Lecture 15: Motion

Motion segmentation

Juan Carlos Niebles and Jiajun Wu

CS131 Computer Vision: Foundations and Applications

What will we learn today?

- Motion segmentation
  - Formulation
  - Method
  - Results

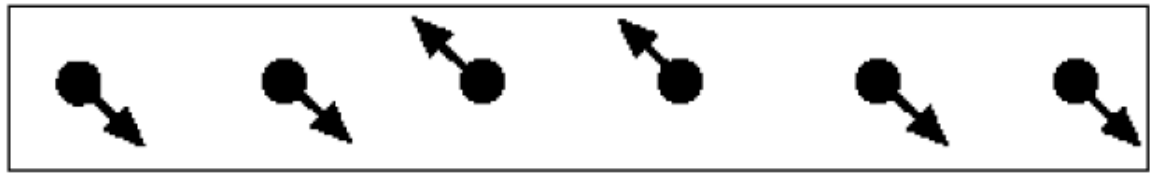
Recap

- Key assumptions

  - **Small motion:** points do not move very far
  - **Brightness constancy:** projection of the same point looks the same in every frame
  - **Spatial coherence:** points move like their neighbors

Source: Silvio Savarese

Reminder: Gestalt – common fate



Common Fate

Motion segmentation

- How do we represent the motion in this scene?

Source: Silvio Savarese

Motion segmentation

- Break image sequence into “layers” each of which has a coherent (affine) motion

J. Wang and E. Adelson. Layered Representation for Motion Analysis. *CVPR 1993*.

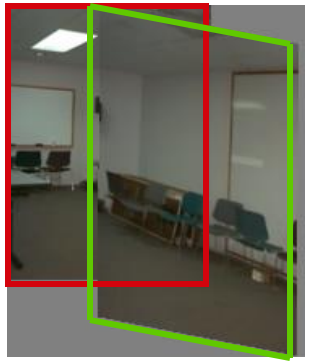
Source: Silvio Savarese

Affine motion

$$u(x,y) = a_1 + a_2 x + a_3 y$$
$$v(x,y) = a_4 + a_5 x + a_6 y$$

- Substituting into the brightness constancy equation:

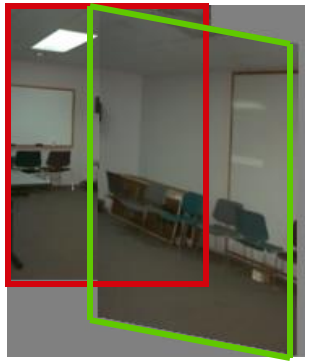
$$I_x \cdot u + I_y \cdot v + I_t \approx 0$$



Source: Silvio Savarese

Affine motion

$$u(x,y) = a_1 + a_2 x + a_3 y$$
$$v(x,y) = a_4 + a_5 x + a_6 y$$



- Substituting into the brightness constancy equation:

$$I_x(a_1 + a_2 x + a_3 y) + I_y(a_4 + a_5 x + a_6 y) + I_t \approx 0$$

- Each pixel provides 1 linear constraint in 6 unknowns
- Least squares minimization:

$$Err(\vec{a}) = \sum \left[I_x(a_1 + a_2 x + a_3 y) + I_y(a_4 + a_5 x + a_6 y) + I_t \right]^2$$

Source: Silvio Savarese

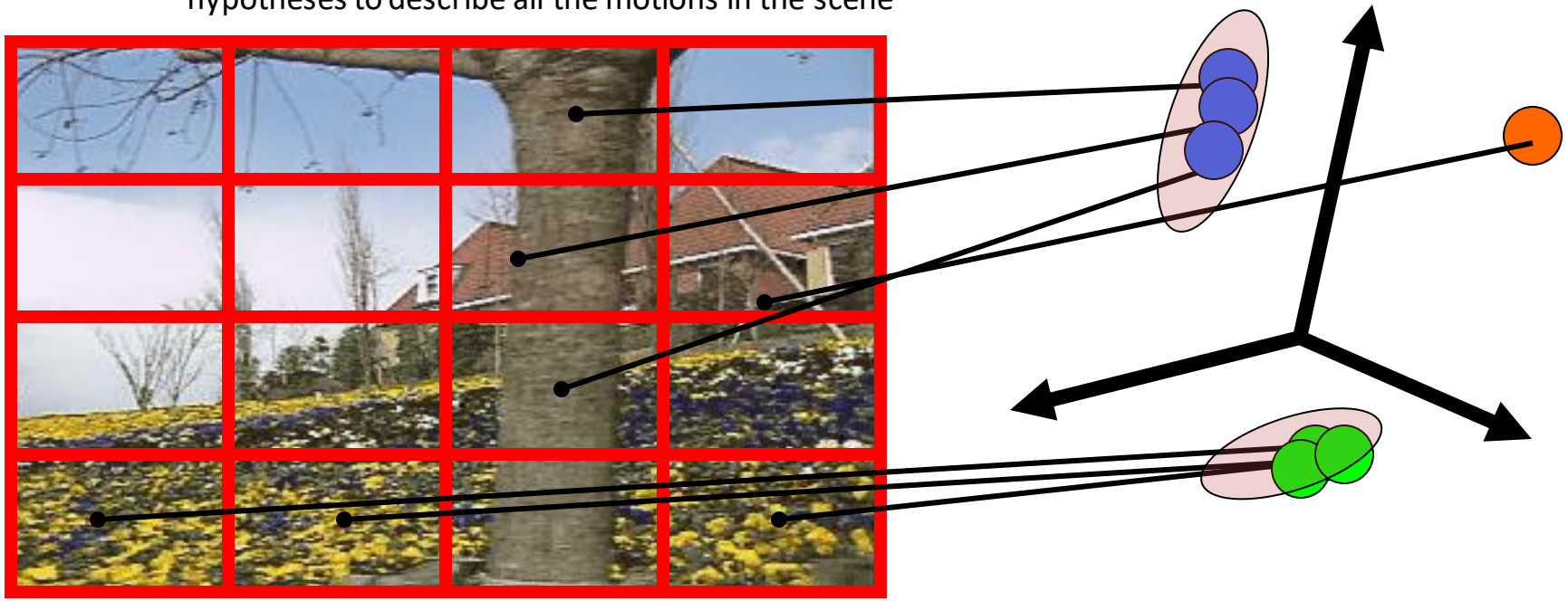
How do we estimate the layers?

