Introducing basic geometric shapes to visually impaired people using a mobile app

Bogdan Troancă
University "Lucian Blaga" of Sibiu
Faculty of Engineering
Victoriei Boulevard 10, Sibiu 55002, Romania
troancab@gmail.com

Alexandru Butean
University Politehnica of Bucharest,
Faculty of Automatic Control and Computer Science
Splaiul Independenței 313, Bucharest 060042, Romania
alexandru@butean.com

Alin Moldoveanu
University Politehnica of Bucharest,
Faculty of Automatic Control and Computer Science
Splaiul Independenței 313, Bucharest 060042, Romania
alin.moldoveanu@cs.pub.ro

Oana Bălan
University Politehnica of Bucharest,
Faculty of Automatic Control and Computer Science
Splaiul Independenței 313, Bucharest 060042, Romania
oanab_2005@yahoo.com

ABSTRACT
The problem of blindness and other eye diseases is highly important as it affects millions of people on the globe. In the same time, the number of modern touchscreen devices is increasing fast. They are widely spread and becoming accessible for education purposes. For those who are born blind it is very difficult to imagine the world as it is and the struggle begins from the early school stages and continues for the rest of their lives. Modern touchscreen devices, also called smart devices, represent a viable solution for people with sight problems due to their rich multimedia experience. Thus, they can be used as assistive devices. This paper describes how learning basic geometric shapes using a smartphone or a tablet can improve several important aspects like: general feeling of using touchscreen devices, perception of a basic figure's shape by simply touching the screen, intuition on how to follow a GPS map. This methodology represents only the initial stage from a long-term learning process that aims to help visually impaired people to understand and use the power of smart devices in order to perceive the world around them as normal people do.

Author Keywords
Sound; vibration; mobile devices; visually impaired;

ACM Classification Keywords
H.5.m. Information interfaces and presentation - Human-Computer Interaction, Miscellaneous. ; K.4.2. Computers and Society: Social Issues - Assistive technologies for persons with disabilities.

General Terms
Human Factors; Design; Measurement

INTRODUCTION

Around the world there are over 285 million people with sight problems, 39 million being completely blind and 246 with low vision. [14]. Visual impairment is unequally distributed across age groups. About 82% of all people who are blind are 50 years or older, although they represent only 19% of the world's population. Due to the expected number of years lived in blindness (blind years), childhood blindness remains a significant problem, with an estimated 1.4 million blind children below age 15 [16].

The market trends [15] reveal that modern devices like smartphones and tablets are becoming cheaper and thus accessible to everyone. In schools these devices are becoming popular and modern learning tools [5] are being developed using modern technology advantages.

Throughout our research we tried to understand how blind people describe, understand and learn basic geometric shapes as well as how they relate these shapes with the surrounding environment. As a proof of concept, an Android app was developed to guide them in the process of learning 2 basic geometric shapes using a touchscreen device.

HOW THE BRAIN OF BLIND PEOPLE WORKS

A very hard thing to imagine for people with no sight problems is what visually impaired people [13] think about geometric shapes. Because of the fact that they never saw how a line or a curve looks like, they simply cannot imagine how these shapes actually are.

While normal people have this major disadvantage, blind people have other important abilities in their favor. These

capabilities cannot be developed by people with good vision, no matter how hard they try. Based on the brain's capabilities to rewire and distribute resources from affected areas, the sensors' migration from vision towards touch and hear, balances the scale and importance of these senses [4] [10]. Therefore, the brain area responsible for sight and hearing develops supernatural abilities. In order to benefit from their unique aptness and obtain maximum results, the entire learning process [11] of visually impaired people should focus mainly on sound and haptics.

For people who are not completely blind, but suffer from various eyesight problems, there are different methods that can be used to help and guide them. These methods are based on the contrast between light and dark [12], which in their case can still be perceived using their eyes. This is the reason why all geometric shapes developed for the experimental system are programmed using this kind of color contrast.

