Development of Color-Distinguishing Application "ColorAttendant"

● Koji Yoshimoto ● Shintaro Kondo ● Yumi Tsuchiya

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In the current situation where mobile phones are widespread in society, and considering the design of public spaces for people with color blindness and their needs for distinguishing colors in daily life, Fujitsu has developed "ColorAttendant", a mobile phone application that helps people to perceive colors. In its development, we practiced the process of human-centered design (HCD). First, we decided on a concept and functions by understanding our user's difficulties and how to address them in their daily life based on the results of interviews with them. Additionally, we adjusted color tints and the color identification function of our application so as to improve its usability. We did this by reflecting in our product the evaluations of people with disabilities and color experts. As a consequence, we were able to launch an application that not only makes it easier for people to perceive colors with simple operations but also provides them with the pleasant experience of discovering unique color names. This paper reports the features and improvements of ColorAttendant based on the HCD process.

1. Introduction

In recent years, the percentage of Japanese people who use a mobile phone for private use has reached as high as 73.9%,[1] making it an indispensable tool for communication and information collection in daily life. Fujitsu has been committed to the development of mobile phones that are more accessible to the elderly and people with disabilities by adopting supportive functions including text enlargement and text readout (voice) functions. The "Raku Raku phone" series[2] is a part of this initiative. Raku Raku phones are mobile phones that are more accessible for people unfamiliar with operating mobile phones as well as those who have difficulty in using mobile phones because of their physical disabilities including visual disabilities.

The ease of identifying colors is one of the visual considerations in the universal design as well as font size and text readout functions. More than three million people in Japan have color blindness. And among the 300 000 people with visual disabilities, some people have total blindness and some have complications of color blindness. These people have difficulty in identifying colors. To address this situation, various considerations can be seen in the areas of signs in public spaces and printed matters. Fujitsu has developed and distributed "ColorSelector" and "ColorDoctor" that help to make Web contents and presentation contents legible, and that do so free of charge.[3] To further promote universal design relating to color, we believe it is essential to offer assistive technologies that can be used by people in addition to the support provided by contents providers.

Therefore, Fujitsu has developed a color-distinguishing application called "ColorAttendant" to help people with visual disabilities or color blindness distinguish colors by applying assistive

technology to mobile phones. This technology uses the camera feature of mobile phones. In its development, we carried out customer-driven selections of concepts and features, evaluation and improvement by implementing human-centered design (HCD) processes.

2. ColorAttendant concept

In the HCD initiative, the importance of accurately understanding how people use a product and clearly defining concepts at the initial stage of its development process is emphasized.[4] Therefore in the development of ColorAttendant, to understand users' behavior and to clearly define the concept of our application, we held interviews with people with color blindness, the target users, to find out what kind of difficulties they had in distinguishing colors in daily life, and to identify which tools and measures they use to address these difficulties. Some examples of the interview results are shown below:

1) One person almost went to a funeral wearing a pale green shirt.
2) Another person who asked a pedestrian for directions was told that the building he was looking for was the one with a red signboard outside, but he was unable to distinguish it from other signboards.
3) When distinguishing colors, red and green filters are used.[note] These filters are convenient because they are suitable for carrying around and are easy to use.

Based on the interview results, we determined that the concept of ColorAttendant should be to offer people an "easy, simple, happy and pleasant" way to distinguish colors. Assuming that the tool is to be used in various situations in daily life, it is important that people can use it with ease and simplicity—characteristics offered by the red and green filters. However, we aimed also to provide users with a happy and pleasant user experience, in addition to the convenience of eliminating difficulties related to color identification.

note) A handmade tool combining red and green transparent plastic filters. Looking at an object through the red filter, red objects look vivid red, while green objects look dark (the opposite phenomena is observed when looking at an object through a green filter). The difference in brightness is used to distinguish between green and red.

3. ColorAttendant features

3.1 Identifying colors of objects photographed

ColorAttendant allows color identification based on the color of images photographed by using the camera feature of a mobile phone.

