ColorOdor : Odor Broadens The Color Identification of The Blind

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Abstract
It is difficult for the blind to perceive colors, so they identify with colors much less in their daily lives. Our research is exploring new interactions to help them recognize colors. *ColorOdor* is an interactive device that can help the blind identify colors through corresponding odors. This article is mainly used to define the connection between color and odor for the blind and thus broaden their cognition of colors through user research. We hope that our research can broaden novel interactions between individuals with disabilities and their environments.

Author Keywords
The blind; Odor; Interaction device.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Many blind people find it difficult to get along in society, which is a colorful world. For instance, it is difficult to communicate with reference to color between blind and sighted people. However, functional disorders of a sense organ may intensify the remaining senses. It is presumed that the blind not only hear better and have better tactile sense, but also have stronger olfaction [1].

Olfaction is the first developed sense system and is highly active early in our lives [2]. In addition, psychological experimentation suggests that our memory of odors is far more effective than our visual recollections [3]. Therefore, we hope to help the blind to live better lives by linking color and odor.

Blind people should retrain their cognition in a manner consistent with the understanding of ordinary people if they want to integrate into mainstream society. However, most people with congenital blindness have a different perception of reality compared to sighted people. Fortunately, blind people have the same sense of smell. Therefore, this can help the blind to understand colors that only sighted people can perceive. Figure 1 presents communication between the blind and normal-sighted people through color and odor sensation.

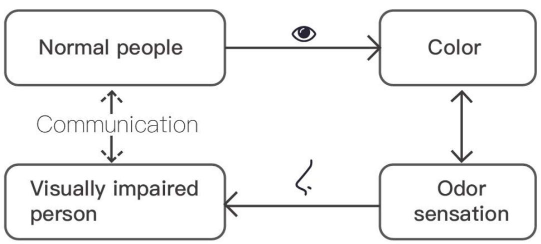

Figure 1: The link between color and odor sensation between blind and normal-sighted people.

We designed a system in this work that includes two devices; one is a pair of glasses with a webcam, the other is an odor storage device. The webcam identifies a color and the odor container releases an odor associated with the specific color. In this manner, blind people can connect odors with their corresponding colors.

This paper explores more application possibilities of odor in cognition. It breaks through the traditional color perception of the blind and makes their world more colorful. In addition, we have researched human–computer interaction in wearable devices for blind people. This research aims to make the blind able to live more conveniently and gain new sensory experiences.

Related Work

There is a lot of research about digitizing odor and color, especially in the field of odor. Kaye suggested in his thorough review [4] that it is difficult to make good classification or description schemes for odors. Besides, research into odor is much more complex than into color, as olfaction is a feeling produced by our olfactory center. Gas molecules make contact with the olfactory receptor cells that exist in the nose, and then the cells send signals to the brain. In this article, the main challenge is the complexity of producing arbitrary odors on demand. Humans can sense a thousand different odors via the olfactory receptors in our nose [5], which is why it is difficult to digitize odor.

There are some related works in the area of olfactory HCI. Most uses have focused on notifications for ambient displays [6]. The history of olfactory research can date back to *Sensorama* [7] in 1962. A decade ago, the HCI research community set out to look into the challenges and possibilities of smell-based technologies [8]. Recent HCI research efforts have focused on user interaction with smell-based technology rather than the

Colour–odor associations by Frieling (2005)

Colour	Odor
PINK	sweet,mild
LAVENDER	sweet,unerotic
MAGENTA	heavy,narcotic,charmingly,sweet
INDIGO	Scentless
BLUE	Scentless
MINT	juicy,frensh to salty
GREEN	fresh,fragrant,perfume.with green fragrance
OLIVE	Musty
LIME GREEN	sour,dry,fresh,bitter
YELLOW	perfume,flower
ORANGE	Hearty
RED	sweet,hefty,hot
GOLD	sweet,good,stunning
OCHER	sourly,neutral
BROWN	aroma,musty

Figure 2: Colors and the associated odors or tastes as they are used for food packaging and advertising.

chemical engineering challenge of reproducing specific scents. For instance, Brewster et al. [9] developed a smell-based photo-tagging tool (*Olfoto*) to elicit memories.

There is a research that aims to inform blind people about their clothing. It provides information about clothing through methods such as vocalization [10], and we hope to do more about blind people's perception of color based on the previous research.

ColorOdor

Color-odor correspondence database. We have searched through some related works to define a one-to-one correspondence between orders and colors. For instance, Heinrich Frieling (2005) explored colors and associated odors or tastes as used in food packaging and advertising (Fig. 2). However, the terms he selected to describe odors or tastes were too vague. Cindy Hsin-Liu Kao [11] has developed a clay-like malleable material that changes orders based on different shapes. Because color is more intuitive than shape, we want to develop an interaction system that releases corresponding odors according to different colors in this paper.

Two blind people participated in our user research (Fig. 3) to determine the odors corresponding to seven colors (white, black, red, yellow, blue, green, purple).

Figure 3: Users smell different flowers, fruits, etc. and then describe the color in their mind.

The reason these colors were chosen is that they are commonly used and easy to distinguish. We recorded the colors that they thought of after smelling different flowers, fruits, etc. Although culture plays a role in color–odor connection [12], we selected the corresponding colors that both volunteers agreed upon. Table 1 shows the defined one-to-one correspondence. Moreover, the database we designed for the color recognition program is based on this correspondence.

