Robotic Perception

Optical Flow (Motion Estimation)

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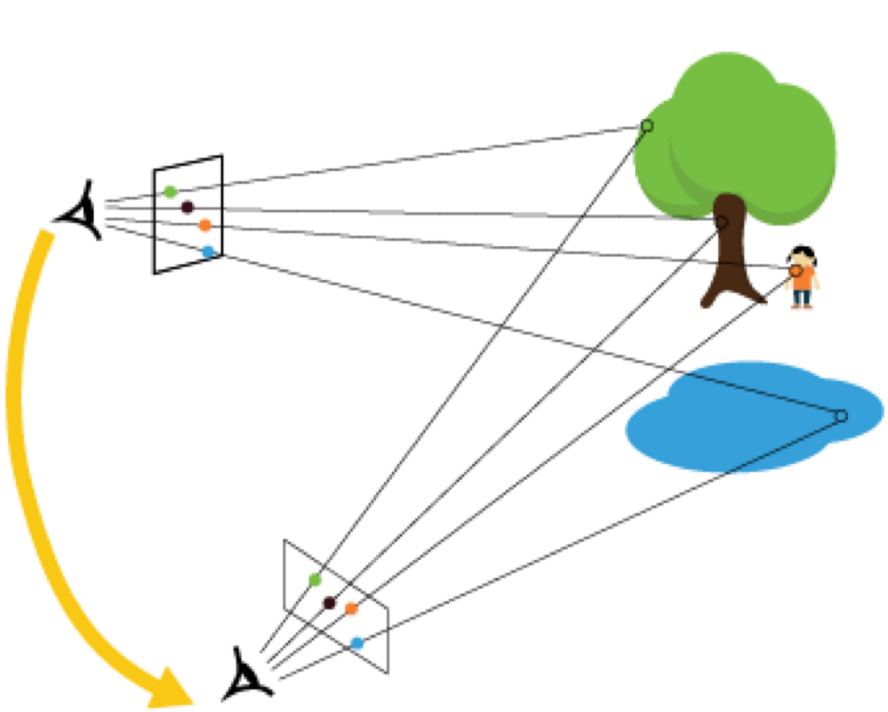
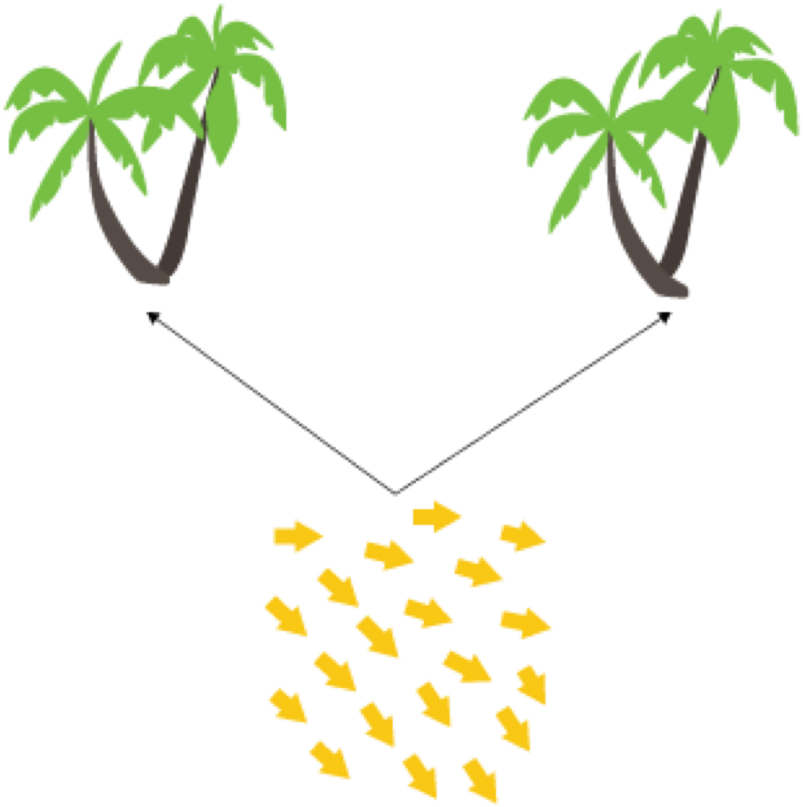
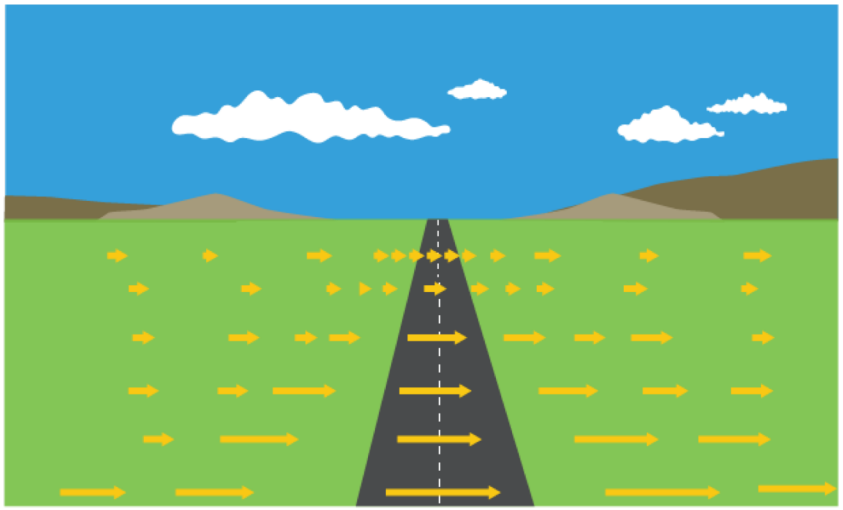
The Problem of Motion Estimation