HOW BLIND PEOPLE LEARN THE GEOMETRIC SHAPES IN A TRADITIONAL WAY

Figure 2: Traditional 3D shapes [2]

Despite the fact that we live in a modern era full of computers, mobile devices and industrial robots that can do almost anything, the learning process is still based on old fashioned techniques. These techniques are advancing very slowly because of the investments required in this field. People with good sight are still easy to educate, thanks to the use of books or computers dedicated to help them read information and perform tasks. On the other hand, visually impaired people cannot use these methods; therefore other procedures must to be developed. They learn Braille [3] for reading, use audio books for gathering information easily and the most important, they develop the tactile sense, through which they can feel and learn shapes, objects and much more.

Regarding shapes, the recommended method for learning them is by guiding the person, using the tactile sense, which is extremely good developed in the case of people with sight problems. In the learning process, they use 3D shapes, as shown in Figure 2. This way, they try to imagine how the shape looks like. Another way to learn basic geometric shapes (ex. rectangle, circle, and triangle) is using plain paper, having the edges emphasized. This way, the edges can be easily distinguished. Regardless of the learning method, the problem of learning more complex shapes remains. Not all objects can be reduces in size so that visually impaired people can perceive them. In this case, they learn the objects based on combination of basic shapes. For example a house is a triangle placed over a square, or a pyramid over a cube. But learning the exact design of a house, or other complex object is impossible. They can only understand a small part from an elaborate and rather complicated design.

THE IMPORTANCE OF HEARING AND TACTILE FEEDBACK WHEN USING A MOBILE DEVICE

The technological progress is a big advantage for all people. The fact that medicine evolves, putting at everyone's disposal complex assistive devices, represents a big step forward for visually impaired people. In some cases, however, these people can face difficult problems while trying to adapt to touchscreen mobile devices. The challenge is to get used to phones and tablets that do not have any buttons. The buttons help them coordinate and do simple tasks, such as calling or sending a message. Although modern devices are developed in order to perform complicated actions in a smart, simplistic way, they are not adapted to blind people necessities; therefore they cannot use them [4].

The most important aspect that blind people rely on when using a device is the feedback or notification sent by the device. Thanks to the extraordinary hearing and tactile abilities that visually impaired people have, when the accessibility option is activated [1], the device becomes more user-friendly. Depending on the action performed by the user, sounds and vibrations will be enabled when the user presses a specific element. For fulfilling his purpose, the element needs to be long pressed or double tapped, depending on how the system is implemented. The vibration is controlled by the vibration motor inside the device, which can be controlled by the programmers during the app development stage. The motor can vibrate different periods of time having different intensities or it can follow a specified vibration pattern.

THE IMPORTANCE OF LEARNING SHAPES USING A DEVICE WITH TOUCHSCREEN

In order to benefit from the technologic development, the devices need to be adapted to the visually impaired people's necessities. The results depend also on the effort these persons make in order to learn how the devices work. A good starting point is learning the basic geometric shapes.

The same way children learn how to draw lines, so that they can write letters and numbers afterwards, blind people have to learn how to draw lines and basic shapes in order to further develop other important abilities. Learning these shapes on a touchscreen will help the user track more complex objects. An important advantage of this learning method is that users are able even to understand a map through tactile and audio guidance. This way, people with sight problems will analyze the basic geometric shapes on the screen and will rapidly identify the route they have to follow. This solution could be a great add-on for the map application [9] for blind people. Figure 3 exemplifies this situation.

