Research Project for Utilization of Human Color Information in Information Systems (Report for 2006 academic year)

Keizo SHINOMORI*, Mamoru OKADA**, and Xiangshi REN***

*, ***Information System Science Division, Department of Information Systems Engineering, Faculty of Engineering, Kochi University of Technology
**Network System Technology Division

*~***185 Miyanokuchi, Tosayamada-town, Kami-city, Kochi 782-8502

E-mail: *shinomori.keizo@kochi-tech.ac.jp, **okada.mamoru@kochi-tech.ac.jp, ***ren.xiangshi@kochi-tech.ac.jp

要約：2006年度に，我々は３つの研究テーマを行った。第１のテーマは，広い面積に色を呈示したときに，小さな面積の場合よりも色の見えが鮮やかに変化する面積効果についてである。我々の研究室は，面積効果の量的測定方法を確立している。そこで，さらに領域分割された色領域を呈示した場合での，色の面積効果を検証した。領域分割された色票が使われた場合は，標準的な大きさの均一色票が使われた時よりも彩度の増加が小さくなった。また領域分割の間の幅の違いは，ほとんど影響しなかった。よって，均一な大きな色領域であることが，面積効果のために重要であることが明らかとなった。

第２のテーマとして，新しいインターフェースパフォーマンスモデルであるSH-モデルが，二次元のポインティング課題にも応用可能であるかどうかの検証を行った。我々は，標準の国際標準化機構9241によって定義される二次元のポインティング課題の実験を開発した。赤池情報量基準AICを評価基準とした結果は，二次元のポインティング課題におけるSH-モデルの有効性を示した。

第３テーマは，手話についてである。手話は，聴力が弱い方々のコミュニケーションとして広く使われている。手話ソングの本及び手話ソングの二次元のアニメーションが，手話ソングを学ぶ方法として使われているが，現在の手話歌の呈示方法では，奥行きを表現することができないし，リズムを教えることもできない。そこで，手話ソング画像における奥行き及びリズムを，手話ソングの３次元のアニメーションを用いて表した。三次元表現の効果は，５つのステージのアンケートによって評価された。

Abstract：Visual information is mostly used as a form of information presentation in information systems when humans use them in any process. Especially, color is important in the presentation. However, utilization of

visual information in information systems has not been well investigated, neither in scientific aspects nor in applicable aspects. Thus, our group is conducting research projects in order to enhance the utilization of visual information, especially color.

In 2006 academic year, we concentrated three research themes. The first theme is the area effect by which an appearance of color in a large chromatic field can be more saturated than the one in a small chromatic field. Our laboratories established the quantitative measurement method of area effect. Therefore, we verified the area effect of color under an area-divided presentation. When the area-divided presentation was used, the increment of saturation became smaller than the one when the normal large reference field was used. But the tendency of the effect is the same. The difference of width between the territories of division was not seen excessively. As the result, we indicated that it is important to have a homogeneous large color area for the area effect.

The second theme is about a verification of an application of a new model, SH-model in two-dimensional pointing tasks. We developed an experiment of two-dimensional pointing task defined by ISO (International Standardization Organization) 9241 standard. The results of AIC (Akaike's Information Criterion) values support the feasibility of the SH-Model in two-dimensional pointing task.

The third theme is about sign language. The sign language is widely used as a communication way of the hearing impaired. Although books the and two dimensional animation of sign language songs are used as the present method of studying sign language songs, the study method of the present sign language song cannot represent depth. Moreover, the rhythm cannot be told. In this research, the depth and the rhythm of sign language are expressed by using the animation of the sign language song of three dimensions. The effectiveness of three dimensional presentation was evaluated by a questionnaire of five stages.

1. Structure of the project

1.1. Purpose

Visual information plays the most important role as a source of information processing related to humans. Thus, visual information is the most used form of information presentation in information systems concerning humans in any process. Especially, color is extensively used in information systems and technologies. However, utilization of visual information in such systems has not been investigated well, neither in scientific aspects nor in applicable aspects.

Our group have conducted research projects in order to enhance the utilization of visual information, especially color, in information systems in collaboration with the Graduate School, Department of Information Systems Engineering of KUT. We also expect that Ph.D. students and masters students in the graduate school join our research projects and acquire high ability as specialists in color science and engineering.

1.2. Outline in 2006

The term of this project is four years and 2006 academic year is the third year, although this is the second year after our project has been supported by the grant for KUT. In this project, research themes fall within one of three research regions below;

(1) Perception region :

Color appearance change with the effect of larger size of chromatic area. (by Keizo SHINOMORI and Mamoru OKADA)

(2) Operation region :

Effect of color on human performance in Human-Computer-Interfaces. (by Xiangshi REN and Keizo SHINOMORI)

(3) Communication region:

Animation of sign language using 3D CG. (by Mamoru OKADA)

Through collaborative work in these three core regions, we expected to establish an easy and accurate ways of utilization of color in information systems and technologies.

We have made progresses in all themes. One result has been published in a journal. Some results have been presented in international meetings and will be published soon as shown in the next section.

1.3. Achievements in 2006 academic year

The 2006 academic year is the third year in our joint project, thus we have some final achievements directly concerning to the project.

Journal paper;

1. Kong, J., Ren, X., and Shinomori, K. (2007). Influence of colors on pointing tasks in human computer interfaces, IEICE Transactions on Information and Systems. Vol.E90-D, No.2, pp.500-508.

