A Different Approach: Colors through Sound

Mihai Ganea*, Andrei Popescu, Mircea Helici***,**
Adrian Ungureanu**, Bogdan Nistor *****, Marius Plesa********

**University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mai: ganea.mihai91@gmail.com)
*** University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mail: andrei_poescu12@yahoo.com)
**** University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mail: helicimircea@gmail.com)
***** University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mail: adrian.ungureanu91@gmail.com)
****** University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mail: andrei.bogdan_91@yahoo.com)
******* University Politehnica of Bucharest, Faculty of Automatic Control and Computers*
(e-mail: marius.plesa91@gmail.com)

Abstract: This paper describes a medical software designed to improve the quality of life of those suffering from sight impairment. We will present a different approach in recognizing objects in the user's vecinity, thus aiding them distinguish items with the help of colors. This paper is structured around the core concept of the application and is intended to present our solution to the reader.

1. INTRODUCTION

[1] According to World Health Organization census, around 180 million people worldwide are visually disabled, of those 40 to 45 million populations are totally blind. This population is expected to double by the year 2020.

According to World Health Organization estimates, the most common causes of blindness around the world in 2002 were:

1. cataracts (47.9%)
2. glaucoma (12.3%)
3. age-related macular degeneration (8.7%)
4. corneal opacity (5.1%)
5. diabetic retinopathy (4.8%)
6. childhood blindness (3.9%)
7. trachoma (3.6%)
8. onchocerciasis (0.8%)

[2] Ten percent of people over the age of 55 suffer from various stages of macular degeneration. Retinitis pigmentosa is an inherited disease that affects about 1.5 million people around the globe. Both diseases damage the eyes'photoreceptors, the cells at the back of the retina that perceive light patterns and pass them on to the brain in the form of nerve impulses, where the impulse patterns are then interpreted as images.

1.1. EXISTING METHODS

1.1.1 INVASIVE

[3] In 2005, an attempt was with an operation ,where the doctors drilled thru both sides of the skull to mound two terminals. Then implanted two triangular plates both holding 200 electrodes, directly on the visual cortex. The image from a camera mounted on glasses is analyzed by the processor and then it sends electrical signals to the electrodes. This way the person would see two white spots one on top of another every time an object was in front of the camera. The scientists hope that after a lot of training the person will be able to detect edges.

[4] Bionic eye

Researchers feel that the bionic eyes for the blind will be ready for human trials by 2013. This bionic eye implant will help people who have lost their sight through traumatic injury or tumors or with diseases affecting eyes like glaucoma and retinal disorders. The implant is based on a small chip that is surgically implanted behind the retina, at the back of the eyeball. An ultra-thin wire strengthens the damaged optic nerve which servers to transmit light and images to the brain's vision system, where it is normally processed.

According to the scientists, these implants do not require a functioning eyeball or optic nerve or visual pathways from eye to brain. The device can also be tuned for use in different environments, both indoors and outdoors. The users may have to wear special eye glasses containing a tiny battery-powered camera and a transmitter, which would send images to the chip implanted behind the retina. The device is both water-proof and corrosion-proof and is expected to will last for at least 10 years inside the eye. It will cost about $US 100,000.

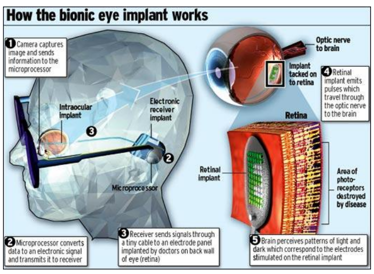

Fig. 1. Bionic Eye

1.1.2 NON-INVASIVE

[5] The RFID navigation system has the following components: RFID Cane Reader, a PDA, and a Bluetooth headset. For the system to work you need a predefined environment, so every route is a RFID tag grid. How the system works: when the cane is close to a tag, the PDA sends audio information through the Bluetooth headset.

[6]In The vOICe, the image is captured using single video camera mounted on a headgear and the captured image is scanned from left to right direction for sound generation. The top portion of the image is converted into high frequency tones and the bottom portion into low frequency tones. The loudness of sound depends on the brightness of the pixel.

Similar work has been carried out in NAVI [7] where the captured image is resized to 32 X 32 and the gray scale of the image is reduced to 4 levels. With the help of image processing technique the image is differentiated into objects and background. The objects are assigned with high intensity values and the background is suppressed to low intensity values.

