CERTIFICATION OF APPROVAL

Mental Model of Blind Users In Developing Gaming Systems

By

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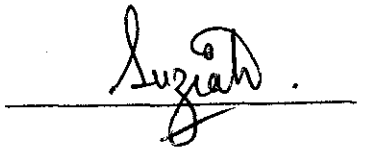

DR. SUZIAH SULAIMAN

ABSTRACT

Advances in technology provide an opportunity for the blind users or visually impaired to gain new knowledge and also undergoing their life as normal people did. Therefore, many researchers get involved in developing and improving software and system applications for them. As we know, designing computer applications for blind users and visually impaired is not easy and very challenging task. Generally, user satisfaction with a system which is determined by how pleasant the system is to use, is considered an important aspect of usability. Although there is growing body of research do research on mental model of blind users to assist designers in system development but there are less focuses on developing in gaming system for them. The vast growing technologies for blind users also has attracted many researchers to get involved in developing and improving software and system applications useful for the blinds. This paper aims to develop the mental model of blind users to assist designers in developing gaming systems. In the introduction part, an explanation on mental model is discussed. Related papers on mental model of blind users were reviewed to enhance the understanding of blind users.

Keywords- Mental model, blind user

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TABLE OF CONTENT

CHAPTER 4 : RESULT AND DISCUSSION

CHAPTER 5 : CONCLUSION

CHAPTER 1
INTRODUCTION

1.1 Background

Blind users or visually impaired are considered as special users who to some certain extent may require some assistance from those around them in order to get on with their lives. This group should be treated equally as normal users since they also have the right to involve in sporting events like normal people. Visually impaired or blind users might be at disadvantage in some sports but does not mean that they are unable to participate in a wide range of sporting events. Through the use of either a guide to help direct them, or the use if sound generating device at the target, many games have been adapted to accommodate visually impaired or blind users [1]. But there is less research on mental model on how to help designers in designing gaming system application for blinds especially in sporting events and also computer games. In order to develop a mental model, designers should know users' understanding of what the system contains how it works, and why it works that way [2].

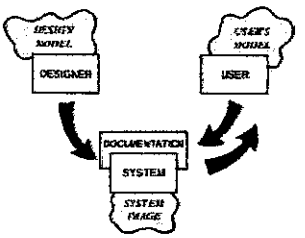


Figure 1 : Interaction design of the system

Since decades ago, mental model had been studied by cognitive scientists as part of efforts to understand how humans know, perceive, make decisions, and construct behavior in a variety of environments [3]. Many researchers have their own definition on mental model. The term "mental model" was first explained since decades ago by Kenneth Craik in 1943[4,5]. He stated that our mind will construct a 'small scale model' of reality that uses prediction of actions and reasons in order to expect future situation in reality [5,6]. Another researcher, the Johnson-Laird volume proposed mental models as a way of describing the process which humans go through to solve deductive reasoning problems. His theory included the use of a set of diagrams to describe the various combinations of premises and possible conclusions [1].

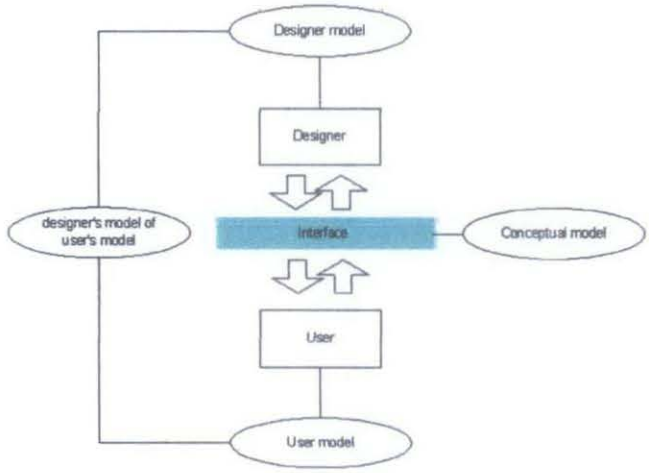


Figure 2: Example of mental model in HCI

Based on the research, much information is currently in accessible for blind users, because it is only visually available [19]. It is quite common for game developer to think in visual terms when they design the interface for the games and often they start from visual designs and use visual tools for their work. The visual appearance of a game for blind users almost always stays the golden standard for understanding its logical structure. Regrettably, it is also inaccessible for blind users, making them dependent on a normal people game and their

proper implementation of accessibility standards. When talk about visual appearance, we do not focus on images or media that are embedded on games but we rather concentrate on the general look of the game where the design of the game example the layout of the games [19].