International conference publishing reviewed proceedings;

1. Keizo Shinomori, Yuki Kakimoto, Mina Hashimoto and Mamoru Okada :"Influence of area-divided presentation to area effect of color", *Proceedings of NEINE'06 (the International Conference on Next Era Information Networking, Kochi, Japan, 17-19 September 2006)*, pp.333-336, 2006.

2. Keizo Shinomori and Daijiroh Haraguchi: "The influence of size, color and shape of target stimuli in a perceived number comparison task", *Proceedings of NEINE'06 (the International Conference on Next Era Information Networking, Kochi, Japan, 17-19 September 2006)*, pp.323-326, 2006.

3. Md. Wahedul Islam and Keizo Shinomori: "Human face detection using skin color model and eye template matching", *Proceedings of NEINE'06 (the International Conference on Next Era Information Networking, Kochi, Japan, 17-19 September 2006)*, pp.84-88, 2006.

4. Ren, X. and Kong, J. (2006). The Information Processing Rate Issue in Human Computer Interface, *Proceedings of Information-MFCSIT'06 (The Fourth International Con-ference on Information, Information '06, and the Fourth Irish Conference on the Math- ematical Foundations of Computer Science and Information Technology '06, MFCSIT'06, August 1-5, 2006, Cork, Ireland)*, pp.381-384.

5. Zhang, X., Ren., X., and Kyo, K. (2006). Developing SH-Model with Consideration of Learning Effect for Pointing Task Evaluation, *Proceedings of APCHI2006: 6th Asia Pacific Conference on Computer Human Interaction (Taipei, China, October 11 - 14, 2006)*, 10 pages, Springer.

6. Kong, J., and Ren., X., and Kyo, K. (2006). Application of the SH-Model in two-dimensional interface, *Proceedings of APCHI2006: 6th Asia Pacific Conference on Computer*

Human Interaction (Taipei, China, October 11 - 14, 2006) , 10 pages, Springer.

7. Kazuhiro Hujitani, Sayaka Tokaji and Mamoru Okada : "About methods to transmit the rhythm in animation of sign language song using 3DCG", *Proceedings of NEINE'06 (the International Conference on Next Era Information Networking, Kochi, Japan, 17-19 September 2006)*, pp.305-306, 2006.

Domestic conference;

Two oral presentations in Japanese.

In following chapters, we show important achievements in original shape with the authorization of publishers. These are No.1 and No. 7 articles in the list of the international conference proceedings shown above in perception region and communication region, respectively. In operation region, summary of the research will be presented.

2. Research achievement in perception region

We summarize the research achievement in perception region by one paper that was published by Keizo Shinomori, Yuki Kakimoto, Mina Hashimoto and Mamoru Okada as the proceedings of NEINE '06. Kakimoto and Hashimoto are undergraduate students in Shinomori laboratory. This chapter shows the paper.

Influence of Area-divided Presentation to Area Effect of Color.

Keizo SHINOMORI, Yuki KAKIMOTO, Mina HASHIMOTO and Mamoru OKADA

Abstract

Area effect of color is phenomenon that the appearance of color is different when the size of visual field larger even in the physically same color. So, our laboratories established quantitative measurement method of area effect. Therefore, we verified the area effect of color under an area-divided presentation.

We tried the appearance-matching test, in which an observer adjusted a small test field until he/she considered the small field was the same with a large reference field or divided large reference in color appearance. Two CRT displays were used in our experiment. They were set to 6500K as a color temperature. One of 162 color was chosen as the reference stimulus and it was displayed as the large reference field on the left CRT display. The small test field was displayed to the right CRT display. The observer controlled all parameters of hue, saturation and brightness until he/she considered the small test field was the same in color appearance with the large reference field or divided large reference field.

We average results in 3 trails for each pattern and for each observer. We plotted our date on u^*v^* chromaticity coordinates. When the area-divided presentation was used, the increment of saturation became smaller than the one when the normal large reference field was used. The increment rate of saturation by the area effect is high when color was between purple and red. The area effect with the normal large reference field is more saturated in color than the one with the divided large reference field. But the tendency of the result is the same. When we made the graph for value of chroma and brightness, the difference of width between the territory of division was not seen excessively. As the result, we indicated from our experiments that homogeneous large color area of even is importance for the area effect.

2.1 Introduction

Visual information plays the most important role as a source of information processing related to humans. Thus, visual information is the mostly used form of presentation of information in information systems concerning humans in any process. Especially, color is extensively used in information systems and technologies. However, utilization of visual information in such systems has not been investigated, neither in scientific aspects nor in applicable aspects. We conducted the research projects in order to enhance the utilization of visual information, especially color, in information systems.

In applicable use of color in human interface, we have to take care of one famous effect, called as "area effect". The area effect causes shifts of brightness and chromaticness when the area size of a color object becomes larger. This area effect has been known well but neither numeric model nor the mechanism has been cleared.

Thus, we started this research to obtain both of them as the final goal. As the first step, in order to verify luminous and chromatic shifts of matching color caused by area effect, we tried the paper-matching test, in which observers adjusted a small test field until they considered the small one was the same with a large reference field in color appearance. As expected, we could measure the area effect and the results of these mating tests was reported in the last meeting (NEINE '05)[1].

Now, we have started to investigate to possible mechanisms that can cause the area effect. As the second step, we tried to deteriorate the area effect by changing stimulus conditions. In this research, we separated the large field by dark lines and the amount of deterioration was measured with the matching test which is the same with our previous experiment[1].

We presented in 162 kinds of large color chips or divided large color chips those have certain hue, saturation and lightness in arbitrary fixed values. The physical chromatic shift between one of the large color chips and a matched small color chip were measured. By this experiment, we examined how color appearance changes in hue, saturation and lightness by the divided field presentation. We aimed to clarify the amount of change and factors to chromatic area effect by the divided presentation.

