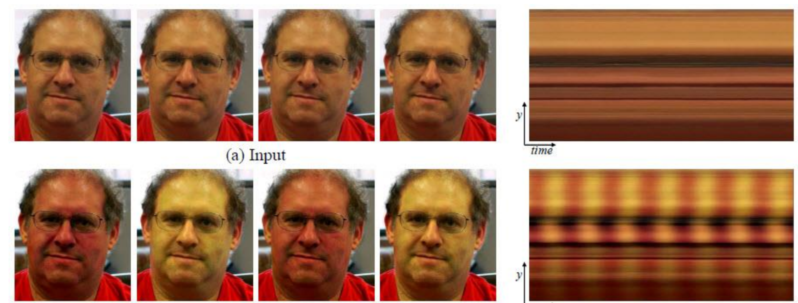
LAB 5
Motion Detection

Image and Video Analysis

P.Zanuttigh
Some material Longin Jan Latecki, Roland Miezianko
And Dragoljub Pokrajac

Motion

- Two related problems
  - Motion detection (LAB 5)
  - Motion estimation (LAB 6)

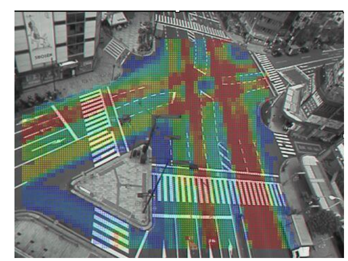


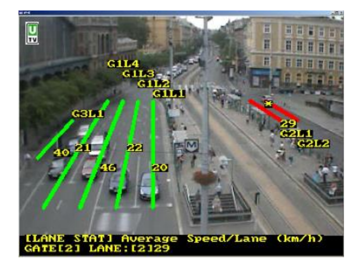
(a) Input

(b) Magnified

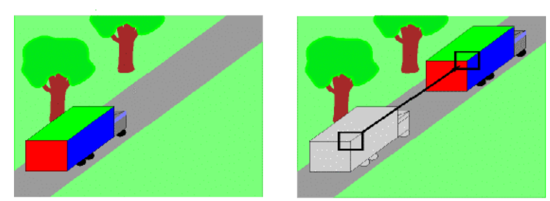
(c) Spatiotemporal *YT* slices

- Video processing
  - Temporal filtering
- Video analysis
  - Security / surveillance
  - Object Tracking , e.g., traffic analysis





- Video coding
  - Remove temporal redundancy



Filmbild 1

Filmbild 2

Motion Detection

- Identify which image points (or regions) have moved
- Typically applies to scenes acquired with a static camera
  - If a moving camera is used camera motion must be detected and compensated firstly
- Motion: typically causes intensity changes
- But many other issues can cause intensity changes
  - Illumination (including shadows and reflections)
  - Camera noise
- On the other side there can be motion with limited intensity changes
  - Objects of uniform color
  - Object and background with similar appearance
- How to handle moving objects that stop at a certain point?

