Today

Early vision on a single image

- Textures
- Motion estimation

Recall: Texture

Patterns of structure from

- changes in surface albedo (e.g. printed cloth)
- changes in surface shape (e.g. bark)
- many small surface patches (e.g. leaves on a bush)

Hard to define; but texture tells us

- what a surface is like
- (sometimes) object identity
- (sometimes) surface shape

Recall: Texture

Core problems:

- Texture segmentation
- Texture based recognition
- Texture synthesis
- Shape from texture

Key issue: representing texture

Textures are made up of

- stylized subelements
- Spatially repeated in meaningful ways

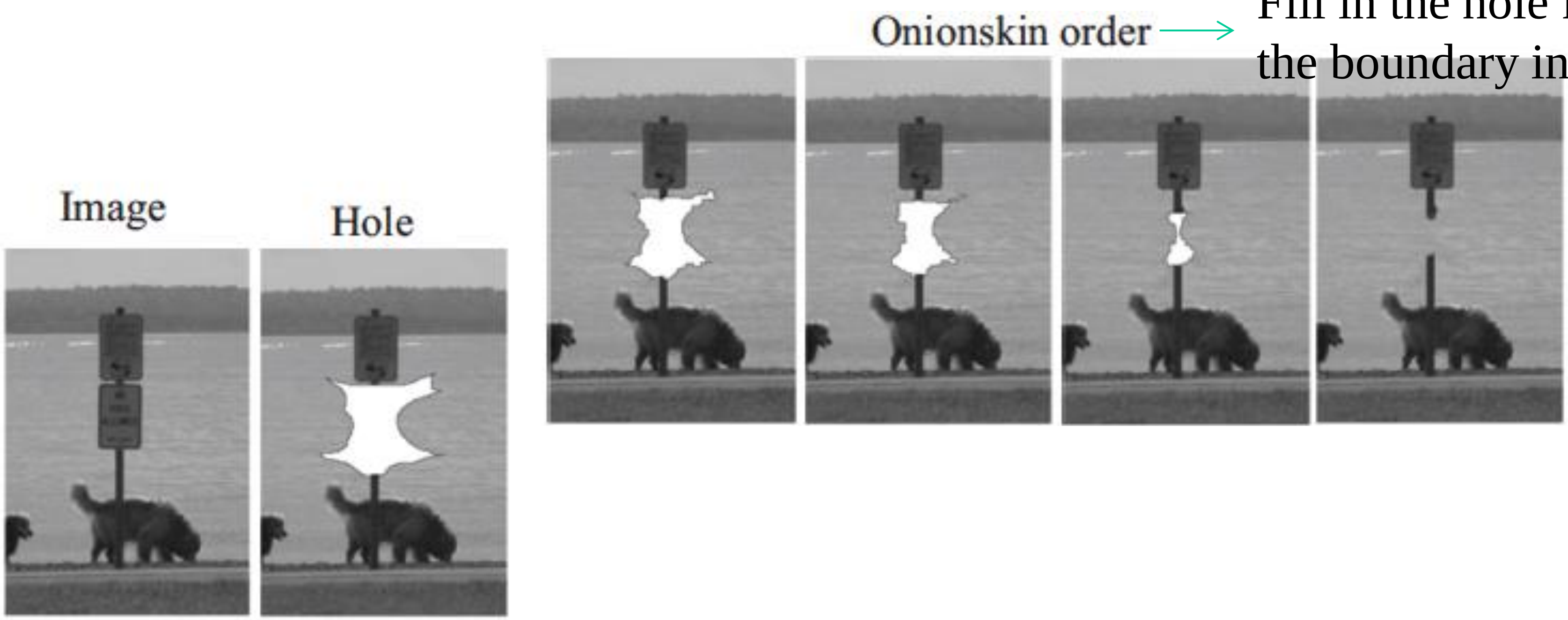
Representation:

- find the subelements
- represent their statistics

Fill in holes by looking for example patches in the image. If needed, rectify faces (lower images).

