2016 IEEE 40th Annual Computer Software and Applications Conference

Braille Text Entry on Smartphones: A Systematic Review of the Literature

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***Abstract*—Nowadays, due to touchscreen, mobile devices have become much more dynamic than in the past. However, due the same reason, those devices are less accessible for blind people. It is expected that in 2018, over half of mobile phone users will have a smartphone, therefore researches about mobile accessibility are very important. So, the aim of this systematic review is to cooperate with new research about methods for braille text entry on smartphones. The systematic searches in 5 databases, resulted in 11 papers that answered the research questions that grounded this work.**

***Index Terms*—Braille, Text Entry, Smartphones, Blind People, Systematic Review.**

I. Introduction

In the world there are around 285 millions impaired visual people, from these, 39 millions are blind [1]. To those people, the technology can expand communication and personal autonomy, minimize or compensate the restrictions related to the lack of vision [2].

Researches show that over half of global mobile phone users will have a smartphone in 2018 [3]. Used as a personal computer, it offers sufficient processing and memory for doing many tasks. However, the touchscreen brought difficulty usability for blind people, that need to use a smooth screen, without tactile sensation, so important for their spatial recognition.

Whereas the sending messages are the dominant way for communication and connectivity between those people [4], this research is about text entry on smartphones for the blind, a important and usual task, so necessary for the users. For this, it was decided for the Braille System, used to literate visually impaired people.

Historically, the first initiative for developing method for reading and writing for the blind people were in XVIII century by Valentin Haüy. He founded in Paris the first school for the education for blind and considered that the main problem was to transform the visible in tangible, thus he adapted the education process. Afterwards, in 1819, Captain Charles Barbier de La Serre, for military purposes, advanced those research. However, only after adoption of Braille System that problem was satisfactorily solved [5].

Developed by Louis Braille, who completely lost his sight at age 5, the Braille System is the writing process most adopted in world and represents in addition to literal symbols, math, chemistry, music etc. Is compound for 63 signals, represented the six points combinations, on two rows (3x2), where each set points form a character (Fig. 1). Some experts believe that an empty cell is also a signal, thereby the system being would be composed for 64 signals. [6].

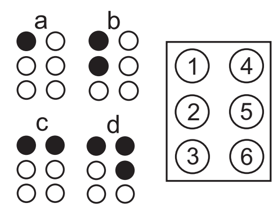

Figure 1: Braille alphabet, letters a, b, c and d.

Thus, to goal of this Systematic Review of the Literature - SRL is expose the main published solutions in the last five years, in important databases, for braille text entry in smartphones. The expectation is contribute with the researchers this theme.

Moreover, this paper is structured as follow: section II presents the Systematic Review of the Literature, with the planning, execution and results. The Planning presents the five research questions, the selected databases and the exclusion, inclusion and quality criteria. The Execution presents the strings formatted according to the specificities of each database and the list of selected papers. The Results presents the brief papers synthesis, with the some characteristics this methods and research questions answered. In section III, Discussion, presents the some considerations about researches, and for last, in Section IV, the Conclusion.

II. Systematic Review of the Literature

The SRL is a way to identify, evaluate, and interpret relevant researches to a particular research question, area or phenomena of interest. Therefore, is more important follow three steps:

0730-3157/16 $31.00 © 2016 IEEE
DOI 10.1109/COMPSAC.2016.74

planning, execution and results. In this SRL the guidelines for the conduction are defined by Kitchenham [7].

A. Planning

The planning was conducted by PixelLab and MediaLab researchers, from the Federal University of Goias.

1) Research questions:

- Q01. Which methods developed braille text entry on smartphones?
- Q02. Which main materials are used for approaches concepts?
- Q03. Which are the main methodologies used for prototypes evaluation?
- Q04. Have the methods used been already compared to others?
- Q05. Which is the performance of the proposed methods?

2) Databases: this study was conducted on five consolidated databases in the scientific scope: ACM Digital Library (dl.acm.org), IEEE Xplore Digital Library (ieeexplore.ieee.org), Science Direct (www.sciencedirect.com), Scopus (www.scopus.com) e Springer Link (link.springer.com).

3) Inclusions of Criteria: studies with an emphasis on: I1. 2011 between 2015 of publications; I2. Interface developed; I3. Interface tests; I4. Auxiliary tools and I5. Tactile interfaces.

4) Exclusions of Criteria: E1. Duplicate titles; Study without: E3. Smartphones, E4. Braille System, E5. Text Entry and E6. methodology or final results.

