THE IMPLEMENTATION OF HUMAN-COMPUTER INTERACTION (HCI) IN MOBILE DEVICES FOR SEARCH AND RESCUE (SAR) OPERATION

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ABSTRACT

Search and rescue (SAR) operations require members who are capable and highly skilled of having a complete set of equipment which is very important in order to help in rescuing the victims whose exposed to the danger that could be fatal to them. However, the ability and skills possessed by each member of the SAR as well as the complete equipment are not sufficient without an efficient and effective communication and control between each member of the SAR in conducting a SAR operation. In this day and age, people are exposed to human-computer interaction concept in line with the growth of mobile computing technology where people started to demand on their needs for applications used. This thesis proposes the implementation of human-computer interaction (HCI) specifically in design on mobile devices to conduct the SAR operations. The research was carried out to determine the appropriate HCI interface design parameters consists of the background colour, font colour, font type and font style with similar font size for usage in the mobile application, based on the usability measures of speed and accuracy of response. To evaluate the usability of mobile HCI application in this research, a User-Centered Design (UCD) for mobile approach methodology is proposed involving three phases which are analysis, design and evaluation. Usability testing is selected to conduct the evaluation experiments in an open area, assigning the 25 test participants selected amongst the cadets of the degree students of Computer Science at UPNM as clients by equipped them with an Android mobile devices and the evaluator to control the Windows server using a prototype design called HCI Test. The minimum brightness of mobile devices is set, and this experiment is conducted during the daylight, in particular, under direct sunlight. From the results obtained, the best HCI design

interface parameters either black background colour or white background colour is chosen as an appropriate HCI parameter to be applied in the mobile HCI application for SAR operation. In summary, the thesis proposes an HCI interface design that focuses on HCI parameter used in a mobile application for Search and Rescue (SAR) operation to provide an effective and efficient command and control (C2) process as well as can provide a better time management and reduce workforce usage in saving human lives.

ABSTRAK

Operasi Mencari dan menyelamat (SAR) memerlukan ahli-ahli yang berkebolehan dan berkemahiran tinggi serta mempunyai peralatan yang lengkap yang mana ianya sangat penting bagi membantu dalam menyelamatkan mangsa-mangsa yang terdedah kepada bahaya yang mungkin boleh meragut nyawa mereka. Walau bagaimanapun, keupayaan dan kemahiran yang dimiliki oleh setiap anggota SAR serta berbekalkan peralatan yang lengkap tidak mencukupi tanpa komunikasi dan kawalan yang cekap dan berkesan antara setiap anggota SAR dalam menjalankan operasi mencari dan menyelamat. Pada zaman ini, orang ramai semakin terdedah kepada konsep interaksi manusia-komputer sejajar dengan pertumbuhan teknologi pengkomputeran mudah alih di mana mereka mula menuntut keperluan mereka untuk aplikasi yang digunakan. Kajian ini dijalankan untuk menentukan parameter reka bentuk antara muka HCI yang sesuai terdiri daripada warna latar belakang, warna fon, jenis fon dan gaya fon dengan saiz fon yang sama untuk kegunaan dalam aplikasi mudah alih, berdasarkan ukuran kebolehgunaan kelajuan dan ketepatan tindak balas. Untuk menilai kebolehgunaan aplikasi HCI mudah alih dalam kajian ini, metodologi Reka Bentuk Berpusat Pengguna (UCD) untuk pendekatan mudah alih dicadangkan melibatkan tiga fasa iaitu analisis, reka bentuk dan penilaian. Ujian kebolehgunaan dipilih untuk menjalankan eksperimen penilaian di kawasan terbuka, menugaskan 25 peserta ujian yang dipilih di kalangan kadet pelajar Ijazah Sains Komputer di UPNM sebagai pelanggan dengan melengkapkan mereka dengan peranti mudah alih Android dan penilai pula akan mengawal pelayan Windows menggunakan reka bentuk prototaip yang dipanggil ‘HCI Test’. Kecerahan minimum peranti mudah alih ditetapkan, dan eksperimen ini dijalankan pada siang hari, khususnya, di bawah cahaya matahari langsung. Dari hasil

