Computer Vision Systems Programming VO

Specific Object Recognition

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Topics

Introduction to object recognition

Specific object recognition (rigid, nonrigid)

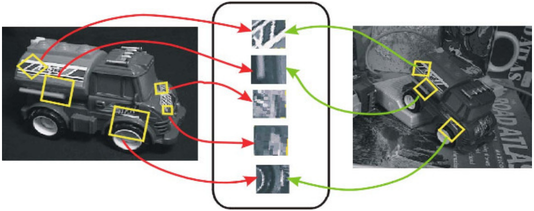


Image from Grauman and Leibe 2011

Object Recognition

Fundamental problem in Computer Vision

Many applications

- Panorama stitching, 3D reconstruction
- HCI and surveillance (face recognition)
- Image understanding (recall Fei-Fei Li's TED talk)

Object Recognition
Taxonomy – Instance vs. Category

Instance recognition (specific object recognition)

- Recognize a specific, uniquely looking object
- Face of a certain person, the Eiffel tower

Object category recognition

- Recognize objects of a certain category
- Human faces, buildings

Object Recognition
Taxonomy – Instance vs. Category

Object Recognition

Taxonomy – Classification vs. Detection

Object classification

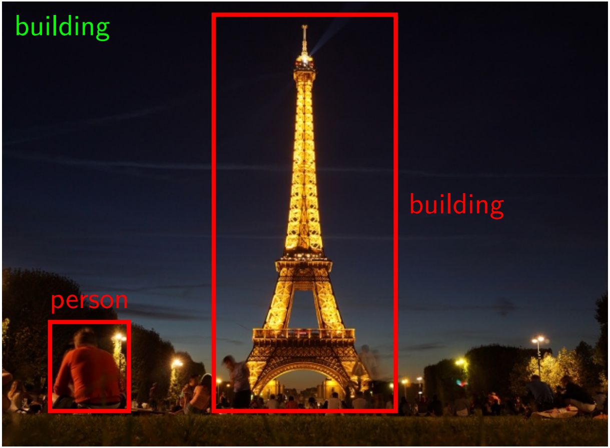
- Recognize main object in image
- Location and other objects not relevant

Object detection

- Recognize multiple objects, possibly of different category

Object Recognition

Taxonomy – Classification vs. Detection



Instances of same category can look very differently

- Illumination, pose, viewpoint, occlusions, background

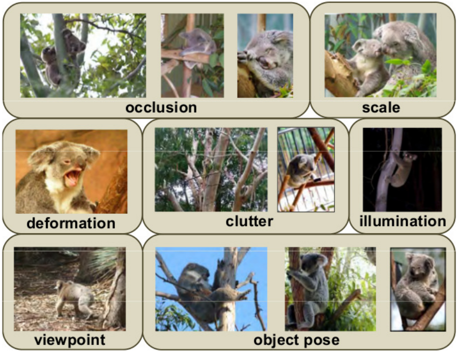


Image from Grauman and Leibe 2011

Specific Planar Object Detection

We want to detect specific planar objects (e.g. markers, books)

- Comparatively easy problem

Challenges

- Unknown object pose and scale
- Partial occlusions
- Illumination

Specific Planar Object Detection

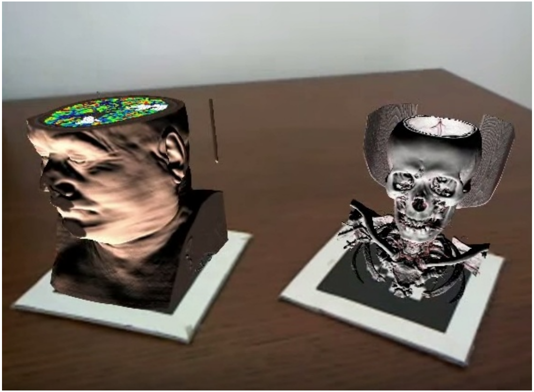


Image from youtube.com

Our problem formulation is

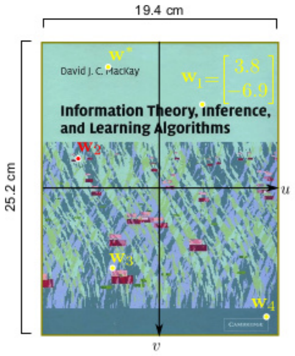
- Given a pixel location in a query image
- Predict location in reference image of sought object

So we know how to select $\mathbf{x}$ and $\mathbf{w}$

- $\mathbf{x} = (x, y)$: location in query image
- $\mathbf{w} = (u, v)$: corresponding location in reference image

Specific Planar Object Detection

Selecting $\mathbf{x}$ and $\mathbf{w}$



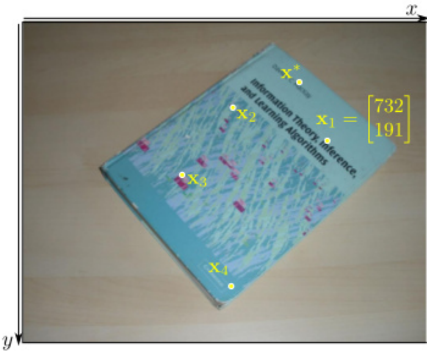


Image from Prince 2012

Images of planar objects are always related by a homography $\mathbf{\Phi}$

- 3×3 matrix mapping between corresponding points

In homogeneous coordinates this means that

$$\lambda \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \mathbf{\Phi} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

The model of choice is thus (disregarding noise)

$$\mathbf{w} = \Gamma(\mathbf{x}) = \begin{pmatrix} u \\ v \end{pmatrix} \quad , \quad \lambda \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \mathbf{\Phi} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

We again learn parameters $\boldsymbol{\theta}$ from samples $\{\mathbf{x}_i, \mathbf{w}_i\}_{i=1}^{n}$

- $\boldsymbol{\theta}$ contains 9 parameters comprising $\boldsymbol{\Phi}$

Usually no exact solution because of noisy $\mathbf{x}_i$

- Formulate as a least squares problem instead

$$\hat{\boldsymbol{\theta}} = \underset{\boldsymbol{\theta}}{\arg\min} \left[\sum_{i=1}^{n} (\mathbf{w}_i - \Gamma(\mathbf{x}_i))^\top (\mathbf{w}_i - \Gamma(\mathbf{x}_i)) \right]$$

This least squares approach is optimal

- If noise is distributed normally with spherical covariance

This is a nonlinear optimization problem

- Solvable using any general nonlinear least squares solver
- OpenCV has an own function `findHomography`

Specific Planar Object Detection

But how can we compute $\{\mathbf{x}_i, \mathbf{w}_i\}_{i=1}^{n}$ automatically?

- Next lecture

Bibliography

Grauman, Kristen and Bastian Leibe (2011). *Visual object recognition*. Morgan & Claypool.

Prince, S.J.D. (2012). *Computer Vision: Models Learning and Inference*. Cambridge University Press.