The basic operation is shown in **Figure 1**. When taking a picture of an object requiring color identification (Step 2), the screen switches to the color identification screen. By operating a cursor on the screen with the D-pad, information about the color of the object on which the cursor is placed is displayed on the screen (Step 3). One of the basic concepts—ease of use—is achieved by this simple procedure.

If this feature is used with a Raku Raku phone with a text readout function, the phone reads out information about the identified color. This allows people with visual disabilities to know the color of an object by listening to this read out.

3.2 Three color display modes

Our interview results revealed that people with color blindness want to know the general color of objects, for example they want to know if an object has a reddish color or a greeny color. Similar needs for information on general color families are also observed among people with visual disabilities. However, because it is impossible to know the subtle color tints of an object, such as its brightness and darkness, only from general information, we believe that more specific explanations about an object's color using adjectives is necessary. Besides, assuming the expanded scope of users for ColorAttendant including people in

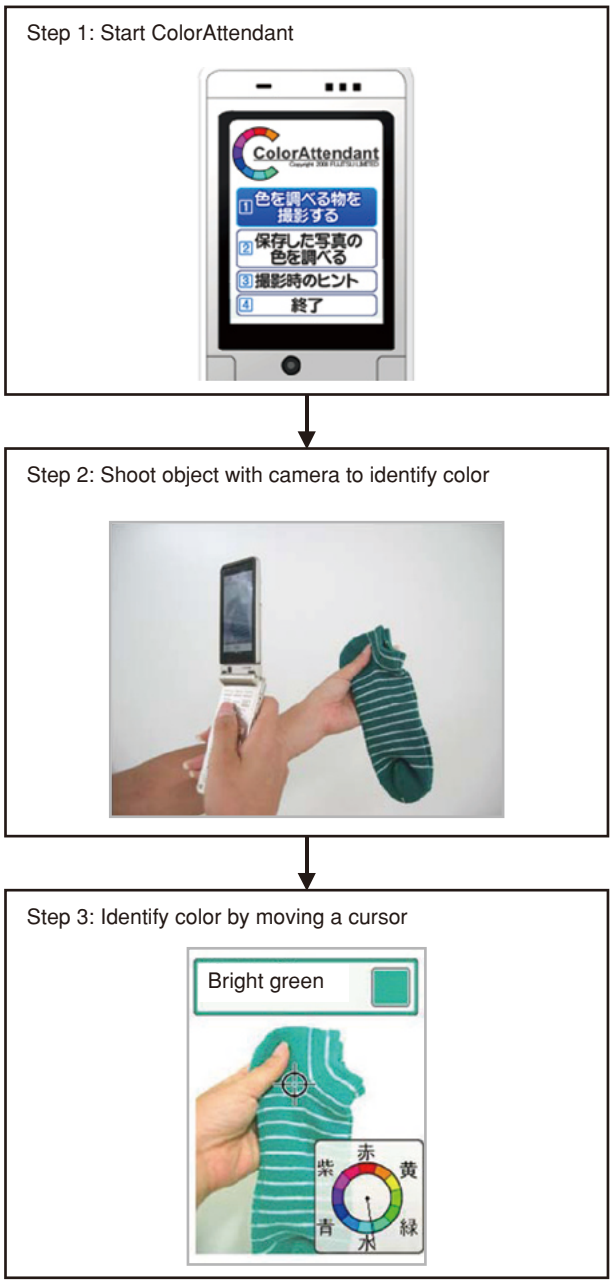
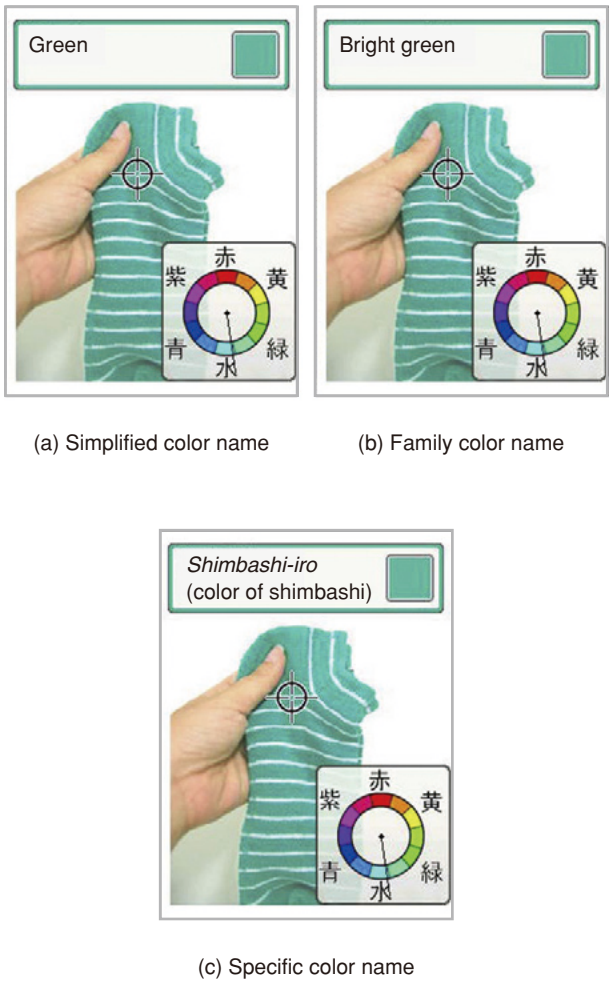


