Analysis of Motion

Recovering observer motion

CS332 Visual Processing
Department of Computer Science
Wellesley College

Recovering 3D observer motion & layout

FOE: focus of expansion
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**

heading point

Directions of velocity vectors intersect at FOE

*But... simple strategy doesn't work if observer also rotates*
Observer Translation + Rotation

Display simulates observer translation

Observer rotates their eyes

Still recover heading with high accuracy

Observer motion problem, revisited

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
Equations of observer motion

<table>
<thead>
<tr>
<th>Translation</th>
<th>Rotation</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(T_x, T_y, T_z)$</td>
<td>$(R_x, R_y, R_z)$</td>
<td>$Z(x,y)$</td>
</tr>
</tbody>
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Translational Component

$$V_x = \frac{(-T_x + xT_z)}{Z} + R_{xy} - R_y(x^2+1) + R_{zy}$$

Rotational Component

$$V_y = \frac{(-T_y + yT_z)}{Z} + R_{x(y+1)} - R_yxy - R_{zx}$$

Where is the FOE?

$\begin{array}{c}
\text{x} = \\
\text{y} = 
\end{array}$

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

$V_x = \phantom{0}$  $V_y = \phantom{0}$

Sketch the velocity field

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

$V_x = \phantom{0}$  $V_y = \phantom{0}$
Longuet-Higgins & Prazdny

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

Rieger & Lawton’s algorithm

- At each image location, compute distribution of velocity differences within neighborhood

Appearance of sample distributions:

- Find points with strongly oriented distribution, compute dominant direction
- Compute focus of expansion from intersection of dominant directions