1. Obtain a set of initial affine motion hypotheses

– Divide the image into blocks and estimate affine motion parameters in each block by least squares
  - Eliminate hypotheses with high residual error

- Map into motion parameter space
- Perform k-means clustering on affine motion parameters

–Merge clusters that are close and retain the largest clusters to obtain a smaller set of hypotheses to describe all the motions in the scene



Source: Silvio Savarese

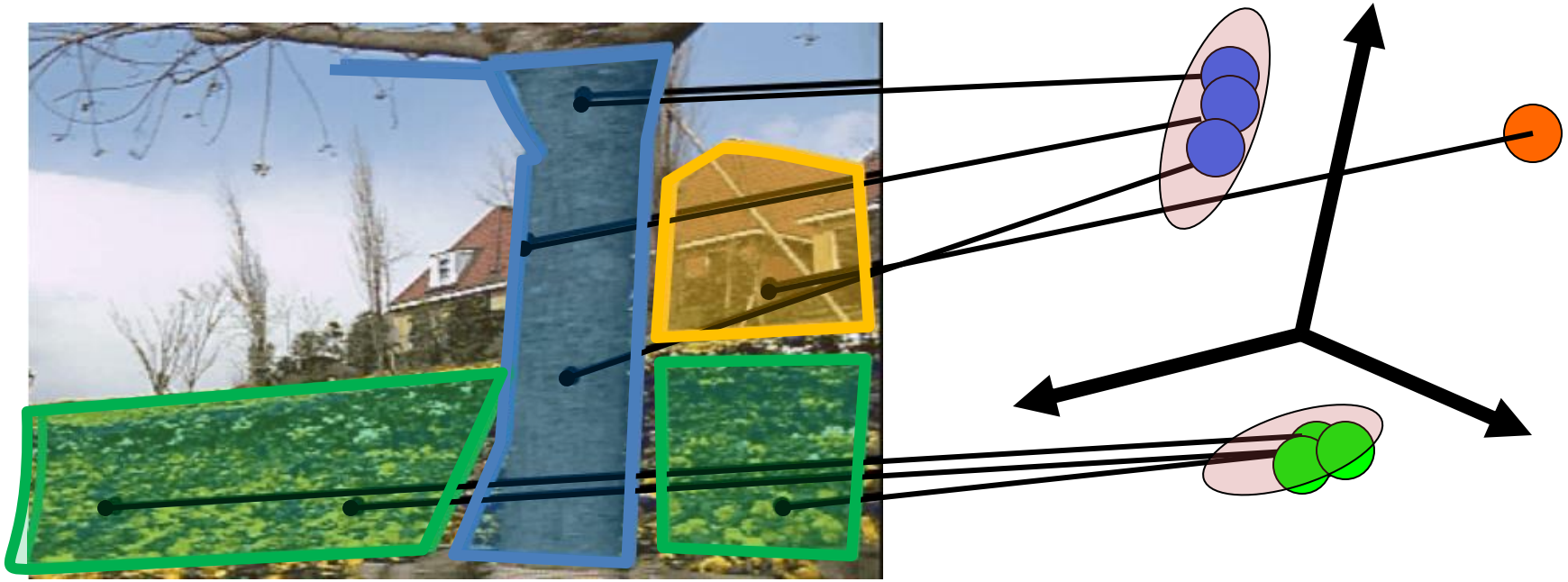
How do we estimate the layers?

