A COMPUTERIZED SELF VISUAL ACUITY TESTING SYSTEM
Method of the Optotype Presentation and Adjustment

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Abstract: This paper suggests the method of the optotype presentation and adjustment for a computerized self visual acuity test. The proposed method is guaranteed credibility by 'KS P ISO 8596' in 2006. Also this system provides convenience to people who take an eyesight test based on gesture recognition of them. And the method of the optotype adjustment for a computerized self visual acuity test is able to measure objective eyesight that excluded subjective judgment of inspector and conjecture of subject's memorization. According to result of experimental comparison between method of using real visual-acuity chart and the system of a computerized self visual acuity test, Our system showed the 98% consistency in the limit of the ±1 visual-acuity level error.

1 INTRODUCTION

A visual-acuity test is fulfilled by using the visual-acuity chart which arranged according to size, then presenting the chart to subject in certain distance to measure their eyesight in general. However, this method is able to involve inspector's subjective point of view because the inspector measures vision. Especially, the result from this method is lack of credibility because same chart is used to test both eyes, so subject might conjecture with one's memorization.

Therefore we propose a computerized self visual acuity test system that is possible to solve those problems(Bach et al., 2009). This system doesn't need inspectors because subjects can take a visual acuity test by themselves to use computerized program, so we can exclude those problems. And the method of gesture recognition is similar to existing visual acuity test that uses visual-acuity chart, therefore subjects don't show negative reaction when they are taking the visual acuity test. Also, it can possibly provide convenience to subjects by inducing their interests for the test.

Especially, our system uses Landolt's Ring which is industry standards, also it uses P ISO 8596's standard visual-acuity chart that suggested by Korean Industrial Standards to measure a minimum resolvable power KS P ISO 8596 (2006). Therefore it is very useful for people who are lack of ability to distinguish shape of object such as little child, the old and the infirm. Also it minimizes a limit of measuring environment by giving selective measure distance. Furthermore measured vision is able to save and maintain through database, so Electronic Medical Record is not necessary.

2 KOREAN STANDARD OPTOTYPE PRESENTATION AND ADJUSTMENT METHOD

The shape and size of optotypes in the visual-acuity chart, the distance and measuring method, and the method of deciding vision level of the self visual acuity test system in our paper is based on Korean Industrial Standards(KS P ISO 8596, 2006).

This content follows 'International Standard ISO 8596:1994(E) Ophthalmic Optic-Visual Acuity Testing Standard Optotype and Its Presentation' .

2.1 Visualization

The visualization fulfills functions that show shape, size and direction of visual-acuity optotype on subject's screen by using adjustment information of the optotype such as direction and gap size of the

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optotype. Delivered information, size of logical visual-acuity optotype and direction of its gap, is made by computer that follows Korean Industrial Standards. Then, this information displayed on screen with pixel unit, which is a physical unit displayed on subject's screen on visualization module by the transformation mapping.

The size transformation mapping means a relation between logical coordinate and physical coordinate. It performs a role that decides how to relate an image that exists in computer as logical coordinate to physical coordinate that we can see. Even though calculated logical coordinate image is realized by Korean Industrial Standards, to show accurate size of visual-acuity optotype can be difficult, because if a resolution of display (an output device) or this device is changed, a physical coordinate of the device also changed.

Therefore we transform 0.01mm unit of logical coordinate to a physical coordinate, pixel, which possibly display on screen by using HIMETRIC mode that is one of mapping mode provides from MFC library of Microsoft. By this process, the image of optotype that displayed to subject is able to show the optotype which has equal standards on equal vision level to resolution of displaying device or its model, because it can maintain a constant size of the optotype no matter how many pixels in the device that has various resolutions.

2.2 Subject's Gesture Recognition

Visualization fulfills functions that show shape, size and direction of visual-acuity optotype on subject's screen by using adjustment information

Gesture recognition module extracts coordinate of starting point Gs(Xs, Ys) and ending point Ge(Xe, Ye) after subject gestures about the visual-acuity optotype as shown in Fig. 1(a). If the starting point and ending point are extracted, it set up an intersection point Gp(Xp, Yp) which is an intersection between a horizontal line that goes to X-axis of the starting point and a vertical line that goes to Y-axis of the ending point. After it gets Gs, Ge and Gp, it calculates a vectorial angle 'Θ' from subject's gesture through below equation (1).

$$\theta = \cos^{-1}\left(\overline{G_s G_p} \Big/ \left\| \overline{G_s G_e} \right\| \right) \qquad (1)$$

Where, $\overline{G_s G_p} = x_p - x_e$ and $\|\bullet\|$: Euclide distance

In this equation (1), subject's gesture angle 'θ' corresponds to a vectorial angle ($0 \le \theta \le 2\pi$) between a horizontal line of the starting point and a segment that connects the ending point Ge to the starting point Gs. If y_e is greater than y_s, θ is computed as $2\pi - \theta$.

