

Edge localisation uncertainty: experiment and model

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experiments, in which seventy subjects took part, showed that the coding of the orientation of the basic features such as line segments and that of a perceptual object such as an office chair varies with the choice of the spatial reference used in pre-attentive vision. We have actually observed that the orientation of the line segments is coded in relation to an orientation reference system formed by the vertical and the horizontal, whereas the orientation of the office chair is coded only according to a single orientation of reference which corresponds to its functional orientation (vertical).

◆ **Concussion of the brain and spatial-frequency contrast sensitivity**

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Contrast sensitivity functions (CSF) with and without two-dimensional spatial white noise were obtained with the aid of a computer-controlled video device, grating charts, and a set of narrow-band filtered optotypes ('E' in four orientations) having different contrast levels in the extended range of spatial frequencies from 0.3 to 40.0 cycles deg^{-1} with a step of 1.6 cycles deg^{-1} . The set of narrow-band optotypes allows us to measure the CSF in the same way as when using the sinusoidal gratings produced by computer-controlled video devices or grating charts.

In emergency clinical practice, we examined about 200 cases of concussion of the brain without evident neurological syndromes. These patients complained of subjective disturbance of vision, or had some uncommon complaints in spite of retaining high visual acuity. We found a general decrease in CSF. In 70% of cases there were remarkable changes of sensitivity in the range 0.3–3.0 cycles deg^{-1} . The changes were identical whether we used a computer-controlled video device, a grating chart, or narrow-band filtered optotypes. However, in practice the use of filtered letter optotypes is more convenient in urgent cases. We propose a new low-spatial-frequency brain concussion diagnostic test. The CSFs of patients with brain concussion are well defined by the level of internal noise.

◆ **Edge localisation uncertainty: experiment and model**

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The detection and localisation of edges play a central role in early vision. Since the results of these processes constitute the basis for all subsequent visual processing, the accuracy with which edge locations can be represented internally is a limiting factor for vision in general.

In this study the concept of edge localisation uncertainty is introduced. Theoretically, edge localisation uncertainty can be described by a confidence interval for edge location in some early visual representation. Edge localisation uncertainty can be assessed experimentally by estimating the spread of the psychometric curve obtained by measuring the frequency of correctly detecting the direction of displacement of a test edge relative to a reference edge as a function of the size of this displacement.

In experiments performed on two subjects, edge localisation uncertainty was assessed for varying average luminance, Michelson contrast, Gaussian edge blur, and additive white noise. Next, a simple linear model based on Marr's theory of edge detection with the use of a $\nabla^2 G$ operator was developed. Despite the simple nature of this model, experimental results and model predictions have been found to be in very close agreement.

◆ **Modelling of high-precision edge extraction phenomena**

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The proposed model of human visual edge extraction is characterised by high precision of spatial localisation for sharp as well as for non-sharp edge structures. This important feature has not been reproduced by known models, and as was shown by Pearson and Robinson (1985, *Proceedings of IEEE* 73 795) it is not clear why contour images derived by different methods and models are not the same as those seen by the human eye. Our model is based on a pixel size optimisation at intermediate calculations and multichannel organisation which corresponds to a real visual system structure. Precision of the model was evaluated by comparing the initial images with the restored ones. Sharp and non-sharp edge structures have been used as basic information for half-tone image restoration (Graham and Schreiber's idea). This explains the high visual contour extraction precision and the high-ratio spatial data compression in the human visual system. It also complements the visual system model such as the one suggested by Simkin [1994 *Threshold Function Model of Vision for Engineers* (NY/Moscow: BSD/Silicon)] and permits image processing without any loss of significant information.