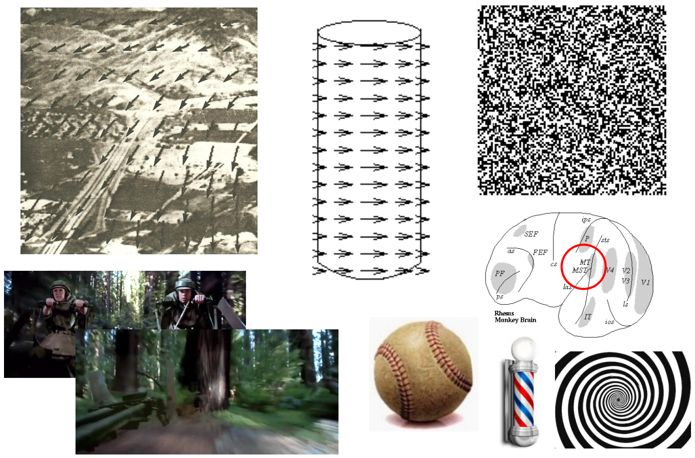
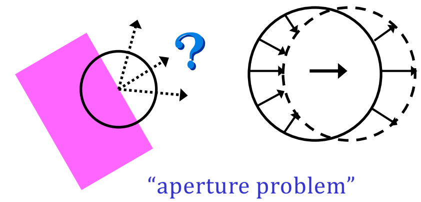
Analysis of visual motion



1

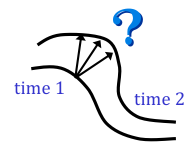
Measuring image motion

velocity field



"aperture problem"

"local" motion detectors only measure *component of motion* perpendicular to moving edge

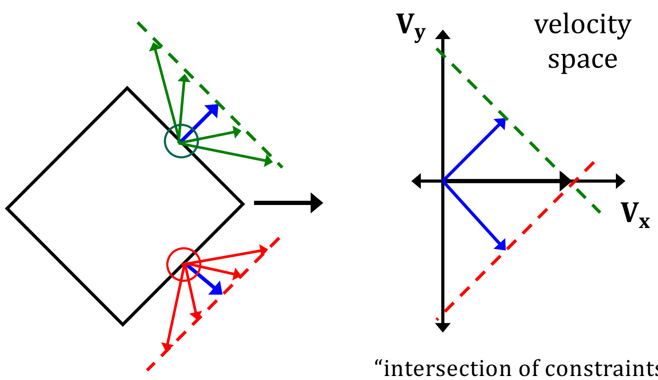


2D velocity field not determined *uniquely* from the changing image

need *additional constraint* to compute a unique velocity field

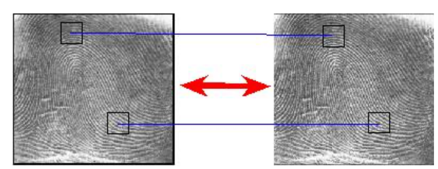
2

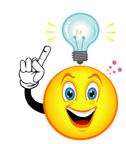
Option 1: Assume *pure translation*



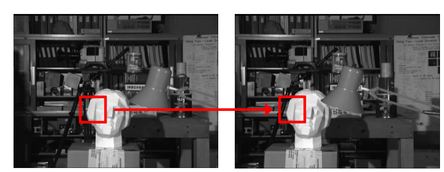
"intersection of constraints"

3





motion measurement strategy!



4

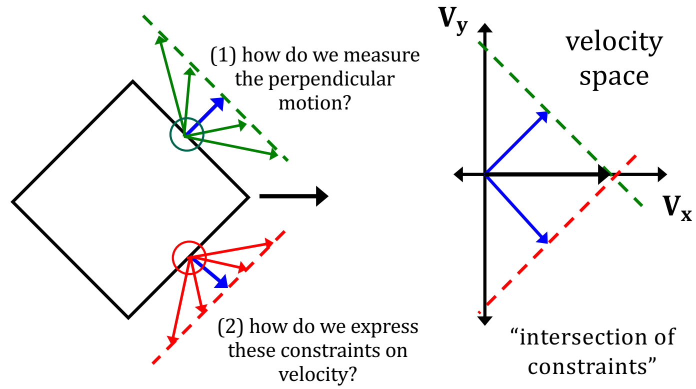
Practical considerations for methods based on pure translation:

- Error in initial motion measurements
- Local image features may have small range of orientations
- Velocities not constant locally

But… such strategies are good for
- detecting sudden movements
- tracking
- detecting boundaries

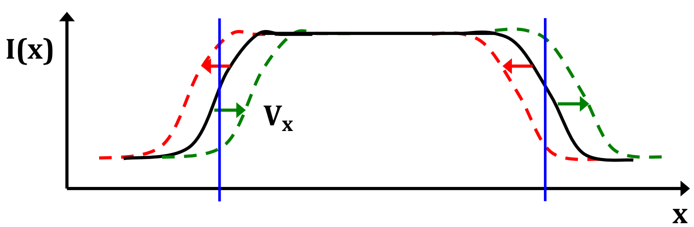
5

Goals for the rest of this video



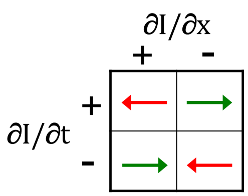
6

Measuring motion in one dimension



- V_x = velocity in x direction
- rightward movement: $V_x > 0$
- leftward movement: $V_x < 0$
- speed: $|V_x|$
- pixels/time step

$$V_x = -\frac{\partial I/\partial t}{\partial I/\partial x}$$



7

Measuring motion components in 2-D

(1) *gradient* of image intensity

$\nabla I = (\partial I/\partial x, \partial I/\partial y)$

(2) time derivative

$\partial I/\partial t$

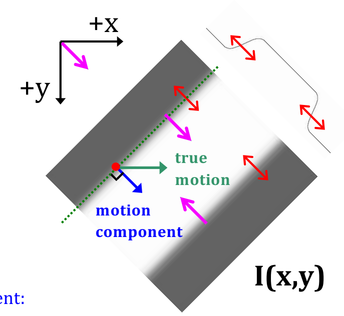
(3) velocity along gradient:

$v^{\perp}$

- movement in direction of gradient:

  $v^{\perp} > 0$
- movement opposite direction of gradient:

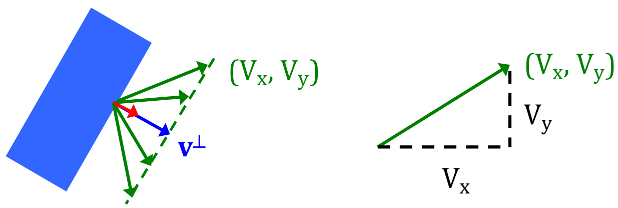
  $v^{\perp} < 0$



$$v^{\perp} = -\frac{\partial I/\partial t}{|\nabla I|} = -\frac{\partial I/\partial t}{[(\partial I/\partial x)^2 + (\partial I/\partial y)^2]^{1/2}}$$

8

2D velocities (V_x,V_y) consistent with $v^{\perp}$



All (V_x, V_y) such that the component of (V_x, V_y) in the direction of the gradient is $\mathbf{v}^{\perp}$

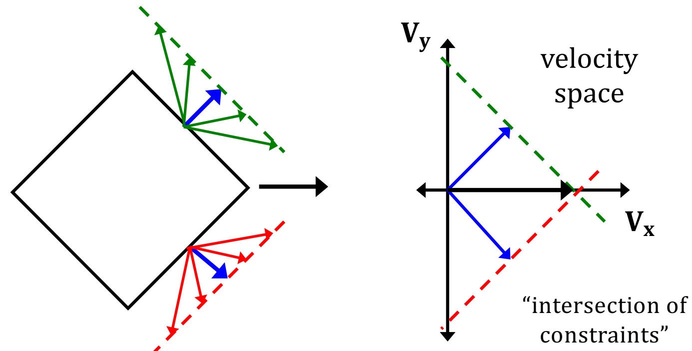
(u_x, u_y): unit vector in direction of gradient

Use the *dot product:* $(V_x, V_y) \bullet (u_x, u_y) = \mathbf{v}^{\perp}$

$$\boxed{V_x u_x + V_y u_y = \mathbf{v}^{\perp}}$$

9

Computing velocity from motion components



$$\boxed{\begin{aligned} V_x u_x + V_y u_y &= \mathbf{v}^{\perp} \\ V_x u_x + V_y u_y &= \mathbf{v}^{\perp} \end{aligned}} \longrightarrow \text{solve for } V_x, V_y$$

10