Mental model is crucial for designers because it reflecting the users' understanding of what the system contains, how it works, and why it works that way [2]. Mental Model is internal to each user's brain, and different users might construct different mental models of the same user interface. Furthermore, one of usability's big dilemmas is the common gap between designers' and users' mental model. Because designers know too much, they form wonderful mental models of their own creations, leading them to believe that each feature is easy to understand [7]. In order to develop mental model in developing gaming system for blind users, little research has being carried on blind users' mental model and there is a need to give more focus on this area as there is less research and studied on developing mental model related in sport game and also computer game for blind users. Thus, this paper will suggest for an improvement on the existing mental model.

1.2 Problem Statement

Mental model was first explained since decades ago by Kenneth Craik in 1943 that can be defined as what our mind represents an event/object to predict the future outcome. The main concern is to understand how knowledge is transmitted to human and represent how human interact with computer. The problem usually arises when the designer developed system that does not meet user's mental model especially for the blind. As there are a growing numbers of blind people using IT technology in their daily life, many researchers are getting involved in developing and improving software and system applications useful for the blinds. However, there is less research on developing application in gaming system for this target group. This could partially due to lack of understanding on the mental model of the blind people when interacting with such a system.

1.3 Objective

The objectives of this project are:

1. To identify the criteria of what blind user want in playing games.
2. To identify the problems that blind users faced when playing games.
3. To propose a mental model based on the criteria identified and Craik's (1943) definition of mental model in order to assist designers to develop gaming system.

1.4 Scope of Study

The scope of the project will be focusing on the blind users and visually impaired. This is because they are having limited access and capability in playing games. The study of the project is to assist designers to develop mental model in developing gaming system.

1.5 RELEVANCY OF THE STUDY

The motivation to conduct this study comes from the aspiration to understand how blind users use tools in their daily life. In addition, the study of mental model in developing gaming system is also aim to help designers to design tools or games according to what blind users need and it also can provide guide to developer in order to develop the game later on.

CHAPTER 2
LITERATURE REVIEW

Mental Models

2.1 Overview of mental models literature

Why do we need to talk about mental models for blind users at all? There is less previously published research on users' mental models in developing gaming system. This study takes the first step in providing insight into users' mental models in gaming system with a view of helping to achieve the long term goal of improving human mental model. This review of the mental models literature begins by examining the nature of mental models research [8]. Besides that, a number of studies that focus on mental model of human both sighted and blind users also had been investigated [9]. Other than that, the reading strategies of sighted and blind users differ. Whereas sighted users can just look at a page to get an idea about its structure, blind users have to build a mental model of the page. Whether they depend on a text to speech or Braille interface, blind users need to parse the serialized data that come across the interface into their mental model for later reference, thus enabling them to get an overview of that game. Takagi [20] proposed an interesting view of mental model after performing an empirical study with five blind probands. He believe that mental model of blind users is rather dependent of the game under consideration and the screen reading environment, which consists of the combination of all necessary hardware and software parts. This study further assume that by carefully selecting its user interface, the screen reader can support and thus determine a specific mental model in its users which is within certain constraints, they are free to choose and thus should be as inspiring as possible. On the other hand, it must be remember no to over engineer the model and it is quite clear that it should be richer than just a text string, but it is important that it will not put too much mental workload on the user.

2.2 Introduction to the nature of mental models research

As stated in introduction, the term "mental model" was first explained since decades ago by Kenneth Craik in 1943[4,6]. He stated that our mind will construct a 'small scale model' of reality that uses prediction of actions and reasons in order to expect future situation in reality [5,6,10]. In other definition, mental model can be defined as what our mind represent an event or object to predict the future outcome [5,10,11]. Craik also viewed all mental model representation as mimicking the physical world and that people operate on mental representations to simulate real-world behavior and produce predictions[8].Besides that, Johnson-Laird (1983) adopts many of Craik's assertions and further argues that mental models are either analogical representation or a combination of analogical and propositional representations, distinct from, but related to images. As noted by Preece et al. (1994), a mental model represents the relative position of a set of objects in an analogical manner that parallels the structure of a state of objects in the world. Johnson-Laird (1983) argues that different people have more or less elaborate mental models, depending on what they need to know. This may be explained by Preece, et al (1994), who notes that mental models are usually constructed when we are required to make an inference or prediction about a particular state of affairs.

2.3 Mental Model for Sighted People

Researches in the domain of sighted people have been actively investigated to create and modify the mental model of human in any situation to improve the usability of the program. Andrew Sears and Julie (2007) agreed that user satisfaction with a system, which is determined by how pleasant the system is to use, is considered an important aspect of usability. User satisfaction is an especially important usability aspect for systems that are used on a discretionary basis such as home computers (Nielsen, 1993).

