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# The Games Design Accesbility For Gamer With Neurological Disorder

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***Abstract***

Computer games have emerged in the past decade as potential media beyond entertainment. Despite its popularity, game accessibility remains a major concern of various researchers. Children population with motor disabilities is a potential target for developing entertainment or therapeutic support games due to their interest to play. This paper presents: (1) a framework for mobile games for children with motor disability using simple hand postures and (2) xgboost decision tree as a hand posture recognizer (98.48 percent training accuracy and 96.76 percent testing accuracy) as a prototype of hand posture-based commands as assistive technology to interact with games.

***Keywords— game accessibility, motor disability, hand motion, xgboost.***

## I. Introduction

Computer games was defined as “a game that is played on a computer” [1] or “a game that you play on a computer or on a small portable piece of electronic equipment,” [2]. In simple words, mobile games are computer games designed to run on mobile devices such as smartphones. In the past decade, computer games become ubiquitous. The advent of mobile phone technology has become an enabler of fast growing game industries that reached revenue $ 94.4 billion or 87% of the world market [3].

Despite a plethora of games developed by a vast number of game producers in the past decade; to the best of our knowledge, only a few games specially designed for peoples with limiting condition or disables as their target segment. On the other hand, the size of this segment is large enough that becomes a huge opportunity for game industry to jump in. For example, in Indonesia, according to the report of Ministry of Health in 2014 the number of people with disabilities with aged 0-59 years was around 67.7 million [4]. Whilst, the total number of disables worldwide is about 15% of the total population [4]. Despite this large opportunity for game industry, designing game for peoples with limiting conditions remains a difficult problem. One of the remaining challenges but also becomes a research gap in game research domain is game accessibility.

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Accessibility in game context can be defined as “the ability to play a game even when functioning under limiting conditions.” [7]. The study by [8] concluded the limiting conditions that affect person’s ability to play a game are mainly: visual, hearing, motor, and cognitive impairments. Motor impairment, in particular, is a loss or limitation of function in muscle control or a limitation in mobility [7].

In the past decade, game accessibility has gained wide attention from various research communities. The study by [7], for example, concluded that game accessibility is a very important aspect of game design due to legal, financial, ethical, and medical reasons. In addition, game accessibility also opened up new opportunities to expand the game product lines to the market. One of opportunities related to the game accessibility is positioning of games as assistive technology.

Assistive technology is a term borrowed from medical therapy world refers to any products or services that improve the functioning of peoples with disabilities. Many studies showed some evidences that participating or engaging in playing game can be instrumental to enhance effectiveness of particular medical therapy to people with motor disabilities [9].

This research aims to reduce a research gap in game accessibility by proposing a design framework for developing mobile game to assist children with motor disabilities to interact with games they like. Another contribution of this study is proposing a game user interface that adopts machine learning technology to facilitate access of children with motor disabilities using simple interaction such as hand postures.

The remaining of this paper is organized as follows. Chapter 2 will explain related works. Chapter 3 will describe research method followed by results and discussion in chapter 4. Finally, chapter 5 will conclude this paper.

## II. RELATED WORK

### A. *Reason to Provide Game Accessibility*

According to the International Game Developers Association (IGDA) report in 2004, the main reasons for provisioning game accessibility are as follows [7]. First, improving user satisfaction: the main motivation of gamers to play games is to seek enjoyment. However, limiting physical condition of the gamers will hinder achievement in playing games. Second, reach out larger game player potentials: in most countries, there are some percentages of population categorized as disables among those need games for entertainment as well as therapy support. This segment is an important niche market for game industry. Third, compliance with regulation: In many countries likes USA, there are regulations about product accessibility including games for the disabled. Fourth, the facilitating learning new skills: by practicing body part (muscle and joints) movements, disable people will get benefit to learn new skills or therapeutic benefits. Finally, facilitating game based learning, for example games to helps people develop social skills through gameplay.

### B. *Game Access for Motor Disabilities*

IGDA [7] concluded that the main conditions which limit a person capability to play games were: vision, hearing, mobility, and cognitive issues. Mobility limitation, in particular, can be categorized further into: (1) paralysis, (2) neurological disorders, (3) repetitive stress injury, (4) age related issues, (5) lack of mobility, and (6) lack of steadiness. In the effect to game playing, each limitation is summarized in Table 1.

