

AQUIR - A System to Generate Quantitative and Customized Vision Measurement Template

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Abstract—This paper presents a visual acuity measurement system, AQUIR, which provides the functionality to generate customized visual acuity charts quantitatively. Visual chart is the basic measure to evaluate the visual acuity. With low variability, the traditional visual chart is inflexible and the same chart is used repeatedly to conduct vision assessment. AQUIR system implements a real-time solution and it can customize the visual acuity test book with more flexibility. The process customizes the background, races and reading habits. The adjustability of font sizes and word sparsity subdivides the diagnostic result levels. Besides traditional printed text version, the codebook can be displayed on back-illuminated electronic devices. It widens the application areas for the AQUIR system and transforms the traditional style of the visual acuity measurement system. The dynamic visual acuity codebook will facilitate the operating procedures of visual acuity measurement and improve the accuracy of diagnosis. By breaking through traditional technology, the flexibility and accuracy of visual acuity measurement is improved and reproduction of the technology on multimedia can be performed.

Keywords— *visual acuity; optotypes; Jaeger chart*

I. INTRODUCTION

Visual acuity (VA) tests are considered the principle quantitative measure to assess the efficacy of ophthalmologic treatments and validity and reliability of VA measurement are important factors. VA measurement involves more than being able to see the optotypes. The patient should be cooperative, understand the optotypes, and be able to communicate with the physician without language barriers. If any of these factors is missing, then the measurement will not represent the patient's real VA.

Text-reading model has been proved to be more beneficial than optotype recognition [1]. There is qualitative difference between text-reading model and optotype recognition. The Text-reading model is more correctly employed in the evaluation of visual impairment rather than in VA measurement [2-4].

Although the standardization of current VA test measurement can provide the general solution, it creates some issues for certain individuals. Due to the difference in character structures between different languages, the same font size requires different acuity power, for example, Chinese characters are much denser than English alphabets. Acuity power correction is also related to an individual's reading habit. Another factor of vision acuity capability is the spacing between rows of words. Furthermore, familiarity of the reading material is related to the reader's education level or cultural background, inevitably affect the reliability of the VA test results. Therefore, there is a need to optimize current VA measurement and generate a customized quantitative vision measurement template. AQUIR (Automatic QUantitative customized vIsion measuRement template generator) is the solution to enhance the flexibility and adjustability of VA measurement.

II. RELATED WORKS

The ETDRS (Early Treatment Diabetic Retinopathy Study) chart was designed to eliminate inaccuracies in the Snellen tests [5]. It incorporates specific design criteria to make it more accurate than the Snellen acuity tests such as: same number of letters per row, equal spacing of the rows on a logarithmic scale (the rows are separated by 0.1. log unit), equal spacing of the letters on a logarithmic scale, etc. Fig. 1 shows several variations of Snellen charts and an example of ETDRS chart.

The pinhole occluder (Fig. 3) is an opaque device with one or more small holes to test visual acuity. The pinhole occluder

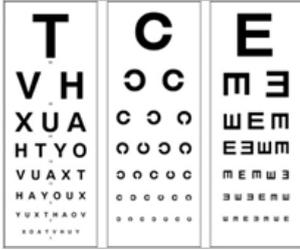


Fig. 1. Snellen charts



Fig. 2. ETDRS chart



Fig. 3. Pinhole Occluder

testing device can distinguish the problem with acuity caused by refractive error. The pinholes only allow the passage of light which is perpendicular to the lens, and thus does not need to be bent prior to being focused onto the retina. The patient is requested to do the VA test with and without pinholes and the ophthalmologists can evaluate according to the difference between these two tests.

The Jaeger chart (Fig. 4) is the most popular method used in near vision acuity test. Text is printed in paragraphs and the text sizes increase from 0.37mm to 2.5mm [6]. The classical Jaeger charts are in English and Roman-type front only and the font sizes are also fixed. These cause some limitations during the VA test. Firstly, there is the language barrier for non-English language speakers such as Chinese and Indians may have difficulties in reading the paragraphs in English. Furthermore, traditional Roman fonts are based on single font type, which may not be able to cover the wide scope of fonts used nowadays, in particular sans serif-type fonts. Finally, the printed Jaeger charts are limited to a few specific VA scores that limit the accuracy and range.

III. PROPOSED SOLUTION

We propose a standard coding mechanism – AQUIR, which can customize the patients’ individual needs and automatically generate the codebook into different forms of printed text.

In our automatic quantitative customized vision measurement solution, codebooks will be generated according to user’s requirement. A standardized score will be given in each page, which represents the acuity requirement to read the actual content on the page. The score bases on the density, sparsity and size of the characters on the page. The codebook, which is customized by specific patients, can provide more exact and reasonable VA power.

The framework of AQUIR (Fig. 5) consists of three parts: input section of customized information, internal classification algorithm for template generator, and output section of codebook.

The input section provides a user interface to initialize the configuration of the codebook. The language to be used for the codebook, which is the paramount novelty of AQUIR, is customized by user. The education background and language proficiency of each person is different, which may lead to trouble reading the given reading material. For instance, some Asian cannot read English words, so the traditional Jaeger charts are not suitable for this case. Meanwhile, character diversity of each language causes the visual diversity of individuals as well. Therefore, the selection of language is indispensable. What’s more, user can select input text file according to individual reading habit and it avoids the repeatable content of VA text chart. The range of font and increment of continuous font are configurable as well. It enables user to adjust the clarity and identifiability of the characters. Number of paragraphs for each font makes the

