Neural Mechanisms for Robust Integration and Segregation of Motion Patterns

Pierre Bayerl and Heiko Neumann

email: {pierre,hneumann}@neuro.informatik.uni-ulm.de

Department of Neural Information Processing, University of Ulm, Germany

Introduction

Pinna and Brelstaff [1] recently discovered a compelling illusion of relative motion in the peripheral field of view.

The illusion of counter-clockwise rotation is perceived when fixating the center of a stimulus and moving towards the image. The illusory effect can be steered by changing the shape or contrast arrangement of the tiles in the pattern.

The left and the central image induce a strong illusory motion percept; the right image has no illusory effect.

Claim: The stimulus parameters and viewing conditions necessary to perceive the illusion unravel basic principles of the underlying mechanisms for motion integration and segregation in visual cortex.

Model

Retina → V1.

▷ Log-polar mapping of the retinal images [2].

▷ Patterns in the retinal periphery are compressed/blurred; rotation, spiral and expansion patterns are mapped to linear patterns in V1 [3,4].

Each visual area in our model consists of 3 parts: An Integration, a Modulatory Feedback [5], and a Competition stage [6].

Retinal receptive field sizes increase with each area by 1:11:30 (in accordance to anatomical data [7,8,9]).

V1: Small Scale Flow Estimation.

▷ Detection of normal flow (sparse and ambiguous).


MT: Medium Scale Flow Analysis.

▷ Suppression of opposite directions [12].

▷ Motion integration along contours: Long-range interactions activated from V2/V4 (V2 & V4 not yet included - but artificially substituted).

MSTd: Large Scale Flow Analysis.

▷ Least squares optimization → dominant direction.

▷ Directional decomposition using dominant axis of motion.

Results & Conclusion

Results:

▷ Relative Motion Illusion (Pinna & Brelstaff [1]).

▷ Complementary case: “Expand Illusion” – not shown.

▷ New Interpretation: Pinna-Illusion as Motion transparency [12].

Conclusions:

▷ Feedback from MSTd is necessary for integration and disambiguation of motion patterns.

▷ Log-polar-mapping is essential for generating orderly organizations of motion signals for subsequent grouping.

▷ Brightness patterns of the tiles are critical for generating direction contrast of initial normal flow between the inner and outer ring.

Current work:

New stimuli predicted by our model + psychophysical experiments.