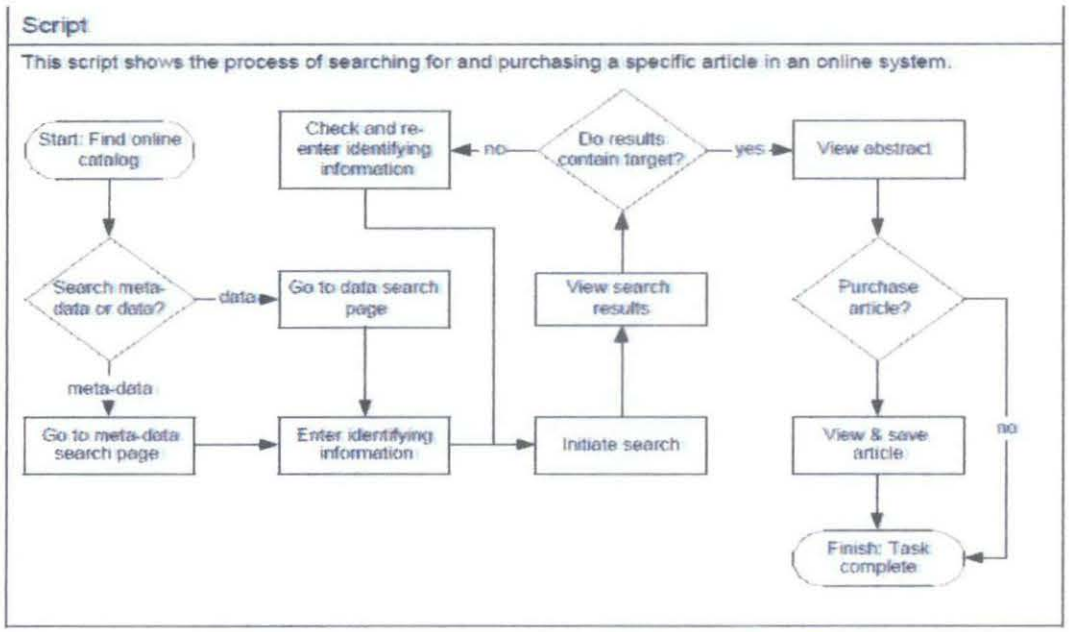


Figure 3 : Examples of mental model of an article and its storage in the system.

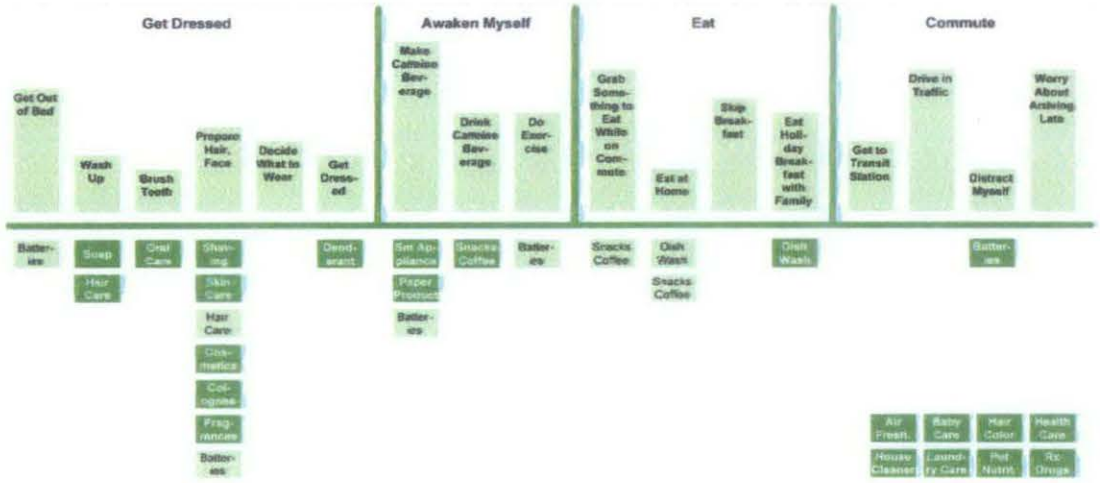


Figure 4 : Example of a mental model in diagram

2.14 Mental Model for Non-Sigthed People

The growing number of users with disabilities especially for blind users has attracted many researchers to cooperate with IT expert to develop various technologies that will ease this group of users in their daily lives. [9,12,13]. Both [12] and [13] have involved an expert domain in their work to elicit expert's opinions and insights in developing future application for the blinds. Advances in technology provide an opportunity for the blind users or visually impaired (VI) people to learn and grasp new knowledge. Even though various technologies are available to the blind users and visually impaired people, yet there is less research on mental model in developing gaming system. Therefore, the main reason is how can we extend further blind users's interest in a specific game so that they can get immerse similar experienced by normal people. Watching is defined as the act of following something with the eyes or the mind[14]. In the mind of a blind users, when listening to a sound they are attempting to form some images and imagine every move, every situation, where the character is, from the special effects done in the movie[15]. By highlighting similarities and differences in user's mental model both sighted and non sightd people, this serve as a stepping stone for achieving the long term goal of enhancing user mental model for non sighted people[9].