2.2 Methods

In our experiments, two CRT displays (MITSUBISHI RDF223G) for stimulus presentation and one monitor for a experimenter were used as shown in Figure 1. They were set to a color temperature at 6500K.

One of 162 colors was chosen as the reference stimulus and it was displayed as the large test field on a lefthand-side CRT display. The small test field in 2 degree of the visual angle was displayed to another CRT display. A shape of the large chromatic field is one of (1) normal square filed in 14 × 14 degree for experiment 1, (2) 49 small fields of 2 × 2 degree, placed as 7 × 7 with separation of

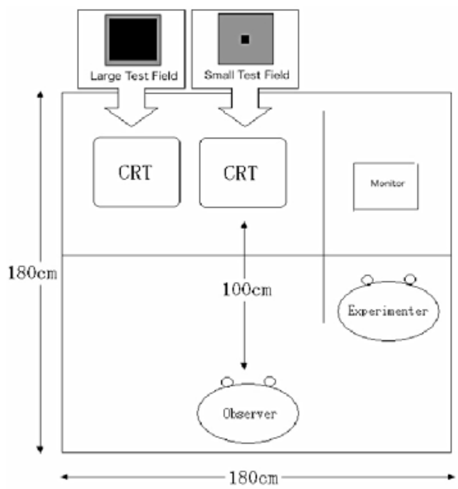

Figure.1: Scheme of the apparatus for experiments.

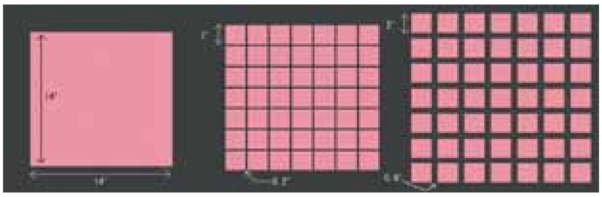

Figure 2 : Scheme of stimuli. Left : normal square filed in 14 × 14 degree for experiment 1, Center : 49 small fields of 2 × 2 degree, placed as 7 × 7 with separation of 0.2 degree dark lines for experiment 2, Right : Same as the central stimulus except with separation of 0.6 degree for experiment 3.

0.2 degree dark lines for experiment 2, or (3) Same as (2) except with separation of 0.6 degree dark lines for experiment 3. The shape of these stimuli are shown in Figure 2. The 162 colors for the reference field were selected with HSB model of the computer screen color. We selected 18 hues, 3 saturation (30, 60, 90 %) and 3 brightness (lightness) (30, 65, 85%).

Observers controlled all parameters of hue, saturation and brightness of the small test field until they considered the small test field was the same with the center of large reference field in color appearance. It took about three hours for one session and the data point is the mean of three sessions. Three normal color vision observers participated in this experiment.

2.3 Results

Original colors of the large reference field (denoted by filled circles) and matching colors of the small test field (denoted by open symbols) were plotted on u*v* chromaticity coordinates as shown in Figure 3. Figure 3(a) and Figure 3(b) show the matching results with the normal square field (Experiment 1) and the divided field presentation separated by 0.6 degree dark lines (Experiment 3), respectively.

As shown in Figure 3(a), colors of the matching field plotted in u*v* chromatic coordinates shows higher saturation than original colors of the large field, especially in hues from red to purple. This result indicates the strength of the area effect in 14 × 14 degree reference field compared to 2 × 2 degree test field. On the contrary, when the large field was divided by 0.6 degree dark lines in Ex-

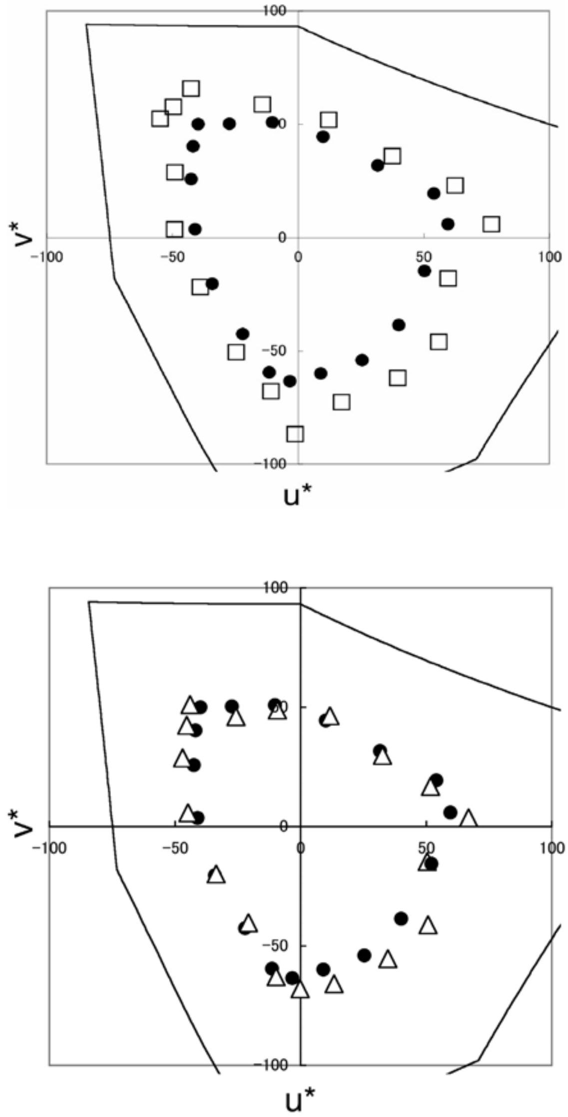

Figure 3: (a) Top panel : u* v* chromatic coordinates of the unchanged large test field (denoted by filled circles) and the matched small test field (denoted by open squares) for observer H.M. in Experiment 1 when saturation and brigtness were set to 60% and 60%, respectively. (b) Bottom panel : Same as in the top panel except open triangles denote the data obtained with the divided field in Experiment 3.

periment 3, the saturation of the matching field reduced and colors were much closer to the original reference colors, as shown in Figure 3(b).