Examples of Motion Fields



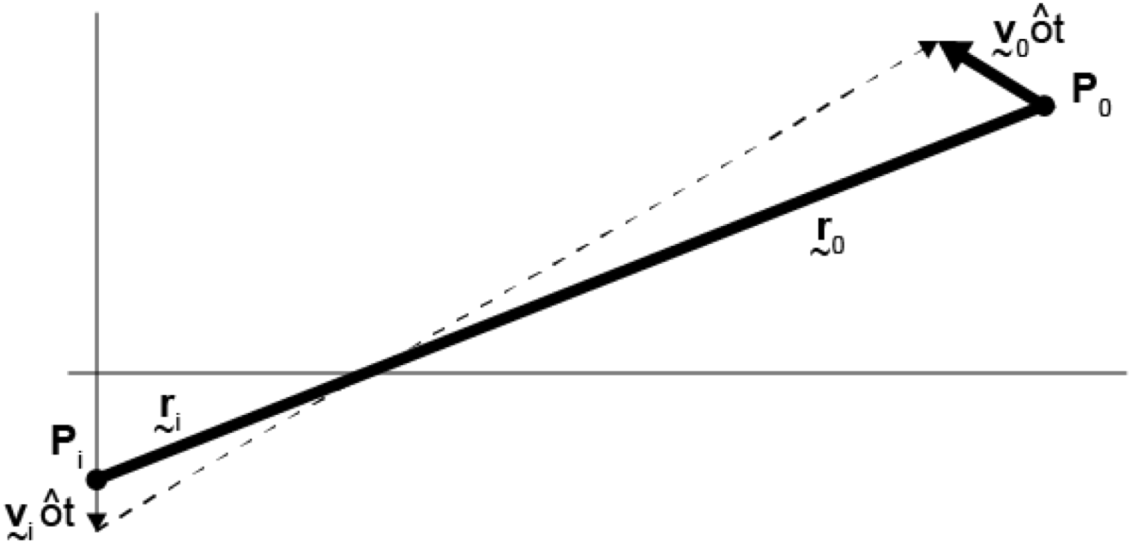
- **Left:** Motion field of a pilot looking straight ahead while approaching a fixed point on a landing strip.
- **Right:** Pilot is looking to the right in level flight.

If Illumination Does Not Change:

- **Assuming that illumination does not change:**
  - Image changes are due to the RELATIVE MOTION between the scene and the camera.
  - There are 3 possibilities:
    - Camera still, moving scene
    - Moving camera, still scene
    - Moving camera, moving scene

Motion Field and Optical Flow Field

- Motion field: Projection of 3D motion vectors on image plane



- Optical flow field: Apparent motion of brightness patterns
- **We equate motion field with optical flow field**

Brightness Constancy Equation

- **Let P be a moving point in 3D:**
  - At time t, P has coordinates (X(t),Y(t),Z(t))
  - Let p=(x(t),y(t)) be the coordinates of its image at time t.
  - Let E(x(t),y(t),t) be the brightness at p at time t.
- **Brightness Constancy Assumption:**
  - As P moves over time, E(x(t),y(t),t) remains constant.

