Fashion Innovation for Blind Children: A Case Study of Intelligent Glove Featuring Perception of Chromatic Color

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Abstract. Blind children are a special group of children. Loss of vision causes numerous obstacles for blind children in life and in study and makes the pleasure of reading, studying, and exploration of the world impossible for them. To ameliorate these limitations of blind children and improve their study experience, we have designed an intelligent glove that considers the handicaps of blind children and enables them to perceive and become aware of the existence of colors using temperature and chromatic-color sensors. When blind children who wear the intelligent glove touches a colored picture, the glove temperature changes with the change in the color coldness or warmness of the picture to perceive chromatic color and object shape. The intelligent glove helps blind children accurately "read" color illustration so that they can enjoy the pleasure of experiencing the picture and its accompanying text in a book. Meanwhile, attempt has been made to enable blind children to learn painting using this method and experience the full painting process. This intelligent glove provides a multi-element interactive experience mode to blind children so that they can better learn and perceive this colorful world through intelligent interaction.

Keywords: Intelligent Gloves Design; Color Sensor; Temperature Sensor; Temperature Controller.

1. Introduction

In the 21st century is the era of intelligence, with the development of intelligent clothing should also be times from time to time, it makes the whole field of intelligent idea further, make the material more and more intelligent, more and more humanized design, technology is more and more efficiency, function more and more rationalization, also more and more comfortable, in wearable devices at the same time bring clothing more added value to its integrating portable and intelligent features, will gradually permeate into People's Daily lives, changing people's way of life.The study of color sensor of the smart gloves use color sensor (mainly for color sensor) converts the optical signal into an electric current, and micro current signal preprocessing, according to (a color sensor and a temperature sensor to the sensor signal, then the temperature control device can automatically control the corresponding load to color data, according to one of the important characteristics of the color is the color temperature is that we say usually cold and warm color, the color ring data input temperature controller) regulate the temperature in the gloves, different temperature in the gloves, the blind children through the temperature to feel the color. This smart glove makes Braille books from illustrations, blind children in reading Braille books with this smart glove, experience of the illustrations in reading fun. At the same time, the technology is "temperature" and "emotion" instead of "cold”. If the smart changed our life, so it should be to change the special people's life, because they need more. I study the smart glove is computer technology, sensor technology, information communication technology, artificial intelligence technique. Through the color sensor, temperature sensor, temperature detector and a temperature controller, the smart glove by temperature have can feel the color of ability, to make blind children can understand and feel the color of. The smart gloves that it conveys are not only a humanistic concern for the blind children, but also to the life of gratitude and respect.

2. Case Study：Intelligent Glove Featuring Perception of Chromatic Color

2.1 Working Theory of the Sensor

Temperature controller, temperature detector, color sensor, controller, and other auxiliary electronic components are combined in the intelligent glove through embedding mode to make the glove capable of color perception. The color sensor (TCS3200) statically recognizes the colors of an object, outputs different frequencies according to the color information, and transmits the output frequency to single-chip processor (MC9S12XS128). In addition RGB color data are obtained after a frequency-sampling calculation using a single-chip processor. According to the RGB color table listed in annex A, a lookup table method is used to determine the color corresponding to its RGB value.

Figure 1 shows that numbers 1, 2, and 3 represent temperature controllers 1, 2, and3, respectively. A temperature-detection sensor is simultaneously configured under each temperature controller, namely, temperature-detection sensors 1, 2, and 3. Temperature controller 1 is dependent on the control of the R value in RGB. The higher the R value is, the higher is the temperature of temperature controller 1, that is, 0–255 respectively corresponds to 10–50 °C. Similarly, temperature controller 2 depends on the control of the G value in RGB, and temperature controller 3 depends on the control of the B value in RGB. The temperature controller controls the temperature of the glove according to the statically recognized RGB color data by the color sensor (TCS3200). Thus, the glove generates different temperatures and enables blind children to perceive color through temperature.