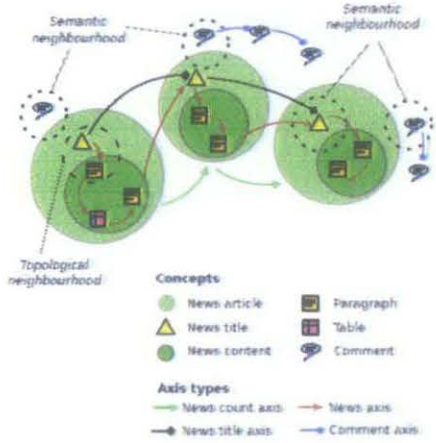


Figure 5 : Example of navigation model to create a website for blind users

The segregation issue and limited capability experiences by the blind users and visually impaired people is the vision of many Blind Associations to resolve[14]. For instance, the deep belief in the rights of the blind to emerge in the society and to show up their capabilities and their great hidden potentials was the base for the attempts done by many parties to resolve the issue[16]. The technologies meant for blind users that make information more accessible for them are already exist, such as screen reader, haptic intefaces, and refreshable Braille[17], but the available solution so far was based on audio description [18], with no capability of the sytem to get a user immersed and engaged into a game. Futher, the solutions had been limited to only applications of movie and video game.Johan Kildal in his thesis [17] has investigated problems that blind users faced while obtaining overview information of numerical data set. His work involves how blind users think in order for designers to design future interfaces for the blind. Even though he did highlight on problems that blind users faced while dealing with numerical data, no mental model for these target users was proposed. Without a mental model, understanding the usability of the system during designing stage may be affected.

In other research, Kurniawan and Sutcliffe investigated that blind user's mental model of new Window environment. Their study which tested on a new screen reader had zed in three stages which are exploration, task action and configuration. In that study, blind users were observed to have three stategies in dealing with new windows environment which are structural, functional and hybrid. Structural mental model can be understood as one or two dimensional agreement of icons or symbols associated with application (represented by a physical location on the dekstop). Functional mental model is created when each application in computers were associated with a userdefined shortcut key (CTRL +MW = Microsoft Words) while hybrid mental model is the combination of these two mental models. From these findings, the mental model of stategies for blind users in coping with new environment is created.As Kurniawan and Sutcliffe's research that focuses on how the mental for the blind work, it serves as motivation for this research project to investigate further on the mental model for blind users. This is because some parts or components in that mental model are proven in helping the blind users during the computer interaction. Based on findings, most researchers currently acknowledge that visually

impired are able to process spatial data and participate in wayfinding tests. However, their performance varies and is in general poorer than sigted people.

CHAPTER 3

METHODOLOGY

This studies choose to use waterfall methodologies as the methology .The waterfall model is a popular version of the systems development life cycle model . Often considered the classic approach to the systems development life cycle, the waterfall model describes a development method that is linear and sequential. Waterfall development has distinct goals for each phase of development. Imagine a waterfall on the cliff of a steep mountain. Once the water has flowed over the edge of the cliff and has begun its journey down the side of the mountain, it cannot turn back. It is the same with waterfall development. Once a phase of development is completed, the development proceeds to the next phase and there is no turning back. Below are the processes involved in completing the study:

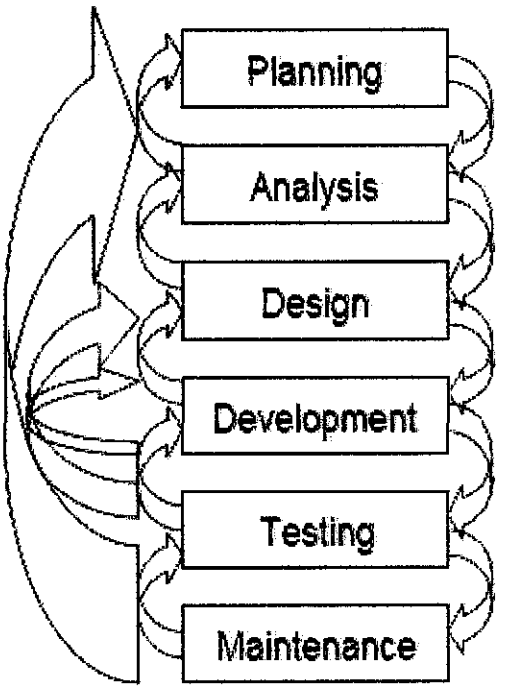


Figure 6 : Waterfall Methodology

Phase 1: Data Gathering -Interview and Survey

3.1 Interview

The first interview and observation have been conducted at the National Council Blind Malaysia (NCBM) in Jalan Samanthan, Kuala Lumpur. The interview session which takes place at NCBM conducted approximately for three hours. The objective of the interview was to get the general information on how blind users used tools to help them to undergoing their life, the technology they used and their general requirements on ideal systems from an expert in the domain. During the interview, probing 'what', 'how', 'why', and 'what if?' questions (Collins and Gentner 1987, Payne 1991, Shadbolt and Burton 1995) were asked at appropriate times before, during and after the observation in order to gain an insights into users' mental models. Blind users have being asked which tools they used in their daily life. This enabled the researcher to gain a degree of familiarity with the tools that might be used during the observation by blind users and hence allowed the researcher to concentrate on asking pertinent and appropriate questions during the observation, rather than to keep up with the actions of blind users. The second interview was carried on, on 1st July 2011 at Persatuan Orang Cacat Penglihatan Malaysia Cawangan Perak located at Medan Kidd, Ipoh. From the interview, a revised mental model will be proposed after collecting more information from the second visit. The feedback from one of the blind users there, called Wong that tried on the game that proposed will be used to identify on what improvement could be make to revise the new mental model. To this end, this project will demonstrate the proposed mental model for blind users to improve the usability during the interaction between blind users and computers. This study will highlight the importance of understanding the user's mental model especially the blind. In enhancing the proposed components for the mental model, there are several limitations that need to be addressed. There include the validity of the components proposed, and the relationship between the new and existing components. This will then lead towards testing the proposed mental model in terms of helping in addressing the usability problems and enable to help designer in designing better software for the blinds.

3.2 Key Milestone and Gant chart

No	Phase	January 2011				February				March				April				MAY			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Planning																				
2	Analysis																				
3	Design																				
4	Development																				
5	Testing																				
6	Maintenance																				

No	Phase	Jun-11				July				August				September				MAY			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	Planning																				
2	Analysis																				
3	Design																				
4	Development																				
5	Testing																				
6	Maintenance																				