2.4 Discussion

To clarify the relative amount of change of the saturation and the brightness in different hues, we plotted ratio of luminance (as the index of brightness) and the ratio of chroma (as the index of saturation) as a function of hue of the large test field in Figure 4 and 5, respectively, for observer HM when all saturation and brigtness conditions are averaged. Chroma was calculated as C*uv (metric chroma)[2]. These ratios were calculated as the ratio of the matching field to the original colors. Thus,

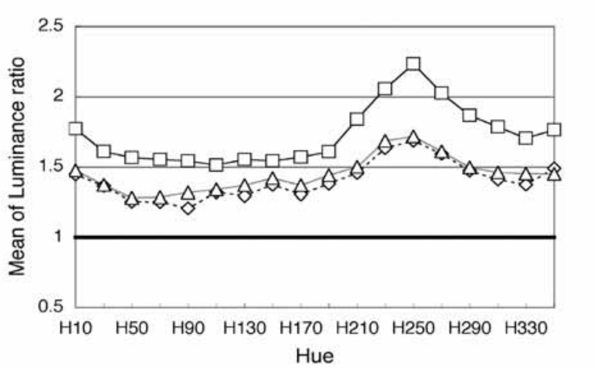

Figure 4 : The mean of luminance ratio in all saturation and brightness conditions for observer H.M.. Squares, diamonds and triangles denote the ratio obtained in Experiment 1, 2 and 3, respectively.

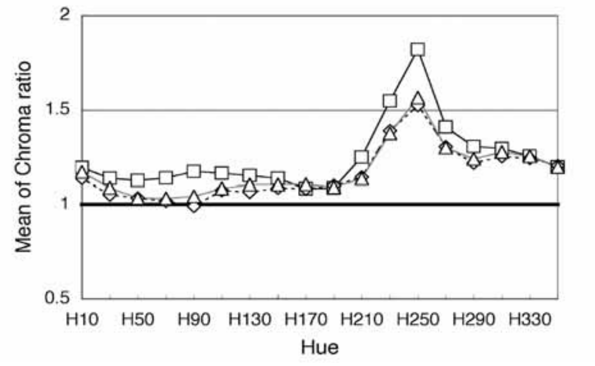

Figure 5 : Same as Figure 4 except Chroma ratio.

the ratio higher than 1 means that chroma or lightness was increased by the area effect in the large field.

As shown in Figures 4 and 5, although averages on brightness and chroma also tended to go up in all hue, the changes of chroma and brightness on blue (around Hue240) became higher than other hues. This fact mentions us that we have to be careful when we think about the area effect in different colors. As shown in Figure 4 and 5, means of luminance ratio and chroma ratio in experiment 3 should be reduced in all hue compared with experiment 1. Furthermore, this tendency of the reduction of area effect is the same for all hue. It means that the area effect deteriorates while keeping a special feature of it. Other two observers' data are almost the same as observer H.M..

2.5 Conclusion

We have already indicated from our previous experiments[1] that luminous and chromatic shifts of matching color by area effect are both in saturation and brightness of the color. At a large view field, human being perceives more saturated and brighter color than the color at the small view field.

From results in this research, we found that the area effect is much deteriorated by dividing the large field. Because the amount of decline of luminance ratio and chroma ratio were not affected by hue, the effect to use the divided large field to "the area effect" does not depend on hue.

Thus, we conclude that it is important to have a homogeneous surface for the area effect. It will be necessary to examine a change for color of a background, and threshold of the area effect by adjustment of the width of dark lines in future.

2.6 Acknowledgement

This research was supported by Grant-in-Aid for Scientific Research (C) (C-2, 16500145) in 2004 to 2005 from the Japan Society for the Promotion of Science. It was also supported by Graduate School Sophistication Special Promotion Support from the Ministry of Education, Culture, Sports, Science and Technology.

2.7 References

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2. Handbook of Color Science [second edition], ed. The Color Science Association of Japan (Tokyo University Publication Inc., Tokyo : Japan), 1998.
3. Mina Hashimoto, Luminous and chromatic shift of matching color caused by area effect, Undergraduate thesis (2004 academic year) in KUT, p.1～p.31.

3. Research achievement in operation region

We summarize the research achievement in operation region by Xiangshi Ren in this chapter.

Application of the SH-Model in Two- Dimensional Interface.

Xiangshi Ren

Abstract

A new model, SH-Model has been approved through AIC (Akaike's Information Criterion) values to be applicable and advantageous over traditional models in one-dimensional pointing tasks evaluation. However, the application of the SH-Model in two-dimensional pointing tasks has not been examined. We developed an experiment of two-dimensional pointing task defined by ISO (International Standardization Organization) 9241 standard. The results of AIC values support the feasibility of the SH-Model in two-dimensional pointing task.

