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Ergonomic design of an object detector device for blind people

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Abstract

Purpose:
The purpose of the paper is to present the study and analysis and a graphical design of a device and especially of the glasses used for the object detector device for blind people. Especial attention was paid on the technical, ergonomic and aesthetic aspects.

Method:
Various scientific papers and patents on the development of devices for navigation and design of glasses for blind people were studied and analyzed.

Result:
The object detector device suffered great modifications from the first sketches up to its last design. The final design obtained satisfactory results. The device is easy to use, is aesthetically nice.

Discussion & Conclusion:
This work allows understanding how to develop devices for people with disabilities and especially for blind people. Also it show how important is the ergonomic evaluation in the development of such devices, taking into consideration that the device is a free hand device and the glasses (which contain part of the electronics used for obstacle detection, as stereo cameras, connectors, USB port, etc.) must be used for a long time.

1 Introduction

In the last decades, with the new technologies improvement, the requirements for the design needs increased considerably [1].

Home technology designs are significant, and have political and social dimensions [2]. Also the development of new and sophisticated devices which help blind or partial people to perceive the surrounding environment, took an important place in the entire World.

Almost all electronic devices for blind people are glasses based devices. The idea of implementation of environment scanning electronics on glasses comes from the requirement of a free hand device [3].

During decades, researchers worked on the minimization of the used electronics in order to adapt it to the glasses, but the design of a new glasses, more comfortable and aesthetic which will include all required technology remain still undisturbed.

2 Design characteristics of the object detector device

From Greek translation ERGONOMICS means the laws at work. The Ergonomic science is focused on the study on decreasing human fatigue and discomfort through product design. The ergonomics applied to the product design requires taking into consideration how the product designs fit the people that are using them, how the movement, posture, etc. affects the user. In any organisation for blind people will not find any specification and requirements for glasses and or device design, but will find specifications for furniture design, wheelchairs, crutches, canes and walkers for disabled people.

There are several characteristics which have been taken into consideration on the design of the device:

1) **Needs analysis**. Its objective is to identify the need for the product by studying user, task, work and environment characteristics. Also is important to identify usability problems on similar or existing products [3]. At this stage on glasses design for blind people no information to compare can be found. The glasses are designed to cover the user eyes. Their opaque colour is to hide the eyes for the aesthetic reasons, in order to not have a great impact on the users with vision. Regarding device specifications, the main objective was to be a device which will cover user requirements as object detection and information of the environment, small and easy to use.

2) **Requirement specification**. This stage has the objective of identification of the required functions of the device and/or elements to be developed. It includes the interface design and the functional specifications of the glasses and whole object detector device. It means that is necessary to drown up the existing glasses and systems and analyse the standards, guidelines, etc. A state of the art or review of another glasses and devices design must be periodically analysed and studied.

3) **Development specification**. After a hard study and analysis, the most important work on glasses and object detection device design for blind is the

development of product specification. At this level is important to take a decision of the advantages and disadvantages of the design and its requirements. At this stage the design of intelligent glasses for blind people must take into consideration not only the aesthetic and functional aspect of the glasses but also the possibility to implement into them the required electronics and technology.

4) **Prototype design**. At this stage the object detection glasses design have an important impact on the development and testing. It is one of the hardest steps of the design and development, due to its large testing time and modifications. At this stage, the product is tested by the blind users.
5) **Device evaluation**. The objective of this stage consists on the verification that the device including the glasses completes with the user requirements and needs. This stage help designers and developers to create a usable intelligent device which will be easy to learn, easy to use, contain the right functions and interfaces. This evaluation will conduct to the development of the next generations.

In order to develop a software and hardware device several design principles and methodologies was taken into consideration:

1) **Control.** The user must always control the device and not feel to be controlled by the device. It is important as is a cognitive system, the end-user to maintain the control over the device and the situation, to take decisions on its navigation task. It means that the blind user must use the device to automate navigation task allowing him to choose and control the object detector device. Also is important to make a concrete design taking into consideration the end user disability. The device should have a personalized interface, with mean that, as is treating with blind people, it is important to develop a tactile or synthetic speech interface. Is necessary to design an interface that: will explain the user about its applications and movements. Also regarding the hardware it is important the device to be a small, easy to use it, commode and not heavy. An important implication is that the device must be open software, where the user could make updates and add new applications.