Wilczkowiak et al., BMVC 2005

Fill in the hole from the boundary inward



Criminisi et al., IEEE TIP 2004

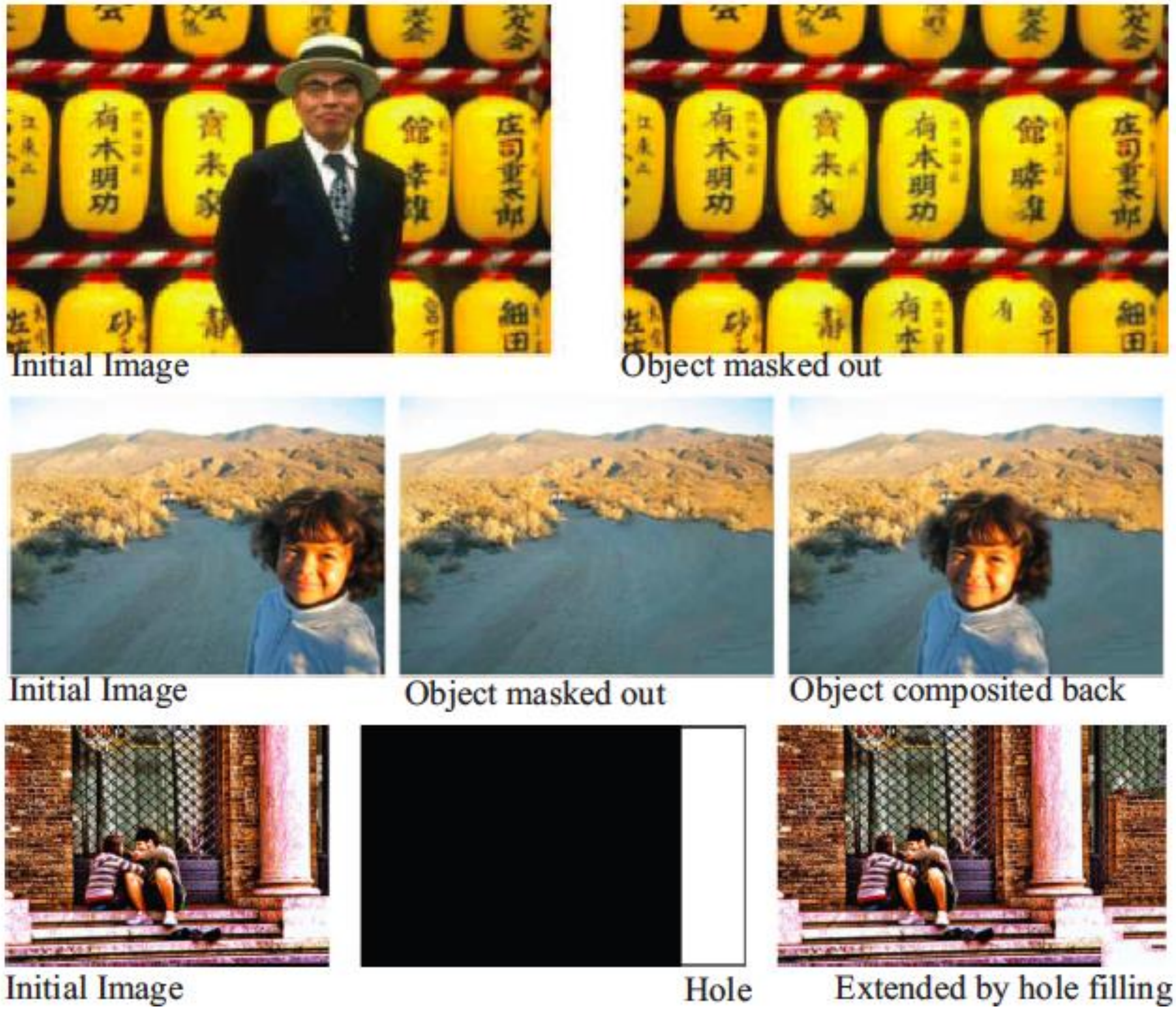


Image fill-in combines texture synthesis, coherence, and smoothing by Bugeau et al., IEEE TIP.

Shape from Texture

Texture is a powerful shape cue

- most likely because small pattern elements deform in predictable ways

Recovering shape from texture

- Identify repeating pattern elements
- Determine frontal view
- From this, determine normal
- Integrate normals to get surface

Shape from texture offers information about lighting

- If pattern elements are repetitions, then
  - brighter (resp. darker) ones receive more (resp. less) light

Shape from Texture

Visual cliff
http://brisray.com/optill/ovision1.htm

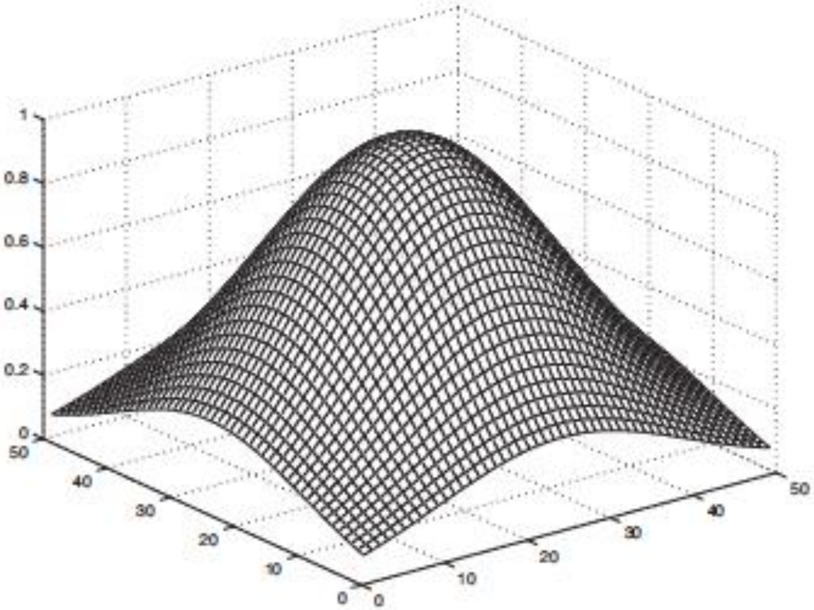


FIGURE 6.19: Humans obtain information about the shape of surfaces in space from the appearance of the texture on the surface. The figure on the **left** shows one common use for this effect; away from the contour regions, our only source of information about the surface depicted is the distortion of the texture on the surface. On the **right**, the texture gives a clear sense of the orientation of the ground plane, how the plants stand out from the path, and how far away the building at the back is. *Geoff Brightling © Dorling Kindersley, used with permission.*

