Neural Dynamics of Motion Grouping Across Apertures

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INTRODUCTION

MOTION GROUPING

How does the visual system group motion signals from different parts of an object into a single percept?

MOTION SEGMENTATION

How to keep motion signals from different objects separate?

WHEN ARE MOTION SIGNALS GROUPED ACROSS APERTURES?

SOLUTION

Use unambiguous feature tracking signals to veto ambiguous signals from line interiors

Proposed by Chey, Grossberg and Mingolla, 1997 to explain speed discrimination and motion grouping in barberpole and plaids
NETWORK DIAGRAM

Layer 1: INPUT

Layer 2: TRANSIENT CELLS

Layer 3: SHORT-RANGE FILTER

Layer 4: SPATIAL COMPETITION

Layer 5: LONG-RANGE FILTER (MT)

Layer 6: DIRECTIONAL GROUPING (MST)

TOP-DOWN PRIMING
FACADE: FIGURE-GROUND

Grossberg, 1994, 1997

T-Junction Sensitivity

Long-Range Cooperation: (+) Bipole Cells
Short-Range Competition: (-) Hypercomplex Cells

The top of the T is assigned to the NEAR depth
The stem of the T is assigned to the FAR depth
BREGMAN-KANIZSA

VISIBLE aperture

INVISIBLE aperture
Layer 1

Model Input = FACADE Output

Single line seen behind

INPUT

Visible aperture

Invisible aperture

Boundary output at FAR depth (from FACADE)

Extrinsic terminators features absent

Intrinsic terminators features present
Layer 2

**DIRECTIONAL TRANSIENT CELLS**

Directional selectivity obtained by inhibitory vetoing processes

No feature tracking produced here

**FRAME 1**

- **Directional Cells**
- **Interneurons**
- **Transient Cells**
- **INPUT**

**FRAME 2**

- **Directional Cells**
- **Interneurons**
- **Transient Cells**
- **INPUT**

**LEGEND:**

- Inactive cell
- Active cell
- Inhibited cell
- Excitatory link
- Inhibitory link
Layer 3

**Short Range Filter**

- Space and time averaging of transient cells
- Spatially anisotropic
- Accumulate evidence for feature tracking signals
- Aperture ambiguity in line interiors

**Legend:**
- Green arrow: Excitatory link
- Pink arrow: Inhibitory link
Sharpen feature tracking signals through

Spatial competition within scale and direction, and

Inhibition from opponent directions
LONG RANGE FILTER AND GROUPING

LONG - RANGE FILTER (MT)
   Across space, contrast polarity and orientation
   Within direction

GROUPING NET (MST)
   Across space
   Within direction
   Competition selects winning direction

TOP - DOWN PRIMING (MST → MT)
   Suppresses all losing directions across MT
Needle Diagrams

8 directions
Layer 2

**Directional Transient Cells**

Visible Apertures

Invisible Apertures
Layer 3
SHORT RANGE FILTER

Visible Apertures

Invisible Apertures
Layer 4

COMPETITION NETWORK

Visible Apertures

Invisible Apertures
Layers 5 & 6

**LONG RANGE FILTER AND GROUPING**

Visible Apertures

Invisible Apertures

**GROUPING**

**NO GROUPING**
**Visible Apertures**

Lorenceau and Shiffrar, 1992

**Input**
- EXTRINSIC line terminators
- Weak feature tracking signals
- Motion signals from line interiors group across apertures

**Perceived Output**

**Model Output (MST Cells)**
INVISIBLE APERTURES
Lorenceau and Shiffrar, 1992

Input  Perceived Output  Model Output (MST Cells)

**INTRINSIC** line terminators
Strong feature tracking signals
No grouping across apertures
JAGGED APERTURES (Percept)

Green lines not in the input

Apertures are **INVISIBLE**

Line terminators are intrinsic

But motion of terminators is ambiguous, so

Line terminators generate only weak feature tracking signals

Motion signals from line interiors group across apertures

Lorenceau and Shiffrar, 1992
JAGGED APERTURES (Model)

Competition network

MST cells

GROUPING
CLASSIC BARBER POLE

Wallach, 1935

Input

MST cells

Perceived Output

Intrinsic line terminators

Invisible rectangular aperture

More horizontal features than vertical

Good feature tracking signals
**MOTION CAPTURE**

Ramachandran and Inada, 1985

Input

Random dots superimposed on grating

Motion of dots is incoherent from one frame to the next

Dots generate no feature tracking signals

Perceived Output

Motion of dots captured by grating

MST cells
**SPOTTED BARBER POLE**
Shiffrar, Li and Lorenceau, 1995

- **Input**
  - Random dots superimposed on grating
  - Dots move consistently down
  - More feature tracking signals going down than right

- **Perceived Output**
  - Motion of grating captured by dots

- **MST cells**
Feature tracking signals that are generated through figure-ground processes veto ambiguous motion signals from line interiors

The strongest feature tracking signals determine perceived motion within an aperture

They also block the grouping of motion signals across apertures
REFERENCES