Figure 1
Basic operation of ColorAttendant.



(a) Simplified color name (b) Family color name

(c) Specific color name

Figure 2
Three types of color name.

normal health, we have proposed a pleasant experience of exploring interesting color names.

Based on this concept, we implemented three types of display mode (simplified color name, family color name, and specific color name) so that users can choose their preferred display mode depending on their preferences and needs (**Figure 2**).

The simplified color name mode is characterized by its familiar color expression which indicates the color family that the object belongs to using simple color names centered on the basic color category[5] acknowledged as a basic system of color categorization in various language populations in the world. The family color name mode is comprised of the 10 basic colors including red, blue and green specified in JIS Z8102: 2001[6] and uses adjectives such as "bright" and "vivid", giving the users an impression of the color of the object in question. The specific color names are the names of colors based on the same JIS standard allocated to more than 200 kinds of objects. These names include interesting color names rooted in

Japanese history and tradition such as *shimbashi-iro* (color of shimbashi), *wasurenagusa-iro* (color of forget-me-nots), and *kakitsubata-iro* (color of irises).

3.3 Intuitive and memorable display of color circle

When buying clothes, people with color blindness can obtain information on the color of some clothing by reading tags attached to that clothing or by asking a shop employee. However, because people's memories tend to fade over time, they sometimes forget the colors of clothes they have bought. Therefore, we employed a color circle in ColorAttendant, in addition to the color name information given in a verbal (semantic) expression. The color circle makes it possible for users to remember the color of an object based on the direction of a pointer, just like the hands of an analogue clock that enable people to intuitively understand the time. In this color circle, the direction of the pointer indicates an object's color tint and the length of the pointer indicates its saturation with reference to the hue circle in the Munsell color order system.[7)]

As color value information, displays based on RGB and CMYK are also supported. RGB tells the user precise numerical information that cannot be identified by only referring to a color name. CMYK is a color order system used in printing, which helps the user to imagine the color from the ratio of the four colors of inks.

