

A Study of Accessible Game Applications on Smartphone for Visually-Impaired Users

Pisit Prougestaporn¹

Siam Technology College, Thailand

¹pisit1979@hotmail.com

and Nutsiri Kidkul²

Braille Institute of America, USA

²myearthworld@gmail.com

Abstract - In recent year, Mobile phone has become an important communication tool for daily living of people worldwide, and most of the mobile phones currently were addressed as 'smartphone'. Due to these such kind of phones offered more advanced computing power and connectivity than an old contemporary style of mobile phone. Smartphones therefore have been repositioned as a new information medium and become a popular tool among people worldwide. Smartphone currently has become not only a primary technology device for general people, but they have been widely used by visually-impaired people. Visually-impaired users could use their smartphone based on their own individual preference such as to download applications that meet their need. But, the key important thing to use smartphone applications like to use internet websites for visually-impaired user was they must first ensure that all applications they need to download were fully accessible for them especially game applications. However there was a prominent lack of research on smart phone accessibility for such people. Also, there were lack of research studies and academic papers presented about accessible smart phone applications for visually-impaired people especially the concept and overview of accessible game applications on smartphone for visually-impaired users. This paper therefore proposed to review the overall concepts and types of accessible game applications on smartphone for visually-impaired Users.

Keywords - Smartphone, Visually-Impaired People, Smartphone Applications, Game Applications, Accessible Game Applications

I. INTRODUCTION

In recent year, Mobile phone has become an important communication tool for daily living of people worldwide.

Several consumer researches have shown that Some areas of the world have enjoyed rapid deployment and high penetration of mobile devices. It is estimated that around 70% of the world's population own at least one mobile phone. Based on the statistics according to Union I.T. (2011), children in United States now are more likely to own a mobile phone than a book, with 85% of kids owning a phone while only 73% owning books.

May et Al. (2005), Most of the mobile phones currently were addressed as 'smartphone', due to these such kind of phones offered more advanced computing power and connectivity than an old contemporary style of mobile phone.

Along with the smartphone fundamental capabilities to make voice call, video call, short/multimedia messages, smartphones therefore have been repositioned as a new information medium (May et al., 2005).

Currently, smart phone usage is common among people of almost all the ages and the emergence of smart phones and devices have

very much influence in their daily activities (Sultan et al., 2015). And according to Kim (2009), there has been increasing number of people who pursue new life style of working, communicating, and playing games through smartphone. In a 2011 study conducted jointly by Google and Ipsos Media CT Germany presented in Union I.T. (2011), via random telephone interviews from amongst the general populations of the United States, United Kingdom, Germany, France, and Japan found that the highest number of smartphone ownership was in the United Kingdom equal to 45%, followed by the United States equal to 38%. The research also clearly implied that there was a shift in usage from computers to mobile devices.

Meanwhile for Thailand according to Prammanee (2015), the number of internet users in the country approached to 30 million people in year 2016 from around only 4.8 million users in year 2002, while there were approximate 85 million mobile phones used in the country, with this number, 48% were smartphones.

For smartphone generally according to Osman et al., (2012), in addition to information processing functionalities such as managing personal time schedule, accessing Internet contents, editing documents, utilizing location-awareness function, the key differentiation function that makes smartphone differed from old style of mobile phone was users could enjoy with wide variety of applications or called as “apps” in short term like news, musics, games, and etc. which users could independently download from various operators.

Xuet al. (2011), Smartphone users were increasingly shifting to using apps as “gateways” to Internet services rather than traditional web browsers.

Applications marketplaces for 3 major holders include iOS, Android, and Windows Phone platforms have made it attractive for developers to deploy apps and easy for users to discover and start using many network-

enabled apps quickly (Xu et al., 2011). In addition, the proliferation of being developed applications could only be expected to continue as smartphone usage grows globally. And, the growth in mobile apps has shown no signs of slowing, with as many as 15,000 new applications being released each week (Freierman, 2011).

And among those various kind of applications released, game application was one of the most population application type downloaded by smartphone users.

Currently, there were several type of game applications available in the market.

According to Rakestra et al. (2013), smartphones have become commonplace and literally hundreds of low priced games with high-quality graphics were available, mobile gaming has become very different due to Apple’s iOS and Google’s open-source Android operating systems were capable of running some of the most innovative games in the market. So such game applications were popular among the smartphone users worldwide.