Forsyth and Ponce, "Computer Vision – A Modern Approach 2e"

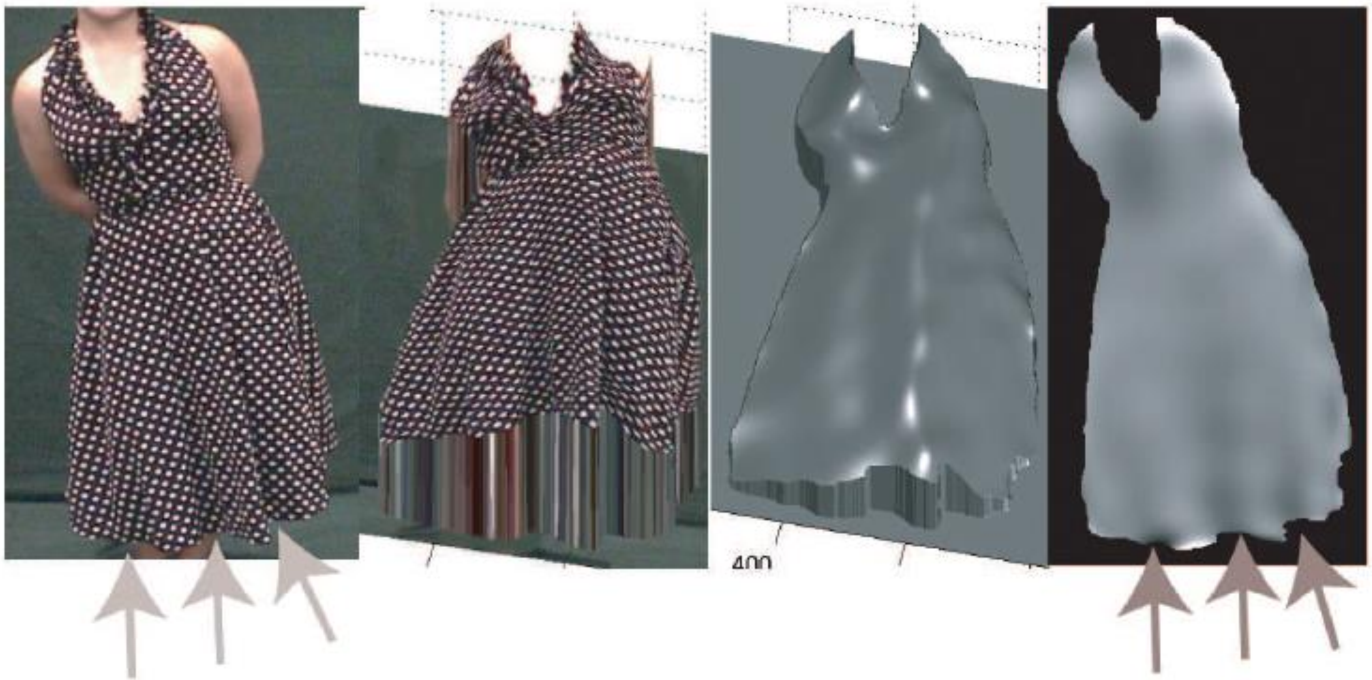


FIGURE 6.21: On the **left**, a textured surface, whose texture is a set of repeated elements, in this case, spots. **Center left**, a reconstruction of the surface, made using texture information alone. This reconstruction has been textured, which hides some of its imperfections. **Center right**, the same reconstruction, now rendered as a slightly glossy gray surface. Because texture elements are repeated, we can assume that if different elements have a significantly different brightness, this is because they experience different illumination. **Right** shows an estimate of the illumination on the surface obtained from this observation. Notice how folds in the dress (arrows) tend to be darker; this is because, for a surface element at the base of a fold, nearby cloth blocks a high percentage of the incident light. *This figure was originally published as Figure 4 of "Recovering Shape and Irradiance Maps from Rich Dense Texton Fields," by A. Lobay and D. Forsyth Proc. IEEE CVPR 2004 © IEEE, 2004.*

If pattern elements are repetitions, then brighter (resp. darker) ones receive more (resp. less) light, so we get an estimate of lighting.

