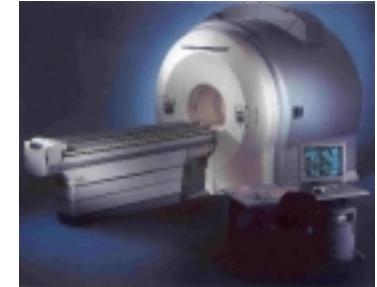


Functionality of MaZda

Andrzej MATERKA
Technical University of Lodz
Poland

COST B11 Working Group 1 "Software and Statistics"



Tasks

- To develop efficient techniques of image processing and pattern recognition, adequate for MRI quantitative texture analysis.
- To develop MS® Windows® computer program with appropriate GUI and agreed set of functions.

Steps in texture analysis

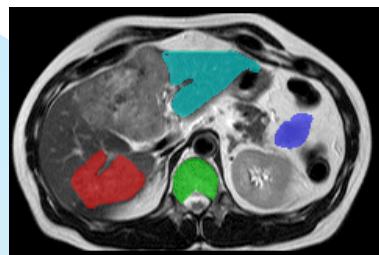
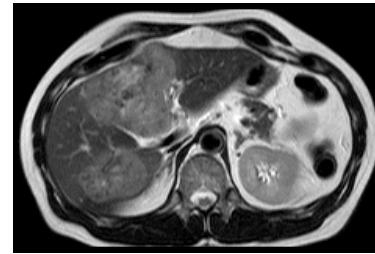


Image acquisition

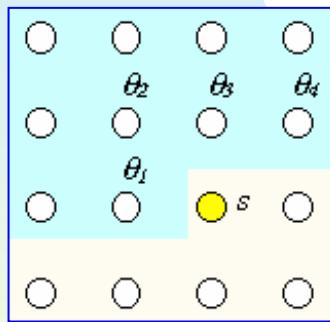


ROI selection

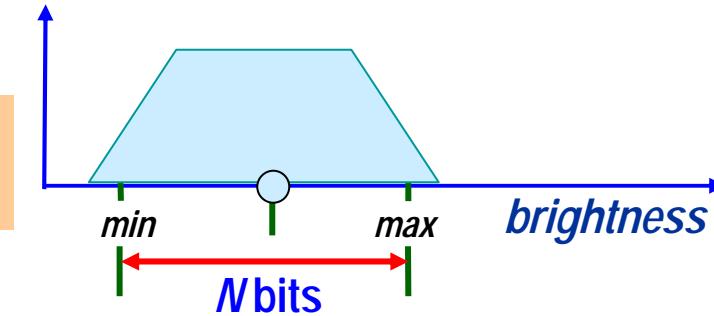
Image normalization

Feature extraction

Feature selection & reduction



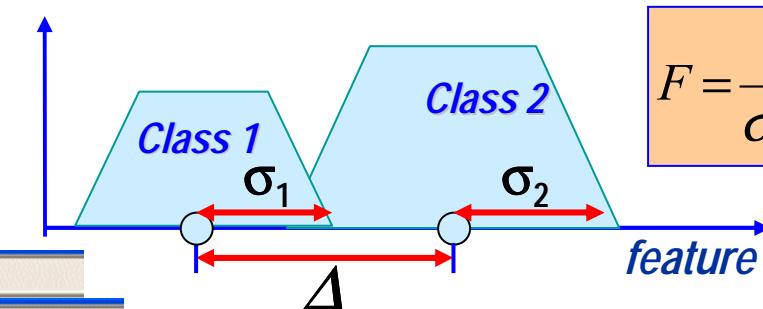
Feature name	F	ps1	ps2
GrKurtosis		0.032185	-0.20762
GrNonZeros		0.98765	0.99383
AreaARM			
Teta1			
Teta2			
Teta3			
Teta4			
Sigma			
WavEnLL_s-1			
WavEnLH_s-1			
WavEnHL_s-1			
WavEnHH_s-1			



