Pattern Recognition Lecture
"Introduction and Outline"

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Marcin's Short CV

Time Period	University	Research Focus
1996–2002	SUT Gliwice	Image Segmentation
2002–2006	FAU Erlangen	Object Recognition
2006–2008	QMUL London	Multimedia Retrieval
2008–2010	Univ. Koblenz	Semantic Multimedia
2010–	Univ. Siegen	Pattern Recognition
2012	UE Katowice	Multimedia Analysis
2012–	Stiftung NV	Cognitive Robotics

Our Place at the University of Siegen

University of Siegen

Faculty IV: Science and Engineering

Depart. for Electrical Eng. and Computer Science

Institute for Vision and Graphics

Computer Graphics and Multimedia Systems
Realtime Learning Systems
Media Systems
Pattern Recognition

RTG 1564 – "Imaging New Modalities"

<table>
<tr><th></th><th>Sensor Development</th><th>Mono-modal Techniques</th><th colspan="2">Multi-modal Techniques</th></tr>
<tr><td>Person Detection Biometry</td><td>A1 - Colorimetric Arrays</td><td>B1 - Biometrics by Multispectral Scattering Models</td><td>C1 - Face Recognition from 2D/3D Sensor Data</td><td rowspan="3">C3 - Information Security</td></tr>
<tr><td>Material Analysis</td><td>A2 - THz Sensor Development</td><td>B2 - Material Detection in the THz Range</td><td></td></tr>
<tr><td>Scene Observation</td><td>A3 - Multi Camera 2D/3D Technology</td><td>B3 - Synthetic Aperture in the THz Range</td><td>C2 - Visual Analysis of Multimodal Sensor Data</td></tr>
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Tutors

Lectures

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Exercises

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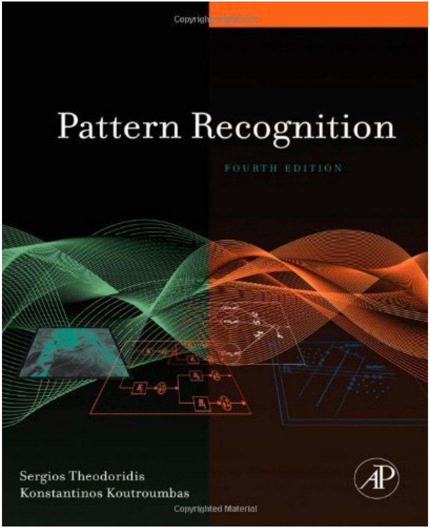
Topics

No	Topic
01	Introduction and Outline
02	Classifiers Based on Bayes Decision Theory
03	Linear Classifiers
04	Nonlinear Classifiers
05	Feature Selection
06	Feature Generation I
07	~~Feature Generation II~~
08	Template Matching
09	Context-Dependent Classification
10	~~Supervised Learning: The Epilogue~~
11	Clustering: Basics Concepts
12	Clustering Algorithms I: Sequential Algorithms
13	Clustering Algorithms II: Hierarchical Algorithms
14	Clustering Algorithms III: Schemes Based on Function Optimisation
15	Summary, Applications, and Conclusions

Accompanying Book



The Term “Pattern Recognition”

Pattern Recognition

is a field whose objective is to assign an object or event to one of a number of categories, based on features derived to emphasise commonalities. In practice, features are often extracted from sensory signals, such as images or audio.

Pattern Recognition

is the act of taking in raw data and taking an action based on the category of the pattern.

Terminology

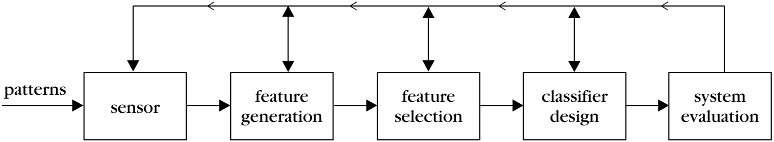
What is the difference between

- Image Processing,
- Image Recognition, and
- Pattern Recognition ?

PR Application Fields

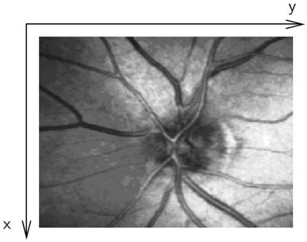
- Machine Vision
- Character Recognition
- Computed-Aided Diagnosis
- Speech Recognition
- Data Mining and Knowledge Discovery
- ...