Background Subtraction

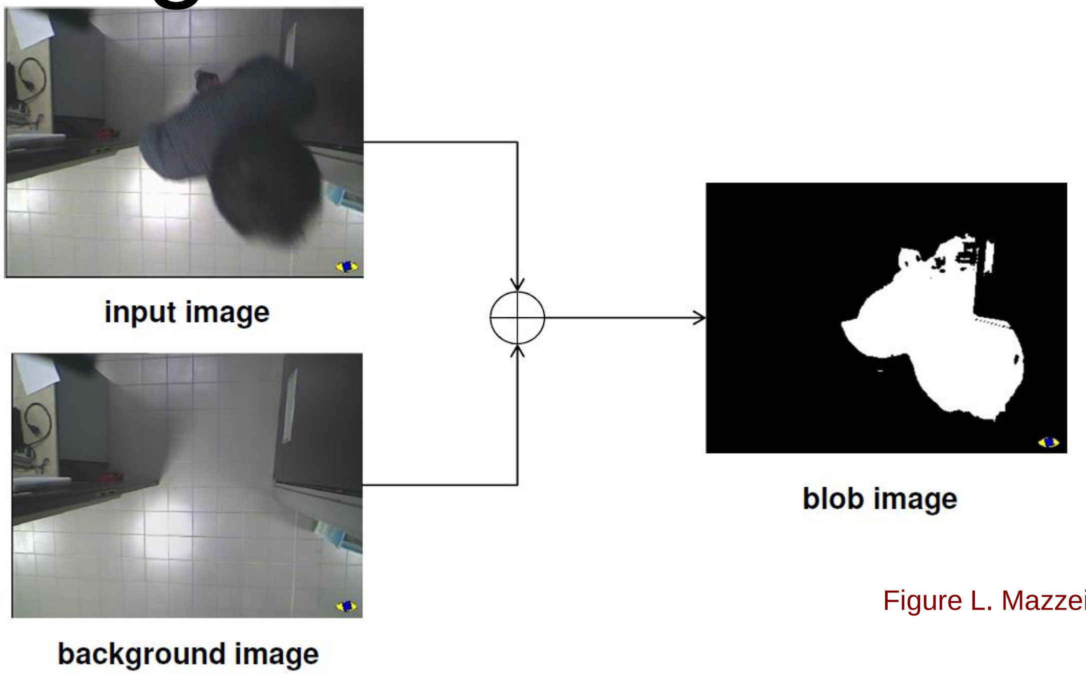


Figure L. Mazzei

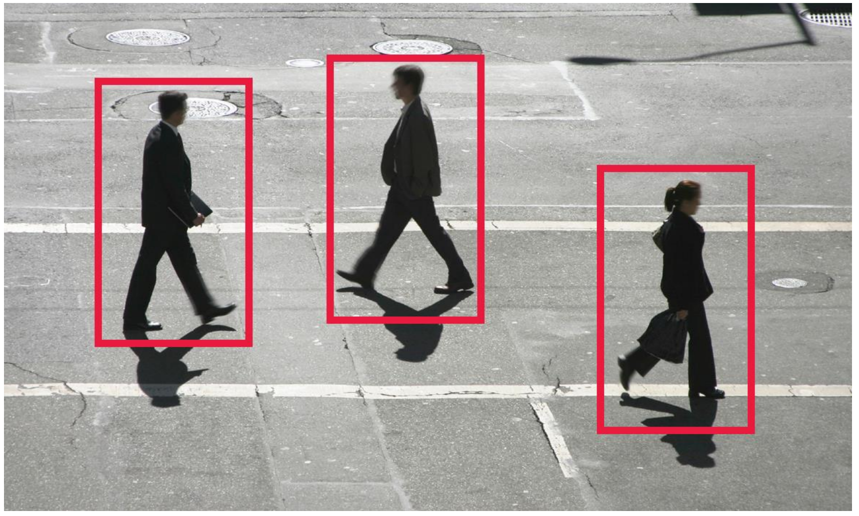
- Uses a reference background image for comparison purposes
- Current image (containing target objects) is compared to reference image pixel by pixel
- Locations where there are differences are detected and classified as moving objects

Motivation: simple difference of two images shows moving objects

Static Scene Object Detection and Tracking

1. Model the background and subtract to obtain object mask (LAB5)
2. Filter to remove noise
3. Group adjacent pixels to obtain objects
4. Track objects between frames to develop trajectories

Motion Detection Algorithms



1. Fixed threshold
2. Fixed threshold on window
3. Background from previous frames
4. Probabilistic background modeling
5. Stauffer and Grimson

Fixed Threshold

$$\rho = I_k(x,y) - I_{k-1}(x,y)$$
$$m(x,y) = \begin{cases} 1 & \rho^2 > T_1 \\ 0 & \rho^2 \leq T_1 \end{cases}$$

- The simplest idea
  - Simple, fast
  - One parameter: threshold T_1
  - absolute value of ρ can also be used
- Issues
  - Poor results
  - Does not account for measurement noise
  - Uniform objects: only edges are detected