Feature name	F	P
S(4,0)		
S(2,0)		
S(3,0)		
S(5,0)		
S(4,-)		
S(1,0)Correlat		0.3770
S(1,-)45dgr_GLevNonU		0.3944
S(5,0)		
Teta3		0.3612
Horzl_RLNonUni		0.3647
S(3,-)		
S(1,0)Correlat		0.4249
S(3,-)		
S(0,2)		0.4389
S(0,3)Correlat		0.4400
S(4,4)		
Vertl_RLNonUni		0.4400
S(1,0)DiVarnc		
S(0,3)DiEntrp		

COST B11, Bergen, May 2002; © by Andrzej Materka

$$F = \frac{2\Delta^2}{\sigma_1^2 + \sigma_2^2}$$



Steps in texture analysis

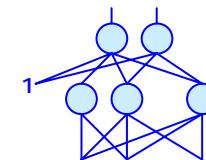


Feature name	ps1	ps2
GrKurtosis	0.032185	-0.20762
GrNonZeros	0.98765	0.99383
AreaARM	1463	1463
Teta1	0.37174	0.30333
Teta2	-0.084613	-0.16263
Teta3	0.24769	0.47548
Teta4	0.067687	-0.099282
Sigma	0.86924	0.85902
WavEnLL_s-1	17106	16196
WavEnLH_s-1	417.31	313.04
WavEnHL_s-1	324.51	442.75
WavEnHH_s-1	222.49	171.27

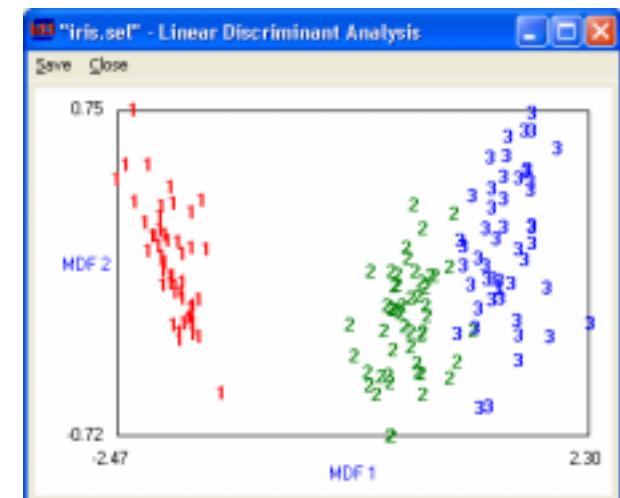
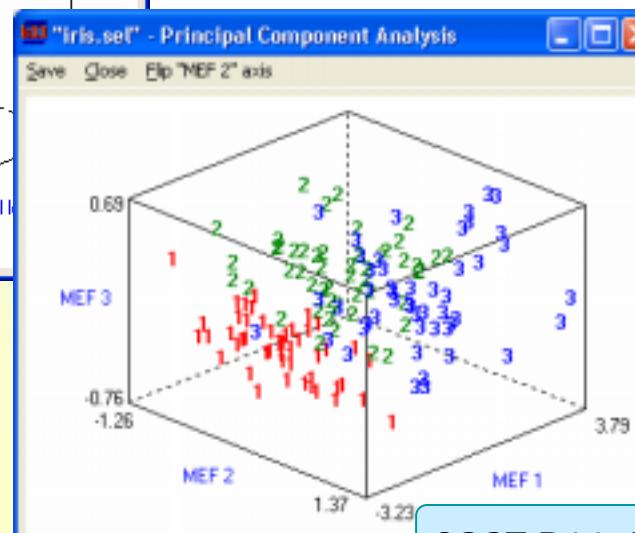
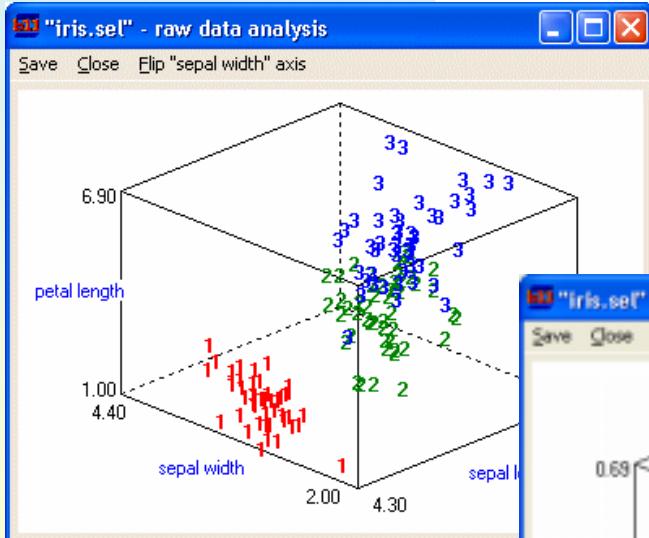
Data transformation
(PCA, LDA, NDA)

