Photogrammetric Computer Vision

Photogrammetric Computer Vision (PCV)

Lab 3

Background Subtraction

Lin Chen

Lab 3 - content

Image Sequence Analysis: Background Subtraction

- Model background using the “Single Gaussian” model
- Sequential estimation of the parameters (mean and variance)
- Background/foreground labelling process
- Noise reduction in the labels
- Evaluation of two different values for the learning rate
- Discussion of the results

Given Data

- Image sequence of a surveillance camera in a station (see last slide)
  - Image sequence "S1 (Take 1-C)" (Cam 3) of PETS 2006 Benchmark data
  - http://www.cvg.reading.ac.uk/PETS2006/data.html

- M-file containing a framework for reading the sequence where you can start from

Background Subtraction: Single Gaussian

Single Gaussian

Key Idea

- Learn background model from past n frames
- Background modeled as a single Gaussian
- Parameters of Gaussian Distribution $N(\mathbf{x} | \mu_\mathbf{x}, \sigma_\mathbf{x}^2)$
  - Mean $\mu_\mathbf{x}$ and variance σ_x^2
- Probability that a pixel is background: $p(\mathbf{x}) = N(\mathbf{x} | \mu_\mathbf{x}, \sigma_\mathbf{x}^2)$
- Parameters are estimated for **every** pixel

Single Gaussian

- Parameters can be estimated recursively

$$\mu_n = (1-\alpha)\mu_{n-1} + \alpha \cdot g(\mathbf{x})$$

$$\sigma_n^2 = (1-\alpha)\sigma_{n-1}^2 + \alpha \cdot (\mu_n - g(\mathbf{x}))^T (\mu_n - g(\mathbf{x}))$$

- α is called *learning rate*
  - Evaluate your results for $\alpha_1 = 1/50$ and $\alpha_2 = 1/1400$

Single Gaussian

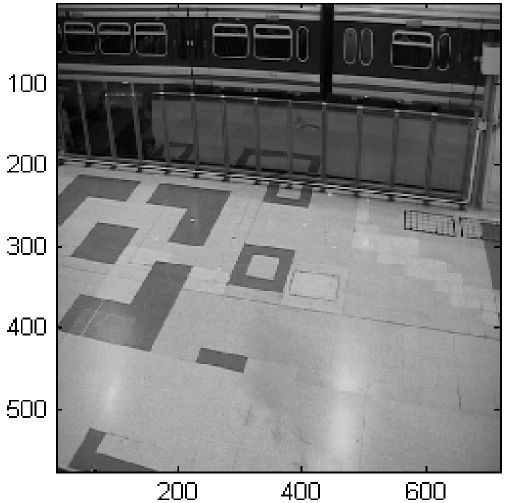
- Background model changes continuously
  - E.g. adaptive to gradual illumination changes
- Use variance as a local threshold

$$\Delta g = \left| g(\mathbf{x},t) - \mu(\mathbf{x}) \right|$$

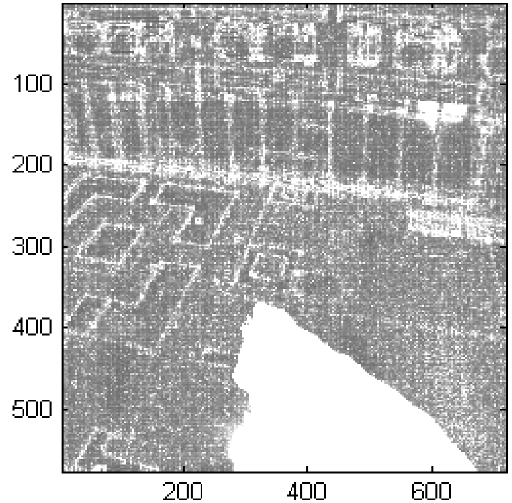
$$\Delta g \begin{cases} > 2.5 \cdot \sigma(\mathbf{x}) & \text{foreground} \\ < 2.5 \cdot \sigma(\mathbf{x}) & \text{background} \end{cases}$$

  … to label foreground/background pixels in each frame
- Reduce noise in the resulting label images by morphological operations (dilation followed by erosion if BG code is 1 and FG is 0)

