Gamepad Vibration Methods to Help Blind People Perceive Colors

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ABSTRACT

Visually impaired people, completely or partially blind cannot perceive the surrounding environment as normal healthy people can. Not knowing how colors and shapes look like is a serious penalty and they have to live with it an entire life. It is known that the human brain adapts and compensates with greater capabilities for hearing and touch when vision is low or missing, that is why blind people develop special skills and perform so good when it comes to music and kinetotherapy. Based on this information we are proposing a method that explains colors using vibrations. In this paper we would like to present a new way of transforming an image to vibration by using the capabilities of an Xbox gamepad. During the study on real blind volunteers, this kind of approach proved to be very effective and promising, allowing them to slightly understand how an image, painting or friend looks like.

Author Keywords

Vibration; colors, modern 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; Measurement

INTRODUCTION

Color is an essential component of spatial recognition and there is a requirement to invest in systems that can help individuals who are blind or visually impaired to learn to perceive colors. Individuals who are color blind and endure different types of color blindness such as achromacy, tritanopia etc. encounter various problems in their daily lives. Blind individuals suffer from color deficiency as well. Individuals who are congenitally blind have to learn about color through artificial ways. A person that experiences blindness at later phases, has the sense of color but the absence of sensory data belonging to color, influences everyday activities. Individuals that suffer from such sensory and cognitive afflictions can be assisted by systems that permit color perception. Regarding the sense of touch, the development of haptic technologies have been growing lately and economical devices are becoming more broadly accessible.

Interesting results are obtained with haptic feedback using different sensors attached to gloves [6]. In this paper we present a first experiment using a novel method that aims to help blind people perceive colors using a gamepad.

Color Perception

In humans, color perception is an essential part of spatial processing. It allows decisive perception of the environment and helps in object detection, analysis, scene segmentation and other spatial tasks. Likewise, color perception plays an important role in social interactions. Color is not perceivable directly through the touch sensors in humans, because, as a feature, is entirely visual. This is one reason why presentation of color data to individuals who are visually impaired constitutes a complicated issue.

One approach regarding this problem is presented [4]. The innovative system which they proposed allows learning, presentation and examination of color information. Their system is based on a procedure that distributes colors as textures through a haptic device. The objective of the considered approach was to enable color perception and to supply a foundation for evaluating color correlation. Initially, users went through a learning phase, that allowed them to relate color to a realistically rendered texture. The testing of the rendering system has been done through a vibrotactile and a force feedback system. In both cases, after the learning phase, users could identify colors with high precision.

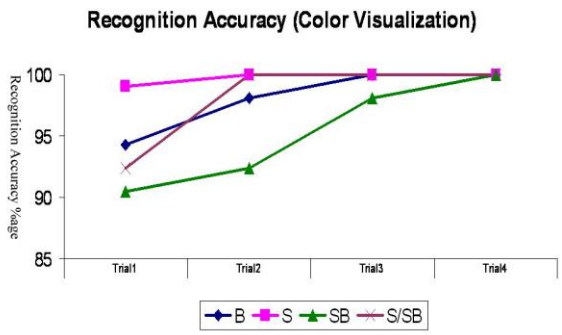

Figure 1. Learning and Recognition of Color

The examination of the learning system to establish the mapping and real-time system for color recognition proves that the proposed methodology may provide a reasonable basis for color perception.

Conceptual Systems

An economical, easily transported haptic device which can transmit 2-D texture-enriched graphical information to visually impaired individuals is presented in [1]. They developed a single finger, inexpensive, point contact haptic device that is extendable to more than one finger. This instrument (Figure 2) is used in order to convert an electronic visual diagram into is haptic form. This would provide supplementary information about part particularity and part direction. The device can identify a wide range of colors and can output a different variety of simulated texture in an appropriate way.

