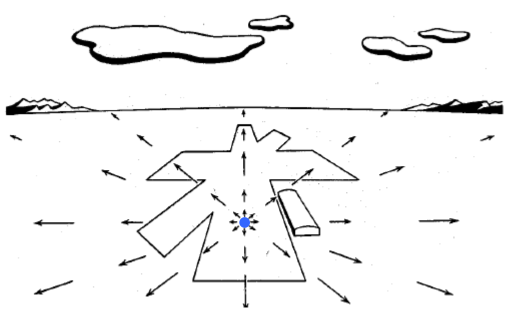
Analysis of Motion

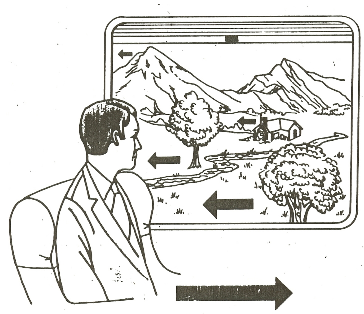
Recovering observer motion

CS332 Visual Processing
Department of Computer Science
Wellesley College

Recovering 3D observer motion & layout



FOE: focus of expansion



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Application: Automated driving systems

DARPA Grand Challenge

https://www.wired.com/story/darpa-grand-urban-challenge-self-driving-car/

Observer motion problem

From image motion, compute:

- observer translation

  $(T_x \; T_y \; T_z)$

- observer rotation

  $(R_x \; R_y \; R_z)$

- depth at every location

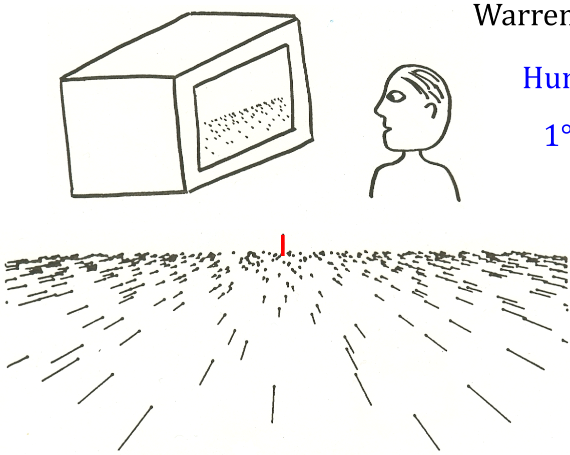
  $Z(x, y)$

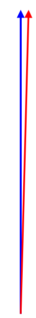
Human perception of heading

Warren & colleagues

Human accuracy:

1° - 2° visual arc





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

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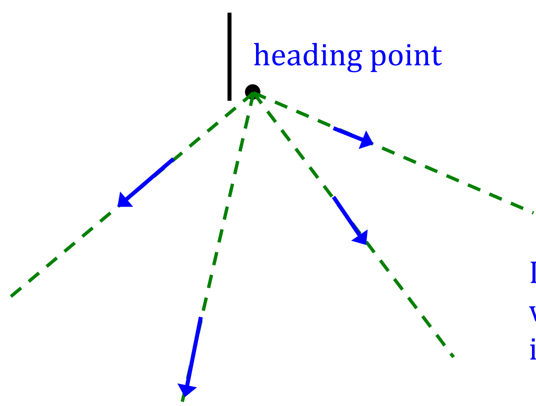
Observer just translates toward FOE



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

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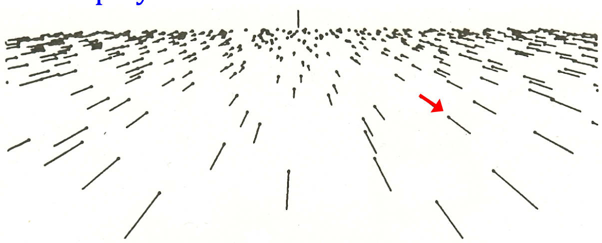
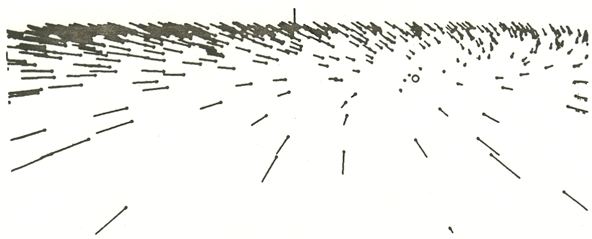
Observer Translation + Rotation

display simulates observer translation



observer rotates their eyes



display simulates translation + rotation

Still recover heading with high accuracy!

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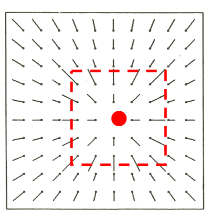
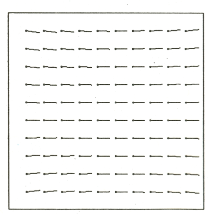
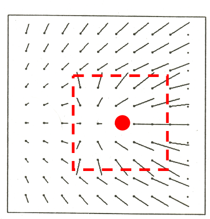
Observer motion problem, revisited



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 every location

  Z(x,y)

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)	$Z(x,y)$

$$V_x = (-T_x + xT_z)/Z + R_x xy - R_y(x^2+1) + R_z y$$

$$V_y = (-T_y + yT_z)/Z + R_x(y^2+1) - R_y xy - R_z x$$

Translational Component

Rotational Component

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Translational component of velocity

$V_x = (-T_x + xT_z)/Z$

$V_y = (-T_y + yT_z)/Z$

Where is the FOE?

x = y =

Example 1: $T_x = T_y = 0$ $T_z = 1$ $Z = 10$ everywhere

$V_x =$ ________ $V_y =$ ________

Sketch the velocity field

Example 2: $T_x = T_y = 2$ $T_z = 1$ $Z = 10$ everywhere

$V_x =$ ________ $V_y =$ ________

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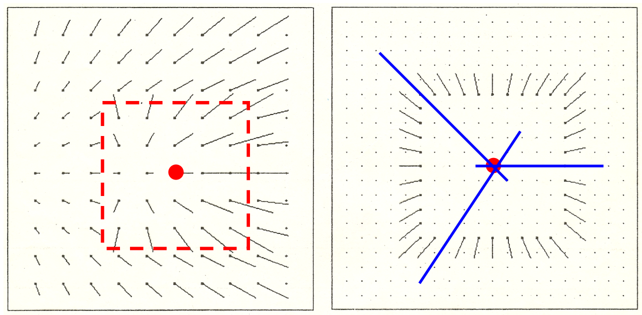
Longuet-Higgins & Prazdny



- Along a depth discontinuity, *velocity differences* depend only on observer translation
- Velocity differences point to the focus of expansion

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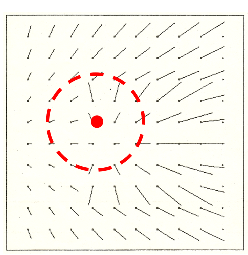
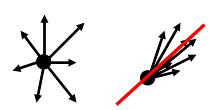
Rieger & Lawton's algorithm

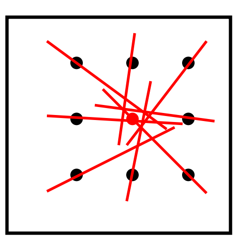
(1) At each image location, compute distribution of velocity differences within neighborhood



Appearance of sample distributions:



(2) Find points with strongly oriented distribution, compute dominant direction



(3) Compute focus of expansion from intersection of dominant directions

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