yang diperolehi, parameter antara muka reka bentuk HCI terbaik sama ada warna latar belakang hitam atau warna latar belakang putih dipilih sebagai parameter HCI yang sesuai untuk digunakan dalam aplikasi HCI mudah alih untuk operasi SAR. Secara ringkasnya, tesis ini mencadangkan reka bentuk antara muka HCI yang memberi tumpuan kepada parameter HCI yang digunakan dalam aplikasi mudah alih untuk operasi mencari dan menyelamat untuk menyediakan proses arahan dan kawalan (C2) yang berkesan dan cekap serta dapat menyediakan pengurusan masa yang lebih baik dan mengurangkan penggunaan tenaga kerja dalam menyelamatkan nyawa manusia.

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APPROVAL

I certify that an Examination Committee has met on 20th September 2017 to conduct the final examination of Nur Syafikin Shaheera binti Mat Zaini on her master thesis entitled 'The Implementation of Human-Computer Interaction (HCI) in Mobile Devices for Search and Rescue (SAR) Operation'. The committee recommends that the student be awarded the Master of Science (Computer Science).

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LIST OF ABBREVIATIONS

C2	Command and Control
COA	Course of Action
CSAR	Combat Search and Rescue
GSAR	Ground Search and Rescue
HCI	Human-Computer Interaction
MCQ	Multiple-Choice Question
MMEA	Malaysian Maritime Enforcement Agency
OODA	Observe-Orient-Decide-Act
PC	Accuracy of Response
RT	Time to Response
PT	Points
s	second
SAR	Search and Rescue
SAROPS	Search and Rescue Optimal Planning system
SMART	Special Malaysia Disaster Assistance and Rescue
UPNM	Universiti Pertahanan Nasional Malaysia
USAR	Urban Search and Rescue

CHAPTER 1

INTRODUCTION

This thesis discusses the search and rescue (SAR) operations on the ground areas, focusing on the implementation of human-computer interaction (HCI) specialised in the design, on mobile application interface. Using the method of usability testing, prototype implemented with emphasis on HCI interface design parameters consists of five elements, i) background colour, ii) font colour, iii) font type, iv) font style and v) font size has been used in the HCI interface. Through the method used, an appropriate HCI parameter is employed in the interface of the mobile application based on the speed and accuracy of response is considered to provide an effective and efficient command and control (C2) for SAR operations.

1.1 Background of Research

For centuries, there has been many search and rescue involved in human lives across the world to save any person in danger or in any disaster that may occur. However, it has been recently referred as “search and rescue” or “SAR” ever since the establishments of many organisations (Cooper, 2005). Search and rescue (SAR) have many definitions and meanings based on the organisations involved. Proceedings of the Provisional International Civil Aviation Organization (PICAO) 1946 has introduced the first clear definition of “search and rescue” term that been used in context today. It was stated in an article in the 1946 Air Sea Rescue Bulletin entitled, “Evolution of SAR: An Editorial” that PICAO adopted the term “search and rescue” and recommended its definition as, “The act of finding and returning to safety the survivors from an emergency incident” (Cooper, 2005). Research by Cooper (2005) also defined the SAR operation as any operation that aims to help someone in trouble, someone who could not solve their problems alone. Based on other SAR organisations, such as Canadian Forces (1998) defines search and rescue consisted of looking for and provision of assistance to persons, ships or other vessels; or feared to be; in distress or imminent danger. Search and rescue has been defined separately by International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual (1999), where a ‘search’ is an operation using available personnel and facilities to locate persons in distress. ‘Rescue’, on the other hand, is an operation to retrieve a person in distress and provide for their initial medical or other needs before having them delivered to a safe place. Other than that, those who possessed the proper equipment and skill have often called as search and rescue people in distress (Cooper, 2005).