3.1 Introduction

The appearance of more and more computer input devices makes designing human computer interfaces a more complex matter. Designers have to choose suitable de-vices from a lot of candidates. Sometimes the choice can be made comparatively easily, but in other cases, when more than a few input devices may be applicable, it is not easy to make a final decision. Many factors including physical characteristics (such as mechanical reliability and installation space) and cost have to be considered. Therefore, empirical experiments are necessary if the best selection from a range of input interfaces is to be achieved. Meanwhile, as a basis for empirical analysis in human interface design, researchers use performance evaluation models to afford prediction and evaluation power.

As a well-known human performance model, Fitts' law (see Equation 1) [1], has been accepted and applied for a long time in the human computer interaction field. In Equation 1, MT is the movement time in which the subject moves a pointing device from one target's center to another target's center. a and b are empirically deter-mined constants.

$$MT = a + bID \tag{1}$$

ID is the difficulty index of the pointing task, which can be expressed as follows:

$$ID = \log_2\left(\frac{A}{W}+1\right) \tag{2}$$

Here W is the target width and A is the distance between the centers of two targets. We call Equation 1 as the ID model of Fitts' law.

Fitts' law had already been applied to computer input device evaluation by Card and colleagues [2] since 1978. After Card and colleagues' avant-garde research of the application of Fitts' law to commercial used input devices, a lot of similar studies have been carried out by using Fitts' law as a comparison base [3].

Nevertheless, Fitts' law formulations (Equations 1 and 2) are based only on the anal-ogy to the information capacity formulation[1] (movement amplitudes are analogous to "signals" and target widths are analogous to "noise"), but not strictly deduction. Moreover, in the ID model of Fitts' law, the factor of individual behavior, or the accuracy difference, has not been considered.

To resolve the problems in Fitts' law, a great deal of work has been done. One solution is to use the effective target width (We) instead of the normal target width [3]. We call it as the IDe model (see Equation 3). Correspondingly, ID is replaced by IDe (see Equation 4).

$$MT = a + bIDe \tag{3}$$

$$IDe = \log_2\left(\frac{A}{We}+1\right) \tag{4}$$

However, doubts still exist regarding its validity [4]. Therefore, we developed a new model (SH-Model) based on temporal distribution to resolve the problem. The new model and the traditional models are compared in experiments using AIC (Akaike's Information Criterion) [5], a criterion for statistical model selection. The results show that the new model is better than the traditional ones in performance evaluation for one-dimensional pointing tasks.

[1] The formulation of Fitts' law was derived from the Shannon Theorem 17:

$$C = B\log_2\left(\frac{S}{N}+1\right)$$

C indicates the capacity of channel, B indicates the bandwidth, S/N indicates the ratio of the average power of signals and noise [6].

3.2 Related works

3.2.1 SH-Model and its application in one-dimensional pointing tasks

Here we give a brief overview. The SH-Model is established based on the general information theory, different from the traditional Fitts' models based on the concept of Shannon's capacity of channel [7][8].

In pointing tasks, the effects on performance can be divided into two parts: the sys-tem effect and the human effect. The system effect can be expressed by the condition of a pointing task such as the amplitude between two targets and the target width. The human effect can be indicated by the accuracy of pointing successfully. Thus, we established a model named as SH-Model:

$$\ln(MT) = a + b\ln(SIs) + c\ln(SIh) \tag{5}$$

In this model SIs shows the effects of the system, and SIh shows the effect of the human. Thus, Equation 5 contains complete information of both the system and the human.

$$SIs = \log_2\left(\frac{A}{W}+1\right) \tag{6}$$

$$SIh = \log_2\left(\frac{1}{Ph}\right) \tag{7}$$

In Equation 7, Ph indicates the successful rates made by subjects in experiment.

Another form of Equation 5 for computing the predictive value of MT is:

$$MT = e^a SIs^b SIh^c \tag{8}$$

3.2.2 Model Evaluation by AIC

There are two main ways to evaluate regression models. The traditional one is to use the regression coefficient. It indicates the degree of fit of models to the observed data but it cannot represent the predictive ability of models, neither can it be applied to nonlinear models. We usually evaluate models by the descriptive ability and the predictive ability. The former shows how well the model fits the data under analysis, and the latter can indicate how well the model predicts the value of data that can be obtained in future under the same condition. With more parameters, the model's descriptive ability will be improved so that the predictive ability will also be improved, but the stability of estimates for parameters will deteriorate so that the predictive ability will decrease. The purpose of statistical modeling is to obtain a model with a strong predictive ability, so the key problem in model selection is how to get a good trade-off between the descriptive ability and the stability of estimates. Thus, it is important to evaluate predictive ability of a model objectively. Moreover, because the SH-Model is a non-linear model, we cannot apply this method to do model evaluation. Therefore, we have to find another model evaluation tool.

Another approach of model evaluation is to use information criteria (ICs), such as AIC [9]. When a number of models are available, we have to select one as the best among the alternative models. Akaike's minimum AIC method [5][10][11], is developed for statistical model selection. This method can be interpreted from a maximization of the expected entropy of the predictive distribution approach [12]. It can be applied to comparisons for not only linear but also nonlinear models [13]. It is a better choice for us to compare the new model (SH-Model) with the traditional models (the ID model and IDe model) with AIC.

AIC is defined on the basis of the maximum log-likelihood and the number of parameters to be estimated by the maximum likelihood method, i.e., it is defined as follows:

$$AIC = -2M + 2N \tag{9}$$

Where, M is maximum log-likelihood of the model (see Equation 10), N is number of estimated parameters in the model.

$$M = \ell(\hat{\theta}) = -\frac{n}{2}\log 2\pi\hat{\sigma}^2 - \frac{n}{2} \tag{10}$$

In Equation 10, n is the number of all the data, and is the estimate for the variance of error:

$$\hat{\sigma}^2 = \frac{1}{n}\sum_{i=1}^{n} e_i^2 \tag{11}$$

In Equation 11, is the residual.