5) Quality of Criteria: It was considered only researches methodologically comproved, with at least five users. Because with 5 users, you almost always get close to user testing's maximum benefit-cost ratio." [8].

Furthermore, the results were categorized in: Hardware or Software, Methods or Extension and Comparisons. In the first, were grouped the new methods for braille text entry, in second, studies about the auxiliary tools and third, study about the comparison between methods.

B. Execution

For SRL execution, used the strings formed by the theme keys words in each database. Below, the strings used:

- ACM: *"blind people" or "visually impaired" and mobile and "text entry" or text-entry and braille*.
- IEEE Xplore: *((((("blind people") or "visually impaired") and mobile) and text entry) and braille).* "Full Text & Metadata", in advanced search.
- Science Direct: *blind or impaired and mobile and "text entry" and braille*.
- Scopus: *blind or impaired and mobile and "text entry" and braille*.
- Springer Link: *blind or impaired and braille and text-entry and mobile*.

In the result, were analyzed the titles and abstracts in order to refine the search. After use the inclusion, exclusion and quality criteria 11 publications were selected. The Fig. 2 shows the graph with the final synthesis date extraction.

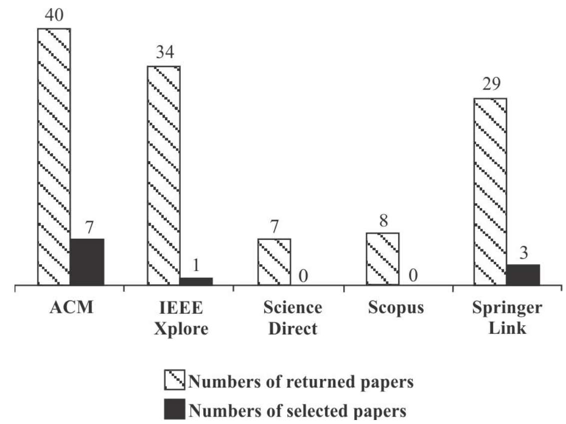

Figure 2: Synthesis Date Extraction

The papers selected are showed in descending order, by publication year:

1) 2015: HoliBraille: multipoint vibrotactile feedback on mobile devices [9].
2) 2014: Touchscreen Mobile Phones Virtual Keyboarding for People with Visual Disabilities [10].
3) 2014: Dots and Letters: Accessible Braille-Based Text Input for Visually Impaired People on Mobile Touchscreen Devices [11].
4) 2014: B#: chord-based correction for multitouch braille input [12].
5) 2012: Input finger detection for nonvisual touch screen text entry in Perkinput [13].
6) 2012: LêbrailleTWT: providing visual accessibility to twitter on touchscreen devices [14].
7) 2012: TypeInBraille: Quick Eyes-Free Typing on Smartphones [15].
8) 2012: An evaluation of BrailleTouch: mobile touchscreen text entry for the visually impaired [4].
9) 2012: BrailleKey: An alternative Braille text input system: Comparative study of an innovative simplified text input system for the visually impaired [16].
10) 2011: Blind people and mobile touch-based text-entry: acknowledging the need for different flavors [17]
11) 2011: BrailleType: unleashing braille over touch screen mobile phones [18].

C. Results

The results are the answer for the research questions.

Q01. Which are the methods developed for braille text entry on smartphones?

In TABLE I is presented the summary of gathered works about methods developed for braille text entry in smartphones. Following it is showed a synthesis about the some characteristics of the methods proposed by the authors. Although, papers are presented in descending publication date, BrailleTouch is described before HolliBraille and the B# because they were developed as extension of it.

TABLE I: Developed methods

Methods	Categories
HolliBraille [9]	H / E
LêBraille [14] [10]	S / M
EdgeBraille [11]	S / M
B# [12]	S / E
Perkinput [13]	S / M
TypeInBraille [15]	S / M
BrailleTouch [4]	S / M
BrailleKey [16]	S / M
BrailleType [18]	S / M

H: Hardware. S: Software.
M: Method. E: Extension.

1) ***BrailleTouch:*** accepted simultaneously six finger on screen, with two hands support which requires the screen in the opposite direction to the use.

- Letter confirm: slide two finger, from left to right.
- Letter delete: slide the finger, from right to left.
- Insert space: slide the finger, from left to right.
- Audio feedback: reading character when one letter is inserted or deleted and when the text is confirmed.