Generally, SAR operation can be carried out in different situations known as, i) ground SAR, ii) mountain SAR, iii) urban SAR, iv) combat SAR and v) air-sea rescue. These environments have their difficulties and risks. However, each SAR operation area also provided their special teams or facilities to save a person (s) in danger such as using the dogs' team, robots, satellites, helicopters and more.

To conduct a mission, especially when dealing with human life is not easy. Several conditions may have occurred, and we need to be aware and alert to deal with it. According to William Pierce (1986), there are four (4) main phases in search and rescue. i) look for victims; ii) get to the victims; iii) stabilise those victims, and iv) move them. The operation of command and control (C2) play an important role to ensure that the SAR can be conducted effectively and efficiently and also to avoid any unwanted incident. Based on Rosen et al. (2002), C2 can be influenced by three (3) environmental factors, which are, i) fog (uncertainty), ii) friction (complexity) and iii) flux (variability). Search and Rescue Document by Department of Civil Aviation Malaysia (DCA) (2011) addressed the fact that current SAR organisations still apply the verbal and visual signals communication to conduct the search and rescue operations such as using walkie-talkies, maps, compasses, arm-and-hand signal and others. All these are acceptable as long as the given information is reachable and the commands are understandable within a team. Based on this fact, the mobile computing technology is already a concept, and it has some relations with the technology of advancement among the rescuers.

Mobile computing technology has emerged and evolved, almost everyone uses mobile computing in some way or another. As stated by Rauterberg (1998), the concept of mobile computing has emerged due to the current advancement of wireless networks and computer downsizing technologies. The ubiquitous use of computing devices in the world today such as mobile and wearable devices, as well as services and applications, enabling people to access the information needed. They may also communicate and cooperate in all kinds of settings, and for an entirely wide range of tasks at anywhere and anytime they want (Henze, 2014). Thus, these technologies have led to the practical need of human-computer interaction (HCI) domain in establishing an efficient communication between the two parties, the team leader and the team members. Based on the current context, the operational definition of HCI is a field of inquiry necessarily evolves in response to changes in the technological landscape (Churchill et al., 2013). It also focuses on technologies and practices that have been widely used, as reflected in the spread of systems and applications (Grudin, 2012).

Dix et al. (2004) explained that the term Human-Computer Interaction (HCI) were commonly used since the early 1980s and managed to attract professionals from different fields to create various concepts and approaches together. It is not just about a single user with a desktop computer, where for a user that may be an individual user or a group of users that work together or each user in an organisation that has been assigned to deal with their task or process. In other words, the user is whoever is attempted to accomplish their work with the help of technology (Dix et al., 2004). It could be any technology that encompassed from a general desktop computer to a large-scale computer system, whereby it is a technology that consists of the elements of process control system or an embedded system where the system may include the non-

computerized parts (Dix et al., 2004). Whereby the term of interaction, it could be any communication that occurred between a user and computer either directly or indirectly (Dix et al., 2004). Direct communication involves the ability of users to give control on the performance of the task, style, knowledge and providing feedback while interacting with the computer. An indirect interaction may occur by monitoring users' HCI behaviour via low-level actions of computer software (Yampolskiy, 2007).

Ever since from the mid-1980s, Apple Macintosh and Microsoft Windows have introduced the desktop metaphor and "windows, icons, menus, pointer" (WIMP) interfaces to the public, until it goes beyond the Graphical User Interface (GUI). The development of user interfaces of the system has been emphasised for the novice users and various interactive applications. The challenge of personal mobile computing has occurred at the right time, and it changed the perception of the public about the computer users simultaneously by changing the ways people work until now (Lokwani & Patel, 2014; Roussel, 2014).