2) **Direct usage**. It means to design the device in such a way that the blind users can manipulate the device directly without necessity to go from one option to another. It is indispensable have visible all the information, this will reduce user's mental work.

3) **Adaptation**. This task allows the user to transfer existing knowledge to the task, providing more stability. It is essential as is treating about new technologies and blind users, to design a device which will not require time on trying to remember the interactions, but provide sense of stability. For example to sounds used to represent the environment must be easy to understand, clear and concrete.

4) **Feedback**. In all technologies the feedback represents one of the main tasks. The object detector device must provide by using audio cues information about every user interaction with the device; to communicate him about its actions and confirm about the selected option.

5) **Aesthetic**. The visual design is an important part of the hardware and software interface. Visual aspects and attributes provide valuable information about device giving the first impression and communicate about particular cues. Every visual element of the device potentially competes on the market and attention. It is essential to provide a pleasant environment that clearly contributes to the user understanding of the information presented.

6) **Simplicity**. The object detector device should be simple to use, easy to learn; to provide access to all functions and applications; to animalize device functionality and maintain the simplicity. To reduce the presentation of information those is not required and communicate adequately to the user. It is indispensable to use natural semantics and elements for a better design. A poorly organised interface and elements make difficult the function of many commands

3 Object detector device design

The main objective is to get the final version of the prototype or device working according to the previously mentioned specifications and requirements.

During nine years, the design of the Electronic Travel Aid for blind people CASBliP (Cognitive Aid System for Blind People) suffered different modifications on electronics and its design by using different environment scanning technologies and diverse methods and techniques of processing unit and representation to the blind user [4]. A great dilemma was to make use of the best and cheap techniques and electronics.

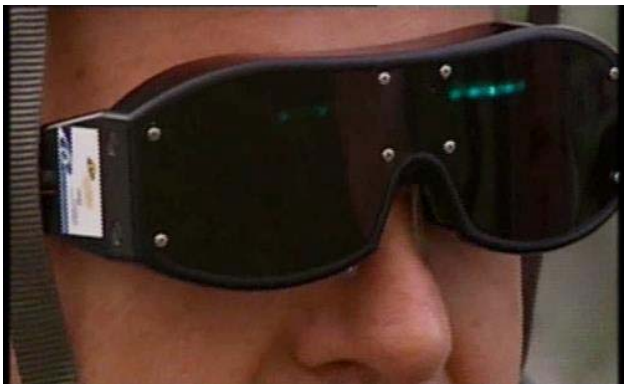

Fig. 1 CASBliP sensory glasses.

The developments of the device have three stages: the early stage, which fit the requirements and implements the existing technology into one single unit able to work properly, it represent the prototype device. The second stage is the improvement stage; its objective is to improve technologic methodologies and the device design. The last stage is the final stage where the main emphasis is to develop and design a device, which will fit all market requirements and ergonomic design.

The early stage of the device was to design a new device that uses technology for pedestrians that incorporates 1x64 lasers with one camera into small glasses, see Fig.1. The lasers represent a big box where all electronic is implemented on (See Fig.2).

It was necessary to maintain the working principles of the existing device for pedestrians and the detection and distance measurement accuracy. Also an important characteristic is to adjust the part of the electronics (the environment scanning elements: the laser illumination modules and the imagine optics) to the glasses parameters and make them functional (See Fig.3). An important task was to adapt the height and the weight of the electronics in order to obtain a working in a comfortable way device. The rest of electronics was included into a Field Programmable Gate Array (FPGA) box.