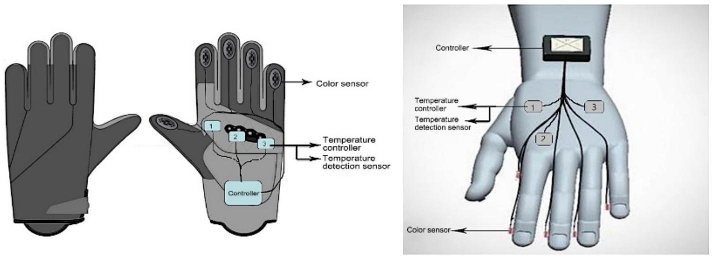

Figure 1. Smart gloves design concept map

2.2 Working Theory of the Temperature Controller

The electronic temperature controller transforms a temperature signal into an electrical signal through temperature-sensing devices such as thermocouple and platinum resistor and controls a relay to activate (or deactivate) heating (or refrigerating) equipment using circuits such as single-chip processors, programmable logic controller, and other devices. For the purpose of this study, the temperature-control system of the intelligent glove utilizes temperature sensor DS18B20 and features an intelligent temperature-controller design. In this system, the DS18B20 three-core mini-type contact-chip temperature sensor performs complete environmental temperature signal collection and transmits the collected signal to a single-chip processor (MC9S12XS128) for processing and complete intelligent control.

2.3 Working Theory of a Color Sensor

Color sensor is also referred to as chromatic-color recognition sensor. The color sensor is designed to consist of an independent photodiode with corrected red, green, and blue optical filters and to perform relevant processing of the output signal so that the color signal is recognized. The basic theory of color recognition is described as follows. 1) Color characteristics: (a) Hue is based on the wavelength and is used to distinguish the characteristics of different colors. (b) Saturation reflects the purity of color; each color type can be understood as the result of the mixture between a certain type of spectral color and a white color. The higher the proportion of the spectral color is, the higher is the color saturation, and vice versa. (c) Lightness describes an attribute of the color brightness and is related to light energy as a measure of light intensity[51]. 2) Trichromatic theory:

We appropriately select three primary colors (red, green, and blue), and combine these colors according to different proportions to generate a visual sense of the different colors. The overall lightness of the three primary colors determines the lightness of the combined color lights. The proportion of the three primary color components determines the chrominance. The three primary colors independently exist, and making up any primary color is impossible. 3. Semiconductor characteristics: Conductivity substantially changes depending on the external optical and thermal stimuli, namely, light- and thermo-sensitive elements. The basic steps of color recognition are as follows: using a color sensor (mainly a color-sensitive sensor) to transform optical signals into an electrical current; pretreatment of the electric current micro signal, analog to digital conversion, and sending the digital signal to a single-chip processor or a microcomputer for processing.

Theory of recognition: Color sensor detects color by comparing the object color with a standard reference color and outputting the detection results when the color of an object matches the standard color within a certain range of error.

2.4 Technical Support for Embedding Design

Intelligent wearable devices usually select an embedding method for integration of hardware equipment such as sensor and electronic components. This hardware equipment is embedded into intelligent wearable devices without affecting the comfort of a person using such wearable devices and in such a manner that it is difficult for the user to be aware of the device. Therefore, hardware devices are excellently integrated into intelligent wearable devices. This design adopts the embedding design technique so that sensing function of the intelligent glove can be ensured, and wearing comfort and good appearance can be realized, as shown in Figure 2.