Stereo vision :

Here the processed image is converted into stereo sound where the amplitude of the sound is directly proportional to intensity of image pixels, and the frequency of sound is inversely proportional to vertical orientation of pixels. Using stereo vision for blind navigation application is in early stages and only limited research efforts has been reported in it. A problem with stereo vision is that every time the camera starts you need to run an algorithm for calibration while a special image is held in front of the camera. It is important to find a way to synchronize the focus points of both cameras.

2. PERSONAL OPINION ON PETER MEIJER

Peter Meijer is one of the personalities directly involved in these scientific areas of research and development. The core of his concept lies within the image-to-sound conversion. One of the profound reasons is that, scientifically speaking, it was proven that human visual cortex can become sound sensitive, thus a person affected by sight impairment could be able to “see” with the help of sounds.

Peter Meijer’s fundamental idea consists in his method of analyzing the image: from right to left. For one second he scans the image and plays a series of sounds (obviously artificial); the height of the sound representing the height of the object and the intensity representing the luminosity.

The advantages of such a representation consists in the fact that it can be applied not only for the surrounding environment but also inside the house or for interpreting graphics or drawings. For a person to be able to rely on this method, a certain period of adapting and understanding the new pattern of orientation is required.

Though a very interesting idea, it still carries some disadvantages. One of the important senses for a person with sight impairment is his or her hearing and, unfortunately, through this method, both ears are covered with one of the headsets, needed to transmit the sounds.

This is one of the reasons with block the help of hearing for these people, a sense so much needed in order to perceive the surrounding environment, making them rely solely on what the camera sees. Another problem is caused by the duration of time required by Peter Meijer’s method, needed in order to analyze the image (1 second). In other words the information is delayed by comparison to the current position of the camera.

A first difference between our method and the one developed by Peter Meijer resides in the choosing of the color spectrum. His choice was to work with black and white, something that we have considered to be unfavorable. Indeed, this may be a good method to provide an insight about what lies in front of a person, but, for instance, one cannot distinguish between two objects similar in shape. Also, we believe that his decision to work alone on this project was not an auspicious one, actually leading to a dead-end.

3. CONCEPT

The issue of sight is indeed a complicated matter, so we decided to approach it in small steps. For the beginning we want to reproduce the way in which miners explore the surrounding, where the only source of light comes from the frontal lantern on their helmets. We believe that the most comfortable solution for a person suffering from sight impairment is to wear the camera fixed on his or her glasses.

In order to send the information from the environment to the users, we will transform the video data into sound. The image used will not be compressed, thus preserving information. Instead we will cut an area of interest in front of the camera.

Thus, we want to offer information related to the dominant color of the objects situated in that region. Thus, we hope the user can differentiate the objects with a certain dominant color, among them, even if they are in a close vicinity. Because for a person with sight impairment, hearing is a very important sense, we decide to send the information via only one headset.

Fig. 2. Region of Interest

4. SOFTWARE DESCRIPTION

For this project we decided to use [9]**OpenCV** (**Open** Source **C**omputer **V**ision) wich is a library of programming functions for real time computer vision. The first problem we met was choosing a simple color spectrum, in order to identify red. The information from the image is interpreted by the computer through a matrix which has A columns and lines its resolution.

The matrix supplies data about each single pixel, with colors ranged between 0-255 on 3 different channels within the RGB (Red Green Blue) spectrum. After a few attempts to identify red on different images, we have noticed that the color variations on the interest area are difficult to interpret, not being able to combine the exact percent in that spectrum. We have also tried the HLS spectrum, mathematically represented as a cylinder, with the following 3 components:

- Hue [8] ” the degree to which a stimulus can be described as similar to or different from stimuli that are described as red, green, blue, and yellow”, represented by the circle’s outer margin, offering information about the color .
- Saturation is a versa starting in the middle of a section parallel with the base. This parameter provides the color saturation.
- Lightness is the cylinder’s height and represents the color’s glow.

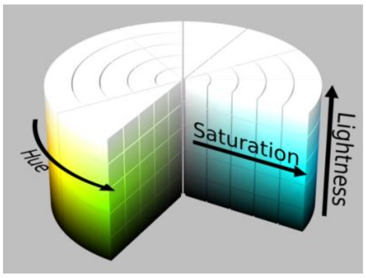

Fig. 3. HSL Cylinder

Fig. 4. Hue Value

Doing tests on these images and using this spectrum we have drawn the following conclusions:

Parameter / Shade	H	S	L
Black	0-360	0-100%	0-13%
White	0-360	0-30%	30-100%
Color	0-360	31-100%	14-100%
Grey	0-360	0-30%	14-29%

Hue is represented on a scale ranged 0-255, and L and S as a percent (100% = 255).

