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Ergonomic aspects of design of a cap with electronic obstacle detector for use by visually impaired people

Nascimento, N.[a], Salvado, R.[a], Araújo, P.[b] and Borges, F.[c]
[a]*Textile and Paper Materials Research Unit, University of Beira Interior, 6201-001 Covilhã, Portugal*
[b]*Institute for Telecommunications, University of Beira Interior, 6201-001 Covilhã, Portugal*
[c] *Campus João Pessoa, Instituto Federal de Educação, Ciência e Tecnologia da Paríaba, 58015-430 João Pessoa – Paraíba, Brasil*

Abstract. The first sentence of the Abstract should follow the word "Abstract." on the same line. The abstract should be clear, descriptive, self-explanatory and no longer than 200 words. It should also be suitable for publication in abstracting services. Do not include references or formulae in the abstract.

Keywords: Obstacles sensor, product design, visually impaired, assistive technology, urban mobility.

1. Introduction

Data from the 2000 census show that in Brazil, about 14.5% of the population carries some form of disability. The Northeast is the region with the highest percentage of people with disabilities: 16.8%. Thus, there are about 148,000 blind people in Brazil and approximately 2.4 million people who claim to have great difficulty seeing. The Northeast region concentrate around 57,400 people who declared themselves blind [1].

This large group of citizens needs assistive technologies to allow an autonomous mobility in urban environments and an autonomous access to public facilities. According to the Technical Assistance Committee of the Special Secretariat for Human Rights (Presidency of Brazil), assistive technology includes products, resources, methodologies, strategies, practices and services that aim to promote functionality related to the activity and participation of persons with disabilities or reduced mobility, promoting their autonomy, independence, quality of life and social inclusion [2].

The most common assistive technology product among visually impaired people is the cane, which allows detection of lower obstacles, helping this way an independent walk. For a very short minority, it is complemented by a guiding dog. Nowadays, there exist several smart canes that include electronic devices for helping and guiding mobility. For instance the *NaVi-Cane* [3], developed by Sungbae Jo, that integrates sensor and GPS is one of the models already available on the market. However, the canes don´t detect higher obstacles that are the cause of several accidents. Moreover, such canes are not affordable by the majority of the Brazilian population who needs.

In this context, fashion products, as for instance smart clothes or smart accessories, that integrate electronic components such as microcontrollers, tiny sensors and actuators, might be considered as assistive technology products. These smart fashion products may complement the function of a regular cane, helping the detection of obstacles in a very discrete and non stigmatizing way. The work of Leonardo Gontijo, consisting on the development of sensors to be hold in different parts of the body, has been reported in social media [4] as a promising assistive technology solution. However, these type of products still remain unaffordable to the majority of the Brazilian visually impaired population.

This paper presents the development of a cap that integrates a sensor of obstacles and an alert system. It is made of Brazilian sustainable materials and may be produced and commercialized at an affordable price. Some preliminary studies of its functionality are presented.

2. Development of the sensor cap

The cap is a fashion accessory universally used. It is very common among the population of the Northeast Brazilian region to protect users from strong sunshine. Therefore, it appears to be a good accessory to be transformed integrating sensors that will allow the detection of frontal and high obstacles.

The main desirable features of this cap are:

- the ability to detect frontal obstacles;
- the low constraint on the user;
- the weightless;
- the low cost;
- the easy learning and usage in daily routines;
- the autonomy (low battery consumption);
- the robustness;
- the aesthetic;
- the easy maintenance.

2.1. The electronic components

In order to be able to achieve the functional features, the cap should integrate a sensor, to detect obstacles, and should also integrate actuators, to inform the user about the risk of impact. The electronic devices should be as small, thin and light as possible in order to be embedded in the cap without constraining the user.

In the cap here presented, the chosen sensor is an optical one, instead of the larger sound sensor that has been used in the smart canes above referred. The optical sensor used is the model GP2Y0A02YK0F, produced by Sharp. It senses object from 20 to 150 cm distance.

Two devices are used to alert for existing frontal obstacles: a standard buzzer and a standard mechanical vibrator. They are positioned in both lateral sides of the cap. They can be used together or separately to alert the user for the risk of impact. Therefore, the user can choose the alert system he prefers or the one that is more perceptible according to the ambience. For instance in noisy ambiences the vibrator is preferred as it might be more perceptible.

In order to connect the sensor to the actuators, the electronic platform named Arduino Lillypad is used. In plus to it, two extra plaques are used to activate each actuator: the buzzer and the vibrator.

The following figure presents the scheme of the cap, integrating the electronic devices, including the batteries.

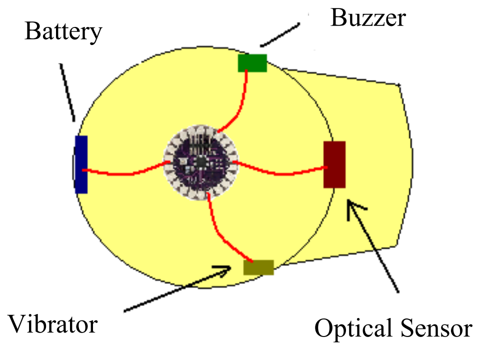

Figure 1 – Scheme of the sensor cap.

A specific software allows to correspond the sensed distance to the frequency of the actuators. Therefore, the sound and vibrations are slowly repeated at 150 cm distance, faster repeated at 100cm and even faster repeated at 50 cm distance from the obstacle.

