complex interaction between the users and the context of use of the system. This interaction produces three context characteristics of users, tasks and environment where a change in any one of these characteristics can definitely change the usability of the system.

2.3.3 PACMAD Usability Model

Harrison et al. [4] proposed a usability model that was inspired and improved from Nielsen’s [6] and ISO’s [12] usability model called the People at the Centre for Mobile Application Development (PACMAD) model. The PACMAD model aimed at producing a usability model that is more relevant to mobile applications and devices. This model is split into two relational parts that go hand in hand, which are the factors that influence usability and the attributes that reflect usability.

The three factors that influence usability are:

a) Users: a wide variety of users require different input methods depending on their physical limitations. The user’s experience with the application also might require a different approach to be considered during the application’s design.

b) Task: extra features added to the application’s design might compromise the user’s ability to achieve his or her goals with the application as it increases complexity and decreases usability.

c) Context of Use: the mobile application should be appropriate for different context usage such as physical locations and user interaction with people or objects. In other words, the environment in which the application is being used.

The seven attributes of the PACMAD model in evaluating the usability of a mobile application are:
a) Effectiveness: determined by the ability of the users to complete specified tasks.
b) Efficiency: productivity of a user in completing the tasks with speed and accuracy.
c) Satisfaction: the user’s feelings towards the application such as comfort and pleasantness after usage of the application.
d) Learnability: the time taken for a user to become proficient in using the application.
e) Memorability: the ability of the user to maintain proficiency in using the application after a period of inactivity.
f) Errors: understand the nature of errors and preventing them from occurring.
g) Cognitive load: amount of concentration needed to use the application. This reflects the ability of the user to use the mobile application while carrying out other tasks and how does these other tasks affect the ability of the user to use the application.

Based on the three usability models reviewed and explained above, both the ISO and Nielsen usability models were created to serve as guidelines to improve usability in the area of user interface design of an application. All three models can be used when designing the user interface of a mobile application but the PACMAD model serves as a better and more thorough usability model as it was created with the intention of improving the usability of mobile applications specifically. It adapted not only the attributes of each usability model but also incorporated the three factors that influence the usability of a mobile application as was previously brought up by ISO. With the world increasing in pace as technologies head towards catering for convenience and the ‘on the go’ concept, it is vital that those factors and attributes be compulsory in all the mobile applications being developed. Therefore, the PACMAD model will serve as the main usability model reference for the next part of the research. It is an all rounded model and is more suitable in developing the proposed priority usability factors framework specifically for emergency related mobile applications.

3 METHODOLOGY

This section focuses on the methods that are carried out to obtain data for the research. The methodology starts with the collection of data. A questionnaire was created and given out to the target users. The questionnaire contained questions based on the usability factors in the PACMAD model to find out which factors matter most to the target users. After that, data from those questionnaires are analyzed to form the framework of usability factors for an emergency related application. Eventually, interpretation is done on the framework to come up with a set of proposed guidelines. Finally, an emergency related mobile application is proposed to demonstrate the use of the guidelines in its user interface design. The steps and outcomes are summarized in Figure 1.

![Figure 1. Research Process and Outcome](image)

The population of this study is defined as mobile device users in Malaysia. The mobile devices are not limited to any particular brand or model and include smart phones, phablets (smart phones that are similar in size to tablets) and also tablets. The age group of the target users is between 16 to 65 years of age, disregarding gender. A quantitative approach is taken to collect data for this study through questionnaires using convenience sampling.

The mobile device users that aided in the research through their response in the questionnaires are chosen at random. Anyone within the target age group and who is willing to participate in this research will be given the questionnaires. This is because in this technological era, most of the people in Malaysia especially those who live in...
urban areas own at least one mobile device or at least know what a mobile device is. During the data collection process, a questionnaire with 16 questions is prepared. The questions are about the usability factors needed for emergency related mobile applications in particular. For each usability factor, there will be either one or two real life application questions. These questions do not directly state the usability factor but rather given situations in which the respondent is required to state their usual response. The final question of the questionnaire required the respondents to pick the five most important usability factors. The respondents were required to answer all the questions in the questionnaire. The questionnaires were distributed to the target respondents through social media and face-to-face.

4 RESULTS

A total of 82 responses were collected from respondents of various ages. The questionnaires are grouped according to the following age groups:
• 16 - 24 years old
• 25 - 30 years old
• 31 - 49 years old
• 50 - 65 years old
The reason for the age groups is because each age group represents the different generations in society. They have different levels of familiarity with technology and have different perspectives when it comes to what usability is. Different age groups have a variety of opinions and reasoning as to what makes a mobile application easy to use or satisfying enough. The responses are analyzed to obtain the usability factors that determine the usability of emergency related mobile applications specifically through its user interface design. The results of the data analysis would be the five usability factors that the respondents feel are most important when it comes to using emergency related applications. Only the top five factors are chosen as these five factors represent the ‘must-haves’ for emergency applications. Usability is subjective as it differs according to the opinions of each individual user. Hence, these are the factors that are important in relation to the nature of the application.