In the meantime, Smartphone currently has become not only a primary technology device for general people, but smartphone has been widely used by visually-impaired people also. General people simply enjoy with a highly visual touch-sensitive display with many small icons and labels on smartphone, but for visually-impaired users, they could simply use touch, motion, screen magnification and voice instead of or in addition to vision-based operations. Visually-impaired users could use their smartphone based on their own individual preference such as to download applications that meet their need. But, the key important thing to use smartphone applications like to use internet websites for visually-impaired user was they must first ensure that all applications they need to download were fully accessible for them especially game applications.

As presented above, smart phones were become ubiquitous in this globalization era and

were popular to use among worldwide population both sighted and visually-impaired users. While according to Sultan et al. (2015), there were a number of recent studies focused on web accessibility for visually-impaired users and tried to address problems faced by visually-impaired users as well as proposed the key guidelines and evaluation concepts to generate accessible websites for visually-impaired people, but however there was a prominent lack of research on smart phone accessibility for such people. Also, there were lack of research studies and academic papers presented about accessible smart phone applications for visually-impaired people especially the concept and overview of accessible game applications on smartphone for visually-impaired users. This paper therefore proposed to review the overall concepts and types of accessible game applications on smartphone for visually-impaired Users. The paper would begin with the definitions of visually-impaired people and general background of smartphone, then followed by overview of smartphone applications and game applications of smartphone, the overall concepts and types of game applications on smartphone for visually-impaired users, and end with conclusion and further study.

II. VISUALLY-IMPAIRED PEOPLE

Various definitions regarding the term “Visual impairment” are identified from several sources. According to Beverley, Bath, and Barber (2007), numerous formal definitions of visual impairment issued worldwide, and all definitions cover a broad spectrum ranging from people who are partially sighted to people who are completely blind. The World Health Organization defined the visually-impaired people as any person who has visual acuity of less than 6/120 [$<20/400$]. According to Jernigan (2002) meanwhile, the legal definition of visually impaired people was those who have visual acuity of not greater than 20/200 in the better eye with correction or a field not subtending an angle greater than 20 degrees.

III. SMARTPHONE

There are several sources have defined the term “Smartphone”, and most of them were similarly conveyed as: A smartphone is a mobile phone with an advanced mobile operating system which combined features of a personal computer operating system with other features useful for mobile or handheld use. In addition to communications functions of a regular mobile phone, smartphones integrated Internet access, maps and location services, calendar and time functions, camera and video recording, and support for running a variety of useful software applications. According to May and Hearn (2005), most of the mobile phones currently addressed as ‘smartphone’, as they offer more advanced computing power and connectivity than a contemporary mobile phone. Along with the smartphone fundamental capabilities to make voice call, video call, short messages, and multimedia messages, smartphones have been repositioned as a new information medium (May and Hearn, 2005). On other words, smartphones have extended List of information processing functionalities such as managing personal time schedule, accessing Internet contents, editing documents, utilizing location-awareness function, and many other exciting applications (Osman, et al., 2012).

According to Coustan & Strickland, n.d. (2012), Smartphones have far greater functionality than normal mobile phones due to their ability to run mobile applications, such applications like to send and receive e-mail, play music, movies, and video games, and even to communicate remotely with computers from virtually anywhere in the world.

Smartphones generally contained various similar components to personal computers. Every smartphone has a processor, random access memory stick(s), USB ports, display adapters, and internal storage devices. Users may even customize and upgrade their devices to suit their individual needs. Smartphones also equipped with a touchscreen to use on the keyboard, together with USB peripherals such as audio headphones and data transfer cables

also available for smartphones (Coustan & Strickland, n.d.), 2012).

IV. SMARTPHONE APPLICATIONS

Application was an abbreviated form of the term “application program” which referred as the designed program to perform specific function towards users or other application program (Park et al., 2009). Meanwhile according to Lee et al. (2012), mobile application was an application program which was being used in mobile phone under mobile environment or being materialized in portable personal digital assistant, then smartphone application referred to the program which has been designed to be operated in smartphone and it could be installed by downloading in specific application sales Outlet. People generally called mobile applications as mobile apps or apps.