Basic Stages of Pattern Analysis



- The stages are highly dependent on each other.
- In order to design an optimal pattern recognition system, they all have to be optimised at once.
- Patterns are analysed at different levels of abstraction.
- Integration of background knowledge into the process may be very useful.

Low-Level Interpretation of Patterns

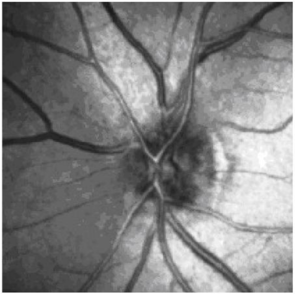


$$\begin{pmatrix} 039 & 041 & 041 & 043 & \dots & 057 \\ 041 & 043 & 043 & 043 & \dots & 066 \\ 041 & 051 & 053 & 055 & \dots & 066 \\ 041 & 051 & 053 & 056 & \dots & 066 \\ \vdots & \vdots & \vdots & \vdots & & \vdots \\ \vdots & \vdots & \vdots & \vdots & & \vdots \\ 054 & 052 & 042 & 042 & \dots & 095 \end{pmatrix}_{150\times 200}$$

$$f(x,y) = \begin{pmatrix} f(0,0) & f(0,1) & \dots & f(0,199) \\ f(1,0) & f(1,1) & \dots & f(1,199) \\ \vdots & \vdots & & \vdots \\ f(149,0) & f(149,1) & \dots & f(149,199) \end{pmatrix} \quad ; \quad f(x,y) \in \{0,1,2,\dots,255\}$$

High-Level Interpretation of Patterns

Input Image



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Gray Level Retina Image

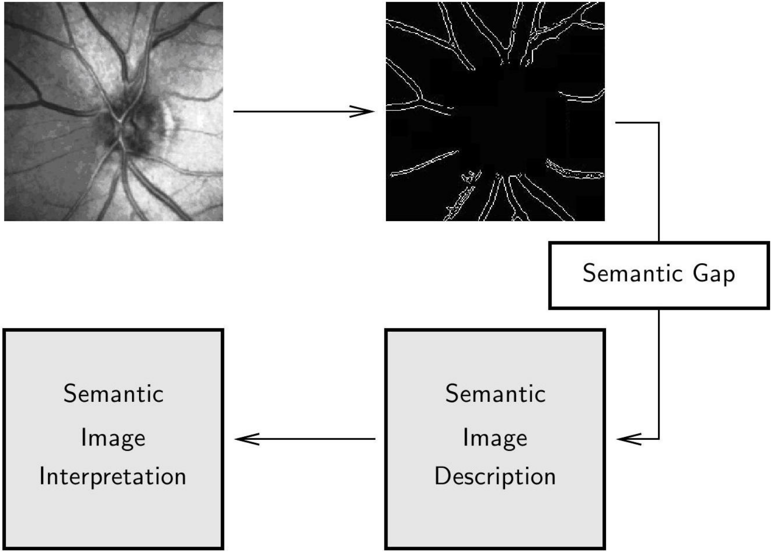
Papilla Shape - OK

Blood Vessel Width - OK

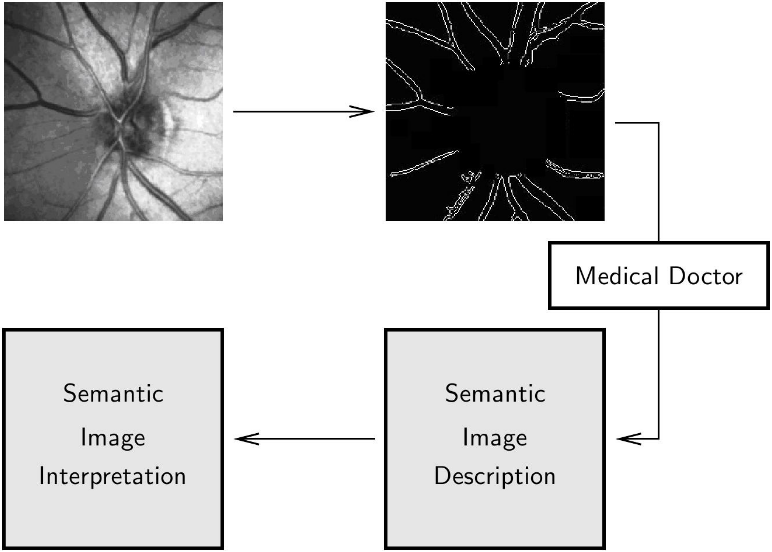
Research Challenges in Pattern Analysis

1. Optimisation of the Entire Processing Chain at Once
2. Combination of the Different Levels of Abstraction
3. Integration of Background Knowledge into the Process

