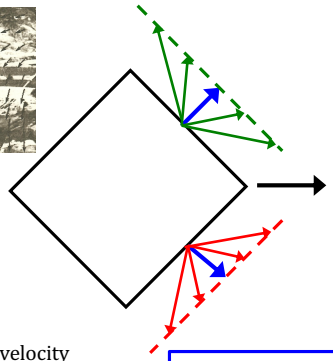
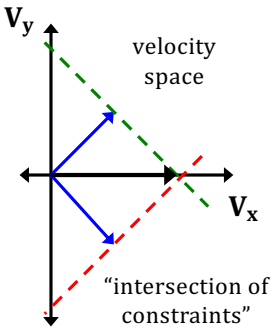
Computing velocity from motion components

velocity field





V_x, V_y : 2D velocity

u_x, u_y : direction of gradient

$v^\perp$: perpendicular motion

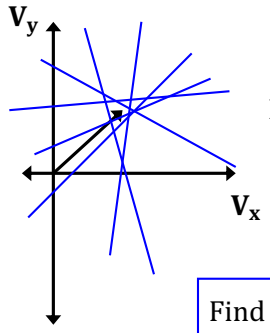
$V_x u_x + V_y u_y = v^\perp$

$V_x u_x + V_y u_y = v^\perp$

solve for V_x, V_y

1

In practice…



"least squares fit"

Previously…

$V_x u_x + V_y u_y = v^\perp$

New strategy:

Find (V_x, V_y) that ***best fits*** all motion components together

Find (V_x, V_y) that minimizes:

$\Sigma(V_x u_x + V_y u_y - v^\perp)^2$

2

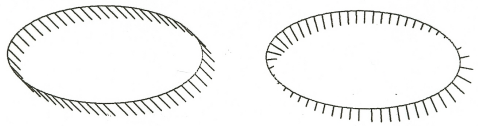
Option 2: *Smoothness* assumption:

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:

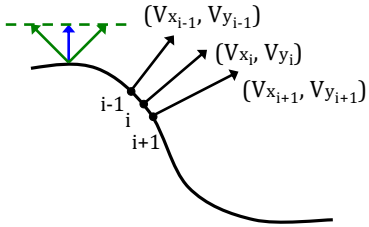


true & smoothest velocity field

initial motion measurements

3

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:

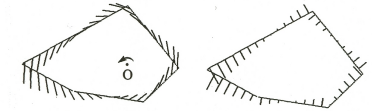
$\Sigma(V_{x_i} u_{x_i} + V_{y_i} u_{y_i} - v^\perp_i)^2 + \lambda[(V_{x_{i+1}} - V_{x_i})^2 + (V_{y_{i+1}} - V_{y_i})^2]$

deviation from image motion measurements + variation in velocity field

4

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

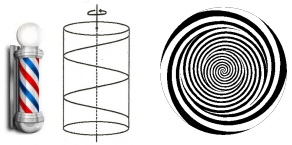
Rotation of rigid objects in 2D and 3D:

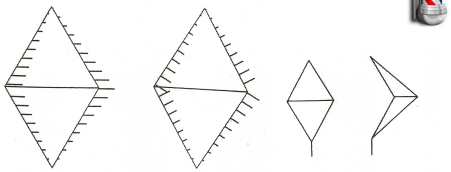


true & smoothest velocity field

initial motion measurements

When is it *wrong?*

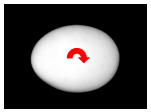




true & smoothest velocity field

initial motion measurements

kinetic depth effect
Wallach & O'Connell



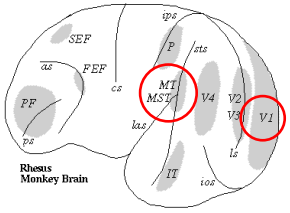
motion *illusions*

5

Two-stage motion measurement

motion components → 2D image motion

Movshon, Adelson, Gizzi & Newsome



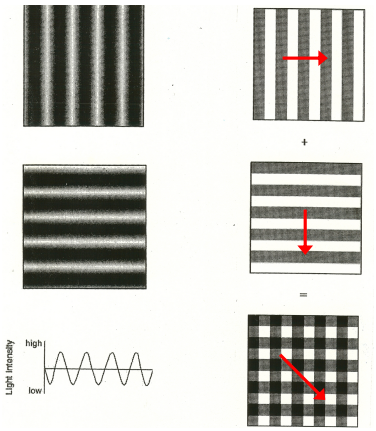
V1: high % of cells selective for direction of motion (especially in layer that projects to MT)

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

lesions in MT → behavioral deficits in motion tasks

6

Testing with sine-wave "plaids"



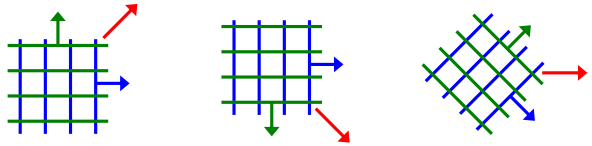
Moving plaid demo:

http://www.georgemather.com/MotionDemos/PlaidMP4.html

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

7

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)** yes **(2)** yes **(3)** no

Pattern cells integrate motion components

e.g. selective for rightward motion of pattern

predicted responses: **(1)** no **(2)** no **(3)** yes

8

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

9