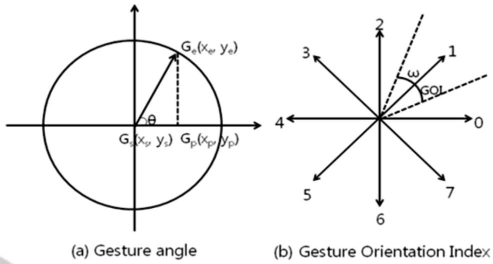

Figure 1: Subject Gesture Recognition.

To identify the visual-acuity optotype, calculates the GOI(GOI: Gesture Orientation Index) value that corresponds to selected visual-acuity optotype direction on Landolt's Ring gap direction 8 through the equation (2) below.

$$GOI = \left\lfloor \frac{\mathrm{mod}(\theta + \omega, 2\pi)}{O_I} \right\rfloor, \text{ where } \omega = \frac{O_I}{2} \qquad (2)$$

In the equation (2), O_I means direction separation distance, but it means $\pi/4$ that one separated direction section of equal separation of 8-direction in our paper(Fig. 5).

ω is a bias value for perceiving a invalid region of the gesture orientation angle as shown in Fig. 1(b), and $\lfloor \cdot \rfloor$ is a floor(•) function.

2.3 Minimum Resolvable Power Test

When subject gestures with using pointing device after seeing a gap orientation of Landolt's Ring, a minimum resolvable test module fulfills the test process of $P_0 \sim P_2$ in Fig. 2 by using GOI value from gesture recognition module and presented optotype information. The minimum resolvable test module distinguishes coincidence between a gap orientation(GOI) of Landolt's Ring by subject and a gap orientation of presented optotype(OGO: Optotype Gap Orientation) through a result of GOI value from gesture recognition module.

If GOI value and a gap orientation of optotype coincided, it increases a value of TRUE CNT and inspects number of presentation to equal level for checking resolvable power. If the number of presentation doesn't exceed the max number of presentation in equal level, it requests an optotype adjustment module to reproduce only a gap orientation of optotype randomly just for judging vision without changing level of optotype. On the contrary this, if the NOP exceeds the MNOP, it requests a percentage of correct answers and a gap orientation of optotype to an optotype adjustment module for raising or reducing the level by the percentage of correct answers.

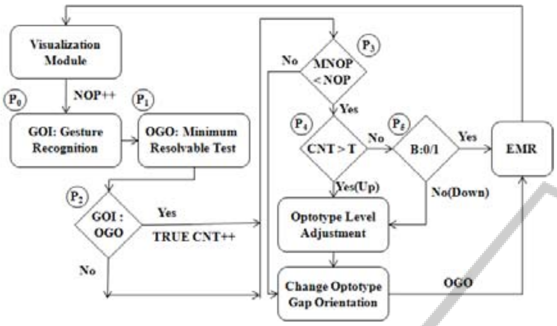

Figure 2: Minimum Resolvable Testing and Optotype Adjustment Process.

2.4 Adjustment of Optotype Level and Visual Acuity Decision

Adjustment of Optotype level is controlled when subject has been judged to obtain minimum resolvable ability or not about the present level. In Fig. 2, applicable process to P_3 ～P_5, is comparing a percentage of correct answers from minimum resolvable module with an actual value of T. T is judging that having an ability of visible resolution which means actual value of 60% and if the value did not exceed, we are expecting that it was not having a visibility of resolvable power. In the case of the percentage of correct answers is above the actual value of T, sight level requests the Optotype size change to upward rating of module by raised rate. In this situation, parameter value of B, Boolean type, is using as confirming and setting up to check that previously offered Optotype rating has the resolvable power of visualization. If the percentage of correct answers is under the actual value of T, sight level would become to downward readjustment and confirms that B value is 1/0. Assuming that downward readjusted sight level of B value is 1, lower vision level adjudges to final vision level so it sent management module of measuring sight data to sight level information. Thus, subject will get the complete result through visualization module.

However, if B value is 0, downward readjusted level would have no sight measured record, and consequently adjusting optotype of visualization module is requested for suggestion of downward readjusted optotype. At this moment, readjustment of optotype level is adjusted by R10 series and KS standard of ratio(KS Q ISO 3, 2002).

