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An Illusory Transformation in a Model of Optic Flow Processing

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We present results from computer simulations of a biologically plausible model of heading detection in the visual motion pathway of higher mammals. These simulations are closely related to a recently discovered visual illusion in optic flow processing in humans. The model reproduces the results described for humans and suggests a possible explanation, namely that humans interpret the illusory stimuli in terms of egomotion. It provides further indication that the visual system makes use of visual information to cope with eye movement effects in dealing with optic flow.

Optic flow Illusion Egomotion Modelling

1. INTRODUCTION

Questions regarding the use of optic flow during egomotion have received increased attention from different scientific communities in recent years. Psychophysicists debate whether the direction of heading can be detected purely visually when eye movements distort the simple radial flow field that occurs from straight observer translation (Cutting, Springer, Braren & Johnson, 1992; Royden, Banks & Crowell, 1992; van den Berg, 1993; Warren & Hannon, 1988, 1990). Neurophysiologists have tried to find a neurobiological substrate for optic flow processing in the visual system of cats (Rauschecker, von Grünau & Poulin, 1987; Rauschecker, 1988; Brenner & Rauschecker, 1990) and monkeys (Saito, Yukie, Tanaka, Hikosaka, Fukada & Iwai, 1986; Tanaka & Saito, 1989; Duffy & Wurtz, 1991a; Graziano, Andersen & Snowden, 1994). Mathematical investigations about the recovery of motion parameters from optic flow have long been undertaken (Bruss & Horn, 1983; Koenderink & van Doorn, 1975; Longuet-Higgins & Prazdny, 1980; Prazdny, 1980; Rieger & Lawton, 1985; Verri, Girosi & Torre, 1989) and are still being pursued (Beusmans, 1993). Recent interest in computational aspects, however, has often focussed on modelling results from psychophysics (Hatsopoulos & Warren, 1991; Hildreth, 1992a, b), or neurobiology (Perrone, 1992; Verri, Straforini & Torre, 1992; Zhang, Sereno & Sereno, 1993), or both (Lappe & Rauschecker, 1993a, b, 1994).

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An important tool for the analysis of vision is the study of visual illusions, since they can potentially give insight into the normal functioning of the system. The ability to reproduce the effects of visual illusions is an important requirement for biologically plausible models of the visual system (Bülthoff, Little & Poggio, 1989; Wang, Mathur & Koch, 1989). Recently, Duffy and Wurtz (1993) described an illusory transformation of optic flow fields. They presented optic flow stimuli containing radial and planar motion to human subjects who were asked to identify the centre of radial motion in these stimuli. Two basic sets of stimuli were used. In the first set, the centre of radial motion was truly displaced from the centre of the screen by vectorially adding a planar motion component, e.g. motion to the right, to a radial stimulus centred on the screen. The result is a radial motion centred at a position away from the centre of the screen [see Fig. 3(A, C), and Fig. 3(B) for centred radial motion). For instance, if planar motion towards the right is added, the position of the centre of radial motion is on the left of the screen centre. However, only half of the dots in the display actually underwent this motion. The other half of the dots remained stationary. The authors call this the *combined* stimulus. Subjects correctly perceived the displacement of the radial motion pattern and accurately identified the centre of radial motion. In the second set of stimuli, the so-called *transparent* stimuli, half of the dots on the display underwent a radial motion centred on the screen, while the other half of the dots now moved simultaneously in one planar direction. This stimulus thus contained transparent radial and planar motion at the same time (see Fig. 4). When subjects were asked to locate the centre of radial motion