According to Rakestraw et al. (2013), the mobile applications industry began with Apple’s introduction of the iPhone, then the phenomenal of applications market continuously grown due to the entry of several competitors into the marketplace, notably Motorola, LG, and Samsung. This competition has given rise to an entirely new product space known as smartphones.

Lee et al. (2012), As mobile contents making environments constituted where anyone can develop application freely, the number of application registration case has been abruptly increased that accumulated registration case in Appstore in Apple increased from around 50,000 cases in March 2009 to accumulated registration case 260,000 during September 2010 with increased rate around 20 times, while the number of accumulated registration case in Google Android Market also increased from around 4,900 cases during March 2009 to the figure 98,000 cases during September 2010 with increase rate around 20 times. And according to data sourced from App store and google android market During the period from February 2010 to February 2011, on an average around 20,000 and 18,000

applications were registered in apps store and google android respectively (Lee et al., 2012). In general, the growth in mobile application market has shown no signs of slowing, with as many as 15,000 new applications being released each week (Frierman, 2011).

Furthermore, Rakestraw et al. (2013) stated that software developers are increasingly realizing that in the near future smartphones could replace many core functions of personal computers, such as e-mailing, instant messaging, web browsing, and even gaming. This could be implied that Smartphone Mobile Applications would soon Overtake Standard Websites in Near Future.

Previously, mobile phone contained general basic applications include phone call software, text messaging, menu screens, calendars, and more. But after smartphone were introduced into the market, mobile application was software that a user can install on a smartphone to perform a particular task. For example: Android has a GPS app which allowed the user to obtain travel directions in real time, or even track the locations of family members from anywhere in the country (Coustan & Strickland, n.d., 2012). Also for apple side, they ifind my friend apps to track specific family members or friends who use iPhone also, together with the communication apps like facetime or Imessage.

Due to the demand for mobile applications increase with the growth in smartphone device usage, currently, consumers enabled to choose various applications from store providers include the Android Market, the iTunes App Store, Nokia Ovi Store, Blackberry App World, Samsung Apps, and Windows Phone Marketplace. Smartphone have grown popular because they were designed for various purposes to meet specific need of users, from entertainment and education, to practical use. Lee et al. (2012), smartphone applications could be categorized into practical applications and entertainment applications. Meanwhile, apple app store has classified their available applications into 11 categories and google android divided into 27 types of application.

But in general, smartphone applications could be classified into seven main types include Games, Entertainment, Social Networking, Travel, Productivity/Education, Utilities, and Weather.

V. GAME APPLICATIONS ON SMARTPHONE

According to Nielsen research (2014), Consumers were spending more time with applications on smartphone than ever before. Over the past half-decade, the proliferation of mobile devices has transformed people into an app-driven society, presenting marketers with new opportunities to connect with consumers by creating more interesting and sophisticated apps to command their attention. And when looking at the types of apps that have been competing for mobile users' attention spans, social networking apps still rule, as people spent nearly 11 hours per month, on average, accessing these apps. Meanwhile, Entertainment viewing, including video, audio, and gaming apps, grew 71 percent among mobile users over the prior year (Nielsen research, 2014). This data implied that game apps were among top mobile applications people spending on.

However before entering into the smartphone era according to Rakestraw et al. (2013), mobile gaming for most users occurred on handheld devices such as a Nintendo DS or Sony PSP. But currently smartphones have become commonplace and literally hundreds of low priced games with high-quality graphics available for users to select, mobile gaming therefore has changed since the introduction of smartphone into the world. Apple's iOS and Google's open-source Android operating systems had high capacity of running some of the most innovative games in the market. As a result Nintendo's and Sony's handheld devices were quickly losing ground to smartphones.

Rakestraw et al. (2013) further stated that In 2009, the Nintendo DS accounted for 70% of revenue generated by portable gaming software in the United States, with the iOS and

Android at 19% and the Sony PSP at 11%, but by 2011, the Nintendo DS fell to 36% while iOS and Android claimed 58% of the revenues from portable gaming software. And according to Newzoo (2015), the game apps in smartphones sold through iOS and Android generated \$6 billion in year 2015.