3.4 Color comparison feature

People with visual disabilities and people with color blindness have difficulties in matching the colors of two objects such as the colors of a pair of socks in daily life. Aiming to address this difficulty, we implemented a color comparison feature that enables two objects to be compared and judges whether or not they are of the same color family. Information on the reference color is displayed in the upper part of the mobile phone's screen and information on the color of the object

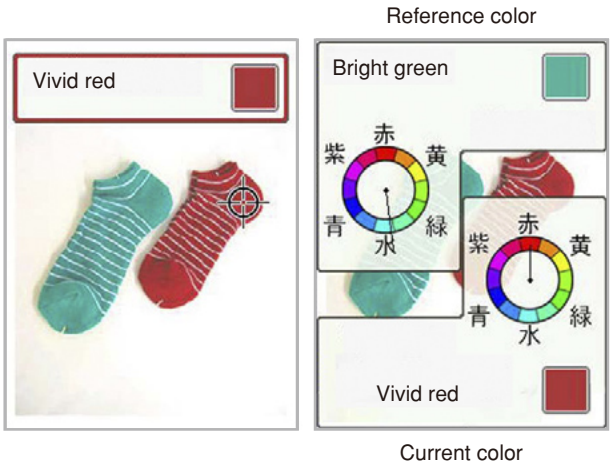


Figure 3
Color comparison function.

to be compared is displayed in the lower part of the screen. Users are informed of the comparison result concerning whether the objects belong to the same color family or have different color tints by the voice feature (**Figure 3**).

Further, users are told the result of the color comparison by having the phone vibrate using the vibration feature of the mobile phone. Because the length of vibration reflects the degree of difference of two colors, people with blindness can recognize how different two colors are not only by using an audible feature but also by using a tangible feature.

3.5 Other features

1) Display of guide line of cursors and location

Because similarity or insufficient contrast between the object image and the cursor that indicates a point for color judgment may lead to illegibility sometimes, cursor guidelines are displayed in a way that they fully cover the screen in the vertical and the horizontal directions. Also as a consideration for people with visual disabilities, the value of X and Y coordinates are displayed and read out.

2) Reading images taken with a camera function

Giving consideration to the situation where

users may be reluctant to judge the color of an object in public, we incorporated a feature into the application whereby people can capture and display the images they have taken and saved in their mobile phones. By using this feature, users can carry out color judgment at their preferred timing in their preferred location based on the images they shot while they are away from home.

3) Storing color information

To address the problem where after a while users forget the colors of the clothes they have purchased, the application has a feature for saving the images used for color judgment including color names and color values. This function enables the users to refer to the color information they have collected in the past by using the image viewer function of computers or mobile phones.

4. Evaluation by people with disabilities and color experts

After completing the development of the pilot version, we had ColorAttendant evaluated as a part of the HCD "evaluation for design requirements" process. People with color blindness, people with visual disabilities and color experts were the evaluators, and they assessed several aspects of ColorAttendant including its convenience and the appropriateness of the color information it produced (**Figure 4**).

Figure 4
Evaluation by a person with a disability.

4.1 Issues pointed out by evaluators

1) People with color blindness

"While it is sufficient to know whether the object is a greeny color or reddish color, I am concerned about a slight inconsistency in the color tints".

2) People with visual disabilities

"When I changed the color display mode from family color name mode to simplified color name mode, the description of the same color changed from dark blue to black. It is confusing".

3) Color experts

"Affected by the lighting when an image was shot and the automatic whitening balance adjustment feature, color tints change depending on whether or not there is a white object or black object in the field".

4.2 Positive perception

1) People with color blindness

- "While I couldn't rely on my perception of colors, I can be more positive if I use this feature".
- "I can't stop using this feature because it is so interesting".
- "Because the red and green filters are not used by everybody, I am rather reluctant to use them in public when I'm away from home. It is nice that I can distinguish colors without reservation by using my mobile phone, an item that everybody carries around".

2) People with visual disabilities

- "I want to use this feature to identify the colors of my clothes (my jackets, trousers etc.) because I have some clothes whose color I don't know. Now, I wear only beige clothes because that is a safe color, but I may use this feature when I buy and wear clothes of many other colors".
- "It is useful to have this feature incorporated in a mobile phone. Because I carry around various types of devices in my daily life such

as a mobile phone, radio and IC recorder, I don't want to increase the number of such devices anymore".