CHAPTER 4

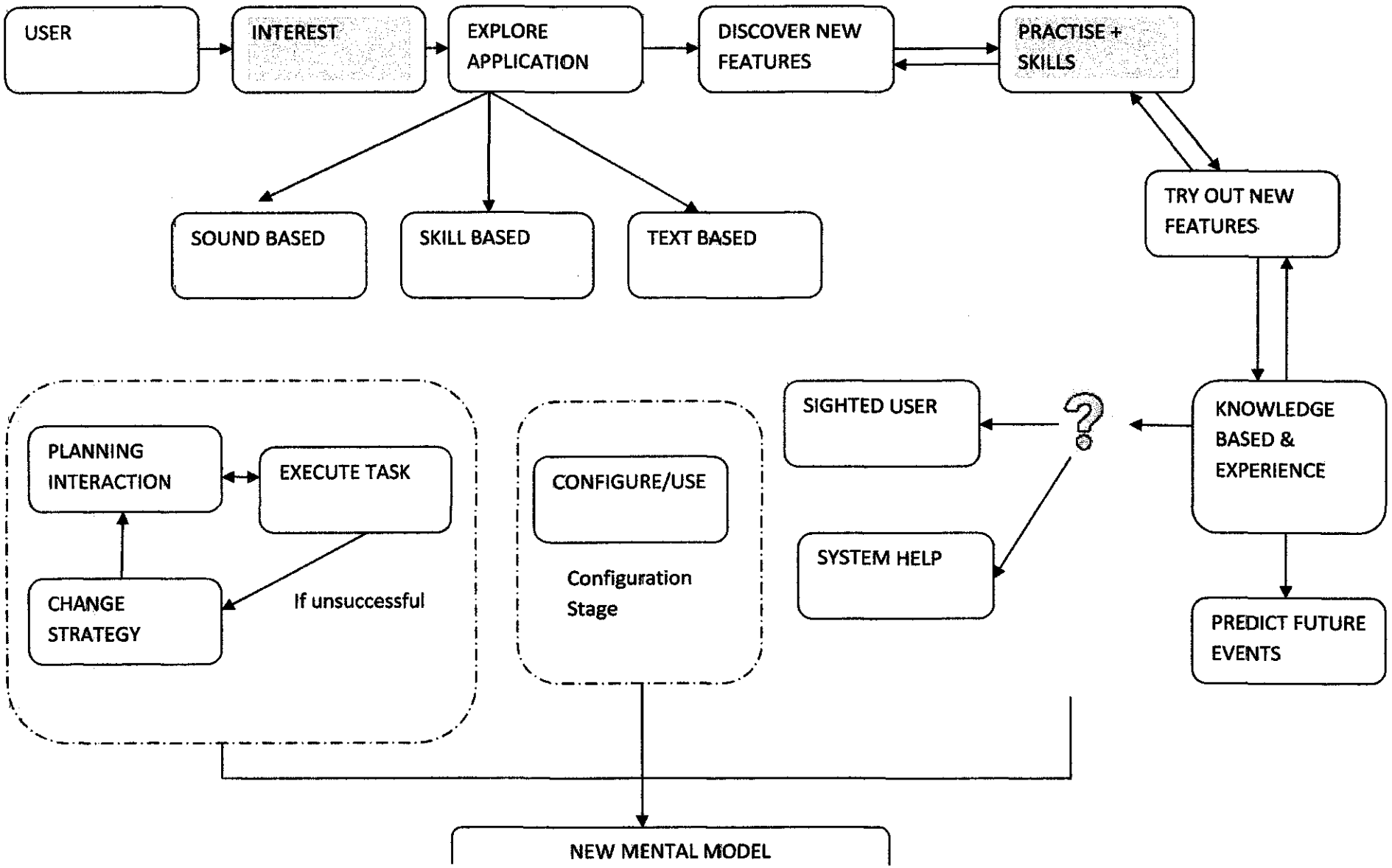
Result and discussion

Based on the second interview, most of the information is the same with the first interview located in NCBM except there is some important information that need took into consideration to revise the previous mental model. During the second interview, two important person that have being interviewed by me which is the blind athlete representative of Sukan Sukma Malaysia and the other one is blind users that expert in computers. Much information from sport game point of view and also computer games point of view. Thus, it helps a lot to differentiate mental model between sport games and computer games for blind users.

4.1 A Proposed Conceptual Mental Model for Blind Users

In processing an improved version of a mental model for the blind, each stage on first mental model that being proposed will be reviewed. Justifications for any improvements suggested are based on established guidelines and recommendations reported by others. It is envisaged that the model should be able to address the usability problem and able to help designer in designing better software for the target group. Below are comparison between first mental model and the revised mental model.

Revised structured based on previous proposed mental model.



4.2 Component of the Proposed Framework

Figure 3 (a) shows the Kurniawan & Sutcliffe's mental model of blind user in a new window environment. Its shows three main components in this model which are exploration, task action, and configuration. Based on study, we understand that only exploration and task action require further enhancement while configuration should remain the same. This happen because these two stages involve more on the users' interaction with the system. Besides that, the configuration stage is the last stage and is only performed once users are comfortable with the system.

1) Exploration

In figure 3 (a), five component are included which are explore desktop, explore applications, discover new features, help, try out new features and existing mental model. Users obtain an overview of a system in the exploration stage. There are eight additional component should be added in the exploration stage. They are:

Skill based :-

This is referring to the normal way of interacting with a system. This component places in Figure 3 (b) is suggested to be place during the exploration of an application. This is due to the interaction with a computer, the blinds will use their skill based on their past action and experience to explore the applications that are available on the desktop. In this case, the user acts as an expert user since he has some past skills. Thus, enable to identify any usability problems, overcoming the problems and move quickly to the next stage which is task action.

Text base :-

During explore application, besides skill based, text based is important for blind users as during the interview with blind users, they shows how they use and read text in the computer. Usually, text based used in reference to a computer application and whose primary input and output are based on text rather than graphics or sound. This does not mean that text based do not have graphics or sound, just that the graphics or sound are secondary to the text. In this case, users can listen to the software that translates the text in computer in order to predict what to do for the next actions.

Sound based :-

One more element in the exploration stage is sound based. It is possible to create sound based interactive entertainment, such as computer games, that is accessible to visually impaired computer users. While most new computer games feature high quality sound effects, and sometimes even advances interactive soundtracks, they usually still rely on graphics to present most of the information. Mainstream computer games are generally graphics-oriented, with sounds added mainly as decorative effects. Therefore, they are most often inaccessible to visually impaired computer users. However, there are alternative ways in which computer games can be created. If approaching design the design from a position where sounds is the central medium and graphics, when present, are added to complement the sounds, it is possible create games that are offers new, innovative challenges.

Knowledge Based:-

This is referring to the conclusion and analytic process that occur when users faced with problem and unexpected situations. The positioning of this component is chosen as Figure 3 (b) shown in because in the presence of the problems, knowledge based is important as users will try out new features based on their existing knowledge and the existing mental model.

Predict Future event :-

Proven from Kenneth Craick definition for mental model, the mental model itself can help users to predict future event. Thus, in the mental model there should be included the component where users will predict the future event while trying out the new features.

Domain experts:-

In this case, the domain expert is the blind users. In HCI, designing technology user with disability is such a challenging task. So, there is a need to get the domain expert to be involved in the design phase as domain expert really known on what their needs and understanding.