Lobay and Forsyth , CVPR 2004

Reading Assignment

Chapter 6 (Texture) of Forsyth & Ponce

Early Vision on Multiple Images: Motion Estimation

Applications

- Motion detection
- Object tracking
- Activity recognition
- Correct for camera jitter (stabilization)
- Video mosaic
- 3D shape reconstruction
- Video compression

Suggested Reading:

- Chapter 8, Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3-D Computer Vision”

Early Vision on Multiple Images: Motion Estimation

Image content in different frames varies because of the relative motion between the camera and the scene

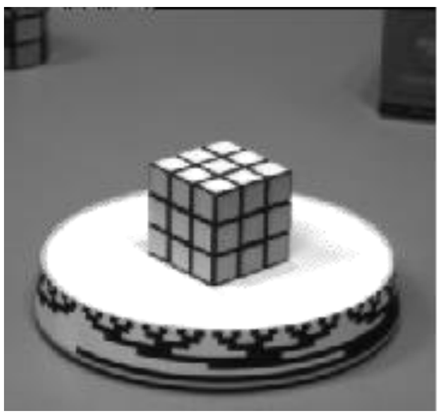
Motion estimation can answer the questions

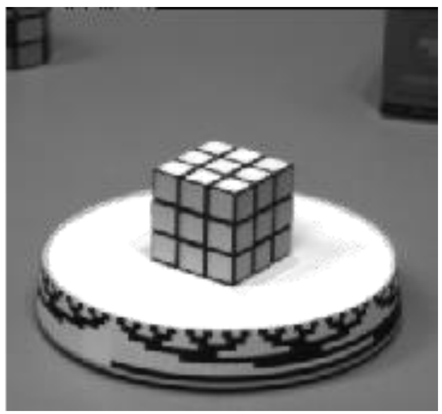
- How many moving objects in the scene?
- What are the moving directions of the objects?
- What are the moving speeds of the objects?
- What are the structures of the moving objects?

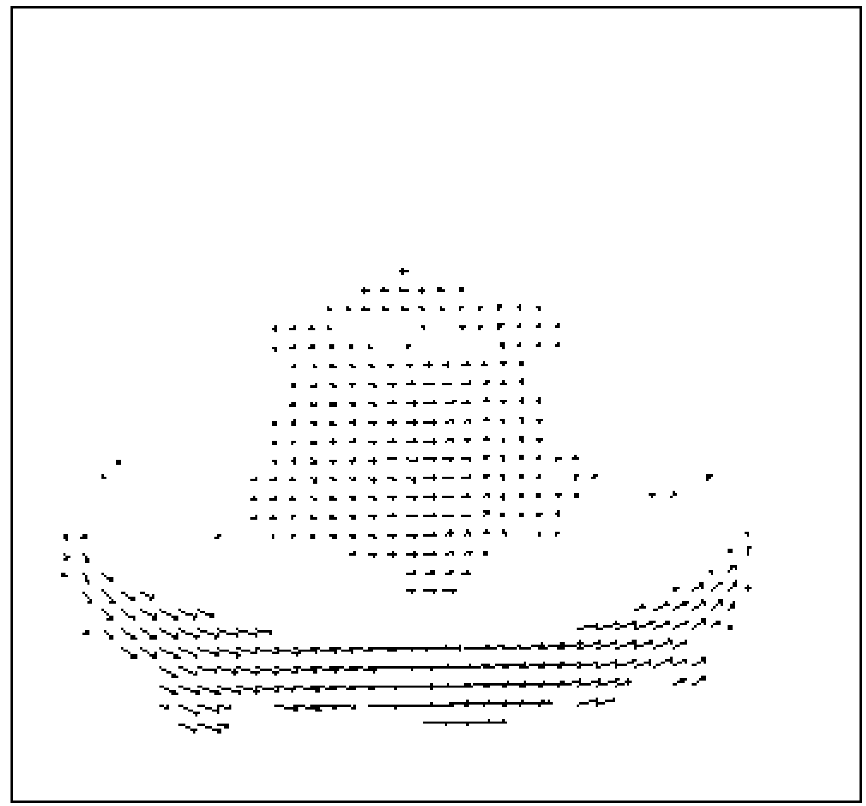
Different conditions:

- Moving objects/scene and static scene/objects
- Moving objects and moving scene

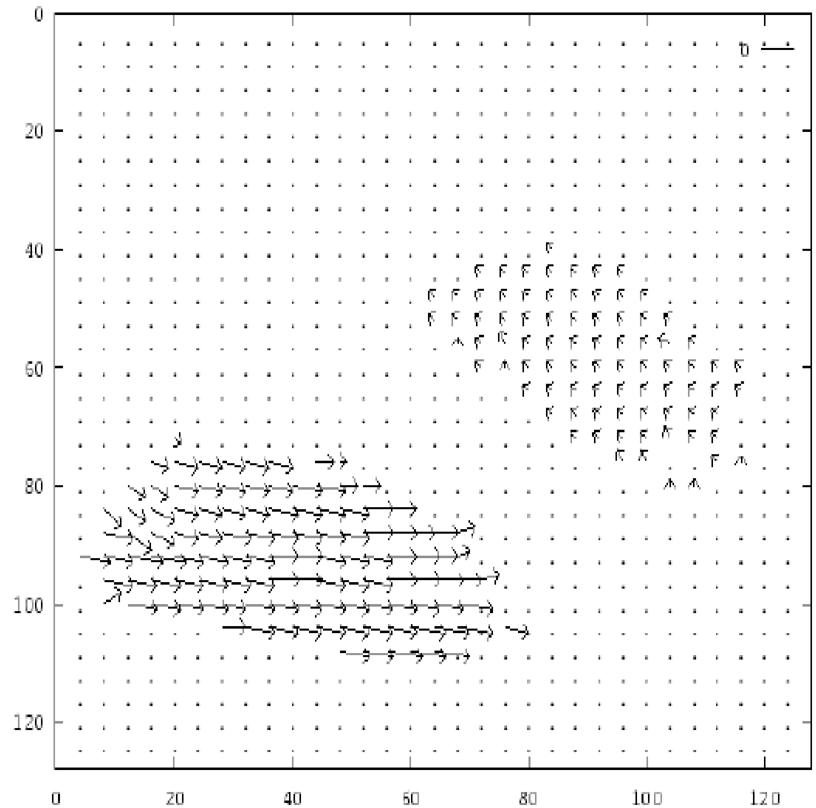
Optical Flow: Measurement of Motion at Every Pixel