2) ***HoliBraille:*** proposed an extension for BrailleTouch. Offers vibrotactile feedback for text entry through six vibrators supports, which also assists in localization from virtual buttons. It is available form of case, composed of: micro USB input for charger, battery, board and vibration motor. The communication between case and smartphones happens through USB.

3) ***B#:*** proposed an extension app for braille text entry, for doing the automatic correction the braille symbol and text typed. For fixed character, is used the N-gram Frequency strategy, prediction, combined with the user typing history. For fixed words, the algorithm uses the traditional approach of auto correction, comparing the typed word with a list of words. The layout of the approach is based on BrailleTouch.

4) ***LêBraille:*** developed for LêBrailleTWT, an accessible app for Twitter, divided the screen in five rows. In the first, presents the typed text, the second to fourth line, the braille buttons and the fifth, presents the buttons: ”cancel”, ”menu” and ”send”.

- Letter confirm: slide the finger, from left to right.
- Letter delete: shake the smartphone.
- Insert space: slide the finger in diagonal.
- Audio feedback: for each selected point and for letter after confirmation. Long touch on the text box, for hear the typed text.

5) ***EdgeBraille:*** interface similar the braille cell. The letter can be inserted through an arbitrary sequence point. Each point is activated or disabled by the finger movement. In order to avoid accidental touch, the area of deactivation is less than for activation. Offer a cape to guide the user on the screen limits.

- Letter confirm: occurs when gets up finger of screen.
- Letter delete: after version update, two new buttons, 7 and 8, were created. The 7, deletes, and the 8, inserts.
- Insert space: touch the screen anywhere, except in points area
- Feedback: vibrotactile and audio, after activation and deactivation from point; only audio after letter confirm and luminous for low vision users.

6) ***Perkinput:*** presents two approaches, with one or two smartphones. In both, the text is typed with only one hand, each smartphone. Before typing, press the fingers on the screen, with the aim of registering your positions with binary numbers: 0 for empty, and 1 for full. The first touch represents the numbers 1, 2 and 3, and the next, 4, 5 and 6. For increasing the precision, the technique Noisy Channel and the historic of interaction user were used. The bluetooth is used for connecting the two smartphones.

- Letter confirm: automatic, soon after the touch.
- Letter delete: slide three fingers on screen.
- Insert space: slide two fingers on screen.
- Audio feedback: there are in all interactions.

7) ***TypeInBraille:*** a horizontal line divides the screen. In the first entry, the points 1 and 2 are considered, in second, 3 and 4, and in third, 5 and 6. For each interaction there are four possibilities: one finger, selects right or left point, two fingers, both points and three fingers, none.

- Letter confirm: after third interaction. To end the letter with one or two interactions, slide the finger from left to right.
- Letter delete: slide the finger from right to left.
- Insert space: touch in left and next, slide the finger two times, from left to right.
- Feedback: audio and / or vibration, according to the user configuration.

8) ***BrailleKey:*** the screen is divided in four parts (2x2). The first line is reserved for text entry: in the left, one touch selects the point 1, two touches, the point 2, and long touch, the point 3. The same applies to the right, for points 4, 5 and 6. The "enter" and "delete" buttons are on second line.

- Letter confirm: touch on ”enter”.
- Letter delete: touch on ”delete”.
- Space insert: double touch on "enter".
- Audio feedback: reading character after confirmation and for reading complete text, press the audio button.

9) ***BrailleType:*** presents three points on each side. On the center, the letter is confirmed and displayed. On each touch, the corresponding number is read and the long touch confirms the selection. For delete this selection, the user should repeat this action.

- Letter confirm: double touch, in screen center.
- Delete: for delete the points before confirmation, slide the finger, from right to left. If empty points, the last character typed is deleted.

- Insert space: double touch, in screen center, however, without selected points.
- Audio feedback: the each touch, the corresponding number is read. After confirmed, the letter or message error is read.

Q02. Which are the main materials used for concepts approaches?

For the tests, were used the smartphones: Samsung S4, Galaxy 5; Galaxy S; Galaxy Nexus; HTC Desire S e HTC Wildfire e o iPod. In the hardware solution, Hollibraille, were used too: vibration motor Sparkfun ROB-08449, the mini FET shield (Sparkfun DEV-09627) and Arduino Nano.

The predominant Operational System is Android. Only BrailleTouch was developed for IOS.

The most used voice synthesizer is SVOX Classic, but it was also cited: Piko, eSpeak e Twidor Player. In some researches, this information was not specified.

Q03. Which are the main methodologies used for prototypes evaluation?