5. Improvement based on evaluation results

We adjusted the color tint and color-distinguishing feature and also improved the application's usability based on the results of the evaluation by persons with disabilities and color experts.

1) Color tint adjustment feature

To address the influence of lighting during the shooting of images and the automatic whitening balance adjustment feature and to improve the accuracy of the application's color-distinguishing performance, we formulated an instruction to include a white object as a reference in the shot. Also, we added a feature to correct for color tints of the whole image by using the white color as reference.

2) Adjustment of color-distinguishing feature in simplified color name mode

Because the number of available color names is limited in simplified color name mode, the judgment of colors tends to be rough particularly for achromatic colors. Therefore, the same color may be described as being dark blue in the family color name mode, while it is judged as being black in the simplified color name mode, resulting in confusion for users.

To address this inconsistency, we adjusted judgments in the simplified color name mode. The scope of colors declared as black or as white among achromatic colors was narrowed to enhance precision. At the same time, we decided to use adjectives used in the family color mode, such as bluish black, for achromatic colors close to white or black with a chromatic element, even for colors displayed in the simplified color name mode.

3) Improvement of usability

We improved the usability issues pointed out in the evaluation by persons with disabilities. In response to a request by a person with color blindness who wanted to know the accent color of some clothes, we added a feature to magnify the image taken. Further, based on input from an evaluator with a visual disability who said that, when moving the cursor, he could understand the image by using the screen center as a reference point, we added a feature to immediately reset the cursor to the screen center with one touch of a number button.

6. Conclusion

We developed a color-distinguishing application called ColorAttendant to identify the colors of objects shot by a camera incorporated in a mobile phone to help people with visual disabilities or color blindness determine colors.

In developing ColorAttendant, we used an HCD development process. Based on the results of interviews with target users, we determined that the concept of ColorAttendant should be an "easy, simple, happy and pleasant" way to distinguish colors. We incorporated a function that provides users with the pleasant experience of discovering unique color names in addition to eliminating their inconvenience. After conducting improvements to reflect the results of user evaluation, we launched an application that can meet users' requests.

We are determined to further commit ourselves to realizing an "IT-supported society accessible for everyone" by improving the features and usability of ColorAttendant. We will do this by implementing the HCD process and by further promoting applications for assistive technologies that operate on mobile phone platforms.

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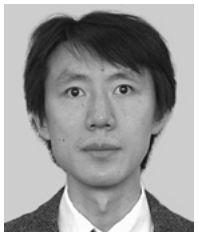
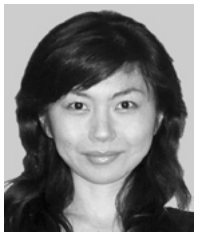


Koji Yoshimoto
Fujitsu Design Ltd.
Mr. Yoshimoto received the B.S. and M.S. degrees in Physics from Tokyo Metropolitan University and Tokyo Institute of Technology, Tokyo, Japan in 1999 and 2001, respectively. He joined Fujitsu Ltd. in 2003, and has been engaged in research and development of accessibility and diversity in ICT. He has been with Fujitsu Design Ltd. since its spin-off in October 2007.

Shintaro Kondo
Fujitsu Design Ltd.
Mr. Kondo received the B.E. and M.E. degrees from Chiba University, Chiba, Japan in 1999 and 2001, respectively. He joined Fujitsu Ltd., Kawasaki, Japan in 2001 and initially worked on quality assurance for network equipment. Since 2008, he has been engaged in the field of universal design and accessibility. He has been with Fujitsu Design Ltd. since its spin-off in October 2007.



Yumi Tsuchiya
Fujitsu Design Ltd.
Ms. Tsuchiya graduated from Shoin Junior College, Kanagawa, Japan in 1994. She joined Fujitsu Ltd. in 2004, and has been engaged in the field of universal design and accessibility. She has been with Fujitsu Design Ltd. since its spin-off in October 2007.