For two models that have different numbers of parameters we can estimate the parameters and calculate their AIC values by using the same set of data. Although more parameters can make the model more descriptive, the minimum AIC method itself can reimburse the deviation brought by the parameters before it gives out the final results. That means that AIC can show the consistency between reality and prediction and can test both the descriptive ability and predictive ability in a model comprehensively [10]. Overall, the model with the smallest AIC value can be regarded as the best one [5].

Therefore, we have decided to use the minimum AIC method to evaluate the models.

3.3 Experiment

We have testified the feasibility of the SH-Model in the different application situations of tablet PC and desktop PC, and have tried different input devices and made the evaluation of the devices [7] [8]. The advantage of the SH-Model over the traditional models has been verified through these studies. However, we applied the SH-Model only in the one-dimensional pointing tasks (see Figure 1) in the previous experiments. In reality, users usually interact with computers through two-dimensional pointing tasks. Therefore, to verify the feasibility of the SH-Model in the two-dimensional environment, we carried out a new experiment.

3.3.1 Subjects

In the experiment, 12 university students of different ages and genders (one female, 11 males, 21 to 30 years, average 22 years old) took part in the two-dimensional pointing task as subjects. All the subjects' dominating hands were the right hand.

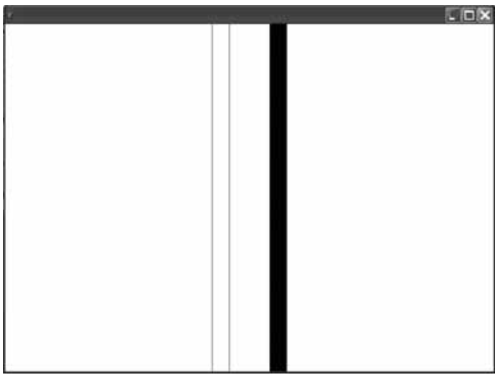


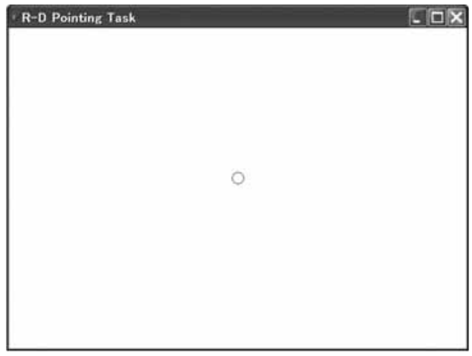
Figure 1 : One-dimensional pointing task

3.3.2 Apparatus and experiment tools

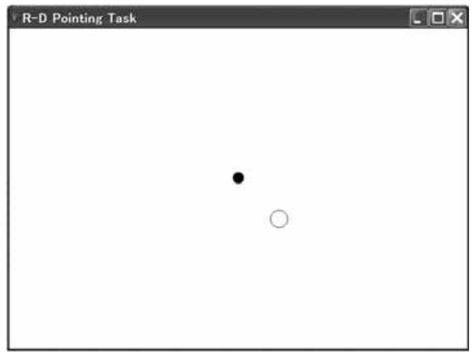
A desktop personal computer (screen size: 43cm /17.0" Diagonal, pixel pitch: 0.264mmH x 0.263 mmV, each pixel on the screen was 0.264 mm wide) and a mouse (Agiler AGM 6124X) were applied in the experiment. The experiment program was designed according to ISO9241-9 standard [14]. The experiment tool interface is show in Figure 2.

3.3.3 Experiment procedures

In the experiment, during the task, first, a white oval (with black round) appeared in the center of the screen (see Figure 2 (a)). We regarded this oval as the Center Oval. Once the subject tapped it, it turned black and simultaneously, there appeared another white oval (with black round) in a position controlled by the program randomly (see Figure 2 (b)). We regarded this randomly appearing oval as the Target Oval. Then the subject tapped the target oval, and this oval would disappear with the center oval turning into white again. Therefore, the subject was required to always tap the white oval on the screen to perform the reciprocal tapping or pointing task. All the subjects were required to perform as fast and accurately as possible. Once a mistake happened, i.e., the input hit made by the subject fell outside the Target Oval, there would be a warning beep. Before the real experiment, all the subjects were given a warm-up practice of ten minutes of the experiment program, since all the subjects were new for the pointing task designed in this experiment.



(a) The center oval



(b) The target oval (white) and the center oval (black)

Figure 2 : Experiment tool interface of the two-dimensional pointing task.

The diagram of the Target Oval was recorded as target width, and the distance from the Center

Oval to the Target Oval was recorded as amplitude. We applied 3 target widths (10, 20, 30 pixels) and 2 amplitudes (100 and 200 pixels). The diagram of the Center Oval is 20 pixels. Every subject performed 12 trials in each of the 6 combinations of target width and amplitude. Therefore, the total number of the taps made by all the subjects in the experiment is 864=3(target widths) x 2(amplitudes) x 12(trials) x 12(subjects). The sequence of the six combinations was changed randomly.

3.3.4 Results

The error rate of the experiment was 5.6%. We calculated the AIC values with the experiment data for three different models. The AIC values and the regression coefficients are shown in Table 1. The AIC values in Table 1 are calculated through Equation 9 and the footnote 2 based on the experiment data (MT, A, W, and Ph). The results in Table 1 explicitly show that even for the two- dimensional interface, the SH-Model can still be more reliable than the other two candidates for pointing tasks evaluation.

