Visual Acuity and Comfortable Distance from a Display

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ABSTRACT

The image perception in humans depends on many factors. One of the most important ones is certainly the observing distance. The distance from which human look at the images is important for studying image perception in general and in particular on display devices. This paper describes a method of measurement of the preferred observing distance among humans of different age, sex, etc. under controlled conditions.

Keywords

visual acuity, display, perception

INTRODUCTION

Presentation of images on display devices has been historically examined from many points of view. They include e.g. signal processing and image resampling methods, perception scale of luminance [2], colorimetry, psychophysical models of human visual system (HVS) [1], or physiology inspired tone-mapping operators for high dynamic range (HDR) images [3, 4]. Although the spatial response of HVS has been examined as well [5, 6], the data obtained through measurement of the spatial response of HVS is not commonly used for geometry perception optimization. Exploitation of the HVS space attributes in the display devices introduces one more problem. In general, the observing distance is not known. This paper presents an approach usable for measurement of the observer's preferred distance form a display device and measurement of the visual acuity under the same conditions based on the statistics obtained in several users.

Aim of The Measurement

Users tend to view the display from the so-called “comfortable distance”; however, such term is very vague, so it needs to be narrowed in order to be more specific. The aim is to find an ideal observation distance which is the best one for examination of details on a still photograph rendered via the display device. As the “examination of details” is still not specific enough and can even be different for different users, the “examination action“ can be made more specific through preparation of a specific task the users should perform so that the image perception in users can be compared and the achieved quality of image perception measured. The task for the users is evaluation of different filters applied on a series of images. Each picture is processed by several filters and the users are asked to subjectively choose which version they like, while in fact, the result is not that important. This leads into spontaneous localization of the users in the optimal observation distance suitable for comparison of the image details.

The question is how does the comfortable observation distance correspond to the visual acuity. Unlike the standard visual acuity measurement, the table of patterns (optotypes) is placed at the chosen distance, onto the display surface. The real visual acuity value is, therefore, relative to the chosen distance, which is measured as well. This approach ensures that the conditions, mainly the focal plane of the eyes, are close to those that apply during observation of the display. In some subjects, the different distances would also cause a need to change glasses which also means that the results in the subject with and without the glasses might not correspond.

The Experiment

Each of the subjects is seated in front of a display on a movable chair and instructed to move freely and position itself into a comfortable position. Several images are then shown in a sequence. Each of the images is filtered by four slightly different hi-pass filters. All four variants of the same image are then rendered on the screen side by side. The order of the filters is always random. The subject is asked to rate all of the four variants by selecting “like” “dislike” or “neutral” icon. The testing screen is shown in Figure 1. The differences between the digital filters are very tiny; therefore, the observer spontaneously chooses the best conditions for careful and detailed examination of the images. After the image rating is finished, they are asked not to move. The screen is then turned white and overplaced by the visual acuity measurement chart (see Figure 2). Subjects are asked to select the finest pattern of horizontal stripes they can resolve. The distance eye to display is measured during the test without disturbing the subjects (using triangulation). The optional reading aids are used throughout the test.

In the first test, many subjects reported difficulties in optotypes resolving, because with some of the densities, the pattern was visible at the field border only. To prevent the inaccuracy caused by this fact, another set of patterns were prepared with faded borders (Figure 3) and the subjects acuity was re-evaluated after the tests were repeated.

Important data

Display model	HP LP2465
White absolute luminance	60.8 cd·m^{-2}
Black absolute luminance	0.245 cd·m^{-2}
Luminance range	1:248
Pixel spacing	0.270mm
Display was calibrated with sensor (Datacolor Spyder 3 Pro)	
Gamma correction	2.2
White balance	6500K
Diffuser underneath the optotypes	
Thickness	3mm
Luminance loss	0.673 (-1.7dB)
Optotypes	
Seven striped optotypes optically transferred to inverse film (Fuji Provia 100F RDP3)	
Minimal density	3.35 cycles·mm^{-1}
Maximal density	4.78 cycles·mm^{-1}
White absolute luminance	15.1 cd·m^{-2}
Black absolute luminance	0.202 cd·m^{-2}
Contrast	1:74
Testing room	
Maximal illuminance measured at the desk	65 lx

