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# Color Assignment for Information Presentation at the Human-Machine Interface of Automated Wheelchair Operation System

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Abstract:Coloring for a human-machine interface's usability is discussed employing the interface for an automated wheelchair operation system as a real example.
Keywords:automated wheelchair, human-machine interface, operator's attention, information discrimination by coloring

## 1.Introduction

The value of information must be conveyed to the partner of communication. Evaluation of information is based on having interest on a particular object. In the case of visual information, attention payed to a particular behavior of something reflects the degree of the observer's interest on it. Colors can carry attention dominance of a particular object or its behavior. This idea can be used deliberate attention distribution in order to have the system supervisor pay attention unconciously to some particular events which have high information values. As an instance to implement the present idea and to evaluate the idea, an automated wheelchair operation system is employed, which has been developed by the authors.

## 2.The Present System

The development of the present automated wheelchair system is reviewed in this section. Fig.1 shows the schematic of the present automated wheelchair system. While conventional systems employs the idea in which necessary processors for wheelchair's move are carried by each wheelchair, in the present system, all the processors are placed off the wheelchair. Moreover the behavior is not determined just mathematically and determined by an expert system based on the rules employed by a human expert and on the operation data. In the present automated system, basically a human, who will be called an operator, can exist as an intervener to solve emergent events. Existence of operators in the system guarantees the system safety. To support the achievement of the purpose of the human operator, the following information is offered to the operator by the automated system:

1)The state of the system.
1-1)When error occurs.
1-1-1)The position(s) of the occurrence of error.
1-2)Under normal operation.
1-2-1)Check of wheelchair in motion.
2)Information on wheelchairs and their surroundings.
2-1)The present position of each wheelchair.
2-2)Existence of objects which interrupt wheelchairs' prescribed courses.
3)Schedule of wheelchair movement.
3-1)Prescribed courses to take.
(Includes detours)
3-2)Control data for the prescribed courses.

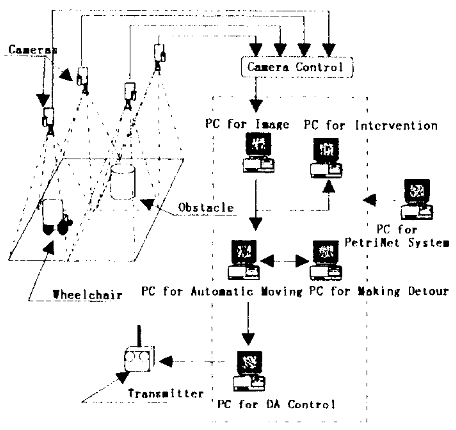


Fig.1 Automated Wheelchair system.

## 3.Fundamentals of the Theory of Color

In general, colors have two aspects; i.e., colors of light and colors of objects. The theory of color mixing deals with the former and color classification systems like the Munsel system are for the latter. In the present paper, colors are handled on a digital computer used for the automated system operation, so color mixing is employed using RGB values.

### *3.1 The CIE System and the Color Primaries*

Fig.2 shows CIE chromaticity diagram. In the diagram, colors can exist only in the area enclosed by the horse-shoe-like figure in Fig.2. An analog color display can deal with the color within the larger triangle in Fig.2 at most. In the ordinary use, display parameters are fixed, and hence colors on the display exist within the smaller triangle. According to color mixing theory, any color can be represented combining three primary colors of red, green, and blue.

### *3.2 Color Cognition and its Psychological Effects*

Colors have a variety of influence on human visual cognitive activity. A human identifies a particular object by discriminating colors of the object. Colors also have some psychological effect on human cognition. There are many researches on colors and their effects on human brain. Some of them which are related to the present paper are briefly described here:

(E-1)As often called "color-blindness," there exist some color deficiencies. People with normal vision, however, have still some tendencies in color sensitivity in general.[1,2]

(E-2)Some characteristics in color vision are:[1]

i)Color adaptation is the phenomenon that continuing to see the same color would change the sensitivity to that particular color in brightness and hue.

ii)Simultaneous color contrast

(E-3)Colors have the following effects on perception:[1]

i)Colors and apparent distance

Colors are largely classified into advancing colors and retreating colors. Under the same brightness, colors of longer wave length such as red, yellow, and orange look advancing than colors of shorter waves.

ii)Warm colors and cool colors

Red, orange, yellow and purple-red look warm and on the contrary, blue-green, blue, and blue-purple looks cool.