- Participants: at least 5 and at most 15. In all cases, the volunteers had knowledge about braille.
- Text entry: alphabet letter and phrases in the English (Corpus of Contemporary American English) or Portuguese (Portuguese Written Language Corpus). Some researches don't mention this information.
- Training: before the experiment the participants conducted a training on the application. Only in Edge Braille, the tests were realized in two steps: the shortest, 5 minutes, and the longest, for two weeks.
- Metrics: the researchers used: WPM, Words per Minutes, and Minimum String Distance (MSD) Error rate. Except in LêBraille, used the adapted instrument of [19], with 10 metrics. Some used Likert Scale questionnaire, for satisfaction test.

Q04. Have the methods used been already compared to others?

TABLE II: Comparisons

Methods	Comparison
BrailleKey, BrailleType, EdgeBraille, Perkinput e TypeInBraile	VoiceOver
BrailleTouch	PACmate BX400
BrailleType	QWERTY virtual, MultiTap and NavTouch
B#	AOSP and Hamming
EdgeBraille	TalkBack
LêBraille	QWERTY physical and QWERTY virtual

One of the selected research [17] only compares four different approaches: BrailleType, QWERTY virtual, MultiTap and NavTouch. It was evaluated: speed, accuracy and users opinion. About BrailleType, the results showed a slow method in spite of being precise. For users, it is easy to comprehend, easy to use, however, they confirm that the method is slow and therefore, perhaps they would not use.

The others, presents the new methods and the compare the methods existing, according TABLE II.

For understanding, a brief summary about VoiceOver, TalkBack and PACMate. These were only described because the other don't uses braille.

- VoiceOver [20]: developed for IOS, it uses gestures and audio feedback with the actions descriptions. About text entry, offers QWERTY keyboard and multiple methods text entry, beyond allow voice typing. Includes the braille keyboard.
- TalkBack [21]: developed for Android, it uses audio feedback with the actions descriptions and alerts and notification. Have BrailleBack support, a service allowing connect a compatible display of braille by bluetooth.
- PACmate [22]: portable computer for Windows Mobile for braille text entry based on JAWS (Job Access With Speech). It has physical keyboard and bluetooth and Wi-Fi connection.

Q05. Which is the performance of the proposed methods?

TABLE III: Performance

Method	N [1]	WPM	Error Rate (%)
LêBraille [14]	10	-	-
LêBraille [10]	9	-	-
EdgeBraille [2]	14	3.97	8.43
Perkinput	08	6.05	3.52
TypeInBraille[3]	10	6,3	8
BrailleTouch	11	17.86	28.6
BrailleKey	05	1,8	5,6
BrailleType	15	1,4	8,9

[1]Participants number. [2]Average the results in the short stage. [3]Average of two stages.

The values described in columns WPM and Error Rate were calculated through arithmetic media the test results and participant numbers. The aim is show the approximate results, thus, is important for the researcher read the original paper, for to know the complete result.

III. Discussion

The research allowed to list 7 different braille text entry methods, in smartphones: BrailleKey, BrailleTouch, BrailleType, EdgeBraille, LêBraille, Perkinput e TypeinBraille.

Based on gestures and touches, the methods keep the same pattern for accomplish tasks. However, the Perkinput and EdgeBraille have peculiar characteristics, as: register the position of the fingers and the use two smartphones and typing by continuous gesture, like swipe, physical cover that provides the tactile sensation of the screen edges.

The apps were developed, mostly, for Android operating system. In 2015, the Android dominated the smartphone market with a share Of 82.8% and the IOS share for decline by 22.3% [23]. This can be a good indicative for the option of OS Android in new researcher, thus, it could reach more users.

For performance evaluation, the predominant metrics in researches were: speed, measured by WPM, and accuracy, measured by MSD Error Rate, probably because the System performance can be measured in many ways, but if we follow the definition of the International usability related performance can be further divided into two concepts: efficiency and effectiveness. In text entry evaluations efficiency is usually measured as input speed or throughput. Speed is usually calculated in characters per second (CPS) or even more often as WPM, Words per Minute. The effectiveness of an input method is normally analyzed from accuracy point of view as percentage of errors, using the statistical method Minimum String Distance (MSD) [24]

Keeping on the analysis of the experiments, it was observed that mostly methods were compared to Voice Over, a consolidated method developed for IOS, that reaches more than text entry and do not have braille focus. No one were compared to the other braille method, thus, there is an open gap in researches, because comparison could result in updates or new approaches.