Optical Flow



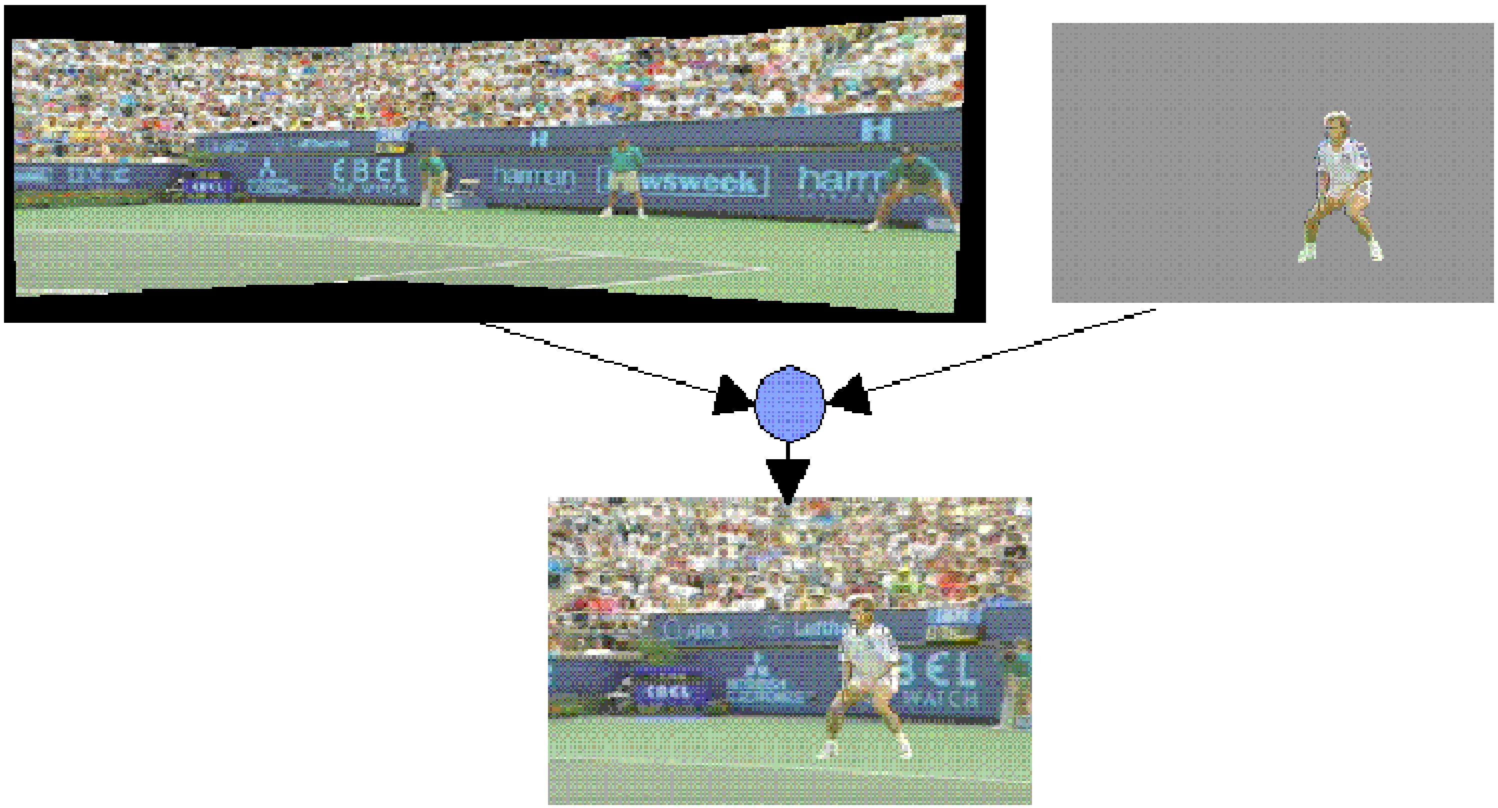
An image from Hamburg Taxi Sequence

Video Mosaics

Video Mosaics

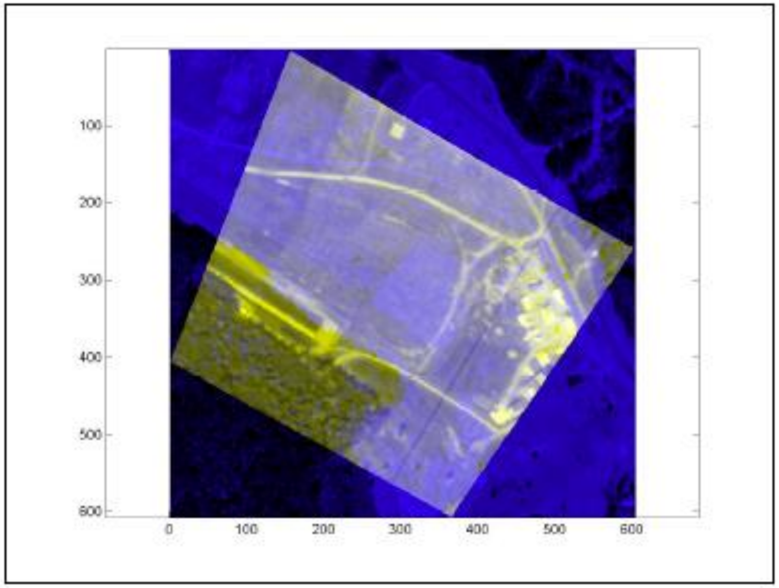
Video Mosaics

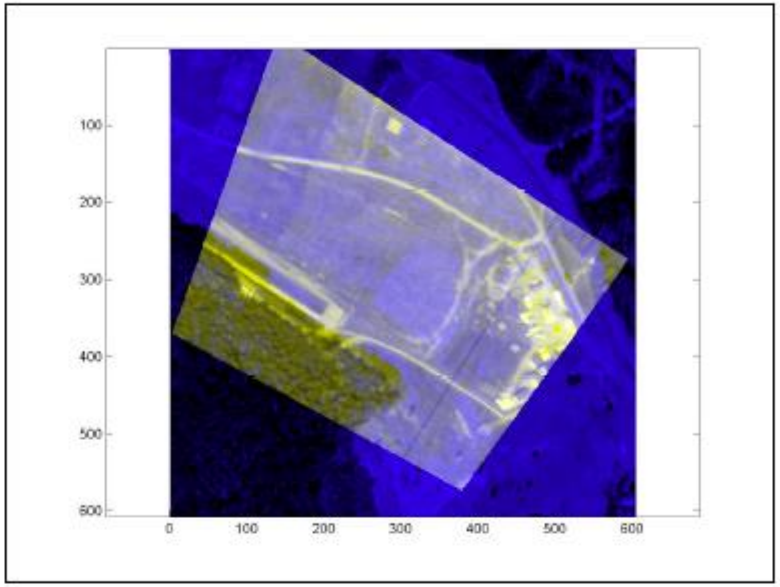
