Pattern Recognition Lecture
Introduction and Outline

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UNIVERSITÄT SIEGEN   IVG   ZESS   Imaging New Modalities DFG-Graduiertenkolleg 1564

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

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"

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

Topics

Date	No	Topic
17/04	PR01	Introduction and Outline
18/04	PR02	Feature Generation
02/05	PR03	Feature Selection
08/05	PR04	Linear Classifiers
15/05	PR05	Bayes Decision Theory
05/06	PR06	Context-Dependent Classification
06/06	PR07	Clustering Basics
26/06	PR08	Sequential Clustering
03/07	PR09	Hierarchical Clustering
10/07	PR10	Summary, Applications, and Conclusions

Accompanying Book
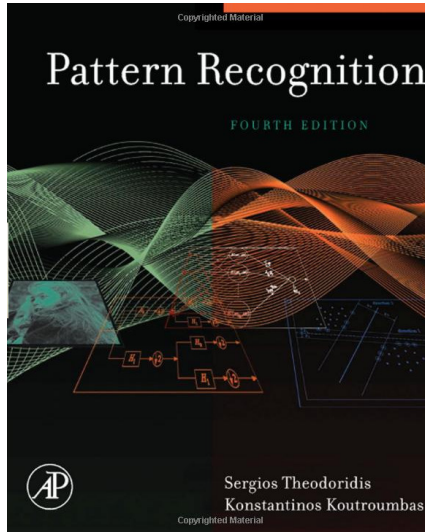
The Term "Pattern Recognition"

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.
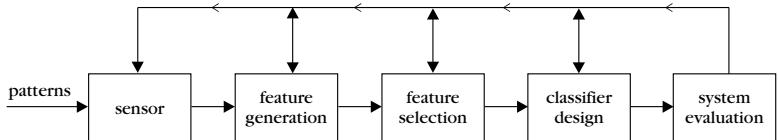
What is the difference between

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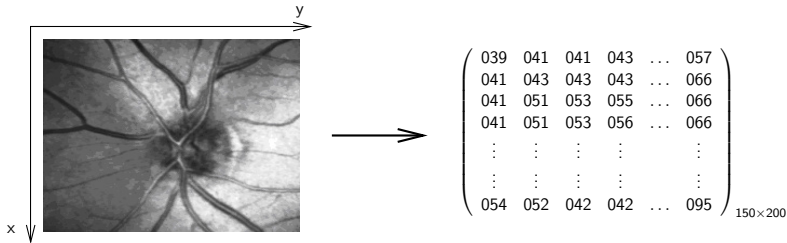- Pattern Recognition ?

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.
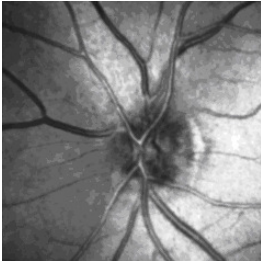
Low-Level Interpretation of Patterns

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

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

High-Level Interpretation of Patterns

Input Image

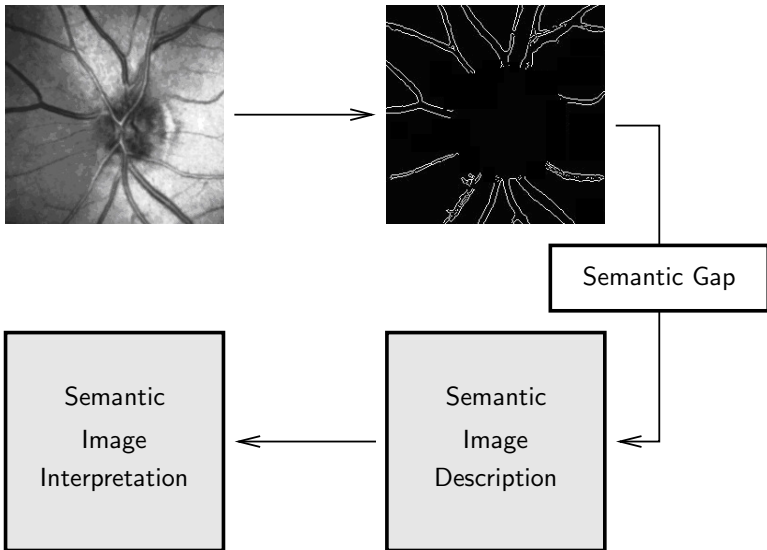

Gray Level Retina Image

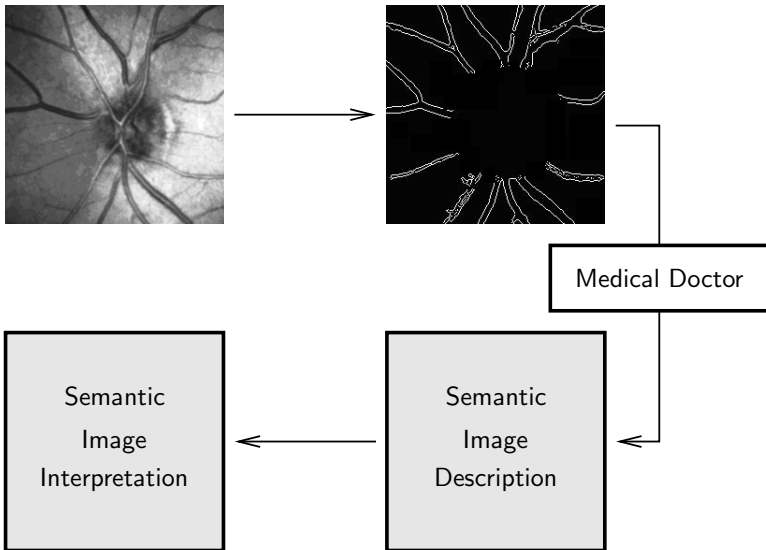Papilla Shape - OK

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

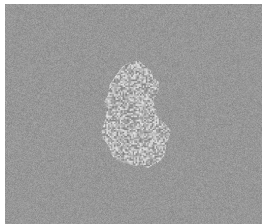3. Integration of Background Knowledge into the Process

Semantic Gap in Image Understanding
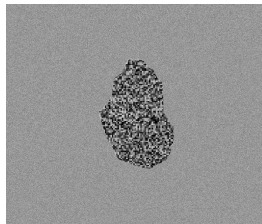
Semantic Gap in Image Understanding

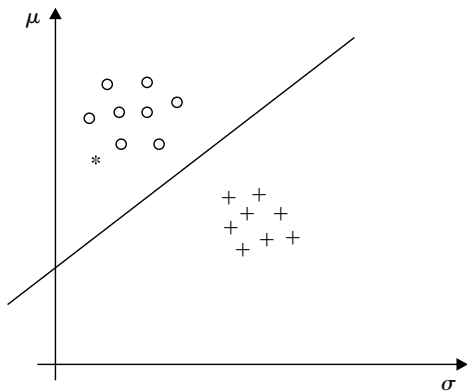# Example for Medical Image Classification

(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 ($+$).

- Descriptors are called feature vectors

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

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

Assumption

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

Unknown

A posteriori probabilities: $\quad P(\omega_1|\mathbf{x})$ 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.

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