The “mobility” term has been widely used in many contexts with various meanings. In the past ten years, the advent of games and mobile phone technology associated this term with hardware of cellular mobile and portable gaming devices [10]. Different meaning adopted in medical context in which mobility is associated to the way human move arms, legs, even eye [11]. In this study, motor disability (mobility disable) refers to a broadest category of disability with various causes. Common causes of motor disability are mainly paralysis, neurological disorders, repetitive stress injury, age related issues and lack of steadiness [7] [12] [13]. From game design perspective, motor disability or impairment is a game design problem which needs to be addressed.

Vickers, Istance & Heron [14] categorized various approaches to implement game accessibility into two broad approaches. First, adding middleware solution to existing (general audience) games. The roles of middleware are to generate standard game interface devices events and pass them into the operating system to be processed by the target game. Second, the developed frameworks as guideline for game design with game accessibility in mind.

On game development sides, some previous studies have explored some possible ways for people with motor disabilities to interact with games. For example, body part motion [3], head and mouth motions [5], eye tracking [6], and eye gaze [11][10]. In related to these studies, various devices to facilitate access to motor disability have been developed in the last decade including: Setting button [5], Remap able key [6], Alternative Configuration [7], Camera Control [8], Moveable [9], Macro ability [10], Save Point [11], Click to Move [12], Input device

[13], Speed [14] and Sensitivity[3]. The challenge, therefore, how to build a framework that unified various technologies as a guideline for game designer to develop games that fit the requirements of the users.

### *C. The Game Design for Gamers with Neurological Disorder*

Game design framework for disables has gained research attention. For example, the study by [14] proposed a general Game Accessibility Development Framework (GADF) which can be illustrated in the following diagram.

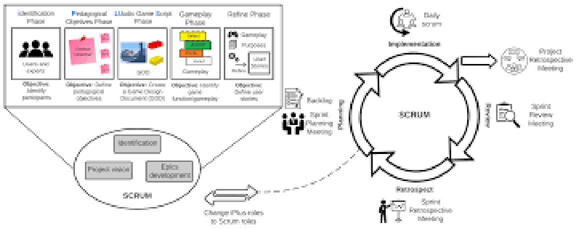


Fig 1. Game Design for Gamers with Neurological Disorder (Source: [14])

The proposed GADF framework suggests game designers to build an adaptive user interface which can automatically detect input device to be used by game players. Similarly, by using task analysis, game designers can select appropriate gameplay with different game genres to be implemented. Although many parts of game designed have been covered, the proposed framework is designed as a generic framework and did not mentioned particular category of disabilities.

In contrast to the framework proposed by [14] as guideline in designing game for general game players, our proposed framework aimed as guideline in designing games targeted to children with motor disability. With such objective, the option for capturing interaction is more limited than those for general game accessibility games depending of body-part (e.g. finger, hand, eye, head) which can be moved.

### *D. Machine Learning as Hand Posture Recognizer*

Recognizing motion from images is one of new opportunities for game accessibility thanks to the advent of machine learning technology. The idea is to develop game user interface modules which were embedded with pertained machine learning to recognize any possible gamers' body parts. For example: eye gaze, head motion, hand motion, hand posture. Several attempts to adopt machine learning model for recognizing human motion from images captured by camera has been reported [15].

## III. RESEARCH METHOD

The research method comprises of several iterative steps namely:

1) Mobile Game Design Analysis

In this study, game design analysis aimed to achieve the following objectives: (1) identifying functional requirement in order a game meets high accessibility requirement to players with limited physical condition, (2) identifying several alternative technologies to implement various access to game for motor disabilities as target users, (3) developing a proposed a game framework that reflect provision of game access for children player with motor disabilities.

This analysis was implemented using several research techniques including literature review of related study reports which were available in literatures. The result of this step was a proposed game design framework as a guideline to design mobile game with high game accessibility, especially for children with motor disabilities.