2.2. The cap

The cap should incorporate the electronic devices in fixed positions that must be accessible, to allow future maintenance of the electronic circuit, battery replacement and so on.

Preliminary prototypes were made by adapting standard caps in order to integrate on them the electronic devices. Further, several specific models of the caps have been drawn to minimize the intrusive integration of the devices and to facilitate the usage of the cap. Therefore, all drawn models of the caps have internal pockets that accommodate the electronic devices. Moreover, in all models the interior is easily acceded by opening a zipper or a Velcro tape.

Several materials were considered, most of all Brazilian materials, aiming to strength sustainable local productions. Figure 2 shows the interior of one of the models produced with goat’s leather, in which the positioning of the several electronic devices are pointed:

1- frontal pocket for optical sensor;
2 – left pocket for the vibration motor drive;
3 – right pocket for the acoustic transducer drive;
4 – back pocket for rechargeable batteries module;
5 - zipper to close and protect the devices.

Figure 2 – The interior of a cap made of goat leather

Figure 3 shows the tested model that is made of goat leather, *tilapia* fish leather and *dourada* fish leather.

Figure 3 – The tested sensor cap

3. Field tests

The developed caps were tested among a population of 100 visually disabled persons, who attend the Association *Fundação de Apoio aos Deficientes – FUNAD*, at João Pessoa, Paraíba, Brazil. The sample consists in 22 volunteers, disabled persons at ages in similar proportion to the population, being 50% of men and 50% of women. It was not considered the origin or cause of the disability. It was not considered the education level neither was religious or social aspects.

The ergonomic aspects of the sensor cap were easily measured [5] with field tests that comprise two set of tests:

1. the training tests, with the aim of learning how to use the cap;
2. the verification tests, with the aim of testing the efficiency of the sensor cap.

For the training tests, the volunteers, using the cap, were sitting and were asked to identify some obstacles that were placed at determined distances: 50, 100 and 150 cm. This training was repeated 10 times.

For the verification tests, the volunteers, using the cap, were moving inside a pavilion were five obstacles were previously prepared. The volunteers were asked to detect the obstacles and to identify their distance from it. This test was repeated 5 times.

Moreover, a questionnaire was filled in order to inquiry volunteers' opinions about some important features of the cap. And interviews were made to collect personal experiences of usage.

4. Results

Considering the 10 attempts of the training tests, volunteers were on average able to identify:

- 94,1 % of the obstacles placed at 50 cm;
- 95,0% of the obstacles placed at 100 cm;
- 92,3% of the obstacles placed at 150 cm.

Considering the 5 repetitions of the verification tests by each 22 volunteers, obstacle :

- I was identified on 96,4% of attempts;
- II was identified on 86,4% of attempts;
- III was identified on 93,6% of attempts;
- IV was identified on 93,6% of attempts;
- V was identified on 93,6% of attempts.

Therefore, results show that most of the volunteers have easily learned how to operate the sensor cap.

The answers to the questionnaire have shown that 18 of the 22 volunteers preferred to have both actuators (vibration motor and buzzer). For 4 volunteers the noise of the buzzer was uncomfortable and distressed. Moreover, in open questions the majority of volunteers revealed they appreciate the possibility to independently switch on and off each of the two actuators.

The interviews allow confirm the idea that the sensor cap is efficient and helpful when used in complement of the cane. Some interviewers loved the cap and would like to use it daily. Some would prefer more discrete caps than the ones tested or even more discrete products than the cap is.

5. Conclusions

One may conclude the optical sensor is efficient to detect frontal obstacles at 50, 100 or 150 cm distance. Moreover, the differentiation of the alarm signal for obstacles at 50, 100 or 150 cm distance are clear and helpful.

The large majority of volunteers have easily and quickly learned how to use the sensor cap. They appreciate the possibility to independently activate each of the two actuators. Most of volunteers use both actuators.

The sensor cap might have a lower price than other similar products of assistive technology. This makes the sensor cap more affordable which might enhance its dissemination among the visual disabled people. By this way, the sensor cap might facilitate urban mobility, improve autonomy and help social inclusion of a large number of citizens.

This work shows how design might promote social inclusion and might reduce stigmas, helping visual disabled people to live better.

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References

[1] IBGE, 2000. IBGE – Instituto Brasileiro de Geografia e Estatística. Relatório do Censo Demográfico 2000: Características gerais da população, resultado da amostra. Access on 30 /01/2011 <http://www.ibge.gov.br/censo/>

[2] CAT, 2000. CAT - Comitê de Ajudas Técnicas. Acess on 25/01/2011, <http://www.acessobrasil.org.br/CMS08/seo-conceito-19.htm>.

[3] IFCA – International Forum Concept Award (2009). Access on 30/01/2011, <http://www.designophy.com/newslog/article.php?UIN=1000001484>.

[4] Bassette, F. (2009). Sensores podem substituir bengalas para cegos. Folha de São Paulo / Universo Online (UOL). Acessado em 22 de abril de 2011, em <http://www1.folha.uol.com.br/folha/equilibrio/noticias/ult263u601024.shtml>.

[5] R. J. Feeney and Margaret D. Galer Ergonomics Ergonomics research and the disabled, Volume 24, Issue 11, 1981, pp 821-830.