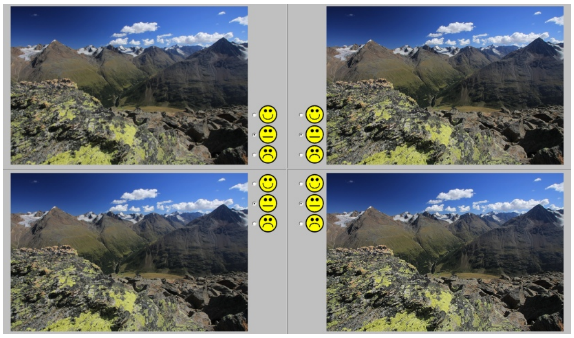

Figure 1: Testing screen

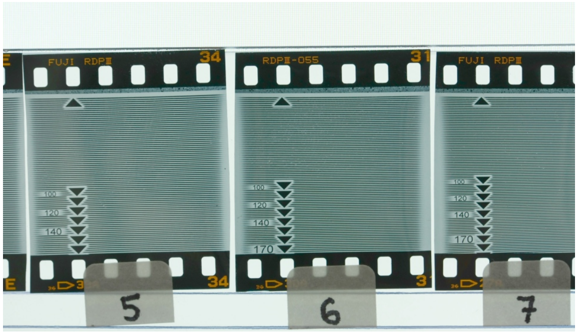

Figure 2: Optotypes

Figure 3: Optotype microscopy scan

Figure 4: Optotype marks for density measuring

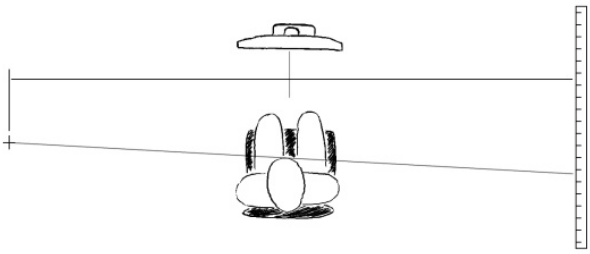

Figure 5: Distance triangulation

Measuring Methods

The distance from eye to the display is read from a marked point on a scale placed far on the side, parallel to the display axis (see Figure 5). The parallax error is compensated by proper scaling of the meter.

The optotypes with exact density could not be made without specialized optics. The optotype set was made with approximate scaling. Control marks were printed among the stripes (see Figure 4). For each of the optotypes the distance between the marks was measured with precise caliper and the density was calculated from the scale factor. Therefore the optotype set does not follow linear nor logarithmic series.

Angular acuity is computed from the relative acuity and eye-to-optotype distance as follows:

$$A_a = 10 \cdot A_r \cdot d \cdot \frac{\pi}{180}$$

where A_a is the angular acuity in cycles per degree, A_r is the relative acuity in cycles per millimeter and d is the distance in centimeters. The 3mm thickness of the diffusing plate underneath the optotypes was omitted in this calculation because of the distance precision issue mentioned above.

The credibility of the result in each subject should be checked by the preferred filter variant. The order of the images was random, so if the subject shows no clear preference, the differences among the filters are likely to be unrecognizable and the subject should be excluded from the statistics.

Conclusions

We propose an approach to measure relationship between visual acuity in humans and a distance selected by each individual user to examine details on a display device. The results of this measurement are important in application of the visual system parameters to the image processing for display devices. It follows that the relative spatial acuity could be possibly applied with the HVS spatial response. It is also possible to design a new, more accurate model of HVS linked to the display device parameters.

In future works, video represents another field of investigation. The preferred observing distance could be possibly very different with moving objects, not mentioning that HVS behaves differently than with still images.

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