A digital diagnosis instrument of Hess screen for paralytic strabismus

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Abstract—The diagnose instrument of Hess screen is an important instrument for ophthalmic diagnoses. It is mainly used for the measurement of paralytic strabismus. This article is about a digital diagnosis instrument of Hess screen for paralytic strabismus, using image manipulation technology and software technology, based on method of making a traditional Hess screen, medical theory of Hess screen diagnosis and oculomotor muscle constitution. This instrument is composed by diagnosis system of Hess screen for strabismus, LCD screen, computer, and red/blue goggles. The diagnosis system of Hess screen for strabismus is consist of automated Hess screen check up and assistant Hess screen check up, the management system of medical record and the result analytic system. It provides integration function of diagnosis of strabismus, data record and analyze. The instrument uses 20 in LCD screen to display and JAVA to implement the function. The clinical test in some hospitals shows: this instrument is convenience, nicety, quick, no hurt, and provides contrast diagnose medical record and after operation medical record. In the end of the article shows analysis of instrument’s error based on the clinical data.

Keywords-Hess screen; image manipulation; paralytic strabismus

I. INTRODUCTION

The diagnose instrument of Hess screen is an important instrument for ophthalmic diagnoses. It is a useful instrument for check up oculomotor muscle. It provides impersonal quantitative analysis of the extent and type of strabismus. In clinic, the result is used as a basis of muscle redress operation and a quantification perform of the muscle. The traditional Hess screen is complicated to handle and costliness. Its subjective error in result recording is serious. It is important clinical meanings and far-reaching community meanings to find a new instrument which can diagnose patient convenience, nicety, quick and no hurt.

Presently, there are some ameliorate researches about Hess screen test. In 1996, Wei Bingzhang developed a new method which used TV camera to take images of light trace issued by patient, and then used correction algorithm of geometric distortion of space image, finally printed the result of HESS test chart. All of the control including grabbing images was performed by a special signal lamp and linked with the computer wirelessly[4]. In 1998, Ma Zonglian developed a new method which used green facular electric torch connected with planar increment angle encoder. It sends angle signal to a single chip to print the result of Hess test chart[3]. These methods still complicated to handle, and the test needs a lot of time. These methods improve way of result recording, but they are lack of management of medical record and analysis of result. So, professional oculists expect to have a new instrument which is easy to operate, low cost, nicety, and can manage the medical record systemically for a long time.

This article is about a digital diagnosis instrument of Hess screen for paralytic strabismus, using image manipulation technology and software technology, based on method of making a traditional Hess screen, medical theory of Hess screen and oculomotor muscle constitution. This instrument is composed by diagnosis system of Hess screen for strabismus, LCD screen, computer, and red/blue goggles. It instead of the LED screen, LED controller and electric torch. It enhances the level of the automated diagnosis and analyzing data intelligently, and lowers the cost. The diagnosis system of Hess screen for strabismus is consist of automated Hess screen check up and assistant Hess screen check up, the management system of medical record and the result analytic system. It provides integration function of diagnosis of strabismus, data record and analyze.

II. MEDICAL PRINCIPLE OF HESS SCREEN

Hess screen check up is based on theory of visual project[1]. The check up uses red/green goggles to separate binocular vision. It uses the difference between cross-eye’s yellow spot projective direction and fine-eye’s yellow spot projective direction to judge motion of eyeball. The theory of Hess chart is using red filament to draw pane according to the
radial line of retina. The width of panes equals $5^\circ$ when a patient at 0.5m away from the screen. There are red marks at the crossing of $30^\circ$ or $15^\circ$ radial line. Inside, outside, up, down rectus and up, down scalene indicating 6 different parts. The patient needs to put on a red/green goggles and try to position the blue mark on red marks on the Hess screen. If the patient is strabismus or oculomotor muscle abnormality, he/she can’t position the blue mark on the red. Because he tested eye is projecting at the shifted direction of the yellow spot.