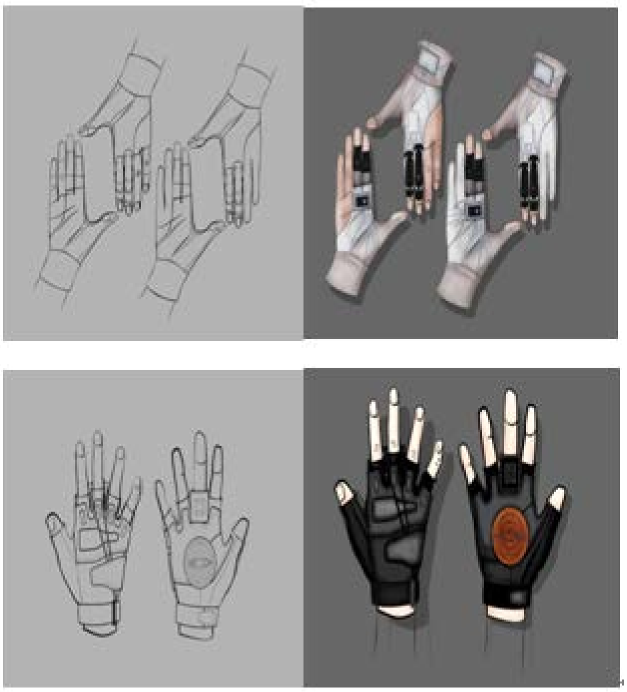

Figure 2. Appearance design sketch of the color sensor of the smart gloves

3. Experimental Design

3.1 Relationship Diagram of the Main Components of the System

The power supply module provides 5- and 12-V power supplies to the single-chip processor and sensor, respectively. When the color sensor detects a color signal, the color signal is converted into a specific electrical signal and inputted into the single-chip processor. The single-chip processor determines the temperature corresponding to the color using a lookup table method according to the data transmitted from the color sensor and then sends a warm-up or cool-down command to the temperature controller. Becoming aware of the temperature rise or drop caused by the temperature controller is impossible for the single-chip processor itself. Thus, a temperature sensor is needed to monitor the temperature in real time, which is then fed back to a single-chip processor (see Figure 3).

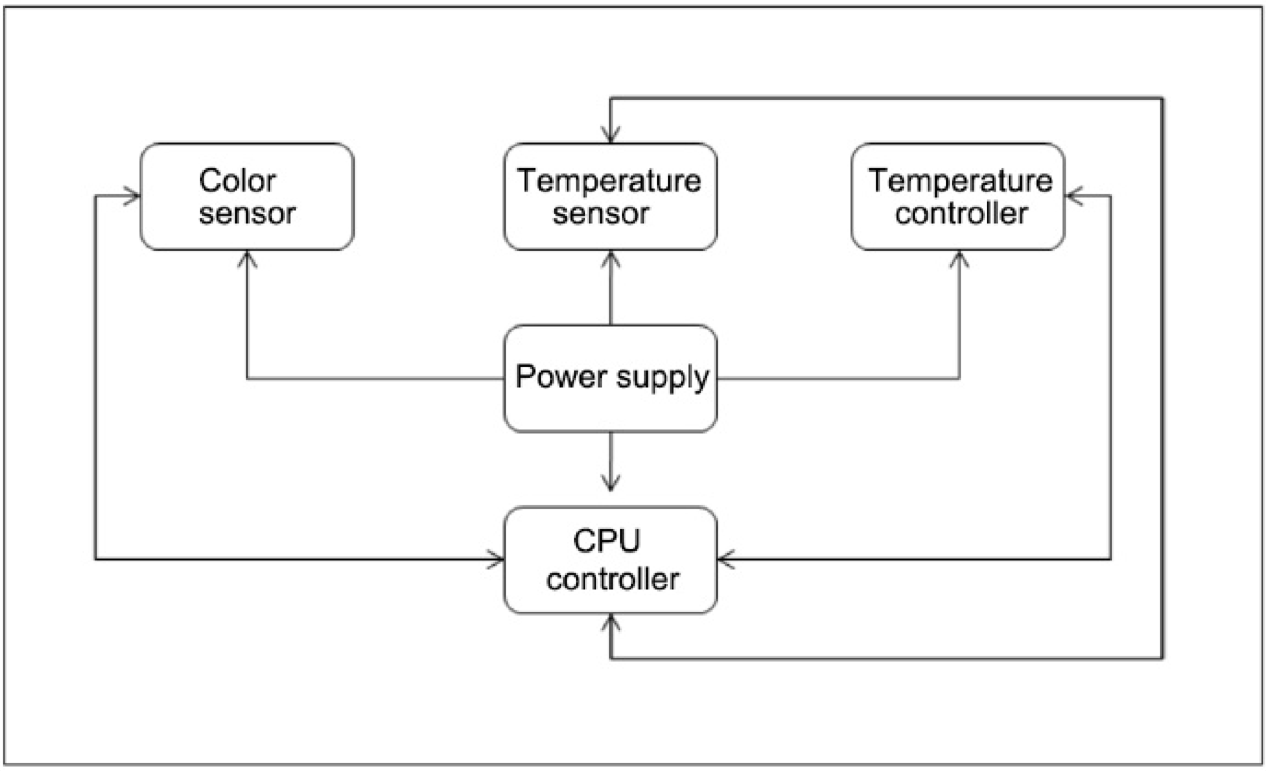

Figure 3. Relationship diagram of the main system components

3.2 Procedure Flow

3.2.1 Specific Control Procedure Flow

(1) Color sensor (TCS3200) is used to detect data corresponding to the color identified by the current sensor.