Open CV has multiple functions of identifying the colors, but for this step we

- Hue: on the OX axis we represent all the 255 points of the circle and on OY the color percent in the image.

- Saturation and Lightness: on the OX axis there will be represented a saturation percent/ color brightness, important being the last value different to 0.

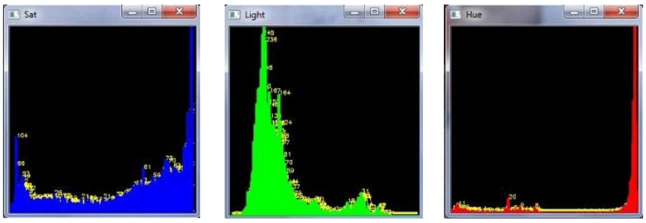

Fig. 5. Histograms H-S-L

Depending on the data interpretation, once identified the dominant color, we will send a characteristic sound. In order to help the user's orientation we will also be helped by the audio volume. This, will be adjusted according to the color surface of the main color.

V EXPERIMENT AND INTERVIEW

We had the opportunity to meet a family with sight impairment and to listen to their life stories and the problems they have been facing. At first, we explained the functioning principal of our program and Mr. Soisun gladly accepted to test it. We want to mention that both partners lost their sight since childhood.

On a table, we placed several red objects of different sizes. We have installed the web cam on a pair of glasses which Mr. Soisun considered to be comfortable. Scanning the table's surface with the camera and hearing the sound for the interest color, he had the reflex of grabbing the object. By scanning the table, each time he was close to the object, was easy to observe that the volume played an important part in detecting the objects with precision.

Also, we noticed that the interest area is too small to identify small sized objects such as a bottle cap, placed at a high distance (1m), because the time needed to find it is rather large.

For us it was important that Mr. Soisun spoke not only in his perspective but also tried to present the problems of the entire community of people with sight impairment, him being a revered member of this community. The underlined problems where:

- The lack of depth sense. They cannot perceive if there is a hole in front of them or if the boardwalk finishes.

- They want to read more books. One of the major issues of books written in Braille is the big volume of such books and the fact that they are difficult to access.

There are two kinds of people with sight impairment:

- Those that were never able to see, which have well developed orientation senses and are much better accustomed with their situation. They are willing to use heavy equipment.

- Those that lost their sight during their lives and who were once able to see. They get accustomed much more difficultly to their situation and the development of their other senses lasts a few years. They are willing to try on only relatively larger equipment.

have chosen to use histograms for all three channels. Analyzing each image pixel and representing the data as a vector we represent it graphically on a 2D area for each channel.

6. CONCLUSIONS AND DIRECTIONS

Until now, Peter Meijer's project, "Seeing with Sound", is one of the technologies most used by the blind community. After the meeting with Soisun family, we realized that our project can develop more than one direction of evolution. We believe that there is no single solution and we must use more than one system which together will form the device.

One of the directions identified is text recognition for books, indicators and to offer them the possibility of using two headphones (synthetic voice).This way we solve one of the fundamental problems of the community.

Street orientation is another important aspect. We want to give them information about the obstacles respectively about the pits located near them and location information of the city(GPS helped by the Video camera, synthetic voice).

Object recognition is a developing field and extremely difficult. We consider that this branch should be treated independently of other areas for a good evolution.

Large scale technology problem is solved, using smartphones. They are small and sufficient processing power.

Combination of these axes, from our point of view, could form an reliable, feasible and affordable system for blind community. In the future we would like to turn it into an Open Source project. We strongly believe that the lonely approach on a complex problem is unbalanced.

REFERENCES

[1] http://en.wikipedia.org/wiki/Blindness
[2]http://health.howstuffworks.com/medicine/modern-technology/bionic-eye.htm
[3] Discovery Channel – Human Body Ultimate Machine – Sight
[4] http://iamrpt.blogspot.com/2012/02/bionic-eye-for-blind-people.html
[5] Ugo Biader Ceipidor, Edoardo D'Atri, Carlo Maria Medaglia, Marta Mei, Alexandru Serbanati, "A RFID SYSTEM TO HELP VISUALLY IMPAIRED PEOPLE IN MOBILITY" RFIDLab –CATTID University of Rome "La Sapienza" Rome, Italy
[6] Peter Meijer, http://www.seeingwithsound.com/
[7] http://hci.uni-konstanz.de/blog/2011/03/15/navi/?lang=en
[8] http://opencv.willowgarage.com/wiki/
[9] Mark Fairchild, "Color Appearance Models: CIECAM02 and Beyond." Tutorial slides for IS&T/SID 12th Color Imaging Conference