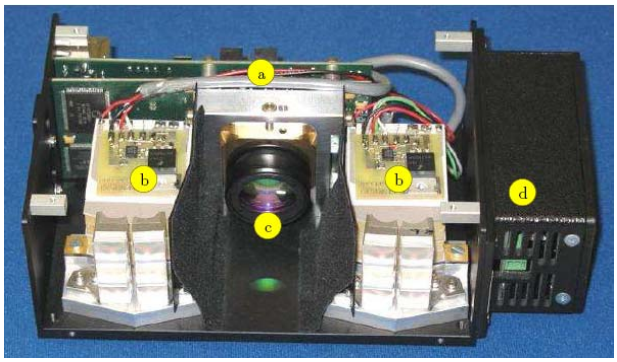

Fig. 2 3D-CMOS sensory system. Which is composed by the electronics board including the array sensor chip (a), laser illumination modules (b), imagine optics (c) and power supply (d).

The 2 3D-CMOS sensory system used for pedestrians presented in Fig. 2 was dismounted into pieces; the laser illumination module and the image optics should be implemented into the glasses. In this case, the electronics was reduced to the maximum eliminating the free spaces and the unnecessary electronics. Having the main environment scanning elements and the general characteristics of the glasses for blind (the width and the length), were designed new glasses (see Fig. 3.) In each part of the glasses crystal was mounted the laser illumination module and in the centre the imagine optics (the CMOS sensor). At the backside of the lasers was mounted the minimum circuits in order to eliminate the weight.

In both parts of the object detector device the structure should be as simple possible with minimum volume and weight.

Total weight of the glasses is 139gr (frame 54gr, circuit board 26gr, laser module 16gr, cover 7gr, lens 34gr and screws 2gr), and the weight of the FPGA is 800gr plus the weight of the power supply that is 300gr.

At the improvement stage of the system design, the objective was to change the FPGA module (see Fig.3) by a small portable computer. In this context the difficult task was to minimize the sensor chip in order to implement it into the glasses. The second requirement was to introduce the acoustic technology and algorithms into the computer software, and design also the end-user graphical interface, adapt the sensory power supply to the portable computer power battery, etc.

At this stage two devices were developed: one laser based device and the second stereovision-based device. For both devices was used one single portable computer.

The portable computer used was a TOSHIBA computer with a weight less than 2 kg.

The laser based device maintained the glasses with the electronics developed into the early stage. Some modification regarding the improvement of the laser illumination module, imagine optics and the circuit board was made. The whole FPGA circuits including the distance measurement circuits and methods and the acoustic module was transformed from hardware into software module. Additionally to the device was developed a new user interface. The interface contained programs for screen reading in several languages: Spanish, Italian, German and English.

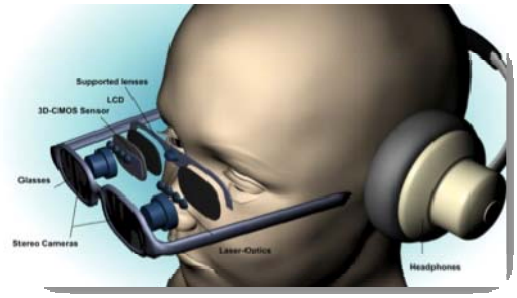

Fig. 3 Integration of the environment scanning elements: the laser illumination modules and the imagine optics into a pair of glasses.

Taking into consideration the limitations of the electronics and the impossibility to reduce more the electronics, the next objective was to change the 3D-CMOS sensor by stereo-vision system and the FPGA and/or portable computer by a small microcomputer. Also an important objective was to change the glasses design. In this case the glasses has been designed to be modern sunglasses where the stereo-vision to be implemented into the glasses frame (See Fig.4).

The new design of the object detector device obtained a great acceptance on the blind end-users [5]. They liked such the design as the functional characteristics of the device.

Fig. 4 EYE 21 a new and modern object detector device design.

4 Conclusion

The design of a new object detection device obtained satisfactory results at the first and second stage. With the obtained design, the device has been modificated by interchanging the sensory module by stereo-vision technology. In this case the device was more esthetically and the used sunn glasses design more modern, which make blind users more confortable and free of the sensation that their blidness is represented by the typical glasses for blind people.

This work allows understanding how to develop devices for people with disabilities and especially for blind people. Also it showed how important is the ergonomic evaluation in the development of such devices, taking into consideration that the device is a free hand device and the glasses (which contain part of the electronics used for obstacle detection, as stereo cameras, connectors, USB port, etc.) must be used for a long time.

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