Computer Binocular Kit: The Return

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Abstract

This paper, describing a computer graphics tool for clinical vision, is the result of an effort in finding out the potential of and possible improvements to a tool to help opticians. The software prototype, the computer binocular kit, generates customized stereo pairs. The results of this collaborative research project show that the eye cooperation ability of a patient can be trained by exercising the eye muscles with the Binocular Kit. However, we want to leave open the possibility of combining the data of patient's eye convergence with other measurements of perceived sharpness and disparity of stereo pairs.

> "However, for the active researcher it is at least as important to master the spirit of cyclopean technique to the extent that he could invent new methods for a particular research problem." — Bela Julesz

1 Introduction

In our presentation to the First Workshop of Cybernetic Vision of 94, the Computer Binocular Kit was an aid to comprehend in space the retinal image we don't see [2]. The kit was a software system designed from a computer science point of view, but opthalmologists were consulted in Denmark and Brasil. Automatic refraction and computers are replacing old clinical methods, but this is an expensive revolution, especially for opthalmologists in the third world [1]. Moreover using refraction as an isolate measure allows undetected problem occurences, that could lead to blindness or death. Refraction still is a science and an art; a part of a medical art [1]. The Computer Binocular Kit is part of this computer invasion of a vision clinic, designed to be a help to doctors within a third world budget.

2 Phases' Historical

The Computer Binocular Kit, an early software version, was implemented on a PC by Castaño Mariño, IME, in 92. The first version of the prototype software, C-implemented in 93 by Távora & Campos [3], has all the features of a small computer graphics system. Stereo images of three - dimensional objects, represented in homogeneous coordinates, could be transformed into 3D. The object and its transformations were animated in the anaglyph viewing. Then observers, using red and green glasses, could comment on their perceptual experience and customize the data or transformation parameters. As verified in the tests, the adjustment of the stereograms by a subject with myopia was made by enlarging the distance between the left and right patterns; thereby increasing disparity. Subjects with hypermetropia reduced this distance; thereby reducing the disparity. These facts suggested the hypothesis that a balance between convergence and disparity, chosen in a customized form by the kit, could help to detect problems with sight. In poor places, it could help people detect the need to look for an opticians care. Furthermore it suggested that an application of a dichoptic method of a computer generated stimuli could be used in vision clinic test.

2.1 Return

In 1995, a Danish group [4] decided to develop an expert system to help opticians, - starting from an analysis of the Computer Binocular Kit [3]. Finding out if it worked, both in theory and in practice, and finally seeing if it could be improved. Soren B. Carlsen and Dannie Kjeldgaard first implemented a restriction to the Computer Binocular Kit, instancing the figure entered always as the unit cube. Then they implemented the kit in turbo C++ on a PC-platform, so it could be taken to opticians. Their initial tests [4] indicated the same data disparities as the tests of Távora and Weber [3] for observers with myopia and hypermetropia. Discussing the tests with D. Jensen, chief of the training of vision clinic at Synoptik, and another optician in Copenhagen, they came to the conclusion that the Computer Binocular Kit can be used for training the cooperation ability of the eyes, as well as the eye muscles. They also decided that it could be a very useful computer tool for training and that it could be marketed to opticians [4].

2.2 Concepts of Viewing

The eyes detect in the spectrum band from 390nm to 750nm. The sensitive photoreceptors on the retina regenerate in seconds and the visual stimulus produced by eletromagnetic energy is interpreted by the brain. On the retina an unstable image that fades and reappears can be seen and the brain will make a best guess, to associate it to visual information. Such is the image that may reveal a solid object. Each ganglion cell on the retina receives information only from a precise area of the visual field. Impulses coming from a variable number of photoreceptors are transmited by a ganglion cell. The location of an object in space depends on the stimulated area of the retina. Each area of the retina has a visual direction. The location in space of the objects is relative to the distance that separates this area from the fovea, and this independs from the position of the eye in its orbit. A postimage in an area of the retina, that determines a location 30 degrees right of the center of the visual field (fovea visual direction), will remain always 30 degrees from the objects, which were fixed by the fovea during the successive eye movements [5]. We only have a clear perception of what is in our field of attention, the rest remains as a blur until the peripheral stimulus reaches a different value from those of the neighbours. That is, when we become conscious then the object is located in subjective space according to the distance of this stimulated area on the retina from the fovea. Simultaneously, an eye movement of new foveal fixation will be signaled and that distance is the amplitude of this movement [5].

