Analysis of Motion

Measuring motion in biological vision systems

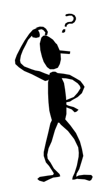
CS332 Visual Processing

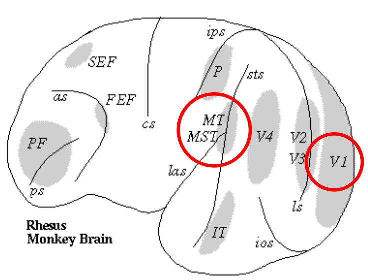
Department of Computer Science
Wellesley College

Two-stage motion measurement

motion components → 2D image motion

Movshon, Adelson, Gizzi & Newsome





V1: high % of cells selective for direction of motion (especially in layer that projects to MT)

MT: high % of cells selective for direction and speed of motion

lesions in MT → behavioral deficits in motion tasks

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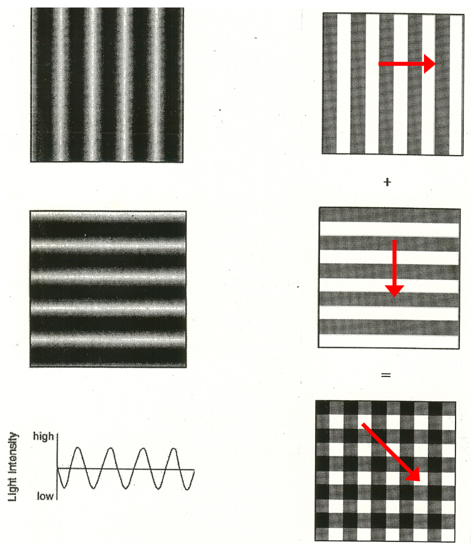
Testing with sine-wave "plaids"



Moving plaid demo:

www.georgemather.com

Movshon et al. recorded responses of neurons in area MT to moving plaids with different component gratings

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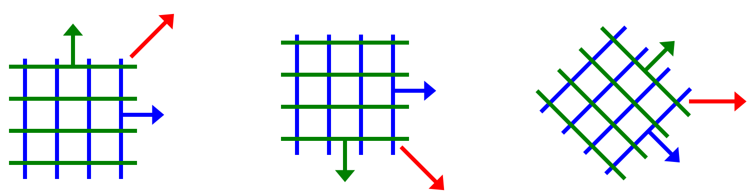
Logic behind the experiments...



(1) (2) (3)

Component cells measure perpendicular components of motion

e.g. selective for vertical features moving right

predicted responses: (1) (2) (3)

Pattern cells integrate motion components

e.g. selective for rightward motion of pattern

predicted responses: (1) (2) (3)

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Movshon et al. observations:

- Cortical area V1:

    all neurons behaved like component cells

- Cortical area MT:

    layers 4 & 6: component cells

    layers 2, 3, 5: pattern cells

Evidence for two-stage motion measurement!

- Perceptually, two components are not integrated if:

    large difference in spatial frequency

    large difference in speed

    components have different stereo disparity

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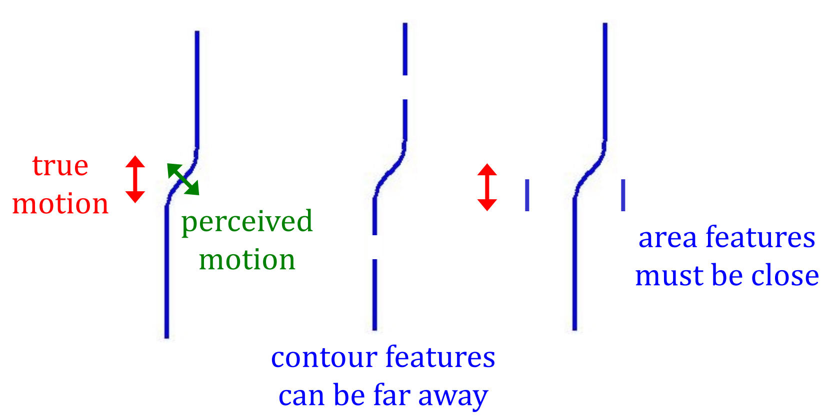
Integrating motion over the image

- integration along contours vs. over 2D areas:

    Nakayama & Silverman



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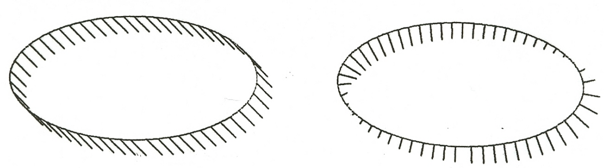
Option 2: *Smoothness* assumption:

Compute a velocity field that:

(1) is consistent with local measurements of image motion (perpendicular components)

(2) has the *least amount of variation* possible

Pure Translation:



true & smoothest velocity field

initial motion measurements

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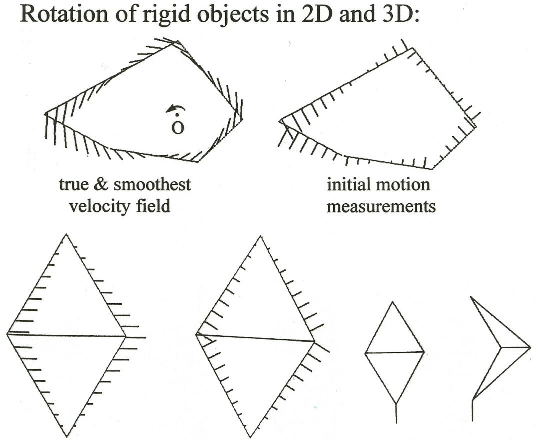
When is the *smoothest* velocity field *correct?*

Rotation of rigid objects in 2D and 3D:



true & smoothest velocity field

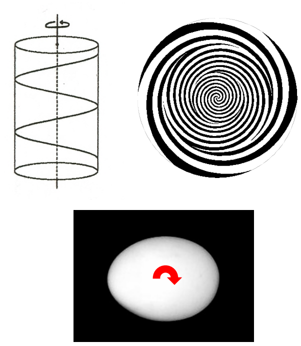
initial motion measurements

true & smoothest velocity field

initial motion measurements

kinetic depth effect Wallach & O'Connell

When is it *wrong?*



motion *illusions*

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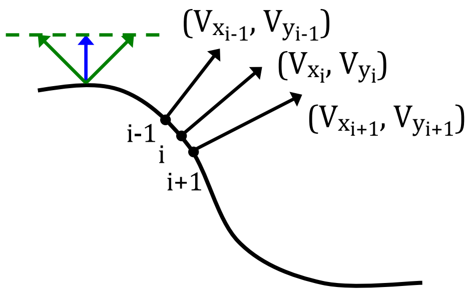
Computing the smoothest velocity field



motion components:

$V_{x_i} u_{x_i} + V_{y_i} u_{y_i} = v^{\perp}{}_i$

change in velocity:

$(V_{x_{i+1}} - V_{x_i}, V_{y_{i+1}} - V_{y_i})$

Find (V_{x_i}, V_{y_i}) that minimize:

$$\sum (V_{x_i} u_{x_i} + V_{y_i} u_{y_i} - v^{\perp}{}_i)^2 + \lambda [(V_{x_{i+1}} - V_{x_i})^2 + (V_{y_{i+1}} - V_{y_i})^2]$$

deviation from image motion measurements **+** variation in velocity field

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