

Schedule

- Exam
 - Wednesday, March 11, 8:00-13:00
 - Skrivsalen
- Presentation of project
 - Monday, March 16, 13:15-15:00
 - In room 2446
 - 10 minutes each group (including questions!)
- Lab reports deadline
 - Before the exam

Topics

- Fourier theory
- Filtering
- Digital geometry
- Mathematical morphology
- Image-based screening
- Image registration, Motion
- Segmentation
- Graph theory, fuzzy set theory
- 3D Vision
- Measurement
- Classification

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theoretical basis

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theoretical basis
image acquisition

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Fourier analysis

- Convolution
 - linear, shift-invariant operation
 - linear local neighbourhood operation
- Fourier transform
 - to understand linear, shift-invariant operations
- Sampling
 - sampling frequency \Leftrightarrow aliasing
 - imaging window causes Fourier transform to be discrete
 - interpolation = convolution

Filtering

- Smoothing
 - linear: low-pass filters  use Gaussian filter!
(linear diffusion)
 - non-linear:
 - adaptive filtering
 - bilateral filter  non-linear diffusion
- Edges
 - first derivatives
 - Canny edge detection
- Lines
 - second derivatives
- Gabor filter
- Hough and Radon transforms

Hough vs Radon transforms

- The resulting parameter space is identical
- Hough = write paradigm
- Radon = read paradigm
- Hough = efficient for binary input images
- Radon = efficient for grey-value input images
- Radon makes it easier to define the parameter space, and how to sample it

Digital geometry

- Grids
 - Cartesian
 - non-Cartesian: hexagonal, FCC, BCC
 - connectivity
- What is a straight line?
- Distance functions and their properties
 - city block
 - chessboard
 - weighted distance
 - ns-distances
 - Euclidean metric
- Distance transforms and their properties

Distance Transform

- Raster scan algorithm
 - propagating scalars, vectors
- Wavefront propagation
 - propagation of scalars and vectors
 - fast marching
- Separable algorithm
 - square of Euclidean distance
- Constrained DT
- Applications:
 - path-planning
 - chamfer matching
 - skeletonization

Mathematical morphology

- Grey-level mathematical morphology
 - from binary morphology through umbra concept
 - max and min filters instead of set logic
- Reconstruction by dilation
 - A.K.A. geodesic dilation
 - dilation masked (limited) by a 3rd function
- Top-hat
- Hit or miss
- Granulometry
 - multi-scale operation
 - size measurement without segmenting object first

Image-based screening

- Experimental design:
 - hypothesis
 - sample preparation
 - positive and negative controls
 - quality control
 - evaluation/benchmarking of method
- Aims:
 - avoid bias in measurement
 - results are meaningful

Image registration

- Geometric transformations:
 - translation, rotation, mirroring, affine transform, perspective
 - B-spline
- Similarity measures:
 - mean squared error, correlation, mutual information
- Or: detect points of interest
 - corner/edge detection, SIFT
- Optimization procedure:
 - gradient descent, genetic algorithms, simulated annealing
 - demons, morphons
 - iterative closest points

Motion

- Like image registration
 - but we can use assumptions on small and smooth changes over time
- Background estimation
 - assumes stationary camera
- Template tracking
 - image registration approaches
- Optical flow
 - assumes constant intensities
- RANSAC
 - corner detection, SIFT

Segmentation

- Threshold
 - bimodal: Otsu, Ridler & Calvard (isodata)
 - unimodal: Gaussian fit, chord method
- Watersheds (normal & seeded)
- Snakes (A.K.A. active contour)
 - different external forces yield different properties
- Level sets
 - can split to detect multiple disjoint regions
- Active shape models
 - ‘trained snakes’: know what shape they’re looking for
- Minimal graph cuts
- Fuzzy connectedness

Finding shapes in an image

- Template matching
 - fixed shape
 - allows binary or grey-value templates
- Chamfer matching
 - more efficient
 - binary templates
- Hough/Radon transform
 - parameterised shapes (outlines only)
- Active shape models
 - shapes with learned variations

Graph theory

- Representation of an image as a graph
 - Paths
 - Sub-graphs and connected components
 - Edge weights
- Graph cut
 - A set of edges are removed from the graph, creating two or more connected components
 - Minimal graph cut: globally optimal segmentation
 - Equivalent to the maximal flow
 - Used in seeded segmentation

Fuzzy set theory

- Fuzzy sets theory
 - membership function
 - fuzzy set operations
- Fuzzy c-means clustering
 - (vs. k -means clustering)
- Fuzzy connectedness
 - fuzzy connected components

3D Vision

- Image formation
 - the pinhole camera
 - projective geometry
 - artefacts and challenges
- Camera calibration
- Depth estimation
 - stereo vision
 - disparity \rightarrow triangulation \rightarrow depth
 - structured light
 - triangulation \rightarrow depth
 - shape from texture
 - size

Measurement

- It is important to use unbiased measures
- Intensity measurements
 - useful when pixel values are related to physical quantity
- Geometric measurements
 - based on binary shapes:
 - size (2D area / 3D volume) – stereology
 - perimeter (2D perimeter / 3D surface area) – stereology
 - derived measures: bounding box, Feret diameters, moments, ratios
 - object counting – stereology
 - using image grey values to improve measurement
 - segmentation-free size distributions using Granulometry

Classification

- Classification is grouping of patterns based on some features
 - choose features so that objects of different classes are separated well
 - curse of dimensionality
 - feature selection vs. extraction
- Supervised classification
 - nearest neighbour
 - linear and quadratic classifier
 - support vector machine
- Unsupervised classification
 - k-means clustering
 - hierarchical clustering