Brightness Constancy Equation

$$E(x(t), y(t), t) = Constant$$

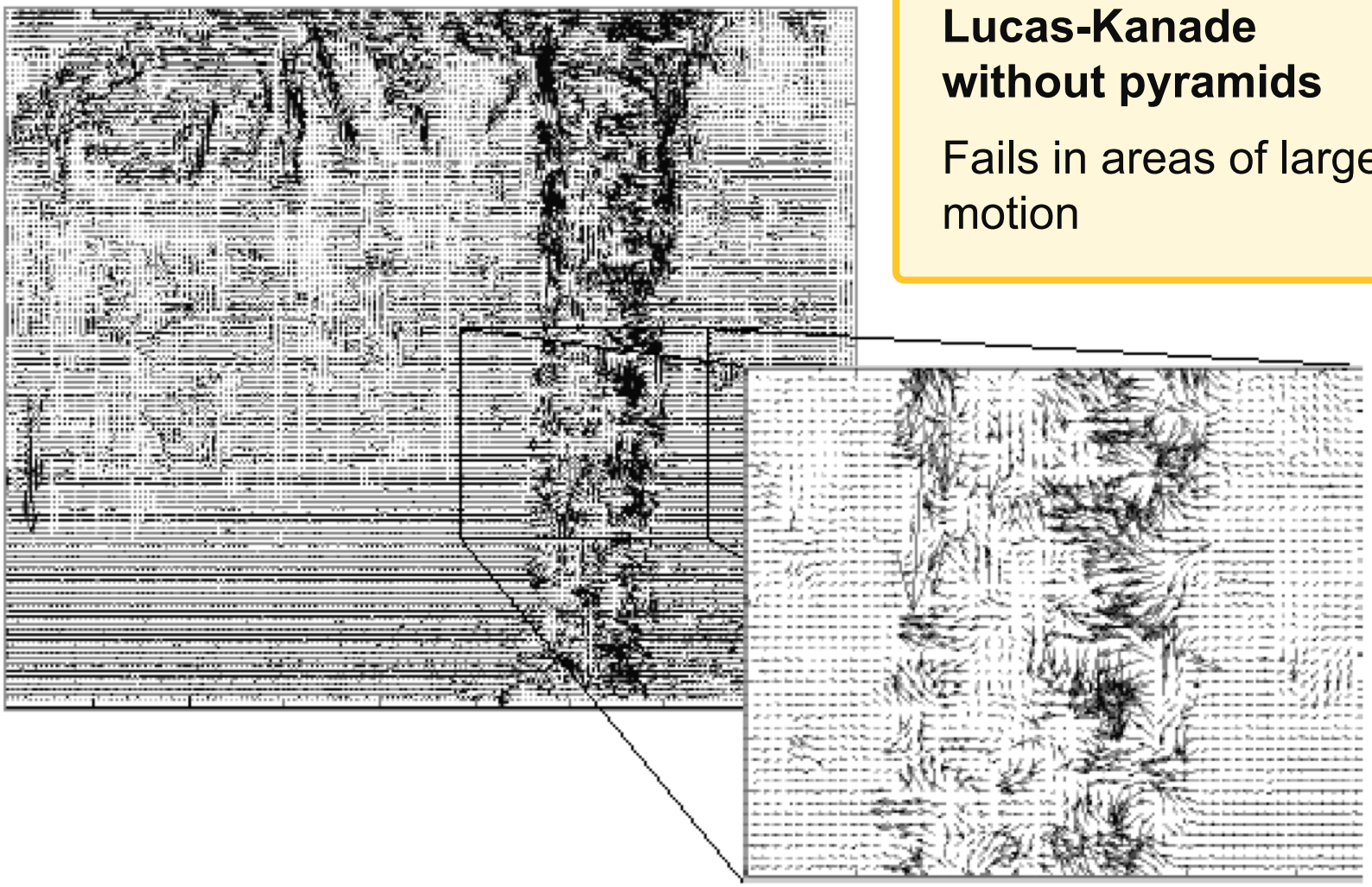
- Taking derivative wrt time:

$$\frac{dE(x(t), y(t), t)}{dt} = 0$$

$$\frac{\partial E}{\partial x}\frac{dx}{dt} + \frac{\partial E}{\partial y}\frac{dy}{dt} + \frac{\partial E}{\partial t} = 0$$