Stereopsis is based on the geometrical fact that two dimensional projections of a three - dimensional object on the left and right retina differ in their horizontal positions; this is called retinal disparity, or binocular parallax. The binocular depth cues besides stereopsis are vergence and correlative accomodation.

The german physiologist Ewald Hering believed that this processing involves the crossing or uncrossing of images that are initially perceived as double because they lie either in front or behind the eye's point of convergence. In random dot stereograms, similar patterns can be perceived in the two fields and these might serve as the basis for fusion. When defocusing one stereoscopic field, even if the pattern printed out of focus is almost obliterated, stereopsis is still obtained and the fields will fuse in a sharp image. The blurred image serves only to convey the required disparity information and is then suppressed [6]. Julesz proved that the main purpose of vergence is to bring the images within Panum's fusional area, where the central nervous system process of stereopsis can operate.

2.3 Open Problem

The opticians interpretation of the tests led Carlsen and Kjeldgaard [4] to believe the Kit can only test for cooperation hability and to state that it's not possible to determine the need of wearing glasses by using the Kit. However there are some points about seeing that should be taken into consideration. From Berry [7], who wrote in 1948 that there are quantitative relations among Vernier, real depth and stereoscopic depth accuities, and also by Díaz and Dias [5] that there exists a strong correlation between stereoscopic and monocular accuities. Besides, one can differentiate normal patients from patients with microtropies. In addition,the corrective lenses only change the vergence, so that the image is formed on the retina, according to the refraction clinic tests of the patient. Therefore there is a possibility of associating, to the customized disparity parameters obtained with the kit other measurements of perceived depth acuities. In the literature one can find formulas for the relation of the disparity of stereograms and the apparent depth of the perceived object [7, 8, 9]. These equations simple geometry gives a direct relation between the disparity of a point in the stereopairs and the distance of the apparent object.

So by increasing the stereogram disparity one could increase apparent object distance from the observer. This statement should be corrected in Hess [2], in tests interpretation. Notice the parallel effect in the size of objects behind the lenses of the myope and hypermetrope, e.g. - myope will increase disparity and its perceived object will have a "more-distant" effect, his lenses reduce the sizes of objects. In the Kit the stereograms are positioned by the patient so that the "object in focus" situation is created, while in usual clinical tests the object is out of focus and lenses are added until the point of focus is reached.

Depth discrimination tends to break down, as the vertical separation of the test rods of the Vernier object decreases in size from the optimal separation. The Vernier discrimination would not be affected by imbalance of the ocular muscle, because the Vernier performance is essentially monocular and does not depend on cooperation of the two eyes [7]. Therefore correlative accomodation (differencial focusing of the two eyes) data can so be obtained. As a consequence, multiple depth situations scenarios should be recreated on Kit for tests.

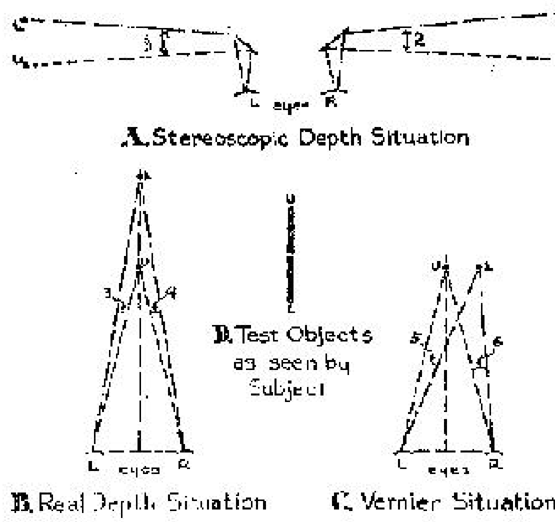

Figure 1: figure extracted from Berry. U and L represent the upper and lower rods. Angles 1 to 6 represent threshold displacements of movable rod U in terms of visual angle $2(<1+<2) = 2(<3+<4) =<5 =<6$, $<1 =<2 =<3 =<4 =<5/4 =<6/4$.

3 Conclusion

New tests with an opthalmologist in the team should be made. This time using random dot stereograms, because they contain disparity information for every point. Instead of testing with anaglyphs, because the colors green and red don't have the same wave length, and that may interfere with the results of the refraction. Further, different tests using animated noise, like the tests made in [10], as well as rivalry,diplopia and Panum area tests could be pursued with the Computer Binocular Kit, aiming to answer the question of the possibility of associating with the data of convergence of the eyes, other measurements of perceived sharpness and disparity of the stereo pairs.

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