Detailed Program – Image Processing Summer School 2010

Monday

08.30-09.00: Registration

09.00-10.00: Introduction to image processing (Peter Horvath)

- Basic definitions (digital image, bit depth, sampling,…)
- What is image processing?
- Histogram transformation
- Mathematical morphology
- Filtering, convolution, Fourier transform
- Segmentation
- Shape feature extraction
- Tracking
- Registration
- Deconvoluiton
- Screening

10.00-11.00: Point operations and histogram transformations (Kalman Palagyi)

- Image operations (point, local, global)
- Examples of point operations: arithmetic operations, image negatives, pseudo coloring, log transform, power-low transform, gamma correction, contrast stretching, thresholding, gray-level slicing
- Histogram (normalized histogram, accumulated histogram)
- Point operations driven by histograms: histogram stretching, histogram equalization, local histogram equalization

11.00-12.00: Filtering and Fourier transform (Kalman Palagyi)

- Noise
- Convolution
- Filtering/smoothing in image space: (weighted) averaging filter, medial filter, sharpening, erosion, dilation, opening, closing, morphological filtering
- Fourier transform
- Convolution theorem
- Filtering/smoothing in frequency domain: low-pass filters, high-pass filters, bandpass filters, bandreject filters, periodic noise reduction

12.00-13.00: Lunch break

13.00-14.30: MATLAB/ImageJ installation, usage/programming tutorial (MM1: Peter Horvath, Aaron Ponti; MI1: Kota Miura, Csaba Balazs)

- MatLab:
  - Installation
  - Programming basics (data types, vectors, matrices)
- ImageJ:
  - Installation
  - ImageJ environment
  - Basic image processing (histograms)

14.45-16.15: MATLAB/ImageJ usage/programming tutorial (MM1: Peter Horvath, Aaron Ponti; MI1: Kota Miura, Csaba Balazs)

- MatLab programming:
  - Scripts
  - Functions
- ImageJ:
  - Point operations
  - Filtering
  - Frequency domain operations

16.30-18.00: MATLAB/ImageJ usage/programming tutorial (MM1: Peter Horvath, Aaron Ponti; MI1: Kota Miura, Csaba Balazs)

- MatLab:
  - Basic image processing operations (histogram, filtering)
- ImageJ:
  - Introduction to macro scripting

Tuesday

09.00-10.00: Image segmentation (Aaron Ponti)

- Simple thresholding
- Histogram-based segmentation
- Clustering-based approaches
- Adaptive thresholding
- Edge detection
- Watershed segmentation
- Markov random fields
- Manual segmentation
- Region-growing
- Active contours

10.00-11.00: Feature extraction and shape representation (Kalman Palagyi)

- Contour-based shape representation: chain code, signatures
- Region-based shape features: features in regionprops (Matlab), skeletons, distance transform,

moments
- Gray-scale features: moments, co-occurrence matrix, Haralick texture features

11.00-12.00: Registration/Stitching (Olaf Ronneberger)

- Registration
  - Motivation for Registration
  - Classification of different registration algorithms
  - basic Similarity measures
  - Transformations, transformation parameters, parameter space
  - Fast registration algorithms
- Advanced Registration
  - Advanced similarity measures
  - Elastic registration
- Stitching

12.00-13.00: Lunch break

13.00-14.30: Registration and stitching (TM1: Olaf Ronneberger, Peter Horvath; TI1: Aaron Ponti, Mario Emmenlauer)

- Gray-level based registration
- Similarity measure function, transformation function, best neighbor optimizer
- Manual Landmark-Based registration

14.45-16.15: Image segmentation (TM2: Aaron Ponti, Alessandra Griffa; TI2: Mark Longair, Kota Miura)

- Manual and automated thresholding
- Edge detection using filters and the Canny method
- Watershed algorithm for object separation
- Active contours
- Trainable segmentation

16.30-18.00: Feature extraction (TM3: Peter Horvath, Alessandra Griffa; TI3: Mark Longair, Kota Miura)

- Binary feature extraction
  - Location, area, shape,…
  - Shape moments
- Grayscale features
  - Entropy, mean, std intensity
  - Haralick features

Wednesday

09.00-10.00: Deconvolution (Alessandra Griffa)

- Introduction to deconvolution
- Image formation model (PSF, OTF)
- Simple deconvolution approaches (deblurring, inverse filtering and regularization)
- Deconvolution algorithms (iterative algorithms, blind deconvolution)
- PSF widening (how the PSF changes in function of the microscope settings; spherical aberration)
- PSF generation: theoretical vs experimental PSF
- Deconvolution pre-processing (background and bleaching correction)
- Images acquisition tips
- Deconvolution examples

10.00-11.00: Tracking (Ivo Sbalzarini)

11.00-12.00: Imaging for Modeling and Simulation in Cell Biology (Petros Koumoutsakos)

- importance of imaging in computational model validation
- importance of the development of computational models from images via reverse engineering processes
- simulations of diffusion-reaction processes
- reverse engineering of a tug of war model for intracellular virus transport

12.00-13.00: Lunch break

13.00-14.30: Deconvolution (WM1: Aaron Ponti, Serge Pelet; WI1: Alessandra Griffa, Pascal Lorentz)

- Importance of the PSF
- Inverse filtering
- Iterative algorithms (Richardson-Lucy)
- 3D deconvolution
- Huygens Remote Manager demonstration

14.45-16.15: Tracking (WM2: Serge Pelet, Aaron Ponti; WI2: Peter Horvath, Pascal Lorentz)

Thursday (Company day)

09.00-09.30: Bitplane

09.30-10.00: Perkin Elmer

10.00-10.30: Coffee break

10.30-11.00: Definiens

11.00-11.30: MathWorks

11.30-12.00: Visualization Sciences Group

12.00-13.00: Lunch break

13.00-14.00: Colocalization (Gabor Csucs)

- Colocalization and image aquisition
- Quantitative colocalization
- Pearson coefficient
- Manders coefficient
- The Costes approach

Friday

09.00-10.00: CellProfiler (Peter Horvath)

- Motivation, environment
- Pipeline system
- Modules
- Case study

10.00-11.00: Screening (Thomas Walter)

11.00-12.00: Detecting phenotypes in live-cell imaging-based screening (Daniel Gerlich)

- Supervised machine learning of cellular morphologies
- Single-cell tracking and hidden Markov model of cellular dynamics
- Assays with multiple fluorophores to score timing phenotypes
- CellCognition open source software for live-imaging-based screening
- Application: RNAi screen for mitotic exit phosphatases

12.00-13.00: Lunch break

13.00-14.30; 14.45-16.15 : Advanced programming I. and II. (FM1: Aaron Ponti; FI1: Mark Longair)

- Visualization
- Creating graphical user interfaces
- Object-oriented programming
- Interfacing with Java
- Interfacing with C/C++