An Example

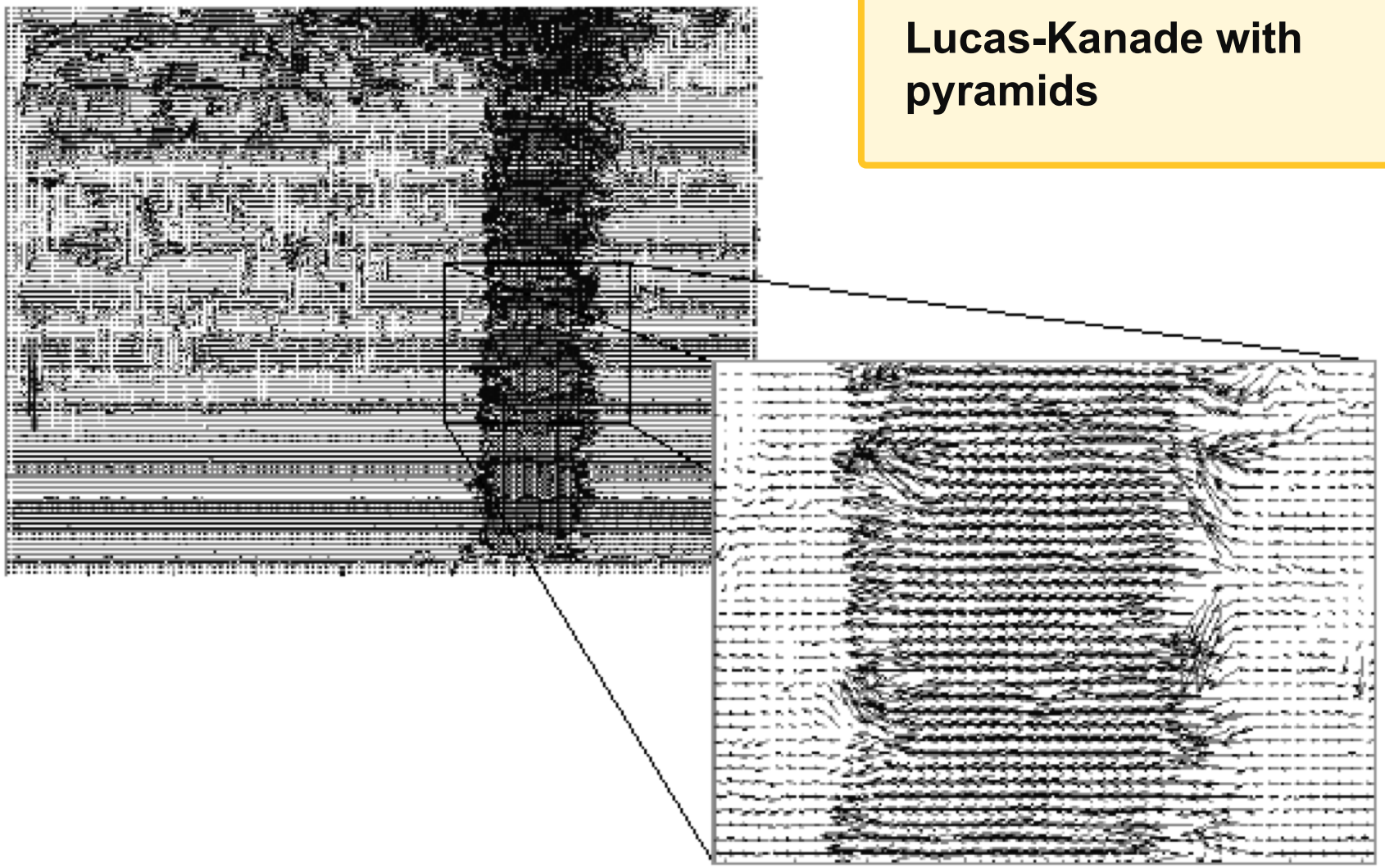
Optical Flow Results



Lucas-Kanade without pyramids

Fails in areas of large motion

Optical Flow Results



Lucas-Kanade with pyramids

Related Material

- Sun, D., Roth, S. and Black, M.J., 2010, June. Secrets of optical flow estimation and their principles. In 2010 IEEE computer society conference on computer vision and pattern recognition (pp. 2432-2439). IEEE.

  (D Sun, S. Roth and M. Black, CVPR 2010)