(E-4)There are colors more eye-catching than other colors: For nine pure colors including black, it is reported that red, yellow, and yellow red are eye-catching, and purple, blue, and blue-purple were least eye-catching.[1]

(E-5)Visual clarity is highest for yellow and yellow-orange. And purple is lowest. Intermediate ranks are yellow-red>orange>red>purple-red>blue-green>blue-purple.[1]

(E-6)Simultaneous visual perception has spacial limitation, and visual acuity or attention is restricted to only the center of the view field.[3]

(E-7)The shape of the object affects recognition. Stationary objects attract less attention than those in motion. If you consider the three elements, color, shape, and motion which affect recognition, then human response time is fastest for the combination of motion and color, and then for the combination of motion and shape, and slowest for the combination of color and shape.[4,5](E-8) Shape recognition of an object is made mainly by its contour and coloring. Straight horizontal lines provide stable atmosphere to the viewer inclined line, unstable atmosphere on the contrary, and vertical lines, that of surprise. Curved lines seem to be soft and attract attention. Further, symmetric objects are easier in recognition than asymmetric objects.[1,6]

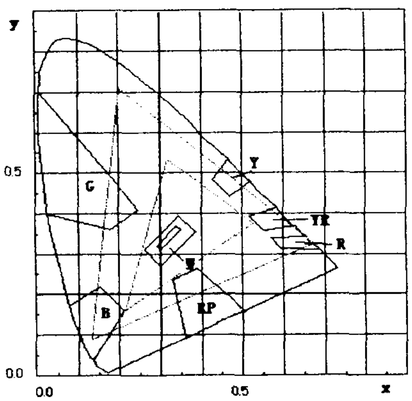


Fig.2 The CIE chromaticity diagram with JIS safety colors.

## 4.Choice of Colors and its Use

In the present paper, the safety colors, as the Japan Industrial Standards specifies, red, yellow-red, yellow, green, blue, red-purple, white, and black are enployed for examination. The reasons why these 8 kinds of colors are employed are:1)They are usually used in daily life, and so the most largest effect can be expected by these colors.2)The individual difference is said to be smallest in the case of these colors.3)On these colors, many researches have been done and much data are accumulated.

Ranges are shown in Fig.2 each of which can be identified to be a single particular color. These areas are out of the range which an analog CRT display can represent, which is shown as a triangle inside the range of the visual colors. So these 8 colors can not be exactly represented on an analog display. In order to be as close as possible to the aboveoriginal 8 colors, psychology of colors are introduced as briefly described in the preceding section. That is, psychological effect on color perception is the action of colors to human mind. So, instead of exact reproduction of the above 8 colors, color images can be reproduced on an analog CRT display. A color image is associated with the name of that particular color. So, a subjects experiment for color image recalling were designed as follows, using a 17in color CRT together with a 17,000-color graphics

adapter:
i) Information presented to the subject.
As the background, two colors black and white are used. And 8 colors are shown as circular stimuli. A prescribed order of showing 8 stimuli and a random order are used to show the subject 8 stimuli. A subject performed two sets of experiments on the backgrounds of black and white. The subjects had normal color vision. The subjects had to adjust their own image not being told the RGB values of the stimuli shown.
ii) The surrounding
Illumination was kept not to directly illuminate the display.

## 5. Experimental Results and Discussion

Color distributions obtained in the above experiment are shown in Figs.3 and 4. In these figures, it is found that difference in combination of background color and showing order does not affect the results. Equivalent color range of color image differs from that of percetual colors. Many of the subjects, i.e.,five of nine subjects, were very sensitive to some particular colors, red or blue or yellow, as was described in Section 3. Fractions of mixing RGB were analyzed instead of the real values. Part of the results, a typical tendency, are shown in Fig.5. In Fig.5, no remarkable individual difference is seen.

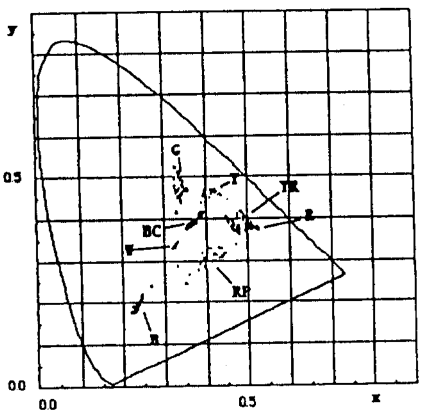


Fig.3 Distributions of colors in subjects experiments.

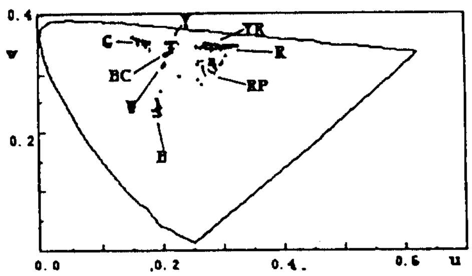


Fig.4 The same results as Fig.3 in UCS diagram.

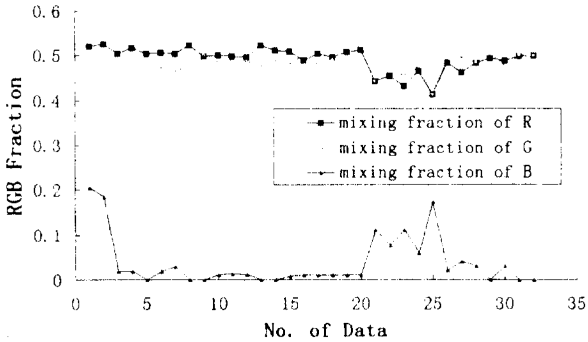


Fig.5 RGB values in fraction for yellow.