(2) The color signal is transmitted to the single-chip processor, which calculates the color corresponding to the current data using a formula.

(3) A liquid-crystal display (LCD) screen directly displays the current color in word form (to allow a person with a normal vision to check the operating status of the sensor at any time)

(4) The lookup table method is utilized to determine the temperature to be controlled corresponding to the current color.

(5) The control mode of a proportional–integral–derivative controller is utilized to manage the temperature-control sensor (i.e., refrigeration element) for heating or refrigeration.

(6) A temperature-detection sensor is employed to detect the current temperature of the temperature-control sensor (i.e., refrigeration element) in real time and to feed back the signal to the single-chip processor.

(7)The single-chip processor determines the real-time operating status of the temperature-control sensor (i.e., refrigeration element) using a comparison method.

(8) A digital tube displays the current temperature of the temperature-control sensor (i.e., refrigeration element) in real time to allow a person with normal vision to check the operating status of the sensor at any time.

3.3 Temperature Setup

3.3.1 Experiment on Hand Discrimination of Temperature Difference

A cold or warm color refers to the temperature difference in the chromatic color. For chromatic purpose, colors are divided into warm color (red, orange, and yellow), cool color (cyan and blue), and neutral color (violet, green, black, gray, and white) according to psychological sensation.

Three temperature ranges are obtained through experimental temperature measurement: cool color: 10–20 °C, neutral color: 20–30 °C, and warm color: 30–40 °C. The discrimination by hand of the temperature difference is detected in these three ranges.

Table 1: Experiment of hand discrimination of the temperature difference

Temperature difference	10–20 °C	20–30 °C	30–40 °C
2 °C	Recognizable	Recognizable	Recognizable
3 °C	Recognizable	Highly recognizable	Highly recognizable
4 °C	Highly recognizable	Highly recognizable	Highly recognizable

In the 10–20 °C temperature range listed in Table 1, the discrimination by hand of the temperature is recognizable for a temperature difference of 2 °C, those for temperature differences of 3 °C and 4 °C are both high. In the 0–20 °C temperature range, we can select a temperature difference of 2–4 °C to design cool-color temperature.

In the temperature range of 20–30 °C, the discrimination by hand of the temperature is recognizable at a temperature difference of 2 °C. Those for temperature differences of 3 and 4 °C are both high. In the temperature range of 10–20 °C, we can select a temperature difference of 2–4 °C to design neutral-color temperature.

In the temperature range of 30–40 °C, the discrimination by hand of the temperature is recognizable at a temperature difference of 2 °C. Those for temperature differences of 3 and 4 °C are high. In the temperature range of 10–20 °C, we can select a temperature difference of 2–4 °C to design a warm-color temperature.

The color temperature of the temperature controller (degree of coldness or warmness) is controlled by the RGB value, and different RGB colors are obtained from the changes in the three color channels of red, green, and blue as well as their mutual superposition. RGB colors represent the three channels of red, green, and blue. The RGB colors are set up according to the theory of color luminescence. For better understanding of this concept, it is similar to the lights of three lamps with red, green, and blue colors superimposed among one another. Chromatic colors are mixed, and the color lightness represents the overall superimposed lightness. The more intense the color overlap is, the higher is the color lightness, i.e., the sum of the mixing characteristics. The more intense the superposition is, the higher is the lightness. Each color of the three color channels is divided into 255 orders of lightness. A lamp lightness of zero indicates the weakest lightness, whereas the lamp lightness is highest at 255. When the values of the three colors are identical, it appears gray. It is a bright white when all three colors are at 255, and it is black when all colors are zero. Therefore, the temperature controller can control the temperature according to the RGB chromatic colors. The temperature of the temperature controller is higher when the R value in the RGB color is larger, and it is lower when the B value is larger. G influences R and B and affects the cool-down function for R and warm-up function for B. Thus, temperature control realizes control of the color temperature in accordance with the above theory as per the RGB value.