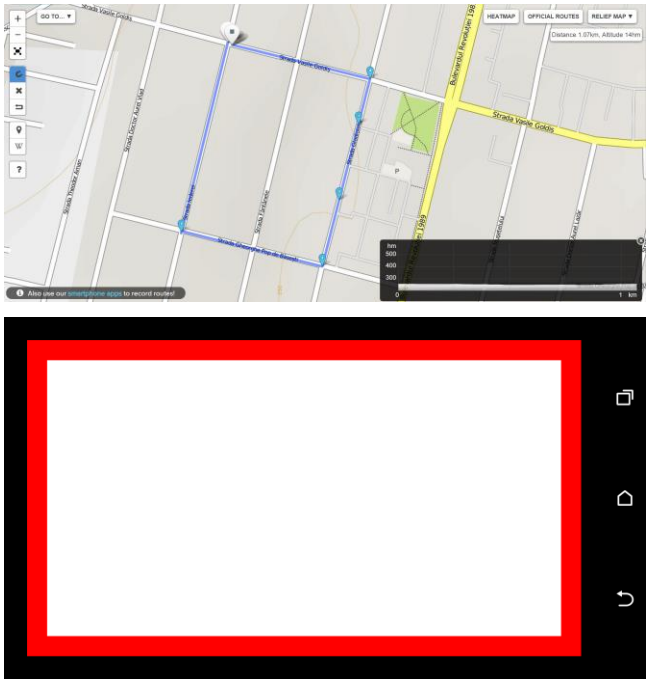

Figure 3: Understanding a map

BASIC GEOMETRIC SHAPES

In this application, there are two different basic geometry shapes that need to be learned by the visually impaired people. These are the rectangle and the circle. For successfully learning these shapes, the activities were implemented in such way, that they will always stay in full screen. This way, the user will not be able to touch the notification bar, which would interrupt the normal interaction. The application was programmed so that at the beginning of each activity there will be a HELP button as large as the screen. This button will force the user to listen to the instructions. The device must be held all time in landscape mode, if not, pressing the HELP button will tell the user to turn it on. The HELP button can be observed in Figure 4, together with the message that the device is held properly. By tapping the screen, the user will hear what to do in the activity. To close the HELP button the user must do a long press action on the screen.

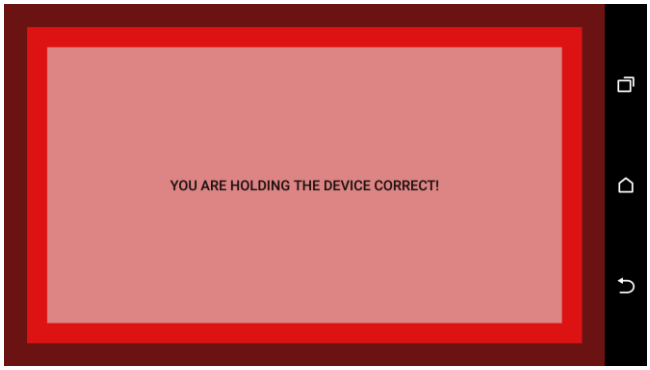

Figure 4: Help button

The activity layout [8] was created so that both geometric figures are drawn using white color on a black background, and having a red outline. These colors were used in programming the entire application because this color contrast can easily be detected by people with sight problems. In order to listen to all the instructions from HELP option as well as the rest of the system, Google Text-to-Speech engine [7] has been used. Another important feedback method used here is the vibration. Thanks to the vibration motor inside the device, the user will feel different vibration patterns depending on the activity and the buttons he presses.

Both activities are being chosen after selecting the difficulty level the user wants.

RECTANGLE ACTIVITY

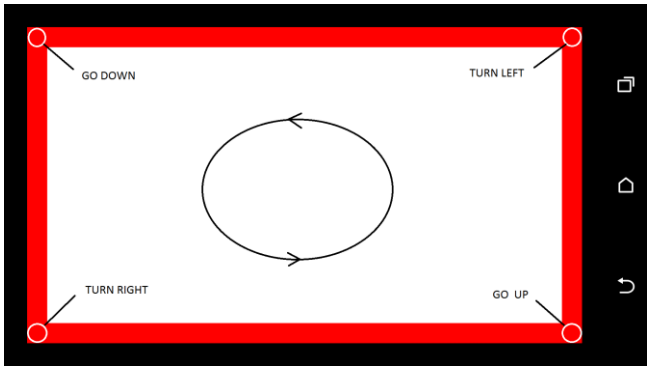

Figure 5: Rectangle Activity

In Figure 5 there is the rectangle activity. The chosen level in this picture is beginner, so that the vibrating outline will be wider and easier to touch. The user is guided by the HELP option to find the vibrating line and to follow it counterclockwise. Touching the line will make the device vibrate. Once the user touches the inner section of the rectangle, the vibration will stop, so that the operator knows he made a mistake and he must find back the vibrating outline of the rectangle. If the shape is drawn correctly, each time a corner is touched, the device will indicate the

next direction the user must followed. A feedback will be given when the user completes the entire shape.