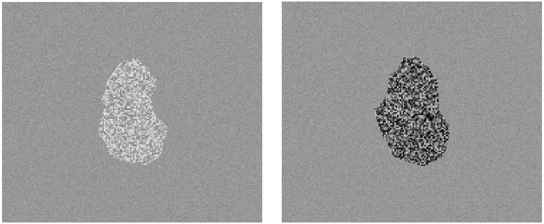
Semantic Gap in Image Understanding



Semantic Gap in Image Understanding



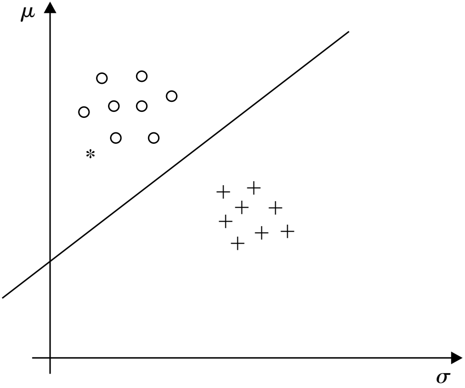
Example for Medical Image Classification



(a) (b)

Examples of image regions corresponding to (a) class A and (b) class B.

Example Descriptors for the Image Regions



Plot of the mean value μ and standard deviation σ for a number of different images originating from class A ($\circ$) and class B ($+$).

Feature Vectors $\rightarrow$ Random Vectors

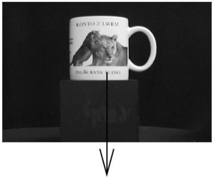
- Descriptors are called feature vectors

$$\mathbf{x} = [x_1, x_2, \ldots, x_l]^{\mathrm{T}}$$

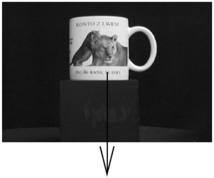
- Each feature vector identifies a single pattern (object)
- Feature vectors are treated as random vectors

Signal Acquisition - Stochastic Process

$f(120, 180) = 219$

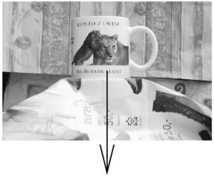


$f(120, 180) = 210$



$f(120, 180) = 208$

$f(120, 180) = 204$



$f(120, 180) = 198$

Bayes Decision Theory for a Two-Class Problem

Known

Classes:	$\{\omega_1, \omega_2\}$
A priori probabilities:	$P(\omega_1)$ and $P(\omega_2)$
Likelihood density functions:	$p(\mathbf{x}\|\omega_1)$ and $p(\mathbf{x}\|\omega_2)$
Pattern to be classified:	$\mathbf{x} = [x_1, x_2, \ldots, x_l]^{\mathrm{T}}$

Assumption

The feature vectors can take any value in the l-dimensional feature space: $\mathbf{x} = [x_1, x_2, \ldots, x_l]^{\mathrm{T}} \in \mathbb{R}^l$

Unknown

A posteriori probabilities: $P(\omega_1|\mathbf{x})$ and $P(\omega_2|\mathbf{x})$

Learning Strategies

Supervised Learning

assumes that a set of labelled training data is available and the classifier is designed by exploiting this a-priori known information.

Unsupervised Learning

clusters unlabelled training data described by feature vectors into similar groups.

Semi-Supervised Learning

applies both the labelled and unlabelled training for designing a classification system.

Pattern Recognition Live

BERTI - Bundesliga Information System

developed at the Institute for Pattern Recognition, University of Erlangen-Nuremberg and Sympalog Voice Solutions GmbH

Let's talk to BERTI: +49 9131 610017