3.3.2 RGB Cold and Warm Color Relationship and Temperature Setting Range

In Table 2, the higher the R value is, the higher is the temperature. The higher the B value is, the lower is the temperature. The G value influences the R and B values. The larger the G value is, the larger is the influence on the R and B values. When R value > B value, the color is a warm color. The larger the difference is, the higher is the temperature. The G value plays the role of cooling down at this point. The larger the G value is, the larger is the temperature drop. The range of colors is red, orange, and yellow, and the temperature setup range is 30–40 °C. When R value < B value, the color is a cool color. The larger the difference is, the lower is the temperature. The G value plays the role of warming up at this point. The larger the G value is, the larger is the temperature rise. The range of the colors is cyan and blue, and the temperature setup range is 0–20 °C. When R value = B value, the color is neutral, and the G value has no effect. The range of the colors is violet, green, black, gray, and white, and the temperature setup range is 20–30 °C.

Table 2: RGB cold and warm color relationship and temperature setting range table

Relationship between R and B values	Cold/warm color	Role of G value	Range of colors	Temperature setting range
R value > B value	Warm color	Cool-down	Red, orange and yellow	30–40 °C
R value < B value	Cool color	Warm-up	Cyan and blue	10–20 °C
R value = B value	Neutral color	No effect	Violet, green, black, grey and white	20–30 °C

Remarks: R value = B value = G value = 255 is white. R value = B value = G value = 0 is black (otherwise, all other combinations result in neutral color)

3.3.3 Color Temperature Setup Experiment

Table 3: Color temperature setup experimental results table

Serial No.	Color		RGB value	Temperature	Temperature difference	Degree of coldness or warmness	Degree of comfort	Discrimination
1	Red		255,0,0	40 °C	4 °C	Hot	Comfortable	High
2	Pink		219,112,147	28 °C	4 °C	Warm	Comfortable	Recognizable
3	Salmon pink		255,69,0	36 °C	3 °C	Moderately hot	Comfortable	High
4	Orange		255,165,0	33 °C	3 °C	Very warm	Comfortable	High
5	Yellow		255,255,0	30 °C	3 °C	Warm	Comfortable	High
6	Olivine		154,205,50	24 °C	2 °C	Slightly warm	Comfortable	Recognizable
7	Forest green		34,139,34	22 °C	2 °C	Moderately cold	Comfortable	Recognizable
8	Lemon green		0,255,0	20 °C	2 °C	Cool	Comfortable	Recognizable
9	Sky blue		0,191,255	16 °C	3 °C	Cold	Comfortable	Recognizable
10	Dark blue		0,0,139	10 °C	3 °C	Extremely cold	Uncomfortable	High
11	Blue		0,0,255	13 °C	3 °C	Cold	Uncomfortable	High
12	Purple		128,0,128	18 °C	2 °C	Cool	Comfortable	Recognizable

Remark: The gray chromatic attribute of black/white is complicated and is not covered in this paper for the time being.

3.4 Color- and Temperature-recognition Experiments

3.4.1 Color- and Temperature-recognition Experimental Processes

This system has a very high requirement on the relevance between the software and hardware, and the change process of the entire experiment is very complicated because everything is subject to the influence of time, space, and other numerous factors; avoiding certain slight errors is impossible.

The specific operation of color- and temperature-recognition experiments in this study is described as follows: First, the power supply of the development board is turned on, and a chromatic color cardboard is flatly placed. Then, a color-collection module under design is rightly and flatly placed on a cardboard under test. The color-collection module is covered by a paper with good light-isolation performance. The value shown in the LCD is then recorded using a pen. Boards of different colors are measured in turn, and the measured data are recorded. In the experiment, three tests are performed for each color. The recorded data are listed in Table 4.

