Basic Algorithms for Digital Image Analysis

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Faculty of Informatics

Introduction

Topics of Course

- Tasks and applications of image analysis
- Image filtering
- Correspondence and template matching
- Detection of edges and corners
- Thresholding
- Hough transform
- Optical flow and motion tracking

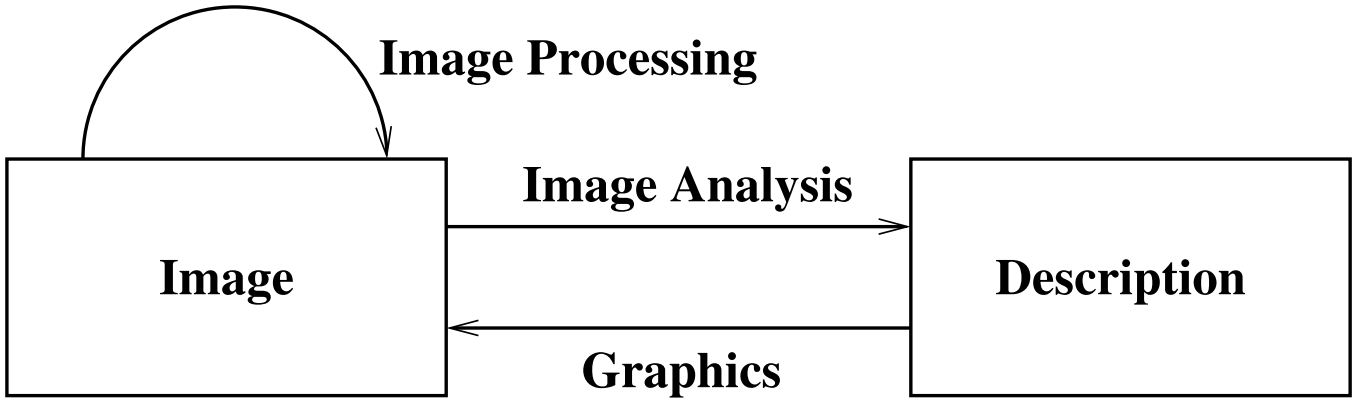
Outline

Basic terms of visual information processing

Area	Input	Output
Image processing	images	processed images
Image analysis	images	image descriptions
Pattern recognition	image descriptions	object classes
Computer vision	images	3D models

- *Images* can mean single image, set of images, or video
- Computer vision involves processing, analysis and recognition

Relation between graphics and image analysis



- Computer graphics: Input math. description, output image
  - direct problem, synthesis
- Image analysis: Input image, output math. description
  - reverse problem, analysis
  - more difficult
- Image processing: Input image, output another image

Outline

Applications 1/3

Applications	Domains
Mail sorting, label reading, supermarket-product billing, bank-check processing, text reading, interpretation of technical drawings	Document processing
Tumour detection, measurement of size and shape of internal organs, chromosome analysis, blood cell count	Medical
Part identification on assembly lines, defect and fault inspection	Industrial automation
Recognition and interpretation of objects, motion control and execution through visual feedback	Robotics

Applications 2/3

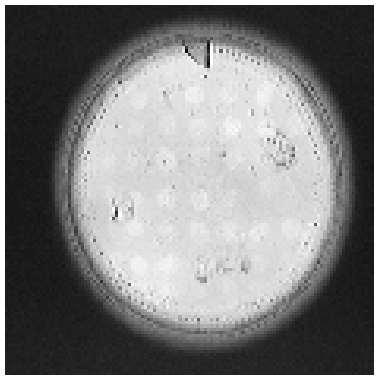
Map making from photographs, synthesis of weather maps	Cartography
Fingerprint matching, face recognition, gait analysis, other biometric measurements, for example, ear, iris	Forensics, security
Face expression analysis, eye motion tracking, gesture recognition	Man-machine interaction
Tracking of cars and people, analysis of events and activities	Surveillance

Applications 3/3

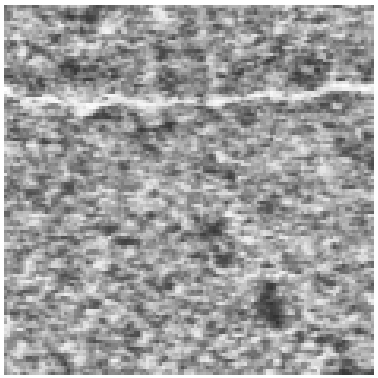
Applications	Domains
Scene reconstruction from multiple views and video, photorealistic models	Virtual reality
Image and video content based retrieval, indexing, representation and coding of shape, texture and motion	Multimedia databases
Target detection and identification, guidance of helicopters, aircraft, missiles and satellites from visual cues	Radar imaging
Multispectral image analysis, weather prediction, classification and monitoring of urban, agricultural, and marine environments from satellite images	Remote sensing