Video Compression



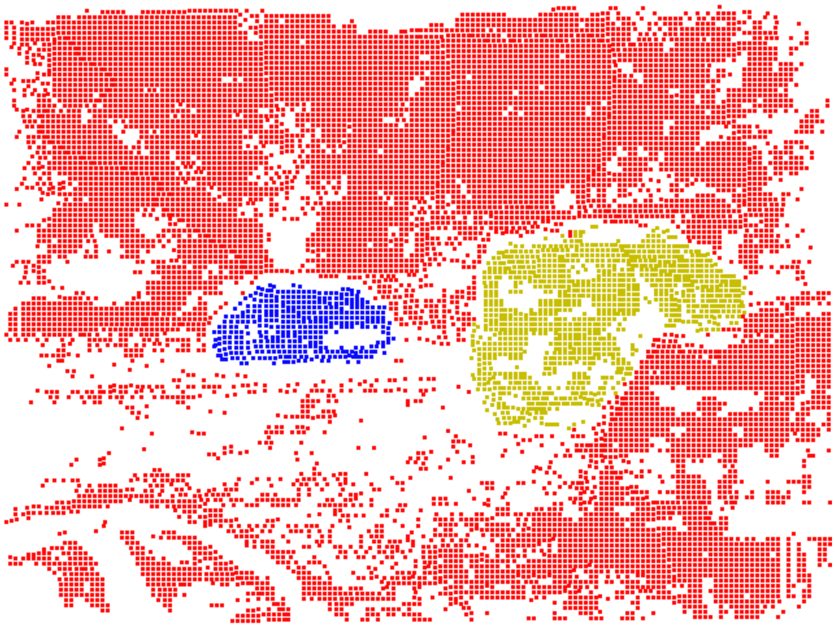
Geo Registration

Results superimposed with the reference image





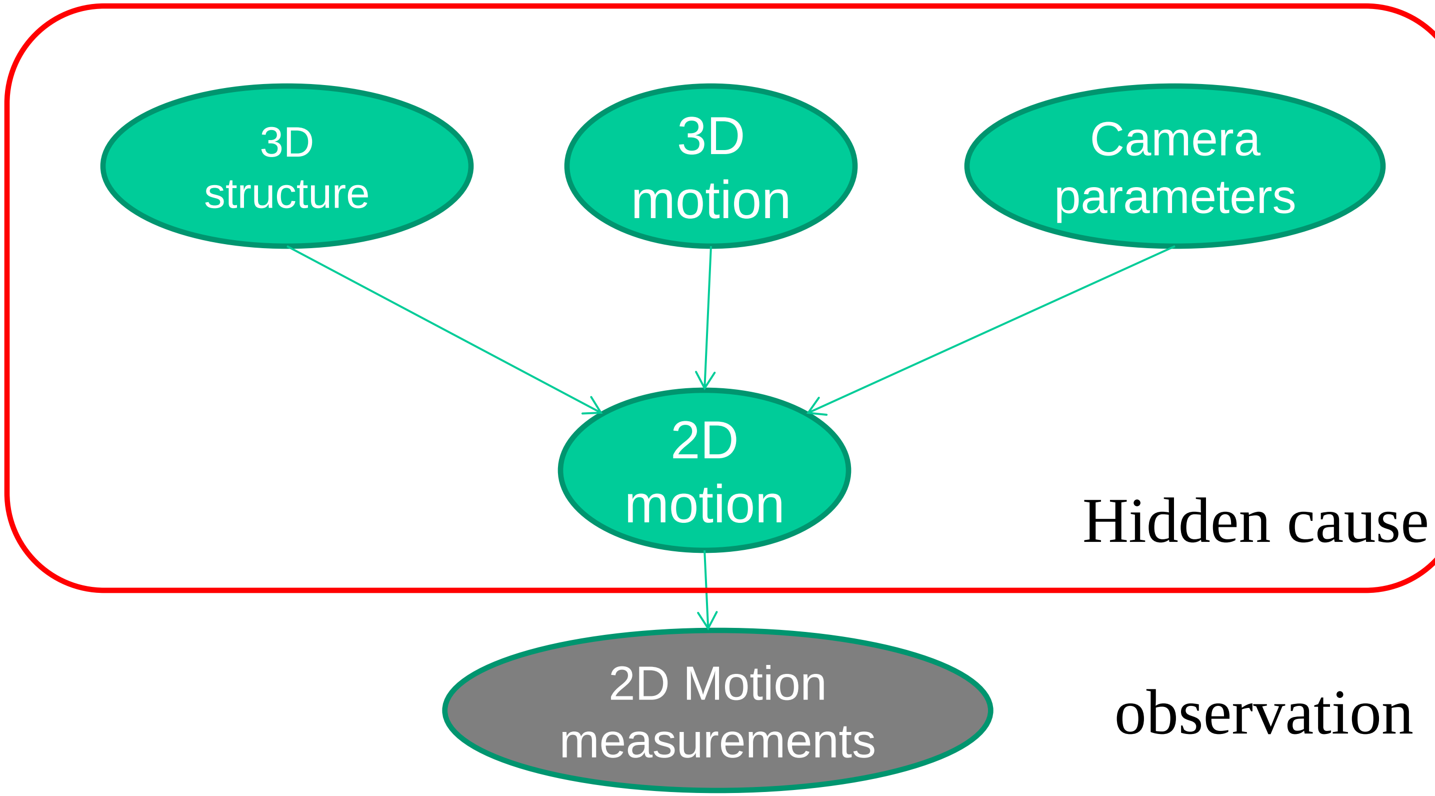
Video Segmentation

http://lmb.informatik.uni-freiburg.de/people/ochs/demos_ochs.html