Sighted users :-

This is referring to users others than the blinds. The involvement of the sighted users is important when blind users are trying to get help when they encounter problems during the interaction with new features.

arniawan & Sutcliffe's Mental Model for nd User

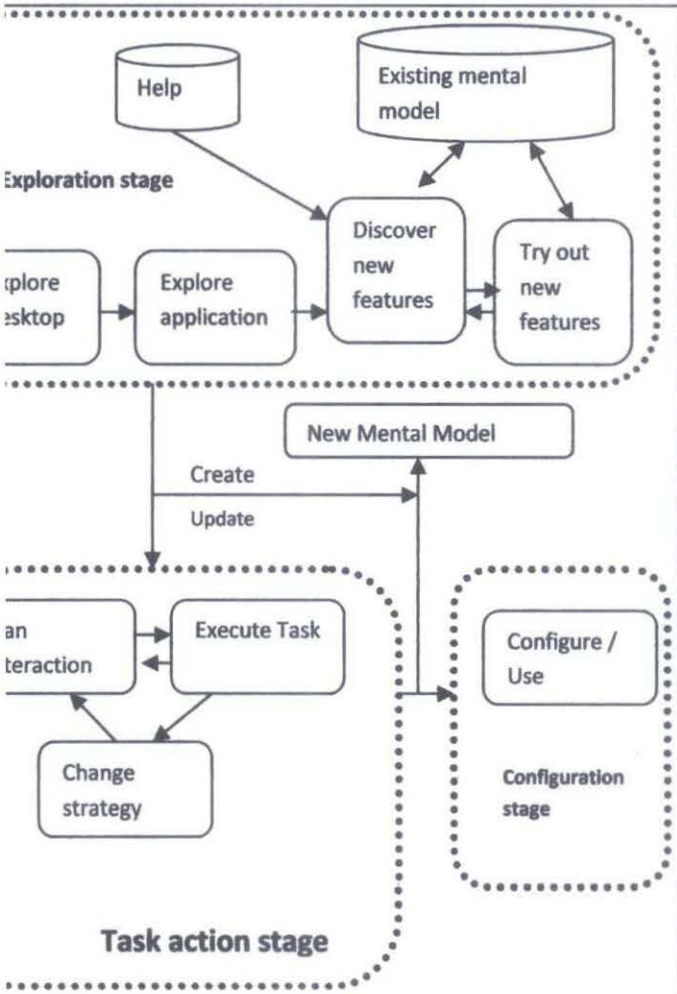


Figure 3 (a)

A Proposed Conceptual Model

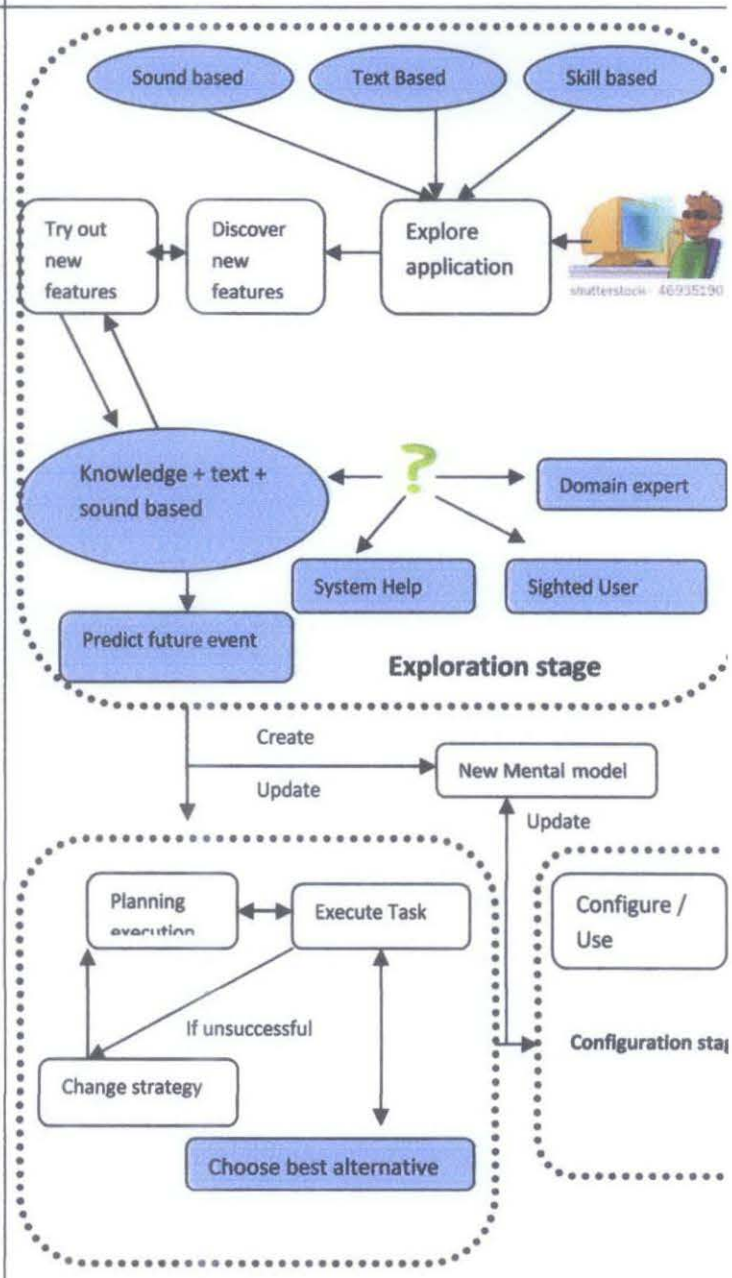


Figure 3 (b)

System Help :-

This is referring to the help that the application provided. Usually, when blind users had encountered problems during interaction, system help could be one of their choices. Although it may not help a lot, but in a certain condition, the System Help could be better solutions as compared to the help for sighted users.