Outline

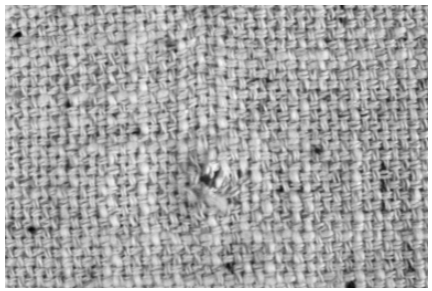
Inspection and quality control



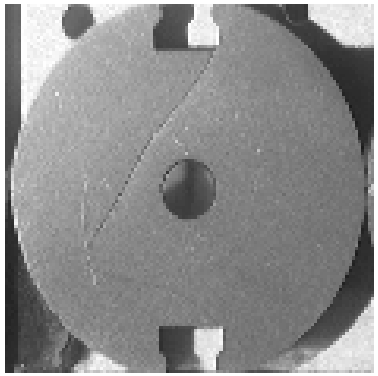
bottle inspection



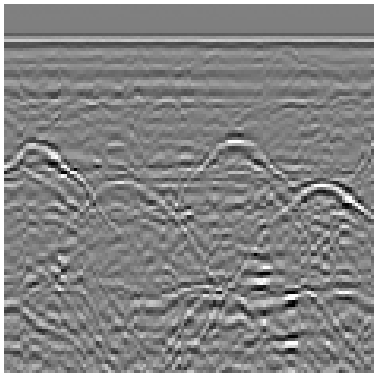
stone crack



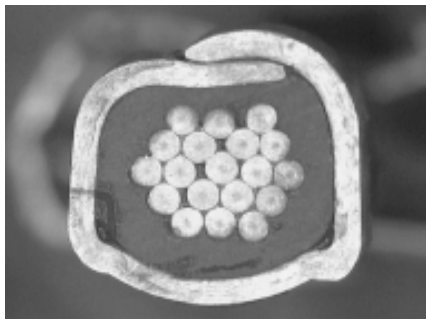
textile defect



ferrite core



soil (ultrasonic)



cable cross-section

Indoor/outdoor scenes, image databases

indr stereo 1

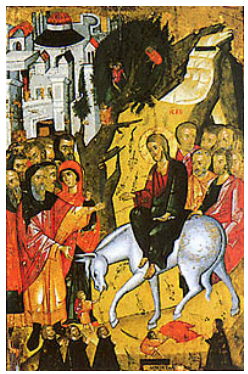
indr stereo 2

outdr stereo 1

outdr stereo 2

logos

photographs

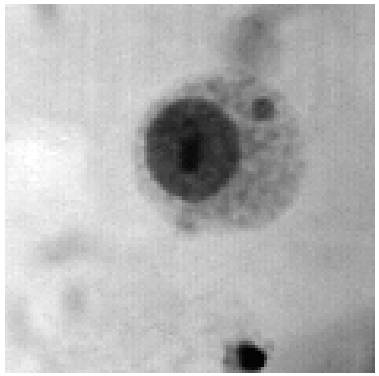


icons/paintings

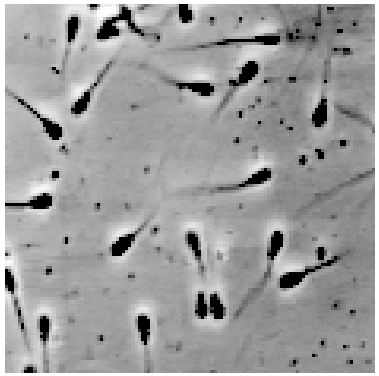
fingerprints

Medical imagery

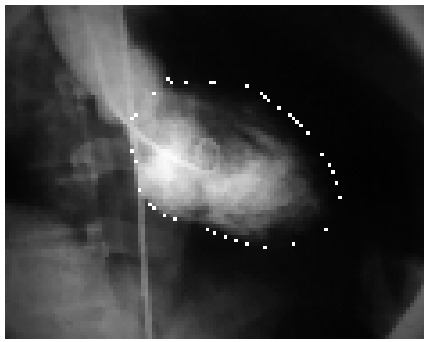
tomography (knee)



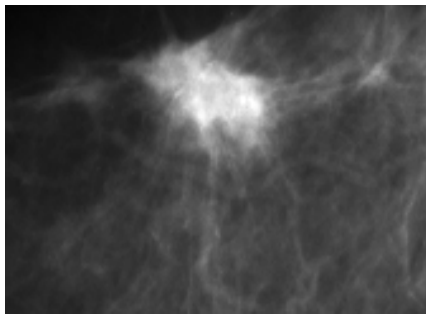
cells (radiology)