Color	Odor
White	Lily
Black	Ink
Red	Rose
Yellow	Lemon
Blue	Blueberry
Green	Camphor leaves
Purple	Lavender

Table 1: One-to-one correspondence between color and odor

Technical design. Due to current technical restrictions such as the size of sensors and available materials, we have implemented a proof-of-concept prototype. The prototype (Fig. 4) consists of (1) a webcam capturing the image of seven colored cards, (2) a laptop with a color recognition program written in a processing language and (3) a piezoelectric transducer system controlled by an Arduino that generates scents by vaporizing liquid fragrances.

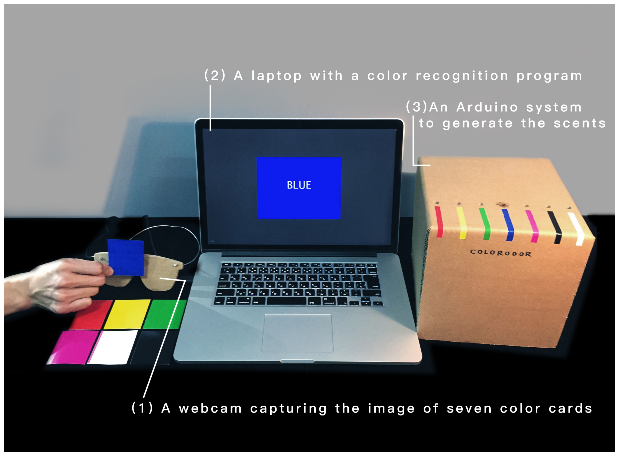

Figure 4: *ColorOdor* consists of a (1) webcam, (2) a laptop and (3) an Arduino piezoelectric transducer system

Interaction. (1) The user dons a pair of glasses with a webcam and turns it on. (2) they randomly take one of our color cards and place it in front of the glasses. (3) The color recognition program on the laptop can automatically identify the color within an hour, display the result on the screen and send the result to the Arduino. (4) The Arduino receives the signal over a Bluetooth low energy module (BLE) and the piezoelectric transducer system generates the corresponding scent (Fig. 5).

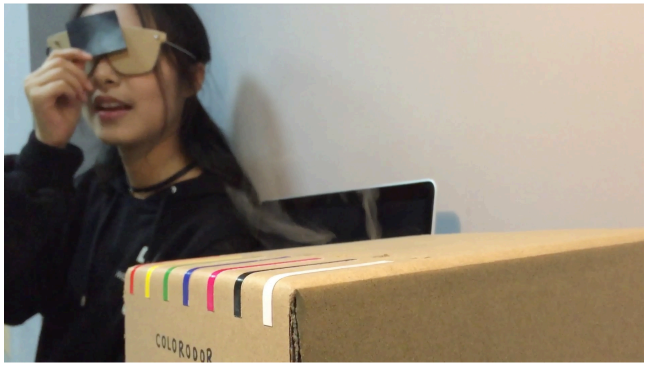

Figure 5: The User smells ink odors and identifies the black color.

Application Scenario

In this scenario, we tried to make it possible for visually impaired people to determine the color of clothes by sniffing, which means that they may get more useful help by connecting scents with other things. Figure 6 presents that a user puts on "*ColorOdor* Glasses" to capture the clothing's color and sends the data to the odor generator attached to the mirror of the wardrobe. The user can identify the color of clothing by smelling the scents.

In addition to the above application scenarios, we use our system in a variety of applications such as to improve blind social life and early education for blind children. We explore how *ColorOdor* helps blind people to interact with others. *ColorOdor* can also be used with children with congenital blindness to learn about animals or plants by touching and sniffing models with their odors.

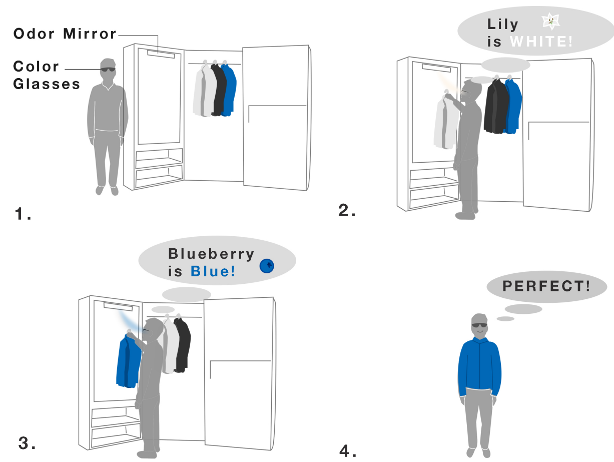

Figure 6: A user called Samon uses *ColorOdor.*

User Test and Discussion

Our blind volunteer placed a yellow mobile phone shell in the middle of the lens (Fig. 7). The computer then identified the color and showed the result on the screen. The odor device released the smell of lemon, and the volunteer realized that the phone shell was yellow. After testing, the volunteer thought that the system could be useful. He described that when he smelled the fragrance of lily, he felt that the smell was fresh and clean, so he immediately answered that the result was white. He thought that our research was very meaningful, especially for patients with congenital blindness.

Figure 7: The blind volunteer tests the prototype.

The test showed that the product is useful for the identification of colors for the blind to some degree. However, the device has some limitations. Some colors such as khaki or navy blue are difficult to recognize; how might we link such colors with odors? We suppose that the concentration of odors may play a role in identifying colors, which is a rich space for future research.

Conclusion and Future Work

In this article, we proposed a prototype system that can emit odors according to the results of color recognition. Our system aims to help blind people who cannot perceive color and thus enhance their sensory experience and improve their integration into society.

The current system can only identify seven colors. In the future, we plan to build a complete color–odor correspondence database in a cloud system so that the database can be updated through a network. Meanwhile, we envision that hardware modules in our system can be integrated into one minimal module that will be able to connect to intelligent blind glasses or a watch.

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