Structure From Motion

Motion Modeling and Analysis



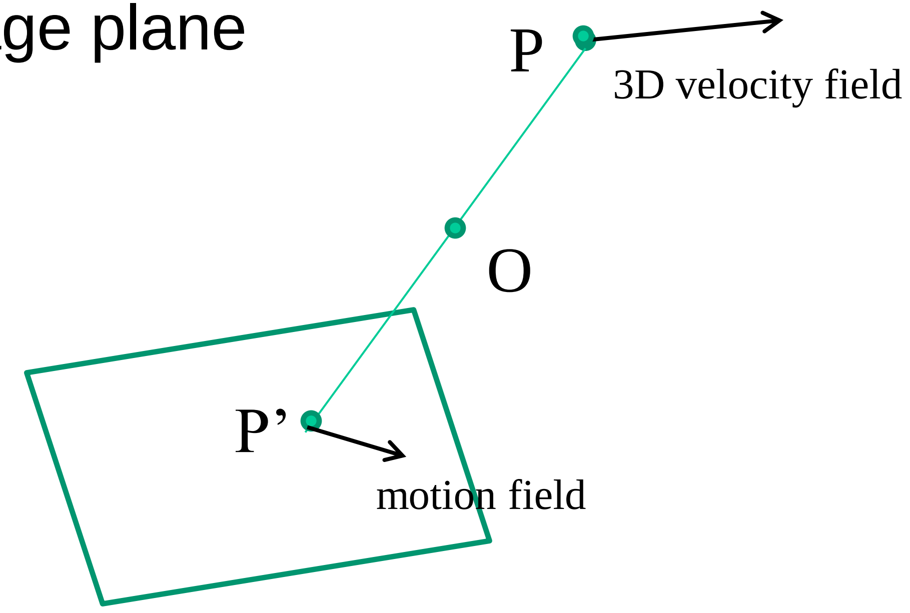
Tasks:

- Estimate 2D motion represented by ***motion field***
- Infer the 3D motion and/or 3D structure