4. Analysis of the Experimental Results

As presented in the above-mentioned experimental results, the intelligent glove that features perception of a chromatic color can generate 12 different temperatures by recognizing 12 colors. Hence, a user can perceive different colors. This design has a high requirement on the relevance between the software and hardware. The program design is complicated, and the fabrication is very difficult. Therefore, certain slight errors could be generated in the experimental process, but these will not affect the intelligent glove feature perception of chromatic colors in terms of recognizing the 12 colors and temperature control. Certain errors occur in the color displayed by the LCD panel and the setup standard color. Numerous factors may generate these errors, such as the existence of external interfering light, different sensitivities to light of the sensor chips, instability of the light emitted from the LED diode in the light supplement module, and certain other influential factors. Therefore, certain errors will unavoidably exist in the experimental measurement, but these do not affect the intelligent glove in terms of recognition of the 12 colors and temperature control.

Table 4: Color recognition and temperature recognition experiment data tab

Color / Result		EXP RGB	Color	EXP RGB	TEMP (C°)	Degree of comfort	Image
Red	First Exp.	255.0.0	√	170.36.47	40	√	
	Second Exp.		√	170.34.46	40	√	
	Third Exp.		√	170.36.43	40	√	
Pink	First Exp.	219.112.147	√	201.84.125	28	√	
	Second Exp.		√	203.86.130	28	√	
	Third Exp.		√	201.84.127	28	√	
Salmon pink	First Exp.	255.69.0	√	190.58.25	36	√	
	Second Exp.		√	190.60.26	36	√	
	Third Exp.		√	192.57.22	36	√	
Orange	First Exp.	255.165.0	√	223.139.10	33	√	
	Second Exp.		√	233.137.9	33	√	
	Third Exp.		√	222.136.12	33	√	
Olivine	First Exp.	154,205,50	√	118,156,37	24	√	
	Second Exp.		√	119,157,39	24	√	
	Third Exp.		√	117,158,40	24	√	
Forest green	First Exp.	34,139,34	√	56,109,49	22	√	
	Second Exp.		√	55,110,46	22	√	
	Third Exp.		√	55,108,47	22	√	
Lemon green	First Exp.	0,255,0	√	52,159,53	20	√	
	Second Exp.		√	53,157,55	20	√	
	Third Exp.		√	50,159,57	20	√	
Sky blue	First Exp.	0,191,255	√	38,174,197	16	√	
	Second Exp.		√	36,175,195	16	√	
	Third Exp.		√	38,172,196	16	√	
Dark blue	First Exp.	0,0,139	√	38,43,106	10	√	
	Second Exp.		√	40,41,106	10	√	
	Third Exp.		√	40,38,107	10	√	
Blue	First Exp.	0,0,255	√	29,47,138	13	√	
	Second Exp.		√	33,46,135	13	√	
	Third Exp.		√	31,44,137	13	√	
Purple	First Exp.	128,0,128	√	101,28,113	18	√	
	Second Exp.		√	98,31,111	18	√	

Remark: There are certain slight errors in the experimental process

5. Summary

This research attempts to combine art with science and technology by combining advanced sensing technology with art painting elements to design an intelligent product—intelligent glove that features chromatic-color perception. This intelligent product design of an intelligent glove provides multi-element painting experience to people who are enthusiastic about art and painting and enables special group of blind persons to experience painting. As a novel model of intelligent wearable device designed for blind persons to perceive chromatic colors, this product combines intelligent technology with painting skill and chromatic-color attributes. The innovation point of the design is to enable blind persons to perform actions similar to a person with good eyesight, experience chromatic colors, perform painting in a different manner, and utilize different painting experience and painting skills in the painting education and reading fields for blind children, which can enable them to enjoy the pleasure of painting and reading. We have broken a natural limitation. We possibly can not only observe things through our eyes but also perceive things through temperature through the painting process. A chromatic-color element is combined with a temperature element. The temperature is used to perceive chromatic color, the chromatic-color is sufficiently utilized, and better perception and expression of things are realized. Thus, blind persons can be brought out from the dark world and be enabled to perceive the multicolored world just like a normal person. The design in this paper conveys and embodies not only an intelligent wearable device but also care for special groups of disabled person as well as appreciation and respect for life.

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