1. Obtain a set of initial affine motion hypotheses

– Divide the image into blocks and estimate affine motion parameters in each block by least squares
  - Eliminate hypotheses with high residual error

- Map into motion parameter space
- Perform k-means clustering on affine motion parameters

–Merge clusters that are close and retain the largest clusters to obtain a smaller set of hypotheses to describe all the motions in the scene



Source: Silvio Savarese

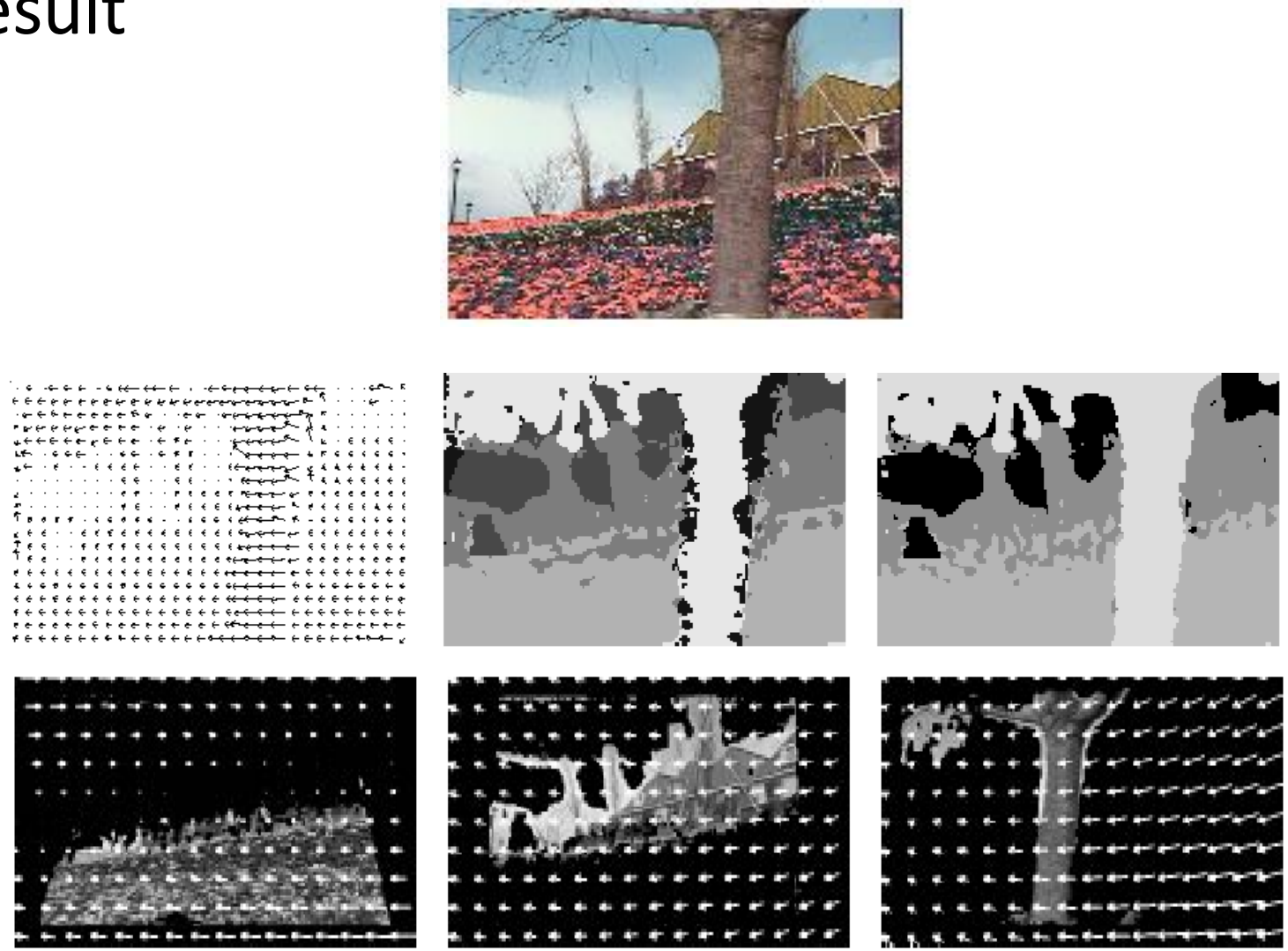
How do we estimate the layers?

1. Obtain a set of initial affine motion hypotheses
   - Divide the image into blocks and estimate affine motion parameters in each block by least squares
     - Eliminate hypotheses with high residual error
   - Map into motion parameter space
   - Perform k-means clustering on affine motion parameters
     - Merge clusters that are close and retain the largest clusters to obtain a smaller set of hypotheses to describe all the motions in the scene

2. Iterate until convergence:
   - Assign each pixel to best hypothesis
     - Pixels with high residual error remain unassigned
   - Perform region filtering to enforce spatial constraints
   - Re-estimate affine motions in each region

Source: Silvio Savarese

Example result



J. Wang and E. Adelson. Layered Representation for Motion Analysis. *CVPR 1993*.

Source: Silvio Savarese

Summary

- Motion segmentation
  - Formulation
  - Method
  - Results