2) Task action

After users explored and get overview of the system that they interact with, they will proceed to the task action stage. In Figure 3 (a), task action stage has 3 components which are plan interaction, execute task and change strategy. In this stage, it is proposed to add one component which is select best alternative like show in figure 3 (b).

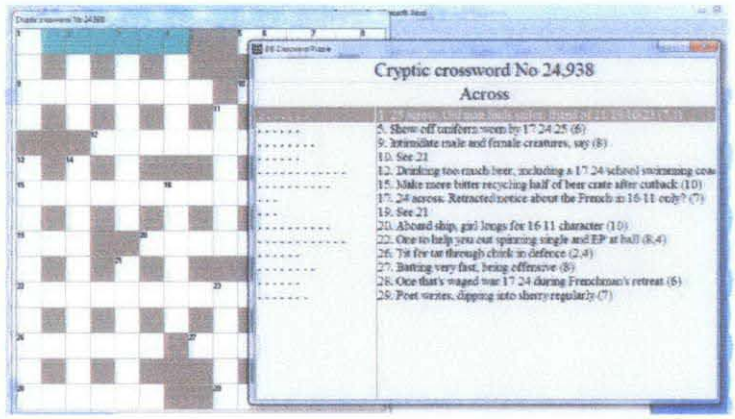
Select best alternative:-

On the proposed conceptual mental model, this component is executed together with the execute task. These two components should come together as users will select the best alternative during the execution of the task.

4.3 Component of the Revised Mental Model

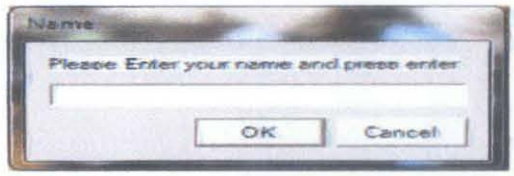
Overall of the revised mental model is the same with the previous one proposed but only certain attribute added based on the information collected during second interview. Interest will be added to the new mental model, as blind users also same like normal people, which is when do something, it's come from your interest either to continue play it again or not. As Wong, the blind users that testing our proposed game on the interview, he said after a blind users discover new features while playing at first time, practice plus skills is common things they do in order to continue playing it again. Skill that they have before this plus practice by themselves can help them to play the computer games without helping from normal people.

Snapshot for the first game (Crossword Puzzle)



This is the first game that proposed to support the conceptual mental model. This game has being testing by one of the blind users during the second interview in order to support all the attributes in the conceptual mental model proposed. Somehow, Jeff Wong, the blind users guy that testing the games make some comments to be improve for the future work. One the weak point that being raised by Jeff Wong is, if this game is for blind users, why developer needs to include the element of visual as the blind users can't see. Besides that, the games is too complicated to blind users as blind users need to enter a lot of keys to start and during playing the games.

Second Games (Super Egg Hunt)



This is Super Egg Hunt Game that proposed to be the future work to support the revised mental model. All the features of this game already presented to Jeff Wong, the blind users guy that tested the crossword puzzle. He supports to do this game as it follow all the attribute in the revised mental model proposed. There are certain strategies that have been identied in doing the futre work whre blind users can employ a variety of different navigation strategies or reading patterns, and these strategies should be well supported by the mental model.

- Play – The most basic pattern start voice output from the current cursor position. Once started, information is pushed to the user in a pre-defined speed until stopped.
- Read – When using a Braille line, the user can control how fast they want to read text (pull).
- Skip-all-links – concept that is built in into modern screen readers Global reading patterns are those pattern that characterize the principal approach of how to navigate through game.
- Text-search – Full text search is very important to blind users, and they often try ti guess words that could appear close to the relevant content they are looking for.

- Stream-oriented – Based on observation that blind users and a stream or string oriented navigation often liberating, because it need less mental model for one dimensional information is a string of text, and this study use this representation when blind users read a book or listen to the news on the radio.
- List oriented – Most current screen readers follow the paradigm.

CHAPTER 5
CONCLUSION

Conclusion and future work

In conclusion, this project has progress update, revised the structured of mental model based on the previous proposed mental model for the blinds .This study highlighted the importance of understanding the users' mental model especially the blind. This study also showed that although users had already posses a mental model but a mismatch between the existing mental models with the new system application would create a problem for users.

In enhancing the proposed components for the mental model, there are several limitations that need to be addressed. There include the validity of the components proposed, and the relationship between the new and existing components. This will then lead towards testing proposed mental model by developing simple games to testing the mental model.

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Appendics

Pictures taken during second interview

Picture 1

Picture 2

Picture 3

Picture 4