Therefore, this research investigated the implementation of HCI or specifically on the interface and interface layout implemented in mobile device whereby to enrich the user interface experiences in order to conduct the SAR operation. This investigation may include the analysis of the speed and accuracy of response of user experiences using mobile technology in HCI. The mobile device is a communicative medium between SAR team leader and SAR team members during the SAR operation.

1.2 Problem Statement

According to Muhamad (2015) and Khalid (2015), the mysterious disappearance of seven Orang Asli children in forest reserves Pos Tohoi, Gua Musang, Kelantan on August 23, 2015, has involved a search process for more than 50 days. The Search and Rescue (SAR) operation involving various government agencies and villagers have found only two children who survived, while five others had died (Khalid, 2015; Muhamad, 2015).

Thus, to continue the SAR operation, government through the Ministry of Education has set up a special committee comprising the Malaysian Armed Forces (ATM), Malaysian Fire and Rescue Department (FRD), the Royal Malaysian Police (PDRM), General Operations Force (GOF), Department of Volunteer Malaysia (Rela), Civil Defence Department (CDD) and Department of Orang Asli (JAKOA) to continue the search and rescue operation for these seven poor children. Hundreds of members from various security agencies were deployed to the scene including the use of air assets as well as tracking dogs owned by ATM and FRD. The radius search has also been extended up to 80 kilometres creating six sectors altogether. Although the security forces have used various means in conducting the search and rescue (SAR), the missing children were hard to find (Khalid, 2015; Muhamad, 2015).

The difficulties were due to the demographic situation of the areas of rolling hills and dense forests. Even though this should not be a problem for rescuers to accomplish their rescue operations, but with the lack of information accuracy, it had caused problems to the mission. According to 8 Infantry Brig. Commander Brig. Gen,

there are many different versions on the trail used by the children and this is the biggest factor in the failure of the search by rescuers to trace the victims (Khalid, 2015; Muhamad, 2015).

Based on the above scenario, every mission requires strategies and tactics. In conducting SAR operations, SAR team must be fully prepared, and tactics will be used to maximise the capability of the search team. In this operation, command and control (C2) will be conducted by the SAR team leader to ensure that the team successfully covers the search area. In a nutshell, the current command and control between SAR team leader and the team members require a clear communications method during SAR operation in dense jungle or forest area. The SAR team leader should be concerned about the location of his SAR team members to ensure that no part of the search area is missed (Alsagoff, 2011).

However, in a dense jungle or forest environment, with a variety of flora and fauna, command and control will be difficult to maintain. The limited visual control may lead to the loss of signal (e.g. using walkie-talkie). Any commands by the SAR team leader requires the SAR team members to react quickly or it may affect the overall operation. The lack of command and control can even lead to loss of SAR team members, and the missing person will not be found even if in the close vicinity (Ferguson, 2008). Also, with the unclear verbal command due to noise and confusion can lead to misunderstandings among the team members with the team leader.

Therefore, understanding of command and control is not an option but a requirement as their function are performed through an arrangement of personnel, equipment, communications, facilities and procedures which are employed by a designated individual in planning, directing, coordinating and controlling resources in the accomplishment of the common goal (Jenkins et al. 2009).

Furthermore, the environment in which SAR operation will take place will determine the level of difficulty of the search operations. The difficulty of the process also depends on the thickness of the forest, and the amount of search required - a factor that can affect the efficiency of the SAR team members during operation. Search operation tactics can also be used differently depending on the rescue environment encountered (Rhea et al. 2009).

As well, time constraints are also an important factor in saving lives (Alsagoff, 2011). The search operation may be affected if the SAR team members cannot or will take a long time to find the exact direction to travel and the target location to reach the victim's position. The fitness of SAR team members should also be considered and requires high endurance for both mentally and physically when carrying out the SAR operation.

In order to address the issues and problems arising, research on the implementation of HCI in mobile devices for SAR operation was conducted. In this research, the client-server system has been developed to identify the best mobile HCI parameters based on the speed and accuracy of response using the Android mobile devices by the team members. Windows platform used as a server that will be