Currently, there are several independent game operators who could create their own unique games with attractive design in several types and styles and push into the market via application stores mainly app store for iOS and google play for Android. Since there were several styles and types of game applications on smartphone available for users to select based on their own preference, application stores have classified game apps into several categories. For app store, game apps were categorized into Action, adventure, arcade, board, card, casino, dice, educational, family, music, puzzle, Racing, role- playing, Sport, simulation, strategy, trivia, and word game. While for google play, there were little different categories provided as there were no dice and educational game, but instead, there was Casual, and other remaining categories were similar to app store.

VI. GAME APPLICATIONS FOR VISUALLY-IMPAIRED USERS

Currently, It is widely accepted that smart phone usage was common among people of almost all the ages and the emergence of smart phones have very much influence for their own daily activities, due to there were tons of smartphone applications available for users to download to fulfill their personal style and preference in addition to basic applications given. There were various application categories available to download, but one of the most popular category among the smartphone users is game application.

But similar to such ordinary people, smartphone usage are necessary for visually-impaired people to support their daily living, as there were several smartphone applications they need to use as well. However although technology is increasing its potential level

which lead to resolve various inaccessibility issues for visually-impaired people like in the context of smartphone that several smartphone application developers closely concern and try to eliminate inaccessibility issues on their applications, there are several smartphone applications especially game applications still inaccessibility for visually-impaired users.

According to Javier and Roca de Togores (2012), even though the developers specially cared about the accessibility issues for visually impaired and tried not to violate the design principles within accessibility issues, but they were not completely successful in providing the friendly interaction for visually-impaired users. Many researchers have worked on accessibility issues arose in smart phones applications e.g. (Robest, 2013); (Brandenburg, 2013); and (Kane and Wobbrock, 2011), but there was a still lack of studies related to inaccessibility smartphone application especially for game applications.

This section therefore would explain the general concept of accessible game applications on smartphone for visually-impaired users and types of game application for visually-impaired user.

A. Accessible Concept for Game Applications

In general, there is accessibility guidelines to create accessibility website for visually-impaired users proposed by world wide web Consortium or W3C (2005), which were categorized into WCAG or web content accessibility guidelines to create accessibility web content, UAAG or user agent accessibility guidelines to create accessibility web browsers as well as to support the assistive technology to access website, and ATAG or authoring tools accessibility guidelines to apply accessibility authoring tools to compose accessibility website for visually-impaired users (Prougestaporn, 2010). But, there were lack of studies specifically proposed about accessibility guidelines to develop accessibility smartphone applications to support visually-impaired users. According to Sultan et al. (2015), Number of recent studies focused on web accessibility for visually-

impaired users and already addressed problems faced by the visually impaired people to use websites, but there was a prominent lack of research on smart phone accessibility for such people.

But however, Sultan et al. (2015) applied the Nielson's design as the basic evaluation measurements for developing accessible smartphone applications to support visually-impaired users. As this study proposed to review the accessible game applications on smartphone for visually-impaired users, this study therefore would apply the nielson's design to focus on the concept of accessible smartphone applications for visually-impaired users on the context of game application as follows:

1. Heuristics Evaluation: Game application developers should concern to design the apps to provide feedback on moving finger in all directions of the screen. The feedback in this context refer to voice message which visually-impaired users can simply listen and understand. In addition, when the users press or select in which functions or options, the application must read out to the users that tspecific function or option was selected. The application should compose with the words, sentences, or phrases that easily understand and interpret.

2. User Control and Freedom: Game application developers should design their applications to provide home button or specific function which user could locate easily for emergency exit.

3. Consistency and Standard: Game application developers should design their game apps to be consistence with the app/software that the visually-impaired user already used and up to the standards so that users would not get frustrated. It mainly focused on reader software, which mean that all accessible game applications for visually-impaired users must effectively run with voice program on users' device.

4. Help User Diagnose: Game application

developers should design their game apps to allow users enable to diagnose what they press or what they select by providing voice to read after they press selection on the game function.

5. Flexibility and Efficiency of Use: Game applications developers should design the apps by avoiding to show empty spaces on the game page, but instead to make application efficient by giving feedback on moving finger at every point via reader function as well as enable the visually-impaired user to select the one which the user wants in order to reduce errors or clicks. Also, the game application developers should design game apps to support visually-impaired users to use mobile gesture or own gesture to play game.

6. Help and Document: Game applications Developer should provide document explanation about how the application was used, so that visually-impaired users could easily interpret and understand how to play. The document should be provided on the specific separate page inside the game apps. Also, the game apps maybe designed to allow users enable switching to explanation page while playing game. In addition, the developers may design the main explanation documented on text and further explanation through voice message inside the game page.