2) Dataset

Data for this study is a secondary data which has been used in a study reported by [12] [13]. The dataset for this study comprises of 74,975 samples that represents 5 classes of hand postures which were collected from 12 respondents that participated in the study. Although the real target was developing hand posture using a mobile device (gadget) camera, in this prototype system, for simplicity reason, the hand posture was captured using a digital camera connected with a computer where the hand posture recognizer was trained and tested.

The hand posture classes under study are: (1) fist with thumb out, (2) stop with hand flat, (3) point with pointer finger, (4) point with pointer and middle fingers, and (5) grab with fingers curled. These basic hand postures are expected represent some basis for designing hand sign-based command for controlling games.

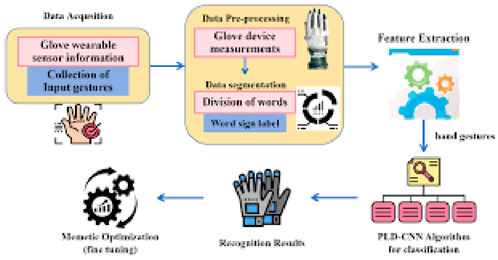



Fig. 2. The Glove for Hand Posture Data Capture (source: [13])

In this study, from the total of 11 markers on the glove, the (x, y, z) coordinates of selected purposively 5 markers used in this study due to a practical reason: data extracted from these markers have no missing values. The marker data was then used as features to represent hand posture using a vector of 15 numbers as follows. Each sample of hand posture $x_i$ was representad as $\langle x_{i0}, y_{i0}, z_{i0}, \dots, x_{i4}, y_{i4}, z_{i4} \rangle$ and the corresponding sample label $y_i \in \{1,2,3,4,5\}$. Before being analyzed, data rescaling and normalization techniques were adopted as data preprocessing.

3) Training Hand Posture Recognizer.

As a proof of concept, a hand posture recognizer was trained as a prototype of hand signal-based commands for motor disabilities to control the game. In the proposed framework, this machine learning classifier becomes a component of game user interface to facilitate gamers interact with the game.

Hand posture recognition is a classification task which can be solved using computer vision method. In this study, the hand posture recognizer is built using eXtreme Gradient Boosting (Xgboost) decision tree proposed by [15] which was trained supervised. Model training used k-fold cross-validation technique so that each sample in the dataset used as training and testing dataset. Due to its simplicity, accuracy was used to evaluate model performance.

Xgboost is a scalable machine learning algorithm which can be used to address classification task. Given a set of n-samples and m-features as a dataset such that: $D = \{(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)\}$ such that each sample $x_i = \langle x_{i1}, x_{i2}, \dots, x_{im} \rangle \in \mathcal{R}^m$, each $x_{ij}$ is feature, and $y_i \in \mathcal{R}$. A tree ensemble model uses K additive functions to approximate a target function so that $\hat{y}_i = \sum_{k=1}^{K} f_k(x_i)$, where: $f_k \in \mathcal{F}$ and $\mathcal{F}$ represents a space of regression trees. As a member of machine learning algorithms, xgboost learning algorithm choose the most optimum set of function from $\mathcal{F}$ to be used in the model by minimizing the following objective function [15]:

$$\mathcal{L}(\phi) = \sum_{i} l(\hat{y}_i, y_i) + \sum_{k} \Omega(f_k)$$

Where: $\Omega(f) = \gamma T + \frac{1}{2}\lambda\|w\|^2$, $l$ is a differentiable convex objective function that measures the difference between the prediction $\hat{y}_i$ and the target$y_i$, and $\Omega$ terms serves as regularize of the model to prevent over fitting. The detail explanation about xgboost decision tree algorithm can be found in [15]