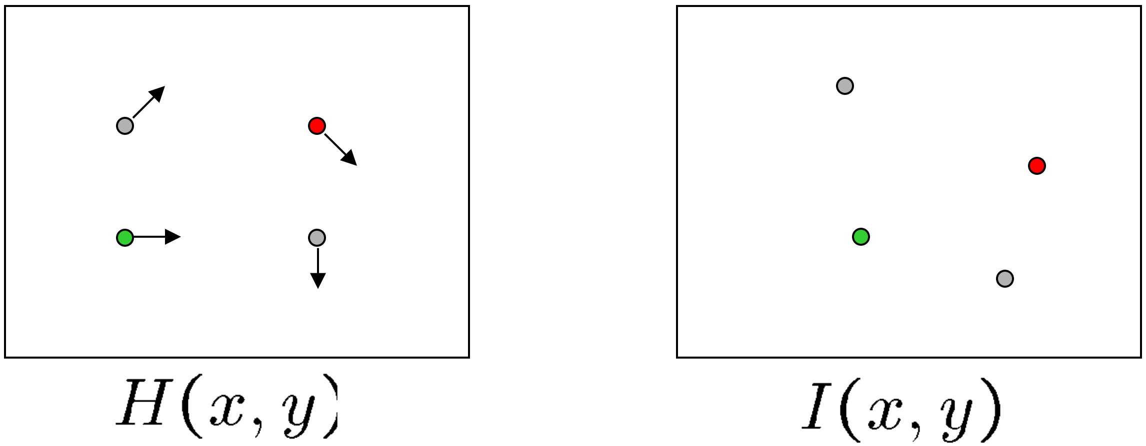
Motion Analysis

Motion field:

- For each image point, a *motion field* is defined as its 2D vector field of velocities caused by the relative 3D motion between the camera and the scene.
- Can be interpreted as the projection of 3D velocity field on the image plane



Optical Flow



How to estimate pixel motion from image *H* to image *I*?

- First, solve pixel correspondence problem
  - given a pixel in ***H***, look for nearby pixels of the same color in ***I***

Key assumptions

- **color constancy**: a point in H looks the same in I
  - For grayscale images, this is **brightness constancy**
- **small motion**: points do not move very far

This is called the optical flow **problem**

Optical Flow v.s. Motion Field

Optical flow: the apparent motion of brightness patterns

Most of the time, optical flow corresponds to motion field

Optical flow ≠ Motion field

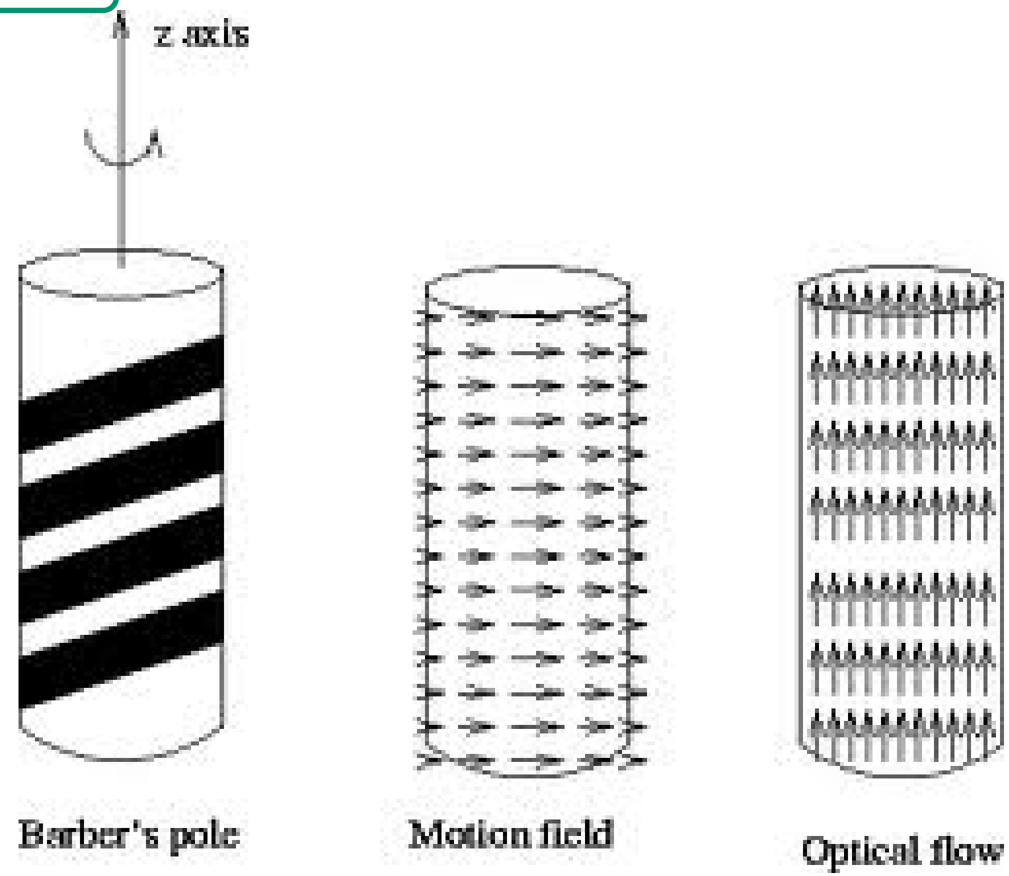


Figure from http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/OWENS/LECT12/node4.html