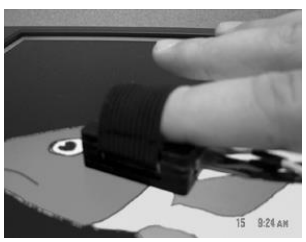

Figure 2. The device interacting with a computer screen

In [2] is introduced a new multimodal device scheme concept in consideration of helping individuals who are blind or visually impaired to be able to draw tactile pictures. The system resides in a multimodal representation able to activate the user's visual, haptic, and/or auditory sensory systems. Most notably, this system will permit the user to "paint" in textures, corresponding to colors, which can be tactually analyzed. Until now, a restricted form of the design has been implemented in MATLAB using a haptic device. A more thorough representation is being assembled in C#, with plans to integrate Microsoft ™ SDKs which allows the use of more than one pointing device. The finalized version will be subject to user testing.

Modern approaches

One example is presented in [3]. They focused on the representation of paintings through haptic displays from their digital image. The haptic display that they created perceives the location of the display on the virtual painting and then adds a tactile feedback in mechanical texture form. This procedure is done with the aim of illustrating the physical brushstrokes. In the near future, they will concentrate on developing a display system, display techniques and picture conversion mechanisms to represent paintings that can be found in public and private art galleries. The system could then be made usable in kiosks, Art Museums or ready for home use on the Web.

In the paper [5], there have been created and appraised two haptic and visual applications for acquiring information on geometrical concepts in group work in primary schools. There were to evaluated applications: The Static Application and The Dynamic Application. The Static Application consists of a 3D environment that encourages learning to distinguish between different angles and drawn shapes. The Dynamic Application is similar to The Static Application but supports cooperative learning of geometrical shapes such as cubes and notions such as volume and area.

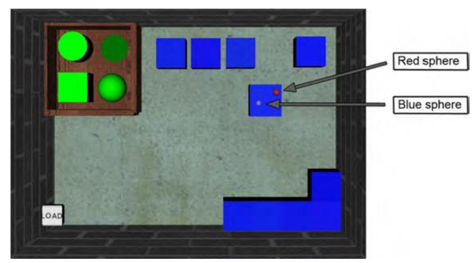

Figure 3. The dynamic application with two users represented by a blue and red sphere respectively.

The outcome of this study has demonstrated that sighted and visually impaired pupils who work in groups in a mutual haptic virtual environment can achieve and preserve a common ground of the physical arrangement and of the objects in a workspace. The most essential thing that the study has shown is the fact that the haptic informative functions can make a considerable improvement to both the overall cooperation and assignments solving method, as well as the involvement of the visually impaired pupil.

VIBRATION TOOL: XBOX ONE CONTROLLER

Microsoft invested over $100 million into refining the controller design for the Xbox One. The XBOX One Controller (Figure 4) is quite similar to the Xbox 360's Controller but with a different handle contour. It has off-set analog sticks, the A, B, X and Y face buttons, a directional pad, the Menu and the View buttons. The directional pad has a traditional design and the battery compartment is slimmer compared to previous XBOX controllers. The Xbox One controller includes a micro USB port: when attached via a USB cable, the controller can operate without battery power.

Figure 4. XBOX One Controller

Gamepad vibration properties

The XBOX One Controller [7] has two vibration motors (Figure 5), a low frequency and a high frequency motor, one in the base of each grip. The functionality of these motors, is to supply force feedback effects to the user. A vibrating motor is essentially a motor that is improperly balanced. In other words, there is an off-centered weight attached to the motor's rotational shaft that causes the motor to oscillate. The amount of oscillation can be changed by the speed at which the motor spins.

Figure 5. Vibration Motors

VIBRATION EXPERIMENT

An experiment was designed in order to test the ability of the users to differentiate between 8 and 6 levels of vibration. For testing, 3 participants were recruited, having the age of 21, 35, respectively 65. At the beginning of the experiment, each user was instructed to press one of the buttons of the XBOX One controller, to feel the vibration. Afterwards, we provided 5 pairs of different levels of vibration, in order to test if the users can perceive which vibration is each pair is powerful. The results are shown in Table 1.