3.4 Discussion

The advantages of the SH-Model over the other two models mentioned in this paper (the ID model and the IDe model) to evaluate the one-dimensional pointing tasks had been approved by the previous work. Since in most cases, users interact with the computer in two-dimensional interfaces, we developed the experiment designed according to ISO9241-9 standard to examine the application of the SH-Model in the two-dimensional pointing task evaluation.

Table 1 shows that the SH-Model obtains smaller AIC value (11458.0) than the other two models (11827.1 for the ID model and 12114.5 for the IDe model). Therefore, it is clearly to conclude

Table 1 AIC values of the experiment data of the three models

Models	Formulations	AIC
ID model	$MT=195.6+218.2\log_2\left(\frac{A}{W}+1\right)$	11827.1
IDe model	$MT=710.1+60.0\log_2\left(\frac{A}{W}+1\right)$	12114.5
SH-Model	$MT=e^{6.14}\left\{\log_2\left(\frac{A}{W}+1\right)\right\}^{0.05}\left\{\log_2\left(\frac{1}{P_h}\right)\right\}^{0.66}$	11458.0

that the SH-Model is better than the ID model and the IDe model in pointing task evaluation in the two-dimensional interface designed in this paper.

Figure 3 to Figure 5 can help to explain the advantages of the SH-Model over the other two models. Figure 3 and Figure 4 show that the numbers of those hits beside the two parts of the regression lines are significantly different. This means that the distribution of the data is obviously different from a normal distribution. On the contrary, from the SH-Model, we can see that the data's distribution beside the two parts of the regression lane are nearly symmetrical (see Figure 5). It means that after taking logarithm transformation of MT in Equation 5, the data follow normal distribution more accurately and with the new model we can evaluate performance better [11][15].

Some researchers also proposed models for two-dimensional applications, such as the two dimensional pointing task evaluation model established by Accot and Zhai [16]. However, application of their model is different from the situation introduced by this paper. Rectangle targets were applied in their experiment. Moreover, some users still prefer to use the ID or IDe models to evaluate the two-dimensional pointing tasks. The IDe model's application in two-dimensional tasks is even defined by the ISO9241-9 standard [14]. Therefore, in this paper we mainly discuss about the

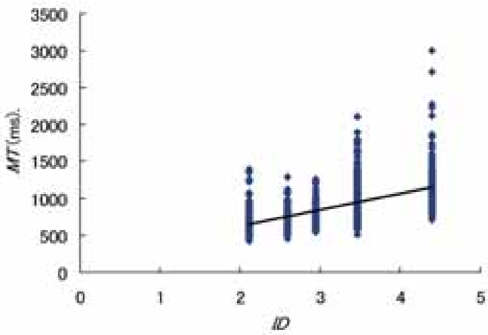


Figure 3 : Regression between MT and ID

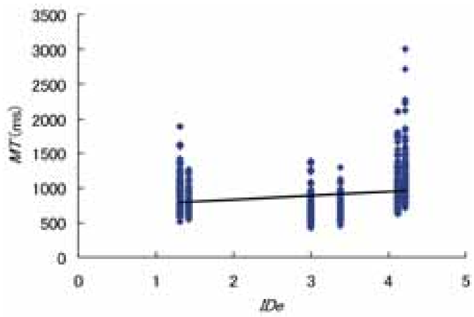


Figure 4 : Regression between MT and IDe

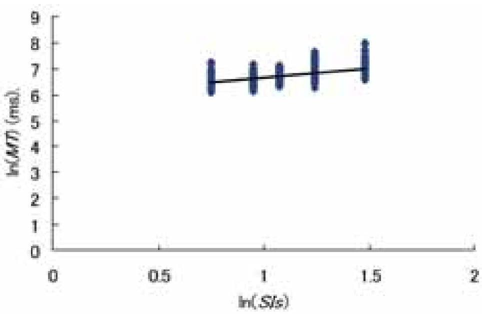


Figure 5 : Regression between ln(MT) and ln(SIs)

comparison between the SH-Model, ID model and IDe model. We regard that for the two-dimensional pointing task defined in this paper, the comparison results will afford us a reliable reference.

3.5 Conclusions

The proposal of the SH-Model helps the researchers of pointing task evaluation to escape from strictly keeping the constant accuracy requirement upon the subjects. Its application has been approved in different interaction situations. However, for the two-dimensional interface, we still need empirical experiment data to support its feasibility. This study approves the usability of the SH-Model in two-dimensional pointing interface. It is an important development study for the SH-Model.

For the future work, we still need to examine the SH-Model's application in two-dimensional pointing tasks with different shapes, such as squares, or rectangles. Some modifications of the SH-Model may be necessary. Then more detailed comparison of most existing two-dimensional pointing task evaluation models can be fulfilled.

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4. Research achievement in communication region

We summarize the research achievement in perception region by one paper that was published by Kazuhiro Hujitani, Sayaka Tokaji and Mamoru Okada as the proceedings of NEINE '06. Hujitani and Tokaji are undergraduate students in Okada laboratory. This chapter shows the paper as shown below.

About methods to transmit the rhythm in animation of sign language song using 3DCG

Kazuhiro Hujitani, Sayaka Tokaji and Mamoru Okada

Abstract

Sing language is widely used as a communications means of the hearing impaired. The book of the sign language song and two dimensional animation of the sign language song are used as the present method of studying sign language song. But, the study method of a present sign language song cannot represent depth. Moreover, the rhythm cannot be told. In this research, the depth and the rhythm of sign language are expressed by using the animation of the sign language song of three dimensions. The animation of the sign language song was verified to 13 testees. Testees are five hearing people, five hearing impaired people, and three sign language interpreter. The experiment evaluation were conducted by the evaluation of the questionnaire of five stages.