In addition to the measurements based on the nielson's design presented above, game applications developers must rely on following conditions in order to develop accessible game applications on smartphone for visually-impaired users:

First, all game applications must support with reader software applications used by visually-impaired users, or either the game itself must provide own voice function to support visually-impaired users.

Second, even the game designed to have beautiful graphic to support sighted users, it should provide text explanation for visually-impaired to interpret or provide voice function to explain the game content so that visually-impaired users could easily understand.

Third, all game applications must designed to support touch screen system that visually-impaired users used on their smartphone.

Fourth, in case the game applications designed to use color as the key function to notify the users or use color as the key function for users to select the specific option, the developers must provide symble or letter to notify visually-impaired users to interpret as well.

B. Types of Game Applications for Visually-Impaired Users

Basically, there are various game applications in different categories that visually-impaired users can access to play, but all accessible game applications for visually-impaired users must be played along with voice function and enabled to play by using ears and hand gesture rather than focusing on eyes gesture. There are several types of accessible game applications on smartphone for visually-impaired users depend on conditions to consider. For example: To consider based on voice function supported, there are two types of accessible game apps as follows:

First, game apps with own voice function to support players. In this type of game, when the users open, the voice function would automatically work to guide the users. Some games required users to turn off voice software on smartphones first such as Audio archery, archery for your ears by LWorks, Papa Sangre game, and Sixthsence the Zombie. But some games no need to turn off voice software used in smartphone first such as several games from Kid friendly software Inc like blindfold space, blindfold bingo, blindfold dominoes, and blindfold horserace.

However, some games required users to use headphone while playing in case those games required ear gesture as the important part to complete the game.

Second, game apps without voice function to support but all players could use voice program available in their smartphone to play.

This type of game such as Naval combat lite by Jonas Eckhardt, tobiasmuehlbauer, and wolfrodeiger GBR, hangman, English vocaburaries by jamsoft, and quizoid, the quiz game by Richard raue. However some games in this type also provide sound function to fulfill the game admosphere while playing such as cheering voice or ding voice to symbolize the playing result or command selected to play such as Tic Tac Toe game.

Then to consider based on graphical design, it could be also classified into two types as follows:

First, game apps without graphical design. For this type of game, all players enable to rely only on voice function to tell. This type of game normally designed to fully support visually-impaired users and generally provide own voice function to support players. Game applications in this type such as all games from kid friendly software Inc.

Second, game apps with graphical design. This type of game provide graphical function for players to view while playing, and enable to work with voice function available on smartphone. In addition to use eye gesture, this type of game were designed to support visually-impaired users to use hands and ears gesture to play. This type of game normally design to support sited and visually-impaired users to play equally without causing any interruption. The game apps in this type such as FC pro by underground creative ltd. And Tic Tac Toe.

VII. CONCLUSION

This paper finally could be concluded that the key important thing to use smartphone applications like to use internet websites for visually-impaired user was they must first ensure that all applications they need to download were fully accessible for them especially game applications. And to create accessible game applications on smartphone for visually-impaired users, the nielson's design could be applied to rely on for creating accessible game applications for visually-

impaired users include Heuristics Evaluation, User Control and freedom, Consistency and Standard, Help user diagnose, Flexibility and Efficiency of Use, and Help and Document. However the key important concept to create accessible game applications for visually-impaired users were all game applications must provide voice function or enable to work with voice software in the smartphones, to support touch screen function, and to allow users to use ears and hands gesture to play.

VIII. SUGGESTION FOR FURTHER STUDY

As this study has reviewed the background and overall trend of smartphone applications particularly in the field of game applications together with concepts and types of accessible game applications on smartphone for visually-impaired users, three possible studies related to visually-impaired people with smartphone applications using could be proposed in the future by relying on the data from this paper are:

First, to study general behavior of visually-impaired people toward smartphone using in terms of activities they done, types of applications they prefer to use, and opinion toward accessible applications available.

Second, to study the effectiveness and efficiency of smartphone applications that fully accessible designed for visually-impaired users. And third, to study and propose the key index or standard measurements of accessible smartphone applications in all categories.

REFERENCES

(Arranged in the order of citation in the same fashion as the case of Footnotes.)

