Recovering 3D observer motion & layout

FOE: focus of expansion

Observer motion problem

From image velocity field, compute:
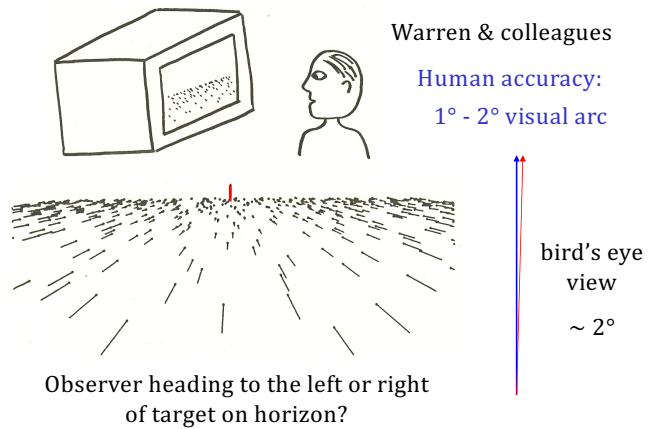
velocity field

- observer translation

  $(T_x \ T_y \ T_z)$

- observer rotation

  $(R_x \ R_y \ R_z)$

- depth at each location

  $Z(x, y)$

R_y

R_z

R_x

(T_x, T_y, T_z)

+y

+z

+x

$(0, 0, 0)$
The reference
coordinate system

+y

+z

+x
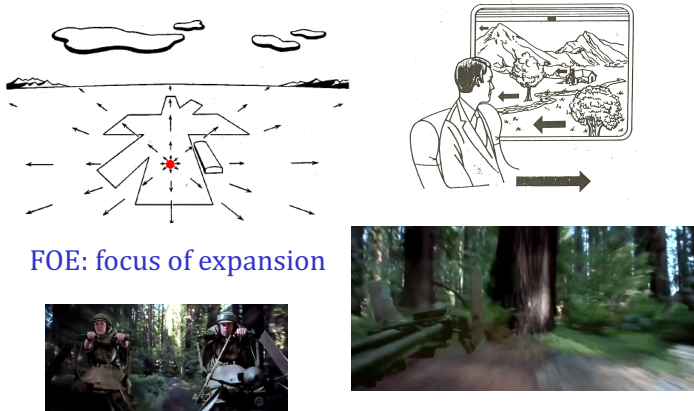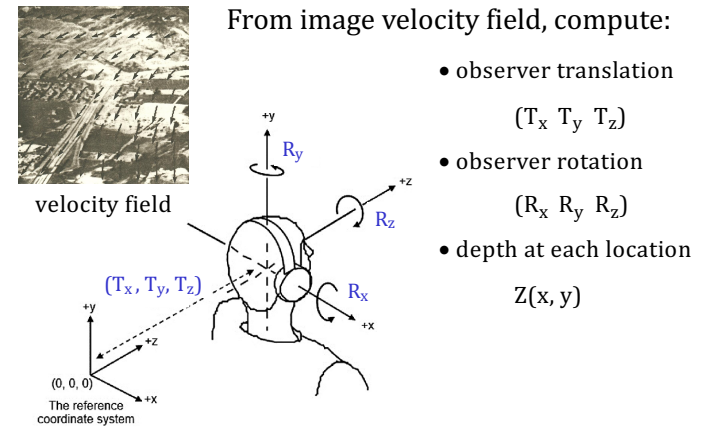
Human perception of heading

Warren & colleagues

Human accuracy:
1° - 2° visual arc

bird's eye
view

~ 2°

Observer heading to the left or right
of target on horizon?

Observer just translates toward FOE

heading point

Directions of
velocity vectors
intersect at FOE

But... simple strategy doesn't work
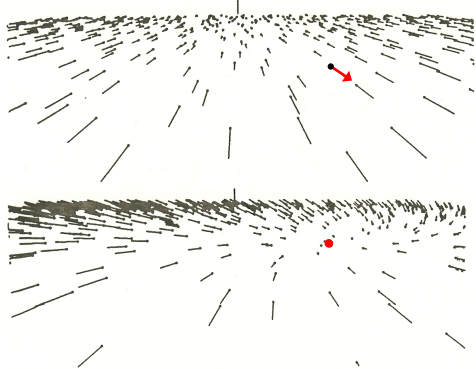if observer also rotates

1

2

3

4

1
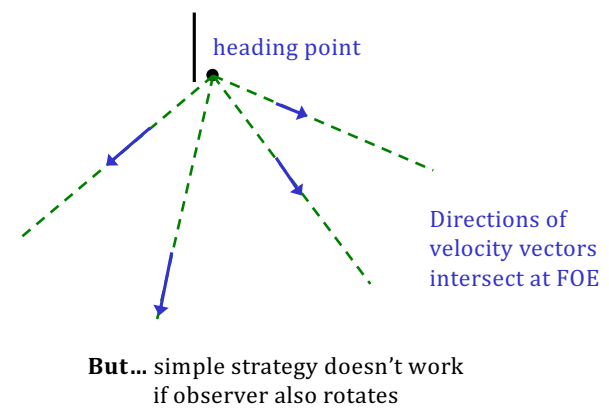
Observer Translation + Rotation

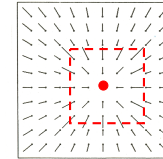display simulates observer translation

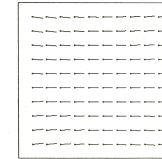observer rotates their eyes

display simulates translation + rotation
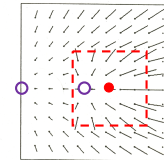
Still recover heading with high accuracy!

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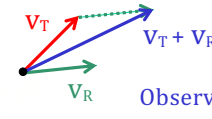
Observer motion problem, revisited

pure translation   pure rotation

translation + rotation

From image motion, compute:

- Observer translation

  $(T_x \ T_y \ T_z)$

- Observer rotation

  $(R_x \ R_y \ R_z)$

- Depth at each location

  $Z(x,y)$

V_T $V_T + V_R$ V_R

Observer undergoes **both** translation + rotation

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Equations of observer motion

Translation	Rotation	Depth
(T_x, T_y, T_z)	(R_x, R_y, R_z)	$Z(x,y)$

$$V_x = (-T_x + xT_z)/Z + R_xxy - R_y(x^2+1) + R_zy$$

$$V_y = (-T_y + yT_z)/Z + R_x(y^2+1) - R_yxy - R_zx$$

Translational Component   Rotational Component

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Translational component of motion

$$V_x(x,y) = \frac{-T_x + xT_z}{Z(x,y)}$$

- V_x, V_y, Z depend on position (x,y)

$$V_y(x,y) = \frac{-T_y + yT_z}{Z(x,y)}$$

- Note $Z(x,y)$ in the *denominator*

- V_x, V_y depend on *ratios:* T_x/Z T_y/Z T_z/Z

  (e.g. doubling both observer speed & depth gives the same velocity field)

- Where is the FOE? $x = T_x/T_z$ $y = T_y/T_z$

8

2