## IV. RESULTS AND DISCUSSION

### A. *Game Accessibility Analysis*

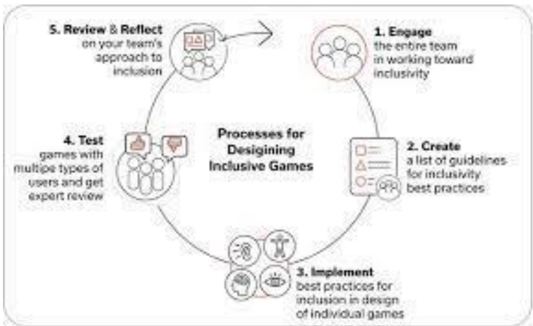



Fig 3. The The design model of accessibility games for neurological disorder

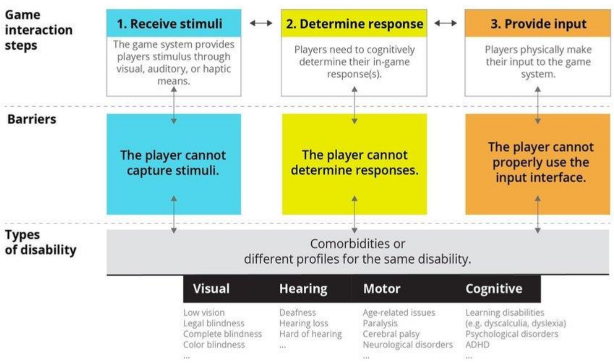



Fig 4. Game accessibility of gamers disorder

The limiting condition of peoples with motor disability hampers them from interacting with general games that require a lot of hand motion and rapid/accurate clicking on the screen (see Table 1). Several possible interaction supports between disables and games have been identified by IGDA [7] as follows. *First*, The keyboard navigation: all commands to control the game can be entered using a customized physical or virtual keyboard with visual and auditory message to give feedback on what has been done. *Second*, Customizable controls: remapping all controls to the game. *Third*, Speaking in-game tutorials/assistance: all explanation or in-game tutorial and automatic help are given through voice and visualization in order the gamers can pick up many of the main points of the game easily. *Finally*, Special devices: expanding hardware support beyond standard devices such as mouse, joystick, game pad and camera to capture eye gaze and head movements to allow player with motor disabilities to play more variety of games.

In this study a prototype of the proposed game user interface is based on assumption that the game player can move their hand in front of camera that was controlled by computer used to run the game application. For this purpose, following the study by [12] [13], a game player utilized a hand glove equipped with some reflectors. A special camera attached to a computer used to run a game will track the hand motion of the gamer as input to a previously trained machine learning-based hand motion recognizer.

### B. *Mobile Game Design Framework*

The critical and distinctive aspects of a game architecture with provision of game accessibility, particularly for children with motor disabilities, are its user interface designed to facilitate interaction with the game suitable with the physical limiting condition of the game players.

Learning from the general framework proposed by [14] and considering specific requirements for the targeted game users, the proposed framework consists of several components namely: (1) input device to capture body-part motions or postures controlled by device drivers and mobile device operating system; (2) adaptive device selection and machine learning to recognize (classify) input data captured by the sensors. This output of this component becomes input for game dynamics; and (3) game applications comprises game dynamics and game mechanics.

The important part in the proposed framework (see Fig. 3) is machine learning-based body-part recognizer. The reason for having this component is as follows. Given widely available sensors to collect data, from game application side, an intelligent agent should be designed to take data collected by the sensors and convert the data into signal that correspond to the game functions that control the game dynamics. This problem opens up much potential utilization of various machine learning methods to process a stream of data that represent gamer interaction with the game application. The collected data using various sensors are then mapped to predefined commands to control games or game dynamics (see Fig. 4).

### C. *Hand Posture Recognizer*

Hand posture class distribution of the dataset used in this study can be summarized using the following histogram.

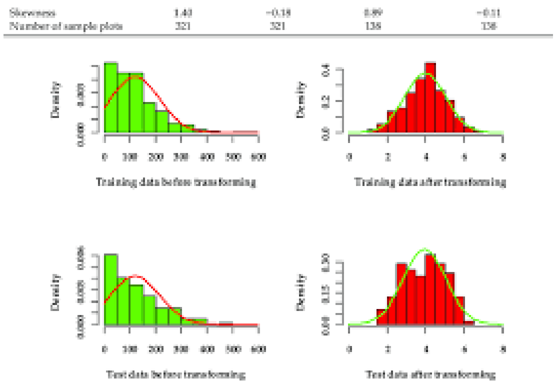

Fig. 5. Histogram of Hand Posture Classes

As can be seen from Fig. 5, frequency distribution of hand posture classes was relatively balance. Learning performance of xgboost decision tree model with hyper-parameters: number of trees = 50, learning_rate=0.15, max tree depth=8 can be summarized as follows:

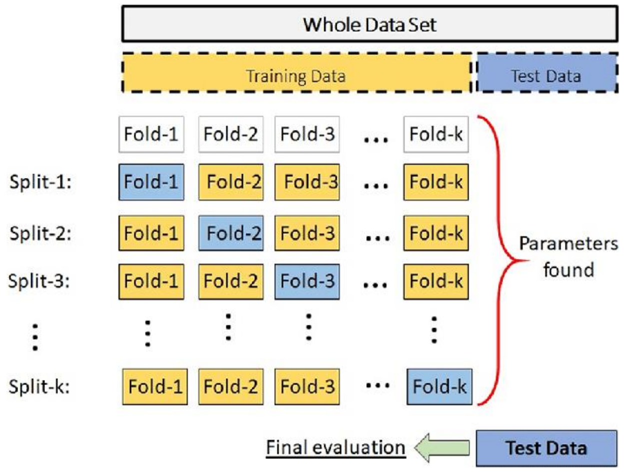
Table 1. Training Performance of Xgboost Decision Tree Model

| Fold | Training Accuracy | Testing Accuracy |
|---|---|---|
| 1 | 98.57 | 96.74 |
| 2 | 98.50 | 96.95 |
| 3 | 98.43 | 96.63 |
| 4 | 98.41 | 96.73 |
| Average | 98.48 | 96.76 |

From the Table 1 above, it can be concluded that the data training are separable and the proposed model achieved high accuracy to recognize each class of the given hand postures.



(a) Training and Data test distribution

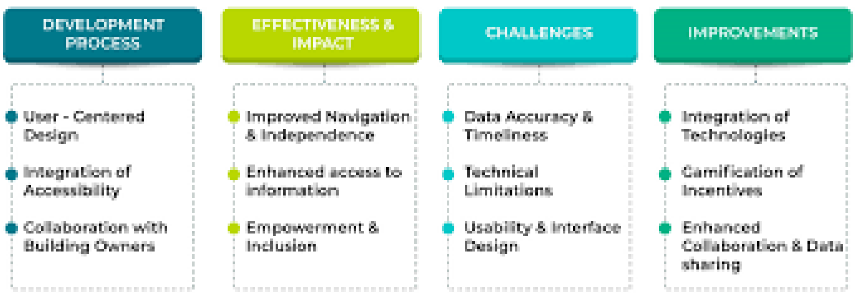



(c) K- Fold cross validation Data Set 3

Fig. 6. Variable Importance Histogram in Each Fold of Training

Fig. 6 showed that each feature of the dataset did not have similar effect to the hand posture classes. In each fold, the change of x-coordinate tend to give less effect to the hand posture class than that of y-coordinate. It means the effect of hand motion in horizontal direction to the predicted hand posture class is less than that of hand motion in vertical direction.

Table 2Accessbility for Games with neurological disorder




## V. CONCLUSION

This research finding validated some previous researches results on game accessibility which claimed feasibility of designing game with natural user interface so that children with some motoric disabilities can engage and enjoy playing computer games. Despite its limited data, the research finding showed some potential to use hand posture as a building block for developing visual commands to control games in the future.

The advent of machine learning based technology in the past ten years gives creative opportunity for game designers in designing and developing game user interface so that the games are not only entertaining and educating but also motoric disability friendly. Exploration of those potentials becomes the next step of this study.

## REFERENCES

[1] Cambridge English Dictionary. Game. Cambridge English Dictionary Online, accessed July 27, 2018. https://dictionary.cambridge.org/dictionary/english/computer-game

[2] Collins English Dictionary. Computer Game. Collins English Dictionary, accessed July 27, 2018. https://www.collinsdictionary.com/dictionary/english/computer-game

[3] Wen, T., Wang, L., Gu, J., & Huang, B. (2009, June). A 3-D acceleration-based control algorithm for interactive gaming using a head-worn wireless device. In Bioinformatics and Biomedical Engineering, 2009. ICBBE 2009. 3rd International Conference on (pp. 1-3). IEEE.

[4] Kementrian Kesehatan RI, "Situasi Penyandang Disabilitas," Bul. Jendela Data Inf. Kesehat., vol. Semester 2, no. 1, pp. 1–5, 2014.