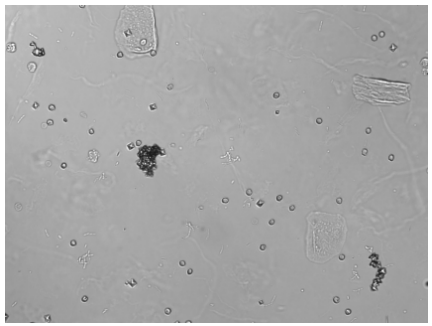
spermatozoa



X-ray (heart)

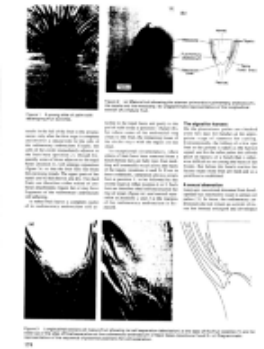


mammogram



cells (urine)

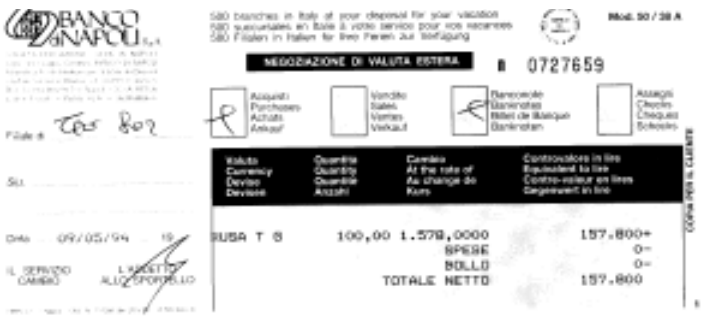
Documents



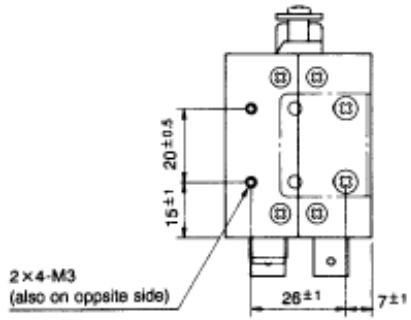
journal page

map

handwriting



bank receipt



technical drawing

Goals of computer vision

Provide methods for solving automation tasks related to processing of visual information, including:

- Detection and recognition of known objects
- Obtaining geometric models of unknown objects
- Computing position and orientation (pose) of objects
- Measurement of spatial properties of objects
  - distances, sizes, etc.
- Measurement of object motion
- Measurement of surface texture and colour

Digital image

Image is spatial representation of object, 2D/3D scene, or another image

- **Intensity image**
  - $I(x, y)$ is proportional to electromagnetic energy reflected by object surface and received by sensor
- **Range image**
  - $I(x, y)$ is function of line-of-sight distance between (r, c) and object in 3D world
- **Tactile information**
  - $I(x, y)$ is proportional to sensor deformation caused by surface at (r, c)
- **Symbolic image**
  - $I(x, y)$ is label, index, or symbol associated with some category
  - colour, land use, soil type

Steps of object recognition 1/2

- **Image formation**: Sensors, illumination, surface reflection models, etc.
- **Enhancement**: Image is composed of informative pattern modified by non-informative variations. Enhance informative pattern based on image data.
  - noise filtering, geometric correction
- **Feature-based segmentation**: Informative pattern is arrangement of *features*. Each feature is set of connected pixels. Assign features to pixels.
  - thresholding, edge detection

Steps of object recognition 2/2

- **Region-based segmentation**, or grouping: Collect together pixels belonging to same feature and form *regions* or other entities (e.g., lines).
  - connected component analysis, edge linking
- **Region description**: Compute properties of regions. Measure spatial/topological relations between regions/entities.
  - areas, centroids, orientations, dimensions, distances
- **Matching**: Interpret image by finding correspondences between measured entities and scene model.
  - recognising a letter based on its measured elements

Literature used in writing this course

- E.Trucco, A.Verri, "Introductory Techniques for 3-D Computer Vision".
- R.Klette, P.Zamperoni, "Handbook of Image Processing Operators".
- I.Pitas, "Digital Image Processing Algorithms".
- R.C.Gonzales, R.E.Woods, "Digital Image Processing".
- R.M.Haralick, L.G.Shapiro, "Computer and Robot Vision".
- B.Jähne, "Digital Image Processing".
- M.Sonka, V.Hlavac, R.Boyle, "Image Processing, Analysis and Machine Vision".