Users	Vibration levels	Accuracy
Participant 1 (Age: 21)	6	80%
	8	50%
Participant 2 (Age: 35)	6	100%
	8	80%
Participant 3 (Age: 65)	6	100%
	8	80%

Table 1. Result of the experiment

The results clearly suggets that is difficult to differentiate between 8 levels of vibration. A system that can help visually impaired individuals to perceive and learn just 6 basic colors is a more reliable / close to reality solution.

Color-Vibration Intensity

In order to implement the system, we chose 6 basic colors that needed to be perceived and learned: white, red, yellow, green, blue and black. Each color out of the 6 must have associated a level of intensity. In this early stage intensities are calculated with just a simple division, that means the difference between 2 consecutive colors is now the same but we plan to investigate in the future if would be better to consider another formula based on the intensity of the colors.

Level of Vibration	Color Associated
1	WHITE
2	RED
3	YELLOW
4	GREEN
5	BLUE
6	BLACK

Table 2. Vibration-Color Association

Converting RGB Images to the 6 Color Set

An important functionality of the system is the conversion of RGB Images to the 6 color set proposed by us. This is done by evaluating the similarity between every pixel in the image with one of the 6 basic colors, followed by the conversion of the pixel to the basic color.

Each pixel has 3 components: Red, Green and Blue. In the first step we used a standard 3-byte RGB conversion algorithm. In the second step we decided that cyan is close to blue and purple to red and this assumption helped us to reduce the number of colors from 8 (standard 3 bit) to 6 . Using this type of approach we decided if the pixel is more similar to red, green, blue or yellow. Another comparison is made between each component and two set values, 80 and 180, to check if the pixel is more similar to white or respectively black. After the testing is done by the algorithm is finished, the pixel is transformed in one of the 6 basic colors. In Figure 6 is presented a famous picture by artist William Henry Hunt that is processed using the method described above.

Original Image Converted Image

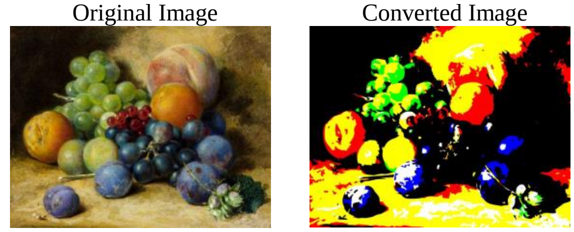

Figure 6. Image Conversion

Interaction with the system

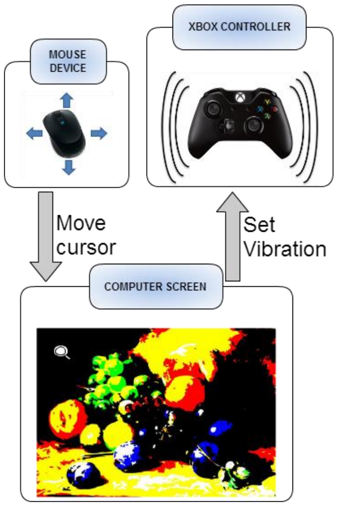

Figure 7. Interaction with the system

As seen in Figure 7, the user is instructed to move the mouse pointer on the processed image on the computer screen. Depending on the location of the pointer on the image, the XBOX controller will vibrate with the intensity associated with the color that is pointed by the mouse.

CONCLUSION

In this paper we have presented a new way of turning images into vibration using an XBOX Gamepad. This method turned to be promising because it was very well accepted by volunteers due to the easy interaction between the vibrating device and humans. A static image is converted to a 6 color scheme and then explored by the visually impaired using a mouse, generating different levels of vibrations.

Initially we decided to use 8 colors, corresponding to 8 different vibration levels, but after the hands-on study with several subjects, numbers have shown that at least in the beginning of this experiment would be better to stick with just 6 vibration settings corresponding to 6 basic colors.

The results of this research are encouraging us to continue the study and explore the capabilities of this method.

Future Development

In the near future, in addition to the XBOX controller, we will try to integrate the use of different types of standard PC controllers or other console controllers. Furthermore, we intend to add a new feature replacing the mouse cursor movement on the processed image by using the analog-enabled joystick of the controller. Since this was an early experiment to establish whether the concept might work, another experiment with more testing subjects and test cases is already in progress.

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