The traditional method of Hess screen check up as follows: There are nine irradiative red LED marks on the Hess screen. The patient sits 0.5m away from the center of screen. The distance between two marks nearby equals $5^\circ$ visual angle. Doctor lightens one red mark, and asks the patient to position the facula of green light electric torch on the red mark. If the patient’s eye is fine, he/she can position at the right place. Strabismus patient can position at the right place. Then doctor records the position of green facula on a Hess chart paper and lightens another test mark. Then patient do the process again. Commonly, it needs to test nine marks for one eye. Then doctor exchanges the red and green eyeglasses of the goggles and tests another eye.

In the traditional method of Hess screen check up, the doctor needs to lighten red marks in turn, and record the position of the green mark in the darkroom. It makes the check up fussy and imprecise.

III. DIGITAL HESS SCREEN DESIGN

In the article, according to the principle of medicinal inspect using Hess screen, we bring forward a new method called digital Hess screen inspect. With this automatic inspect method, diagnose process will become more convenience, and the result will be more precise and objectivity. Digital Hess screen will have integrative functions such as inspect, automatic diagnose calculate, result record and analyze.

The user data manage module mainly records patients’ information such as personal information and their inspect history. Doing this will help doctor manage the whole inspect process effectively, and the abundant history data will help their research and diagnose analyze.

A. Digital Hess Screen Inspect System Design

Digital Hess screen inspect system displays inspect graphics on a special computer screens which we use 20 inch LCD screen due to the limitation of current hardware device. In the program, we use the distance from patient to screen as variable to calculate the corresponding inspect graphics and draw on the screen, the error occur in the conversion process will be discussed in part 4. If the screen is too smaller then expect, the distance from patient to screen must be shorten as a result, but for the fixed distance between two eyes, so the conversion process will make the error increases, and the inspect result will not as precise as expect. The lower the cost of LCD screen, the bigger possibility of using a large LCD screen. We use 20 inch LCD screen in this system.

B. Digital Hess Screen Diagnose Analyze System Design

The system of diagnose and analysis compare patient’s Hess chart with the diagnostic Hess chart in the database to distinguish the muscular torticollis and ocular torticollis[2]. The system can differentiate paralytic strabismus and intercommunity strabismus according to the size and symmetry of two eye’s Hess chart. At the same time, we know the state of oculomotor muscle. We can find out the paralytic muscle, and analyze the state of antagonistic muscle, indirect antagonistic muscle and mate muscle. It provides valuable reference for the operation.

If the direction of paralytic muscle on the Hess chart lessens, it has oculomotor dyskinesia[2]. The paralytic eye’s chart is small. This eye is primary deviation. Another eye is secondary deviation. When paralytic eye stares, the mate muscle contract overage. So the chart of paralytic eye is smaller. And the healthy eye’s chart is larger.

The programme can do an intelligentized analysis of the result of Hess chart check up and provide example and gist to doctor for diagnose. Doctor can diagnose roundly and expediently according to the analysis.

C. Digital Hess Screen Data Manage System Design

Hess screen data manage system mainly track and record inspect and diagnose result, besides it system can also analyze the data and print out the result. Compare to the traditional Hess screen inspect which take place in darkroom and will make errors in manual data recording, digital Hess screen system has many advantages, for example, computer can automatic memorize the precise position the patient pointed out, after the inspect process, computer will work out the diagnose result according to the coordinate of test marks and print it out, at the same time, all the inspect data will be saved to database which can be used in the later management. For more reason to use the digital Hess screen, the system can print out two eyes diagnose result separately, and even contrastive inspect result of two history records in order to indicate the change after operation with the patient, this style of printing paper can reveal the treatment effect and avoid medical treatment dissension.