From the results of the analysis, a final framework will be proposed to model the usability factors that cater specifically for emergency related applications. The produced framework will serve as a basis for the proposed user interface design guidelines that will eventually answer the main question of this research study, which is about the user interface guidelines for emergency related mobile applications.

The data obtained is separated into two parts. The first part is the data obtained from analyzing the importance of each usability factor from the questions that are related to the usability factor. These questions do not directly state the usability factor but instead, emphasize an individual factor each and also how it is applied in the mobile application. Most of the questions for this part ask about the reactions of the respondents given a certain scenario, which indirectly focuses on a particular usability factor. Table 1 shows that most of the respondents regardless of age place a high level of importance on the factors Efficiency, Effectiveness, Satisfaction, Learnability and Error Handling.

| Table 1. Importance of Usability Factors by Age Group |
|-----------------|--------|--------|--------|--------|--------|----------|
|                | 16-24  | 25-30  | 31-49  | 50-65  | Grand Total |
| Effectiveness  | 46     | 12     | 13     | 7      | 78      |
| Efficiency     | 45     | 10     | 12     | 7      | 74      |
| Satisfaction   | 33     | 10     | 9      | 6      | 58      |
| Learnability   | 35     | 10     | 9      | 7      | 61      |
| Memorability   | 24     | 10     | 8      | 6      | 48      |
| Error Handling | 30     | 7      | 7      | 6      | 50      |
| Cognitive Load | 17     | 5      | 5      | 1      | 28      |

The second part is the data obtained from the last part of the questionnaire where the respondents are required to choose the top five factors that they deem most important when it comes to an emergency related mobile application. The question is direct and the definition and explanation for each usability factor is given to the respondents for them to understand better. Figure 2 shows that the top five usability factors chosen are Effectiveness, Efficiency, Satisfaction, Learnability and Error Handling.
This shows that the results are consistent with Table 1. Even with direct or indirect questions, the same factors are of utter importance.

5 DISCUSSION

With the top five usability factors selected by the respondents, a framework can be proposed. This framework shows the five usability factors that all emergency related mobile applications must have. To omit any one or more of these factors will greatly reduce the usability of the given application. The framework is shown in Figure 3.

![Usability Factors](image)

**Figure 2.** Overall importance of usability factors

**Figure 3.** Framework of Usability Factors for Emergency Related Mobile Applications

A set of guidelines for user interface design of emergency related mobile applications is drawn from the proposed usability framework. Each usability factor in the framework is elaborated to show how it should be applied in real application development. The following guidelines are set according to the order of usability factors in the proposed framework. The guidelines are:

a) The user interface should be designed in a way that it helps users to learn and fully utilize all the functions of the mobile application. The interface should have just the right amount of functions and options in one screen but yet remain its simplicity so that the user catches the meaning of each function and how to use them fast. The users must be able to complete the tasks they intend to do before using the application.

b) The user should be able to perform a function and complete it with minimal screen changes without compromising on the number of information in one screen. The faster and more accurately the user is able to successfully complete the tasks, the more efficient the application is fulfilling its purpose during an emergency. This can be done through a direct and simple user interface design.

c) Each user should have a feeling of contentment during and after using the application. The user interface should contain layouts and designs that ease the user. Users should want to use the application again and again and be able to rely on it when the situation arises.

d) The user interface should consider users with different backgrounds and learning capabilities. Age plays an important role when it comes to learning abilities. The user interface should be simple and easy to learn for a variety of users.

e) Errors become a huge problem especially when faced by users who are not so proficient with the application or even a mobile device. Each application needs to come up with a proper error-handling interface to effectively assist the user in case of an error and also to ensure that the user does not give up interacting with the application. Unclear instructions or bad error handling layouts might cause an error to prolong even though it might be something simple thus turning the user away from the application.

6 PROPOSED IMPLEMENTATION

This section proposed a mobile application named ‘Help!’, an Android based emergency facilities locator. The aim is to demonstrate the use of the
guidelines obtained from the usability framework above in designing the user interface.

6.1 Background

During an emergency situation, every second counts. Usually, we have to wait to be rescued or helped after calling the ‘999’ hotline as the call agent needs to make further contact to the appropriate emergency facility in the right location. Time can be saved if we can just call the nearest emergency facility directly. Furthermore, if emergency happens to us who are in an unfamiliar or new location, we usually do not aware of our exact location and the types of emergency facilities nearby. Many of us also find it challenging to notify our loved ones when we are in an emergency situation especially if we need to notify more than one person. It would be convenient if we can just press a button on our mobile phones and all our loved ones are notified about the emergency.

