Intelligent Support Tool with Dynamic Image Processing for Color Universal Design

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1. Introduction

An intelligent image processing system for color universal design was developed and evaluated. Public signs and direction boards must be readily understood by all people including the elderly, people with color vision deficiencies and people with vision injuries. However, most of designers are not aware of these special visual characteristics. In addition, those designs should be comfortable for people with normal vision. To support the designers, we propose a new system in which visual-modification can be automatically conducted based on simulations of several visual characteristics simultaneously.

2. Dichromat Vision

People with normal color vision, called trichromats, have three kinds of cones whereas people who cannot distinguish between specific color combinations caused by cone defects or absence are diagnosed with color vision deficiencies. About 5% of males and 0.2% of females have color vision deficiency in Japan. They sometimes face difficulties to perform daily activities due to confusion with their color information interpretation.

Figure 1 shows a color conversion model of dichromats by Brettel et al.[1] A color Q is transformed to Qp in Protanope or Qd in deuteranope simulation. We modified luminance transformation to simulate actual characteristics of dichromats vision.

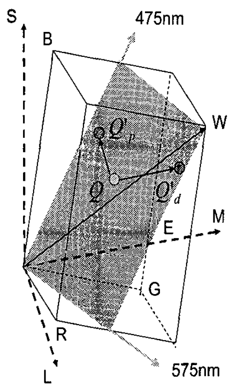
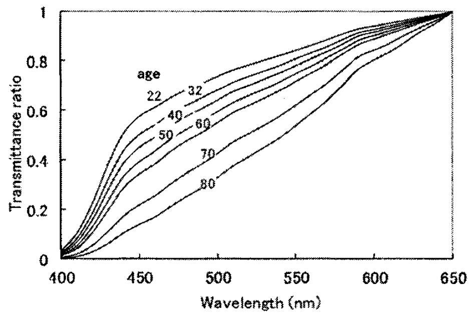


Fig.1 Brettel's model on dichromat simulation

3. Age-Related Changes of Color Vision

Japan is the country with the highest proportion of elderly citizens aged 65 or over. Elderly have different visual characteristics from young people. For example, the yellowing of the crystalline lens with age decreases the amount of light that reaches the retina especially for short wavelength lights (blue or green) as shown in Fig.2. Figure 3 shows the pupillary area of young (20's) and elderly (70's) as a function of log illuminance, indicating that the pupillary area is quite small in the elderly under low illuminant level in comparison with young people. However, previous study[2] reported that color appearance seen by the elderly is radically different from the one seen by young people, suggesting that a neural color constancy mechanism is involved in age-related changes of human vision.



Fig,2 Spectral transmittance of human lens at several ages

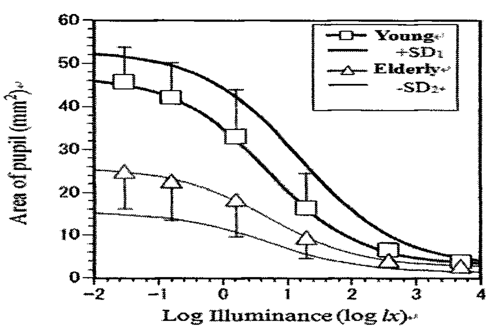


Fig.3 Pupilary area's function of young and old observers

4. Age-Related Changes of Spatial Vision

Figure 4 shows that contrast response functions of old and young observers. The vertical axis represents contrast response P_c derived from a contrast discrimination experiment[3], and the horizontal axis represents the contrast of a Gabor patch which was used as visual stimulus. To simulate the appearance seen by the elderly for young observers, we have to convert the contrast of the image so as to assign the same contrast response for both observers. An example was illustrated in Fig.4 using C_E and C_Y. In addition, we simulated cataract vision by using spatial image filters.

5. Automatic Recoloring System

As the first step for our system, we detected low-visibility regions in images via quantized colors, called clusters, given by a *k*-means algorithm. Generally, the decrease of luminance level is caused by aging, where low brightness regions can be indistinguishable from others in images. Along with this, since the color gamut of people with color vision deficiencies is reduced to some extent, specific color combinations are difficult to be distinguished. We calculated luminance differences and color differences defined by the Euclidean distance in the CIELAB color space between all clusters in original image and simulated image. Comparing these differences, we can detect low-visibility regions that should be compensated. As the second step, we recolored these low-visibility regions to optimal colors. We selected optimal colors that make luminance differences and color differences between low-visibility clusters increase so as to emphasize color contrast. Moreover, because we introduced a constraint algorithm with color conspicuity and basic color categories, we can preserve the naturalness of the original image (e.g. Fig.5).

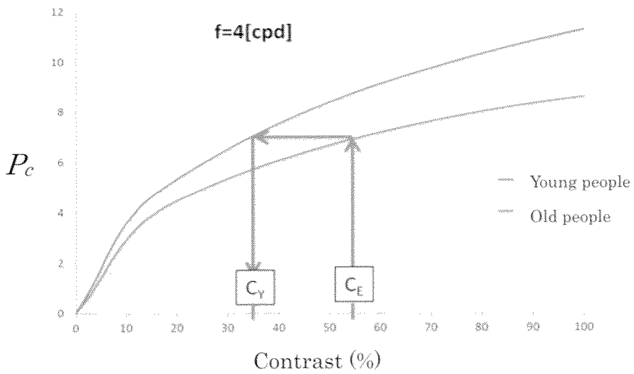


Fig.4 Contrast transformation between old and young observers

6. Evaluation Experiment

The results of paired-comparison evaluation experiments carried out with 8 elderly subjects and 3 subjects with color vision deficiencies indicated better visibility in some recolored images produced by our system over the original images.

7. Conclusion

We developed an intelligent support tool for color universal design by using image processing techniques and evaluated the system by conducting experiments. The results supported the feasibility of the system.

Acknowledgment

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References

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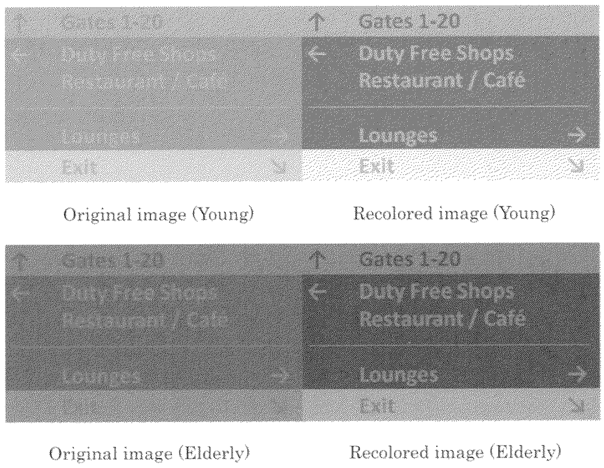

Fig.5 Appearance of original and recolored images