The researches were accomplished only by voluntary with braille knowledge, however, not all experienced in the use of technologies. So the profile voluntary can be influenced in results, because the experience, for example, tends to transform in an easier task. It is also noted, the training with important factor. In these researches, only Edge Braille accomplished short and long training for analyzing the speed and accuracy.

The performance result, Table III, was compiled and showed the BrailleTouch faster, however, showed least accuracy. The Braille Type is slower but median accuracy. The Perkinput has higher accuracy and ranks third in speed only to the information available it is very difficult to rank with accuracy, yet, this table can be a good indicative.

Other two methods were found that proposed auxiliary tools: the B# and the HolliBraille. With common researchers, they were designed for BrailleTouch, however, the characters and words correction and components that allow the tactile sensation are extremely relevant for the new researches.

New methods can be developed with the aim become the text communication more fast and precise. Furthermore, this solution should to provide privacy for the user, which can not be limited by voice recognition.

IV. Conclusion

This paper presents the braille text entry methods on smartphones. It was approached the last five year of published researches in relevant databases. The research questions considered the materials, methods, experiment and performance.

In order to follow a systematic search only the publications which fitted all inclusion and quality criteria have been selected, so it is important that the reader has attention on these criteria, to understand the scope of the research and what it could still be searched to complement their studies.

Finally, it is expected that this work become an important source of research for future researchers, and that, in fact, it can support the development of more comprehensive approaches and satisfactorily meet the visually impaired.

V. Aknowledgment

The authors are grateful for the support of all members PixelLab and MediaLab, of Federal University of Goias.

References

[1] W. H. Organization. (2014) World health organization. visual impairment and blindness. [Online]. Available: http://www.who.int/mediacentre/factsheets/fs282/en/

[2] J. C. Braga, A. C. C. Campi, Jr., R. J. P. D. Graduando, and N. H. da Cunha Albernaz, "Estudo e relato sobre a utilizaÇÃo da tecnologia pelos deficientes visuais," in *Proceedings of the 11th Brazilian Symposium on Human Factors in Computing Systems*, ser. IHC '12. Porto Alegre, RS, Brazil: Brazilian Computer Society, 2012, pp. 37–46. [Online]. Available: http://dl.acm.org/citation.cfm?id=2393536.2393542

[3] T. eMarketer Daily Newsletter. (2014) 2 billion consumers worldwide to get smart(phones) by 2016 - see more at: http://www.emarketer.com/article/2-billion-consumers-worldwide-smartphones-by-2016/1011694sthash.em9ydl9d.dpuf. [Online]. Available: http://www.emarketer.com/Article/2-Billion-Consumers-Worldwide-Smartphones-by-2016/1011694

[4] C. Southern, J. Clawson, B. Frey, G. Abowd, and M. Romero, "An evaluation of brailletouch: Mobile touchscreen text entry for the visually impaired," in *Proceedings of the 14th International Conference on Human-computer Interaction with Mobile Devices and Services*, ser. MobileHCI '12. New York, NY, USA: ACM, 2012, pp. 317–326. [Online]. Available: http://doi.acm.org/10.1145/2371574.2371623

[5] J. A. L. S. Baptista. (2000) A invenção do braille e a sua importância na vida dos cegos. [Online]. Available: http://www.gesta.org/braille/braille01.htm

[6] M. G. B. M. R. F. C. d. O. Edison Ribeiro Lemos, Jonir Bechara Cerqueira, "Grafia braille para a língua portuguesa." Brasília, DF, Brazil: Ministério da Educação, 2006, pp. 11–65. [Online]. Available: http://portal.mec.gov.br/seesp/arquivos/pdf/grafiaport.pdf

[7] B. Kitchenham, "Procedures for performing systematic reviews," *Keele, UK, Keele University*, vol. 33, no. 2004, pp. 1–26, 2004.

[8] J. Nielsen. (2012) How many test users in a usability study? [Online]. Available: http://www.nngroup.com/articles/how-many-test-users/

[9] H. Nicolau, K. Montague, T. Guerreiro, A. Rodrigues, and V. L. Hanson, "Holibraille: Multipoint vibrotactile feedback on mobile devices," in *Proceedings of the 12th Web for All Conference*, ser. W4A '15. New York, NY, USA: ACM, 2015, pp. 30:1–30:4. [Online]. Available: http://doi.acm.org/10.1145/2745555.2746643