[5] Song, Y., Luo, Y., & Lin, J. (2011, November). Detection of movements of head and mouth to provide computer access for disabled. In 2011 Conference on Technologies and Applications of Artificial Intelligence (pp. 223-226). IEEE.

[6] Alhargan, A., Cooke, N., & Binjammaz, T. (2017, October). Affect recognition in an interactive gaming environment using eye tracking. In Affective Computing and Intelligent Interaction (ACII), 2017 Seventh International Conference on (pp. 285-291). IEEE.

[7] K. Bierre, M. Hinn, T. Martin, and M. McIntosh, "Accessibility in Games: Motivations and Approaches," … Pap. Int. Game …, 2004.

[8] B. Yuan, E. Folmer, and F. C. Harris, "Game accessibility: A survey," Univers. Access Inf. Soc., vol. 10, no. 1, pp. 81–100, 2011.

[9] Palisano, R. J. (2006). A collaborative model of service delivery for children with movement disorders: a framework for evidence-based decision making. Physical Therapy, 86(9), 1295-1305.

[10] Kumar, D., & Sharma, A. (2016, September). Electrooculogram-based virtual reality game control using blink detection and gaze calibration. In Advances in Computing, Communications and Informatics (ICACCI), 2016 International Conference on (pp. 2358-2362). IEEE.

[11] Lu, F., Okabe, T., Sugano, Y., & Sato, Y. (2014). Learning gaze biases with head motion for head pose-free gaze estimation. Image and Vision Computing, 32(3), 169-179.

[12] A. Gardner, J. Kanno, C. A. Duncan, and R. Selmic. 'Measuring distance between unordered sets of different sizes,' in 2014 IEEE Conference on Computer Vision and Pattern Recognition(CVPR), June 2014, pp. 137-143.

[13] A. Gardner, C. A. Duncan, J. Kanno, and R. Selmic. '3D hand posture recognition from small unlabeled point sets,' in 2014 IEEE International Conference on Systems, Man and Cybernetics (SMC), Oct 2014, pp. 164-169.

[14] Vickers, S., Istance, H., & Heron, M. J. (2013, April). Accessible gaming for people with physical and cognitive disabilities: a framework for dynamic adaptation. In CHI'13 Extended Abstracts on Human Factors in Computing Systems (pp. 19-24). ACM.

[15] Chen, T., & Guestrin, C. (2016, August). Xgboost: A scalable tree boosting system. In Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining (pp. 785-794). ACM.

[16] V. Ghini, S. Ferretti, and F. Panzieri, "Mobile Games Through the Nets: A Cross-layer Architecture for Seamless Playing," Proc. 3rd Int. ICST Conf. Simul. Tools Tech., p. 7:1--7:8, 2010.

[17] M. Furini, "An architecture to easily produce adventure and movie games for the mobile scenario," Comput. Entertain., vol. 6, no. 2, p. 19:1--19:16, 2008.

[18] Y. Francillette et al., "Development of an Exergame on Mobile Phones to Increase Physical Activity for Adults with Severe Mental Illness," Proc. 11th PErvasive Technol. Relat. to Assist. Environ. Conf. - PETRA '18, pp. 241–248, 2018.

[19] K. M. Gerling, R. L. Mandryk, M. V. Birk, M. Miller, and R. Orji, "The effects of embodied persuasive games on player attitudes toward people using wheelchairs," Proc. 32nd Annu. ACM Conf. Hum. factors Comput. Syst. - CHI '14, pp. 3413–3422, 2014.

[20] E. Mena and C. Bobed, "Mobile Agents for Mobile Games," Proc. 2nd Work. Mob. Gaming - MobiGames '15, pp. 37–42, 2015.

[21] C. Wiberg, "Game-Inspired Architecture and Architecture-Inspired Games," pp. 68–70.

[22] G. W. Tigwell, R. Menzies, and D. R. Flatla, "Designing for Situational Visual Impairments," Proc. 2018 Des. Interact. Syst. Conf. 2018 - DIS '18, pp. 387–399, 2018.