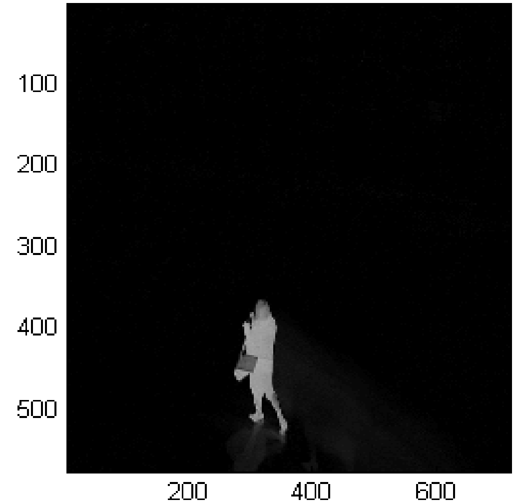
Example



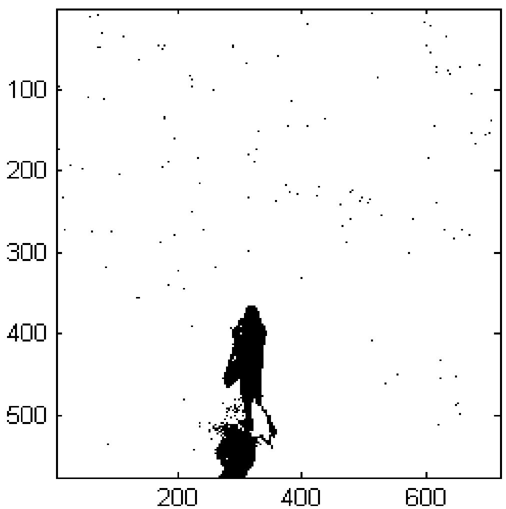
Mean



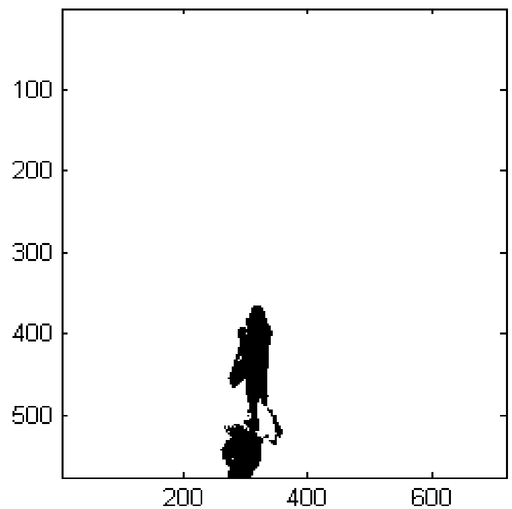
Variance



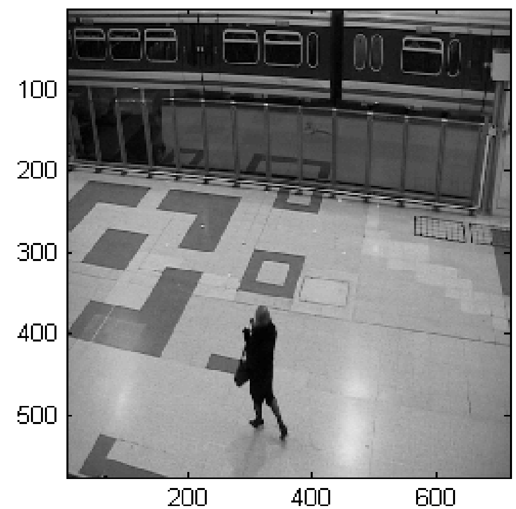
Delta



Mask



Mask without noise



Input image

Discussion

- The implementation of the background subtraction algorithm is to be applied to the given image sequence.
- As a result we expect images for 2 different frames with α =1/50:
  - the background mean image,
  - the background variance image,
  - the difference image of mean background and current frame,
  - the binary foreground/background mask
- The obtained results are to be discussed with the two values for α (care should be taken about shadows, reflections, people/things standing still, etc.) and explain why certain cases turn out with a wrong label.

Hints

- Work in grayscale intensity images
- **Don´t use loops!** (only one to iterate the images)
- Use matrix indexing and vectorized operations instead!

  E.g.: ***bg(delta_g*** *> 2.5*sqrt(**sigma_square**)) = 0* or element wise square like **.**^2

- Initialize μ_x with the grayvalues of the first image
- Initialize σ_x with a value of, e.g., 10 for every pixel

- Use *imagesc* for graphical output
- Use *drawnow* to wait for the figure to plot

Deadline for the submission of results:

January 30th, 2020

The image sequence can be downloaded from my Dropbox Account:

https://www.dropbox.com/sh/whf5haze25mqtlq/AADgfsXLggl1hDOlsFbho8G_a?dl=0

*Submission of **written report** with answers to the questions in printed form*

*and **Matlab code** to Lin Chen*

chen@ipi.uni-hannover.de