If we define current Optotype Diameter as OD_c, a bigger Optotype Diameter which adjusts to one level reduce as OD_u, a smaller Optotype Diameter which adjusts to one level increased as OD_d, and R10 series as a constant of ratio R(=about 1.25), we can define adjusting Optotype Diameter as the equation (3) and (4) below.

$$OD_u = OD_c \times R \quad (3)$$

$$OD_d = OD_c \times \frac{1}{R} \quad (4)$$

The OD_u value which is one level reduced Optotype Diameter equals to a value of multiplying current Optotype Diameter(OD_c) to a constant of ratio(R) and it corresponds to 125% magnification of OD_c value. Also, if we multiply 1/R, a reciprocal of R, to OD_c, the OD_d value which is an one level increased Optotype Diameter becomes 80% magnification of OD_c value.

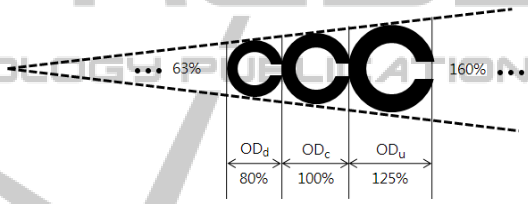

Figure 3: Scale Ratio of Optotype Diameter.

The function of measured distance change is adjusting Optotype's size of 1.0 sight level presented according to originally subject inputted measured distance through data management module. Adjustable ratio also can be defined by R10 series of R which is constant number of magnification as blow equations (5) and (6).

$$OG_{new} = OG_c \times \left(\frac{D_{new}}{D_c}\right),$$

where OG_c = 1.5mm, D_c = 5m (5)

$$OD_{new} = 5.0 \times OG_{new} \quad (6)$$

In above equation, D_c is 5m which means standard measure distance and OG_c is 1.5mm which means gap size of optotype that being one minute of arc at the standard measure distance. D_{new} is measuring distance which is selected by subject and values of OG_{new} and OD_{new} are indicated diameter of ring and gap size of optotype of sight level that is coordinative by subject measured distance.

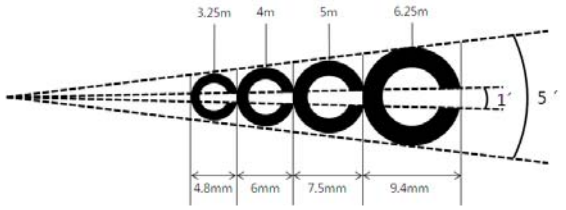

Figure 4: Visual Acuity 1.0 Level Size by selecting a measure distance.

Thus, when the subject is selecting the measure distance of D_{new}, the standard measure distance of D_c and ratio multiply by the standard optotype size of OG_c value so OG_{new} is calculated which will be using with gap size of optotype of the new 1.0 sight level at the selected distance. If the value of OG_{new} is found, OD_{new} would be calculating and sending to visualization module of Optotype.

As shown by Fig. 5, another operation of adjusting optotype is producing one of way from eight ways of optotype gap randomly by a computer, sending as visualization module for new Optotype presentation with Adjusted Optotype diameter value.

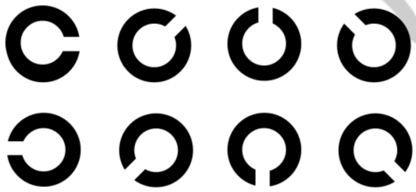

Figure 5: The 8-orientation of Optotype Gap.

3 EXPERIMENTS

All process of the computerized self visual acuity testing system is implemented to Visual C++(GDI: Graphic Device Interface) of Microsoft Windows XP. We used 32 inch normal monitor that applies 1024×768 pixel resolution display device. The performance evaluation of the system is fulfilled by 100 subjects who compare our method to original visual acuity test and the option of choosing distance doesn't evaluate to each distance so it evaluated to standards distance. As the results (Table 1) compared with two methods, 87% of subjects was corresponded to test result of eyesight measured table and the rest of discordant 13 of testers was showing that 98% of credibility in the limit of ±1 visual acuity level error.

Table 1: Measurement Result of Implemented System (: Margin of Error ±1 Visual Acuity Level).

Number of Subjects	consistency	inconsistency	
		inner of error limit	outer of error limit
100	87%	98%	2%

4 CONCLUSIONS

The Computerized Self Visual Acuity System provides flexibility to measure environment by choosing measure distance and Gesture Recognition increases subject's convenience also, it has less negative reaction because it is similar to existing method of measuring. Also the method of the optotype adjustment for a computerized self visual acuity is able to prevent presumption to memorization of subject and prevent most of subjective measurement of subject or inspector.

Especially it is able to apply to manage database of estimating vision without any additive works on EMR system anywhere such as ophthalmology and optician's shop.

if it increases subject's concentration by change of measuring distance, change of visual-acuity chart presentation location and visual-acuity chart type and make up for tiredness of eyes to use an output device such as electronic ink that using another medium, our Self Visual Acuity Test System will be effective.

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