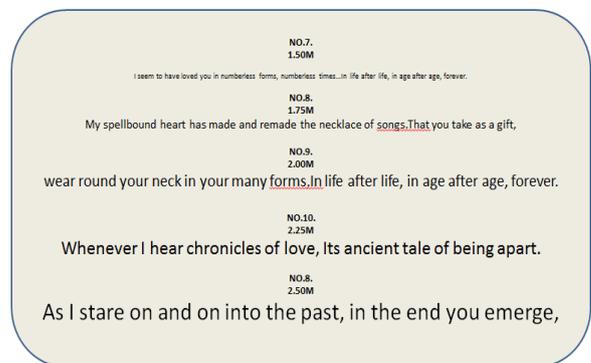


Fig. 4. Jaeger charts used for near acuity test text-reading instead of optotypes recognition

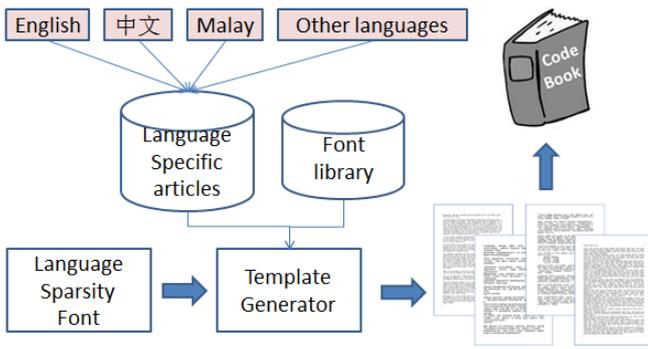


Fig. 5. AQUIR framework

digital products are developing rapidly, an alternative and flexible way of the usage is displayed on back-illuminated electronic devices, such as laptops, tablets and mobile phones.

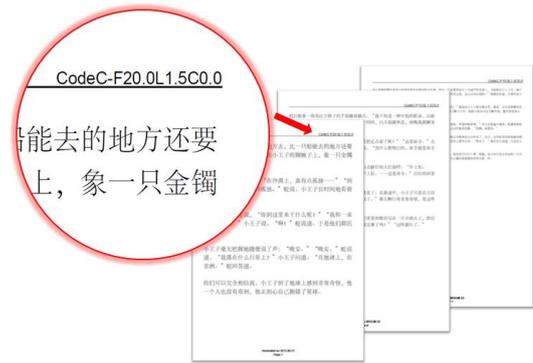


Fig. 6. Several pages (charts) from a codebook generated automatically via AQUIR

layout more flexible. The types of leading and kerning for the text are another two crucial factors of the VA chart, especially for near VA measurement. It determines the resolution among words.

The approach to locate the end of a sentence of Chinese:

- a) If it's a closing quote, it ends a sentence.
- b) If it's a period, a question mark, an exclamation mark or an ellipsis, and at same time, it doesn't follow by a closing quote, it ends a sentence.

Since there is no closing quote in English sentence, a counter need to be involved to make the quotes a pair.

The approach to locate the end of a sentence of English:

- a) If it's a quote and the counter is an odd number, then it doesn't end a sentence.
- b) If it's a quote and the counter is an even number, it ends a sentence.
- c) If it's a period, a question mark, an exclamation mark or an ellipsis, and at same time, it doesn't follow by a closing quote, it ends a sentence.

These two approaches can successfully detect the boundary of sentence and provide the output module paragraphs with whole sentences.

The unique code of each page, which includes parameter information, is on the top-right hand corner and is quantifiable for VA measurement. The parameter includes language types, font size, leading size and kerning size. Fig. 6 shows the sample of codebook template. The unique code of sample page generated by AQUIR represents Chinese language, STSongStd-Light (Song Ti) font face, from font size 25, to size 5, with the font size increment of 1 and, both leading and kerning is set as normal. The professionals can easily get the diagnosis according to the given unique code on each page.

The forms of the codebook are flexible, which is determined by users' requirement and hardware condition. The

The portable devices provide a robust and individual platform and allow the patients easily to customize the VA codebook. It makes it possible for patients to download the application online and carry out the VA test from home.

The detection of each sentence in the paragraph is sentence boundary disambiguation (SBD). SBD is also known as sentence breaking, is the problem in natural language processing of deciding where sentences begin and end. Since AQUIR allow user customize the input text file, the processing module should have the functionality to identify the boundary of each sentence. Because of the ambiguity of punctuation marks, the sentence boundary identification is challenging. For instance, quotation marks may denote the beginning of one sentence, the end of one sentence or the pause of one sentence.

Due to the diversity grammar of Chinese and English, the SBD are distinct for these two languages. We need to design the algorithms for them independently.

Table 1 shows the comparison between codebook generated by AQUIR and Jaeger Charts.

TABLE 1 COMPARISON AGAINST PRIOR ARTS

Characteristics	AQUIR	Jaeger Charts
Language	Extendable to multiple	English, fixed
Font Type	Configurable	Roman fonts, fixed
Font Sizes and spacing	Customizable	Several, fixed
Visual Acuity Scoring	Adaptable	Several, fixed
Content	Selectable	Fixed
Use-case	Print/Electronic	Print only

IV. CONCLUSION

Current detected area of VA inspection is focus on the center vision, and the VA chart is used to check the macular area foveal VA. Diagnosis and detection of presbyopia or myopia have social and clinical significance, as the doctors can get quick and initial situation of visual function. The efficiency, clarity and comfort of daily sense of vision are the main factors during the optical correction of presbyopia and myopia.

AQUIR is a system to generate quantitative and customized vision measurement template and it provides a customized mechanism to detect and diagnose presbyopia and myopia. The template generated by AQUIR is another possibility for VA measurement. By breaking through traditional technology, the flexibility and accuracy is improved and multi-media production is realized.

Since AQUIR is a customized codebook template generator and the input text files is optional, more investigation in children VA measurement can be made. There is another potential application that it can be integrated in to eye health assessment system.

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