4.1 Introduction

4.1.1 Background

Sign language is widely used as a communications means of the hearing impaired. This experiment focused on the sign language song. The book of the sign language song and two dimensional animation of the sign language song are used as the present method of studying sign language song. However, the depth of sign language cannot be expressed in the book and animation. Moreover, the rhythm of the song cannot be told in the book and two dimensional animation. As a result, the happiness of the song is not transmitted to the hearing impaired.

4.1.2 Purpose

The sign language song animation is made by using 3DCG. Sign language is expressible by this animation whether. Whether the rhythm can be told on the screen displays is verified. And, the animation speed at which the sign language song is understood easily is verified.

4.2 Animation making

4.2.1 The song is chosen

The hearing impaired is not accustomed to songs from early age. Therefore, song tends to come to hate hearing impaired while growing up. The song "Mr. elephant " was selected so that the child was able to enjoy.

4.2.2 Animation

This time, SHADE was used to express solidity and the depth of the sign language song. To express sign language, the animation of human's model was produce. The rotation collaboration was used to apply movement to animation.

4.2.3 Rhythm

To transmit the rhythm, monkey's animation was produced. Monkey's animation was produced so that a child might become familiar to the expression of the rhythm. Animation that expressed two rhythms was prepared. The hearing impaired understand the rhythm by tapping the shoulder. Therefore, the animation tapping the shoulder was produced. Hearing people takes the rhythm by beating the hands in general. Therefore, the animation beating a tambourine on the side of the sign language animation was produced. The rhythm of lyrics and the rhythm of song were prepared. The animation speed at which sign language was understood easily was verified. The kinds of speed were prepared, as 15 seconds, 21 seconds, 30 seconds and 39 seconds.

4.2.4 Problem of animation

The background was the color of sky. Therefore, the sky color and the arms were not able to be distinguished when the arms was raised up. Whenever the sing language of each word ended, the hands of the model were got down. However, the operation shows the meaning in which sing language ends. For the hearing impaired and the sign language interpreter, the rhythm of the song was not able to be understood.

4.2.5 Improvement of animation

The background was changed into green gentle to eyes. The animation of model's hands that arms did not put down was produced in each word. The animation inserted the rhythm count of the song under lyrics was produced. The animation of the explanation of each word was shown. Next, the sign language song animation was shown. The animation of movement from the front and movement from the diagonal was produced for each word. Moreover, the explanation by sentences was added at the side of the animation [Figure 1].

Figure 1 : Improvement before of animation and Improvement after of animation

4.3 Experiment

4.3.1 Content of experiment

The animation of the sign language song of three dimensions was made. The animation of the sign language song was verified by 13 testees. The experiment evaluation did the evaluation of the questionnaire of five stages.

4.3.2 Experiment result

The movement of sign language was able to be judged accurately [Figure 2]. As for the speed of animation, 15 seconds and 21 seconds were suitable for testees. As the expression method of rhythm, the rhythm was understood inserting the rhythm count of the song under lyrics [Figure 3]. However, the rhythm not surely understood.

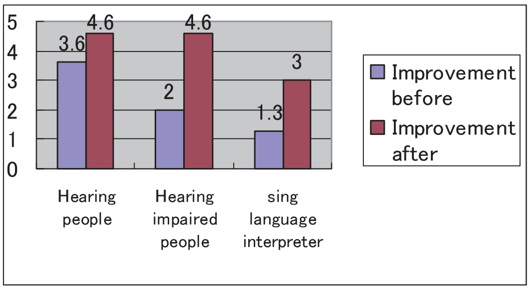

Figure 2: Understanding level of sign language

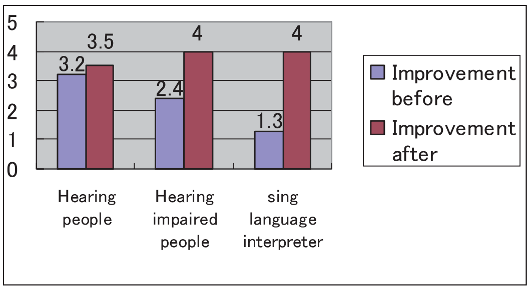

Figure 3: Understanding level of rhythm.

4.4 Conclusion

The purpose of this research is to apply 3 dimension animation to the expression of sign language and the rhythm. Sign language was able to be expressed from the expression result by three dimensions animation. The expression method of the rhythm has improved more than the animation of the first time. However, the rhythm was not surely understood. If the rhythm can be told from the result of the questionnaire, the sign language animation will be effective as a method of studying the sign language song [Table 1].

Table 1. Result to education software of sign language song.

	Yes	No
All testees	13	-

4.5 Reference

1. Kazuhiro Hujitani, Sayaka Tokaji and Mamoru Okada, "About methods to transmit the rhythm in animation of sign language song using 3DCG", *In Proceedings of NEINE' 06 (International Conference on Next Era Information Networking, Kochi, Japan, 17-19 September 2006).*

5. Future work

In order to enhance research progress in this project, we have introduced some Ph.D. students in Special Scholarship Program in KUT and some of Mater students. With these graduate students, research themes shown above will be continued and also, we are expecting to make new research themes in Perception region. We hope achievements will be more and better and also, we are expecting to establish some researches in Communication region, starting in 2007 academic year soon.

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