[10] A. R. Façanha, W. Viana, M. C. Pequeno, M. de Borba Campos, and J. Sanchez, "Touchscreen mobile phones virtual keyboarding for people with visual disabilities," in *Human-Computer Interaction. Applications and Services*, ser. Lecture Notes in Computer Science, M. Kurosu, Ed. Springer International Publishing, 2014, vol. 8512, pp. 134–145. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-07227-2_14

[11] E. Mattheiss, G. Regal, J. Schrammel, M. Garschall, and M. Tscheligi, "Dots and letters: Accessible braille-based text input for visually impaired people on mobile touchscreen devices," in *Computers Helping People with Special Needs*, ser. Lecture Notes in Computer Science, K. Miesenberger, D. Fels, D. Archambault, P. Penaz, and W. Zagler, Eds. Springer International Publishing, 2014, vol. 8547, pp. 650–657. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-08596-8_100

[12] H. Nicolau, K. Montague, T. Guerreiro, J. a. Guerreiro, and V. L. Hanson, "B#: Chord-based correction for multitouch braille input," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI '14. New York, NY, USA: ACM, 2014, pp. 1705–1708. [Online]. Available: http://doi.acm.org/10.1145/2556288.2557269

[13] S. Azenkot, J. O. Wobbrock, S. Prasain, and R. E. Ladner, "Input finger detection for nonvisual touch screen text entry in perkinput," in *Proceedings of Graphics Interface 2012*, ser. GI '12. Toronto, Ont., Canada, Canada: Canadian Information Processing Society, 2012, pp. 121–129. [Online]. Available: http://dl.acm.org/citation.cfm?id=2305276.2305297

[14] A. R. Façanha, M. d. C. C. Araújo, W. Viana, and M. C. Pequeno, "Lêbrailletwt: Providing visual accessibility to twitter on touchscreen devices," in *Proceedings of the 18th Brazilian Symposium on Multimedia and the Web*, ser. WebMedia '12. New York, NY, USA: ACM, 2012, pp. 313–320. [Online]. Available: http://doi.acm.org/10.1145/2382636.2382703

[15] S. Mascetti, C. Bernareggi, and M. Belotti, "Typeinbraille: Quick eyes-free typing on smartphones," in *Computers Helping People with Special Needs*, ser. Lecture Notes in Computer Science, K. Miesenberger, A. Karshmer, P. Penaz, and W. Zagler, Eds. Springer Berlin Heidelberg, 2012, vol. 7383, pp. 615–622. [Online]. Available: http://dx.doi.org/10.1007/978-3-642-31534-3_90

[16] N. Subash, S. Nambiar, and V. Kumar, "Braillekey: An alternative braille text input system: Comparative study of an innovative simplified text input system for the visually impaired," in *Intelligent Human Computer Interaction (IHCI), 2012 4th International Conference on*, Dec 2012, pp. 1–4.

[17] J. a. Oliveira, T. Guerreiro, H. Nicolau, J. Jorge, and D. Gonçalves, "Blind people and mobile touch-based text-entry: Acknowledging the need for different flavors," in *The Proceedings of the 13th International ACM SIGACCESS Conference on Computers and Accessibility*, ser. ASSETS '11. New York, NY, USA: ACM, 2011, pp. 179–186. [Online]. Available: http://doi.acm.org/10.1145/2049536.2049569

[18] ——, "Brailletype: Unleashing braille over touch screen mobile phones," in *Proceedings of the 13th IFIP TC 13 International Conference on Human-computer Interaction - Volume Part I*, ser. INTERACT'11. Berlin, Heidelberg: Springer-Verlag, 2011, pp. 100–107. [Online]. Available: http://dl.acm.org/citation.cfm?id=2042053.2042066

[19] P. M. P. d. Oliveira, "Avaliação de uma tecnologia assistiva sobre amamentação para pessoas cegas," 2009.

[20] A. Acessibility. (2015) Voiceover for ios. [Online]. Available: http://www.apple.com/accessibility/ios/voiceover/

[21] G. Play. (2015) Google talkback. [Online]. Available: https://play.google.com/store/apps/details?id=com.google.android.marvin.talkback&hl=pt_BR

[22] F. Scientific. (2015) Blindness solutions: Pac mate omni. [Online]. Available: http://www.freedomscientific.com/Products/Blindness/PACMateProductFamily

[23] I. Research. (2015) Smartphone os market share, 2015 q2. [Online]. Available: http://www.idc.com/prodserv/smartphone-os-market-share.jsp

[24] M. Koivisto and A. Urbaczewski, "Accuracy metrics in mobile text entry," in *Proc. 1st IASTED Conf. on Human-Computer Interaction*, 2005.