CIRCLE ACTIVITY

In figure 6, there is the circle activity with medium level. The vibrating line will be smaller this time, being harder for the user to follow it. This means he already knows how a circle looks like, but needs to practice. Best practice would be to follow this line until perfecting the technique.

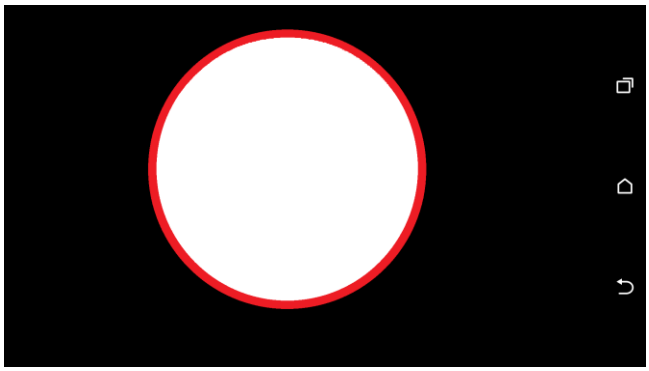

Figure 6: Circle Activity

CONCLUSION

A tool like this could be successfully used in the learning process of blind children from specialized schools. By learning these shapes, they can understand how different objects look like and in the same time will also start to get familiar with touchscreen devices.

By learning geometric shapes on a touchscreen device, visually impaired people could even start to understand and use the routes from different standard mobile mapping systems, like Google Maps [6].

The circle and the rectangle activities represent only the first phase of a comprehensive learning process that uses the power of mobile devices. After several successful testing sessions with blind people volunteers we plan to take the user experience to the next level. The first step will be to implement vibrations, audio guides and menus for other basic shapes like triangle, star, and serpent line.

After the subjects will start to adapt and perceive the shapes faster and faster, a good approach would be to combine basic shapes with more complex shapes (ex: house - rectangle and triangle).

ACKNOWLEDGMENTS

This work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/134398 and POSDRU/159/1.5/S/132395.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 643636 "Sound of Vision".

The results presented in this research study were possible due to the help of National Association of the Blind People in Romania / subsidiary Sibiu and other subjects who have offered to be volunteers for testing and feedback sessions.

REFERENCES

1. Accessibility Tools on Android Devices SDK. https://goo.gl/x2NWkH
2. American Printing House for the Blind, Inc. http://goo.gl/59wYZ7
3. Braille. https://goo.gl/ItLKfc
4. Butean A., Bălan O., Moldoveanu A., Moldoveanu F., Touchscreen Based Audio and Vibro-Tactile Applications as Assistive Systems for People Suffering from Eye Disorders, The 22nd International Congress on Sound and Vibration
5. Butean A., Moldoveanu A., Morar A., From Classic Math School Books To Interactive Gamified Elearning, The 11th International Scientific Conference eLearning and Software for Education, Vol. 1, ISSN: 2343–7669, ISSN–L: 2066–026X, 2015
6. Google Maps Navigation. https://goo.gl/HzQkrN
7. Google Text-to-Speech. https://goo.gl/TwE0Id
8. Layouts in Android. http://goo.gl/cso9HO
9. Nisha K.K., Pruthvi H.R., Hadimani S. N., Reddy Mohana G.R., Ashwin T.S., Domanal S., An Android GPS-Based Navigation Application For Blind, The 7th International Symposium on Visual Information Communication and Interaction, pp. 240, 2014.
10. O'Connor A., Really? The Brain Gets rewired if one of the Senses Is lost, Well - New York Times, http://goo.gl/TdIcPq
11. Suggested Teaching Strategies: blind and visually impaired students – Newcastle University. http://goo.gl/SBi8fM
12. Tips for Making Print More Readable. http://goo.gl/BftSs5
13. Visual impairment. https://goo.gl/4iHcDT
14. Visual impairment and blindness. http://goo.gl/1eHNlY
15. Worldwide Smartphone Average Selling Price Will Plunge To $265 By 2017 : IDC http://goo.gl/IapfvR
16. John Jill Technology - Blindness and Visual Impairment: http://goo.gl/GW88au