[23] A. Akkawi, S. Schaller, O. Wellnitz, and L. Wolf, "A mobile gaming platform for the IMS," Proc. ACM SIGCOMM 2004 Work. NetGames '04 Netw. Syst. Support games - SIGCOMM 2004 Work., p. 77, 2004.

[24] S. Harper, C. Goble, and R. Stevens, "Prototype mobility tools for visually impaired surfers," Proc. twelfth ACM Conf. Hypertext Hypermedia HYPERTEXT 01, vol. 筑波大学, p. 33, 2001.

[25] P. Service and L. Search, "No Title."

[26] R. Hamzah and M. I. M. Fadzil, "Voice4Blind: The talking braille keyboard to assist the visual impaired users in text messaging," Proc. - 2016 4th Int. Conf. User Sci. Eng. i-USEr 2016, pp. 265–270, 2017.

[27] B. Lamont, “Deafblind UK expands operations in Northern Ireland to further reduce isolation and enhance the lives of older deafblind people,” Work. with Older People, vol. 17, no. 4, pp. 164–169, 2013.

[28] D. Doughty and K. Doughty, “Journal of assistive technologies.,” J. Assist. Technol., vol. 7, no. 4, pp. 228–234, 2013.

[29] G. Papanastasiou, A. Drigas, C. Skianis, M. Lytras, and E. Papanastasiou, “Patient-centric ICTs based healthcare for students with learning, physical and/or sensory disabilities,” Telemat. Informatics, vol. 35, no. 4, pp. 654–664, 2018.

[30] O. Lahav, “Virtual reality as orientation and mobility aid for blind people,” J. Assist. Technol., vol. 8, no. 2, pp. 95–107, 2014.

[31] J. Meurer, M. Stein, D. Randall, and V. Wulf, “Designing for way-finding as practices – A study of elderly people’s mobility,” Int. J. Hum. Comput. Stud., vol. 115, pp. 40–51, 2018.

[32] S. Holt and N. Yuill, “Tablets for two: How dual tablets can facilitate other-awareness and communication in learning disabled children with autism,” Int. J. Child-Computer Interact., vol. 11, pp. 72–82, 2017.

[33] Á. Fernández-López, M. J. Rodríguez-Fórtiz, M. L. Rodríguez-Almendros, and M. J. Martínez-Segura, “Mobile learning technology based on iOS devices to support students with special education needs,” Comput. Educ., vol. 61, no. 1, pp. 77–90, 2013.

[34] B. J. Westphal, H. Lee, N.-M. Cheung, C. G. Teo, and W. K. Leong, “Experience of designing and deploying a tablet game for people with dementia,” Proc. 29th Aust. Conf. Comput. Interact. - OZCHI ’17, pp. 31–40, 2017.

[35] B. Leporini and M. Hersh, “Games for the rehabilitation of disabled people,” Proc. 4th Work. ICTs Improv. Patients Rehabil. Res. Tech. - REHAB ’16, pp. 109–112, 2016.

[36] “P335-Gotfrid,” pp. 335–336.

[37] R. M. Bottino, L. Freina, M. Ott, and F. Costa, “Cloud-mobile Assistive Technologies for People with Intellectual Impairments,” Proc. 5th Int. Conf. Digit. Heal. 2015 - DH ’15, pp. 103–104, 2015.

[38] A. G. Szykman, J. P. Gois, and A. L. Brandão, “A Perspective of Games for People with Physical Disabilities,” Proc. Annu. Meet. Aust. Spec. Interes. Gr. Comput. Hum. Interact. - OzCHI ’15, pp. 274–283, 2015.

[39] L. Salvador-Ullauri, A. Jaramillo-Alcázar, and S. Luján-Mora, “A Serious Game Accessible to People with Visual Impairments,” Proc. 2017 9th Int. Conf. Educ. Technol. Comput. - ICETC 2017, vol. 2016, pp. 84–88, 2017.

[40] A. Jaramillo-Alca and S. Luja N-Mora, “Mobile Serious Games: An Accessibility Assessment for People with Visual Impairments,” ACM Ref., vol. 6, pp. 1–6, 2017.

[41] D. Miller, A. Parecki, and S. A. Douglas, “Finger dance: a sound game for blind people,” Proc. 9th Int. ACM SIGACCESS Conf. Comput. Access., pp. 253–254, 2007.