Example (1)

a. Original scene

b. Same scene later

Subtraction of image a from image b

Subtracted image with threshold of 100

Example (2)

Image M. Piccardi

Background Modeling

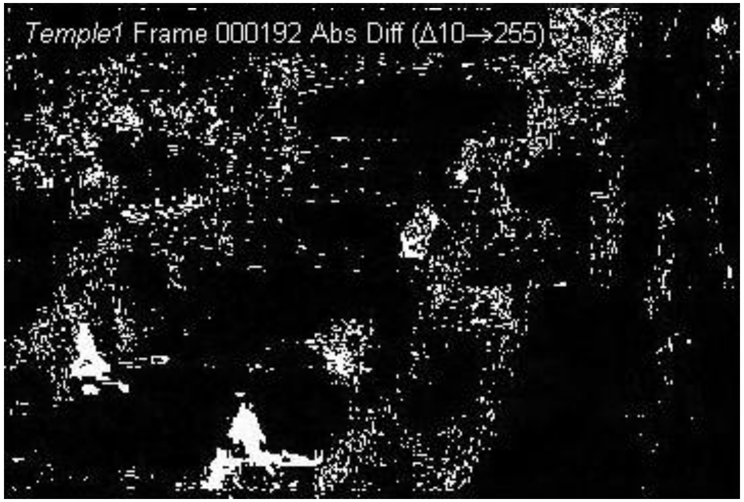
$$\rho = I_k(x,y) - B_k(x,y)$$
$$B_k(x,y) = \alpha I_{k-1}(x,y) + (1-\alpha)B_{k-1}(x,y)$$
$$m(x,y) = \begin{cases} 1 & \rho^2 > T_3 \\ 0 & \rho^2 \leq T_3 \end{cases}$$

- Model the background from previous frames
- Background : average, median or running mean of the intensity in a set of previous frames
  - For LAB5 implement the running mean, simpler and faster!
- More complex background estimation algorithms for high performances (*optional: implement also mean/median*)
- Two parameters: threshold and learning rate (α) used to compute the background

Background Subtraction

Background Image

Current Image



Probabilistic Approach

$$P_{bgr}\big(I(x,y)\big) = \frac{1}{R}\sum_{i=1}^{R} \mathrm{e}^{-\frac{[I_k(x,y)-I_{k-i}(x,y)]^2}{2\sigma^2}}$$

$$m(x,y) = \begin{cases} 1 & P_{bgr}(x,y) \quad \leq T_4 \\ 0 & P_{bgr}(x,y) \quad > T_4 \end{cases}$$

- Model the background probability at each pixel from R previous frames
- Typically a zero-mean Gaussian PDF is used
  - only the exponential part to have probabilities in the [0,1] range
- Model the background as a mixture of R Gaussians, one for each of the considered previous frames
  - Fast implementation: at each new frame remove older Gaussian and add a new one
- Threshold in the probability space
- Robust to noise
- 3 parameters: standard deviation (σ), threshold (T_4) and number of frames(R)

LAB 5

1. Try to detect the pixels corresponding to moving objects using a simple thresholding of the intensity difference in subsequent frames
   - *optional: use the color difference in a uniform color space or an average of the differences on R,G and B*
2. Estimate the background, e.g., using the running mean, and compare between the background and the current frame for the motion estimation. Comment on the behaviour of the algorithm when α varies
   - *optional: use the mean and the median for background construction*
3. Try to use a probabilistic approach based on the mixture of Gaussians model presented in the lectures. Comment on the dependency of the algorithm behaviour on the number of considered frames (R) and on the Gaussian standard deviation (σ)
   - *optional: use some adaptive parameters taking ideas from Stauffer and Grimson approach*
4. *(optional)* Develop a simple motion detection scheme in order to detect when there is movement in the scene (e.g., based on the number of foreground pixels or on the presence of connected set of moving pixels larger than a certain size)
5. *(optional)* Combine with LAB6 for tracking of moving objects