IV. PROTRACT DIGITAL HESS CHART

A. Principium of Calculate Hess Chart

Digital diagnosis instrument of Hess screen for paralytic strabismus is based on theory of Hess screen. The check up uses red/blue goggles to separate binocular vision. It is important to protract the right Hess chart in digital Hess screen check up. According to the theory of Hess screen, it is impossible to draw Hess chart and test marks directly on the LCD screen at present. Because of the LCD screen is smaller then traditional Hess screen. The distance between patient and LCD screen should be shortened to make the Hess chart smaller. But the distance should far enough to see the screen clearly. Because of the human’s visual field is rotundity. According to the relation between rotundity and tangent, we know if the further distance between tangent and the centre of a circle, the wider width of visual angle on the screen. On the
assumption that there are two pictures on which drew a line, the length of lines is L1 and L2, the distance of two pictures to eye is S1 and S2 (S1>25cm and S2>25cm), and the two pictures at a same horizontal height, if L1/L2=S1/S2, the length of two lines is the same in visual. Such as Figure 1. According to this theory, we can adjust the distance between Hess screen and patient’s eye without influence on the veracity of result.

![Image](image_url)

**Figure 1. Assumption**

The check up marks on the Hess Screen request that when the patient staring at this mark, his/her angle of visual need to arrive at some degrees. The human’s visual field is rotundity, and the LCD display is a plane. Such as Figure 2. The point on the sphere should mapping to the plane using solid geometry[6]. Point O is the center of patient’s eye. Point O’ is the center of Hess screen. Point A is on the spherical surface that tangent with the screen. When the eye stares at the point A, visual angle is 5°. We need to mapping the A to the screen, and calculate the coordinate of A’. Such as Figure 3. All the coordinate of the marks should calculate as the same.

![Image](image_url)

**Figure 2. Sketch map of visual field**

![Image](image_url)

**Figure 3. Sketch map of mapping**

The unit of the coordinate of the calculation is cm or mm. But in the programme, its unit is pixel. The unit must be conversed according to the size and the resolution of the screen. The width of 20in LCD screen’s display area is 41cm. Its height is 31cm and resolution is 1400*1050. So the space between pels=screen’s width/ transverse resolution=screen’s height/ lengthways resolution. The space between pels of 20in LCD screen is 0.293mm. If we draw a 100 pixels line in the program, it equals a 29.3mm line.

B. **Error Analysis**

A volunteer patient takes the clinical trials with digital Hess screen system after the traditional inspect process. Compare the two result graphics, which one was manual recorded by doctor and the other was automatic record by computer, we can find the errors between them were completely less than 1mm. The result shows the precision of digital system is enough in ophthalmic inspect. In fact, the max error always occurs at the farthest borderline of screen, but in common way we use the central 9 points in practical inspect, so the actual error will be smaller.

Emphatically, in the actual inspect, the distance from patient to screen should not less than 25cm. Because, firstly, if the distance become more shorter, it will short then the eyes clear sight distance, the image of graphics on the inspect screen will be not ideal. Secondly, for the distance of two eyes was fixed, error will increase when shorten the distance from patient to the screen.

V. **CLINICAL APPLICATION AND RESULT**

In clinical application, we use 20in LCD screen as main body of displaying the Hess screen. The host computer has P4 CPU, 512MB ram, 80GB hard disk, Windows XP/2000 operation system and the developing environment of java. The tool software of the system is eclipse 3.1. The database software is Microsoft Access.

There are two groups of Hess chart. The group one is recorded by doctor in traditional Hess screen check up and the two is automated recorded by digital diagnosis instrument of Hess screen.

![Image](image_url)

**Figure 4. Comparison of two methods**
We compare the two groups in figure 5, and find two groups are the same basically. The error is very minor. The doctor diagnoses the right eye’s lateral rectus paralysis. The instrument according to the method of analyzing, diagnoses the right eye’s lateral rectus paralysis too.

VI. CONCLUSIONS

Hess screen is useful strabismuses technique of inspecting. With the iatrical principle of Hess screen, computer science and digitized techniques, we develop the product named digital Hess screen inspect equipment in paralytic strabismus, which can be run on ordinary computers. This equipment has integrative functions as Hess screen inspect, user data automatic recording and result paper printing, with these functions doctor can do the inspect more convenient and precise.

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