Table 1 shows the distribution of RGB fractions among individuals. The above result shows the objectiveness in adjusting color for use in a human-machine interface such as the present idea. But that no remarkable difference was present means that it is difficult to specify an individual's preferred colors and to employ them for use in his interface activity. An expert-system based adjustment may be expedient.

Table 1 Distribution of RGB values in fraction.

| color | Mixing fraction | | |
|---|---|---|---|
| | R | G | B |
| Red | 1.0-0.81 | 0.0-0.18 | 0.0 0.09 |
| YellowRed | 0.55-0.77 | 0.23-0.39 | 0.0 0.13 |
| Yellow | 0.41 0.53 | 0.41-0.50 | 0.0-0.17 |
| Green | 0.0-0.21 | 0.76-1.0 | 0.0-0.34 |
| Blue | 0.0-0.12 | 0.0-0.25 | 0.72-1.0 |
| RedPurple | 0.49-0.67 | 0.0-0.11 | 0.30-0.53 |

## 6. Color Arrangement for the Objects on the Screen

### *6.1 Circumstances Setting*

[I]The state of the system must be realized by the human supervisor ( or the operator) only when the system is malfunctioning due to some cause. This is accomplished by compulsorily changing the content presented on the computer screen by the automated system.
[II]The information on the states of the wheelchairs and their surroundings is the ordinary presentation objects for the supervisor-system interface to deal with. And hence it is on the screen for a long time which tends to make the supervisor lose vigilance. So, easily recognizable form of presentation is required. And since the objective of the system is to supervise the automated wheelchairs, a wheelchair should be easily distinguished from other objects. So first, the shape of a wheelchair is set to be

special. And then, the change in wheelchair location is shown in the basis of the absolute coordinate system fixed in the wheelchair movement space.Thus, the wheelchairs and obstacles which hamper the wheelchair to go along the prescribed course are as follows:

(1)Wheelchair

It is depicted by a pentagon as combination of a rectangle and a isosceles triangle.

Reason: Constituted only by straight lines.

Information carried: Present location, direction to go, the width of a wheelchair.

(2)Obstacle

A circumscribed circle or a split circle connected by two straight lines for a slender object.

Reason: Constituted mainly by a circle.

Information carried: Size of an obstacle.

[III]Schedule of wheelchair movement

The human supervisor's role in the system is to confirm the safety of a wheelchair movement. So, knowing the schedule of a wheelchair is important. For a human to see what course a wheelchair is to take, the most apparent way is to be shown by a visual means. And the technique is important. In order to know the possibility of collision between a wheelchair and some obstacle, it is the best way to see what location the wheelchair's body is going to take at any moment in the course toward some prescribed place. To do this in the present system, shown to the supervisor is not only the course of the figure center of the wheelchair's body (as its top view) but also the area occupied by the wheelchair at any moment during its movement together with some tolerance taking into account a small fluctuation of its move. Fig.6 shows a monitor screen for the supervisor in which the wheelchair together with an obstacle, the course and the tolerance for course movement is shown.

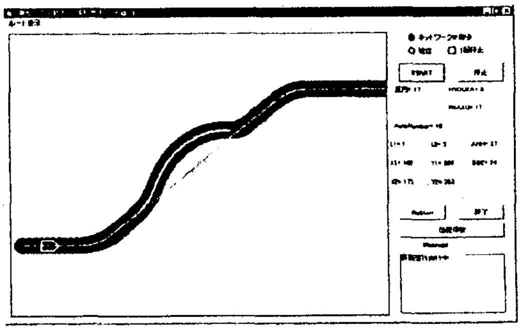

Fig.6 A monitor screen for the supervisor where the wheelchair, an obstacle and the course, etc. are depicted.

*6.2 Coloring Plan*

(1)Wheelchair(The first priority)

*(i)*Highest eye-catchingness is required, and hence advancing and warm coloring is suitable. *(ii)*Because of the most longest attention taking, visibility is requested in order to reduce the supervisor's load.

(2)Width of the course to be traced by the whelchair(The second priority)

*(i)*In judging the safety of the vehicle, rapid response is required. So, colors of visibility and of safety is desirable. *(ii)*Basically the course is of safety-guaranteed. From this viewpoint, excessive intervention by the supervisor must be avoided. And hence safety color is desirable. *(iii)*Since the above conditioning of safety color overlaps with that of the wheelchair, coloring of the course width should be colored in complementary color of that of the wheelchair.

(3)The course (The third priority)

The same conditions must be satisfied as the course width. Keeping complementary relations with the colors of the wheelchair and the width, they must disturbe each other's visibility.

(4)Obstacles (The fourth priority)

High visibility is required, especially for moving obstacles and in the emergency. Colors implying danger are desirable.

Based on the above consideration, the color for each item was determined as follows. However, the 8kinds of colors are insufficient to satisfy all the conditions discussed above. Hence, some compromise was introduced under the following additional conditions on priority: *(1)*Eye-catchingness, *(2)*Visual clarity, *(3)*Psychological effects. Then, the decisions are:

i)Wheelchair=yellow.

ii)Width of the course=purple-red.

iii)The course=blue.

iv)Obstacle=red.

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