6.2 System Architecture – ‘Help!’

Help! uses the mobile device’s Global Positioning System (GPS) function to detect the current location. From that location, the nearest emergency facility type such as police station, fire station or hospital is displayed along with contact numbers, address and distance from current location. The chosen emergency facility can be called directly. The overview of the system architecture is shown in Figure 4.

Besides that, the application also allows five phone contacts and one emergency message to be saved. The emergency message will be sent to all five contacts when the ‘Panic’ button is pressed. The features of ‘Help!’ are shown in Table 2.

Table 2. Features of ‘Help!’

<table>
<thead>
<tr>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection of current location</td>
<td>The system is able to detect the user’s current location based on the GPS function in the mobile device</td>
</tr>
<tr>
<td>Allows selection of emergency facility type</td>
<td>The user can choose what kind of emergency facility is needed such as hospital, police station or fire station</td>
</tr>
<tr>
<td>Display all the nearest emergency facilities</td>
<td>The system is able to show all the emergency facilities and their details based on the current location of the user</td>
</tr>
<tr>
<td>Call the selected emergency facility</td>
<td>When the user chooses an emergency facility, the application dials the emergency facility directly without needing the user to type out the contact number</td>
</tr>
<tr>
<td>Save emergency contacts and an emergency message</td>
<td>The system will be able to save up to 5 phone contacts and also one emergency message. The user can also edit those contacts and message</td>
</tr>
<tr>
<td>Panic button</td>
<td>The system will send the emergency message using SMS to the saved emergency contacts when the button is pressed</td>
</tr>
</tbody>
</table>

6.3 User Interface Design – Help!

Based on the guidelines mentioned in section 5 above, the user interface design of ‘Help!’ is illustrated and described in the following subsections.

a) Main Menu

The main menu page as shown in Figure 5 is designed to ensure effectiveness, efficiency and satisfaction. All the features can be easily access in a single page with direct and simple design as mentioned in the guidelines.

![Figure 4. System Architecture of ‘Help!’](image-url)
b) Location of Emergency Facilities
Once the user selects ‘Hospital’ icon from the main menu, the list of nearest hospitals from the current location will be displayed along with the details as shown in Figure 6.

In Figure 6, the map above the list will be marked with the hospitals that are listed to show their exact position on the map. The blue dot is the user’s current location. The interface is similar if user selects ‘Police Station’ or ‘Fire Station’.

c) Dial Screen
Once the user selects the desired facility from the list in Figure 6, the dial screen will appear with the contact number as shown in Figure 7.

User may choose to make the call by touching the ‘call’ icon or abort. This interface design gives great satisfaction to the user.

d) Current Location
When a user is at an unfamiliar location, the user can select ‘Current Location’ icon from the main menu. The user can then touch the ‘zoom’ icon at the top right of the screen to determine his/her exact location on the map. The interface is as per Figure 8.
e) Setting
The setting function is to allow the user to add/save/edit/delete emergency contacts or emergency message. The checkbox must be checked before pressing the ‘Save’ button to ensure the changes made are saved. A pop up error message ‘Select the checkbox’ will be displayed if the user press ‘Save’ without ticking the checkbox. The design of the interface is as shown in Figure 9.

Figure 9. Setting

f) Panic Button
The panic button can only function if the user saved the relevant input in ‘Setting’. Else, no notification will be sent.

6.4 Adopted Guidelines

The proposed user interface design has adopted all the guidelines and demonstrated that the new usability framework is practical and suitable in designing emergency related applications. Table 3 summarizes the adoption of the guidelines versus each interface design in ‘Help!’.

<table>
<thead>
<tr>
<th>User Interface</th>
<th>Adopted Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Menu</td>
<td>a, b</td>
</tr>
<tr>
<td>Location of Emergency Facilities</td>
<td>a, b</td>
</tr>
<tr>
<td>Dial Screen</td>
<td>c</td>
</tr>
<tr>
<td>Current Location</td>
<td>a, b, c</td>
</tr>
<tr>
<td>Setting</td>
<td>a, b, c, d, e</td>
</tr>
<tr>
<td>Panic Button</td>
<td>e</td>
</tr>
</tbody>
</table>

7 CONCLUSION

The limitation of this research is that the findings cannot be generalized and the assumption is that the responses provided by the participants are true. Nevertheless, the findings provide quick guidelines to mobile apps developers on the factors that need to be focused on when designing emergency related applications, which have been well demonstrated in Section 6. This research has taken a more focus path than what normal usability researches did and contributed both in theory as well as practical implementation.

7 REFERENCES