- [1] Beverley, C., Bath, P., and Barber, R. (2007). "Can two established information models explain the information behavior of visually impaired people seeking health and social care information?". *Journal of Documentation*, 63(1), pp. 9-32.

- [2] Brandenburg, C. (2013). "Mobile computing technology and aphasia: An integrated review of accessibility and potential uses". *Aphasiology* 27(4). pp. 444-461.
- [3] Coustan, D. and Strickland, J. (2012). "How Smartphones Work - How Stuff Works". <<http://electronics.howstuffworks.com/smartphone.htm>>. Accessed 31 July 2016.
- [4] Freierman, S. (2011). "One million mobile apps, and counting at a fast pace". *The New York Times*. <http://www.nytimes.com/2011/12/12/technology/one-million-apps-and-counting.html?_r=0>. Accessed 10 May 2016.
- [5] Javier, S. and Roca de Togores, J. (2012). "Designing Mobile Apps for Visually Impaired and Blind Users".
- [6] ACHI. (2012). "The Fifth International Conference on Advances in Computer-Human Interactions".
- [7] Jernigan, K. (2002). "A Definition of Blindness". National Federation for the Blind. <<http://www.nfb.org>>. Accessed 11 August 2015.
- [8] Kane, S.J. and Wobbrock, J. (2011). "Fully Accessible Touch Screens for the Blind and Visually Impaired". University of Washington.
- [9] Kim, J.T. (2009). "The readiness and prospect of 2009 IT industry". *Journal of Local Informatization*, 54. pp. 84-91.
- [10] Lee, H.S., Kim, T.G., and Choi, J.Y. (2012). "A Study on the Factors Affecting Smart Phone Application Acceptance". *International Proceedings of Economics Development & Research*.
- [11] H. and Hearn, G. (2005). "The mobile phone as media". *International Journal of Cultural Studies*, 8(2). pp. 195-211. <<https://newzoo.com/insights/trend-reports/>>. Accessed 3 September 2016.
- [12] Nielsen Research. (2014). "Smartphones: So Many Apps, so much time, Media and entertainment". <<http://www.nielsen.com/.../so-many-apps-so-much-more-time-for-entertainment>>.
- [13] Osman, M.A., Talib, A.Z., Sanusi, Z.A., Shiang-Yen, T., and Alwi, A.S. (2012). "A Study of the Trend of Smartphone and its Usage Behavior in Malaysia". *International Journal on New Computer Architectures and Their Applications*, 2(1). pp. 275-286.
- [14] Park, J.S., Han, P., and Kang, B.G. (2009). "A study on the acceptance for mobile applications (App Store)". *The Korea Society of Management information Systems*. pp. 160-164.
- [15] Prammanee, S. (2015). "Live Digital, Live More: Thailand ICT Business Landscape and Digital Trend 2016". 2015 International Conference of Telecommunication Society, Seoul, Korea.
- [16] Prougestaporn, P. (2010). "Development of a Web Accessibility Model for Visually-Impaired Students on E-Learning Websites". 2010 International Conference on Educational Network and Technology, Qing Huang Dao, China.
- [17] Rakestraw, T.L., Eunni, R.V., and Kasugani, R.R. (2013). "The mobile Apps Industry: A Case study". *Journal of Business Cases and Applications*, pp. 9.
- [18] Robest, Y. (2013). "VisionTouch Phone for the Blind". *The Malaysian journal of medical sciences: MJMS* 20(5).
- [19] Sultan, N., Siddiq, K., Rashid, T., and Farooque, M. (2015). "Evaluation of Smart Phone Applications Accessibility for Blind Users". *International Journal of Computer Applications*, 127(3).
- [20] Union, I.T. (2011). "Global ICT Developments". <<http://www.itu.int/ITU-D/ict/statistics/ict/index.html>>. Accessed 10 April 2016.
- [21] W3C. (2005). "Essential components of web accessibility". <<http://www.w3.org/WAI/intro/components.php>>. Accessed May 2008.
- [22] Xu, Q., Erman, J., Mao, Z.M., Pang, J., and Venkataraman, S. (2011). "Identifying Diverse Usage Behaviors of Smartphone Apps". *Proceedings of the 2011 ACM SIGCOMM conference on Internet Measurement Conference*. pp. 329-344.