[42] S. B. Fajardo-Flores, L. S. Gaytán-Lugo, P. C. Santana-Mancilla, and M. A. Rodríguez-Ortiz, “Mobile Accessibility for People with Combined Visual and Motor Impairment,” Proc. 8th Lat. Am. Conf. Human-Computer Interact. - CLIHC ’17, pp. 1–4, 2017.

[43] A. Jaramillo-Alcazar, S. Lujan-Mora, and L. Salvador-Ullauri, “Accessibility Assessment of Mobile Serious Games for People with Cognitive Impairments,” 2017 Int. Conf. Inf. Syst. Comput. Sci., pp. 323–328, 2017.

[44] J. M. López, N. M. Medina, and R. P. de Lope, “Interaction in video games for people with impaired visual function,” Proc. XVII Int. Conf. Hum. Comput. Interact. - Interacción ’16, pp. 1–2, 2016.

[45] B. Gallagher and H. Petrie, “Initial results from a critical review of research on technology for older and disabled people,” Proc. 15th Int. ACM SIGACCESS Conf. Comput. Access. - ASSETS ’13, pp. 1–2, 2013.

[46] M. Poyade, G. Morris, I. Taylor, and V. Portela, “Using mobile virtual reality to empower people with hidden disabilities to overcome their barriers,” Proc. 19th ACM Int. Conf. Multimodal Interact. - ICMI 2017, pp. 504–505, 2017.

[47] M. I. H. R\'\ios, S. S. Silva, E. I. R. D\'\iaz, and N. T. Monterrosa, “YAMI: Auxiliary Complement to Enable Visually Impaired People to Use Mobile Devices,” Proc. 8th Lat. Am. Conf. Human-Computer Interact., p. 24:1--24:4, 2017.

[48] A. M. Cook and J. M. Polgar, “Technologies that Assist People Who Have Disabilities,” Assist. Technol., pp. 16–39, 2015.

[49] J. Colman, J. Briggs, A. Good, and L. Turner, “Investigating multi-player online video games for brain-injured people,” J. Assist. Technol., vol. 8, no. 3, pp. 124–137, 2014.

[50] L. Chmiliar and C. Anton, “The iPad as a mobile assistive technology device,” J. Assist. Technol., vol. 9, no. 3, pp. 127–135, 2015.

[51] L. Rello, G. Kanvinde, and R. Baeza-Yates, “A mobile application for displaying more accessible ebooks for people with dyslexia,” Procedia Comput. Sci., vol. 14, no. Dsai, pp. 226–233, 2012.

[52] N. Al-Mouh and H. S. Al-Khalifa, “The accessibility and usage of smartphones by Arab-speaking visually impaired people,” Int. J. Pervasive Comput. Commun., vol. 11, no. 4, pp. 418–435, 2015.

[53] S. L. Maatta and L. J. Bonnici, “An evaluation of the functionality and accessibility of e-readers for individuals with print disabilities,” Electron. Libr., vol. 32, no. 4, pp. 493–507, 2014.

[54] E. E. Abdallah and E. Fayyoumi, “Assistive Technology for Deaf People Based on Android Platform,” Procedia Comput. Sci., vol. 94, no. Fnc, pp. 295–301, 2016.

[55] H. Ahn et al., “DOWELL : Dwell-time Based Smartphone Control Solution for People with Upper Limb Disabilities,” CHI EA ’15 Proc. 33rd Annu. ACM Conf. Ext. Abstr. Hum. Factors Comput. Syst., pp. 887–892, 2015.

[56] E. P. S. Nunes, A. R. Luz, E. M. Lemos, C. Maciel, A. M. Anjos, and L. C. L. F. Borges, “Mobile Serious Game Proposal for Environmental Awareness of Children,” 2016.

[57] V. Real and C. Science, “State of the Art of Accessible Development for Smart Devices.”

[58] A. Lopez-Basterretxea, A. Mendez-Zorrilla, B. Garcia-Zapirain, A. Madariaga-Ortuzar, and I. Lazcano-Quintana, "Serious games to promote independent living for intellectually disabled people: Starting with shopping," Proc. CGAMES 2014 USA - 19th Int. Conf. Comput.