$$\mathbf{p}_i = \Phi^T (\mathbf{x}_i - \boldsymbol{\mu})$$

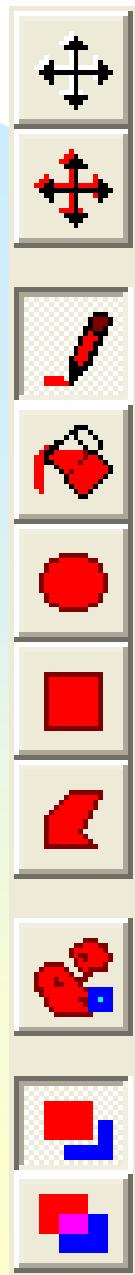
$$\mathbf{q}_i = \Psi^T (\mathbf{x}_i - \boldsymbol{\mu})$$



Texture classification
(k-NN, ANN)



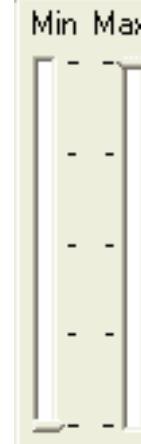
MaZda, ver. 3.08



graphics toolbar

Editing ROI

grey-scale palette
sliders



ROI color selector

Clear



Zoom-in, zoom-out



image layer
selector

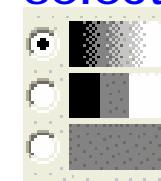
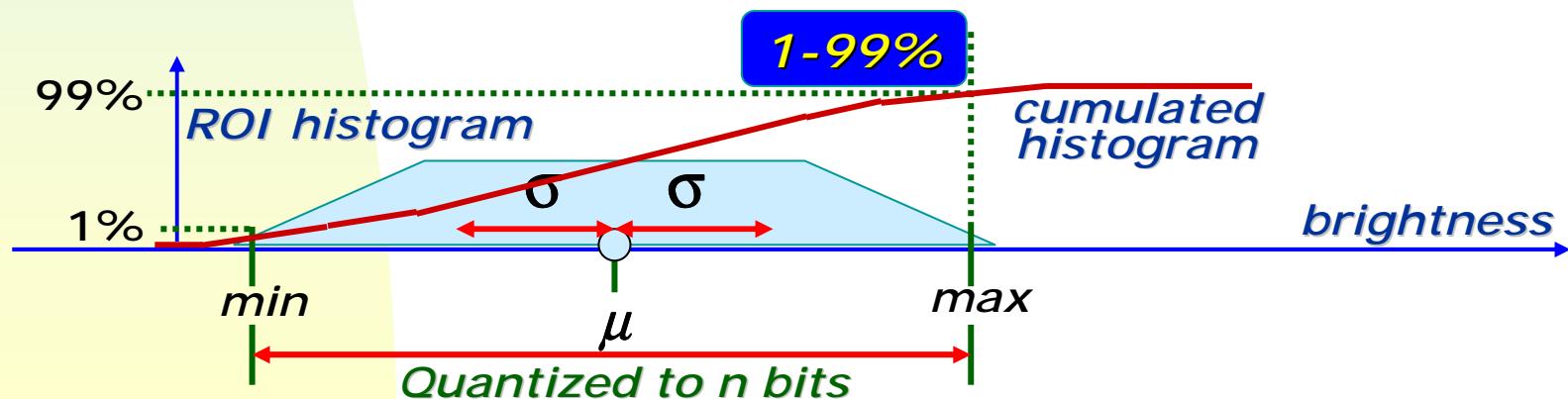
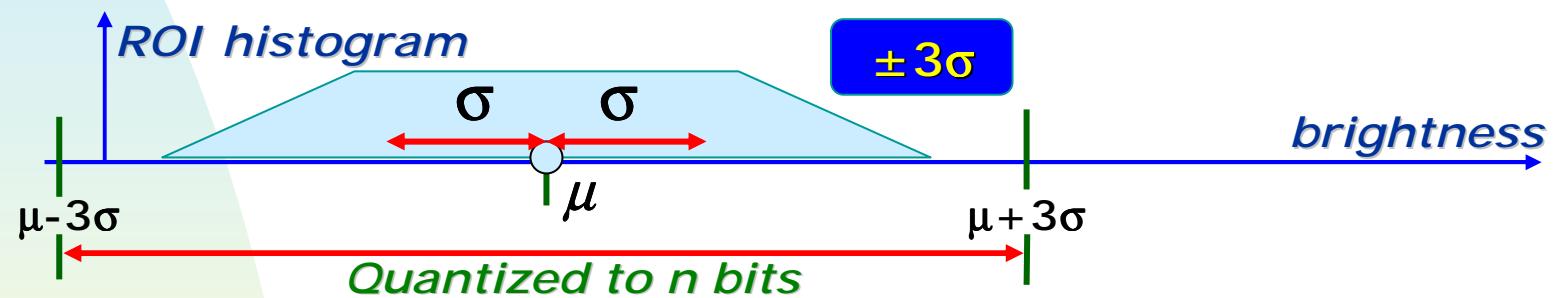
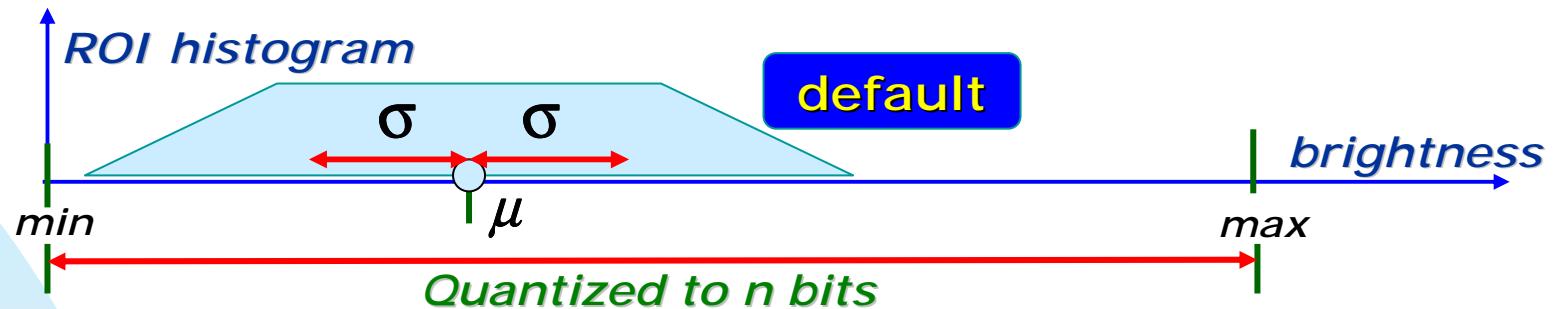
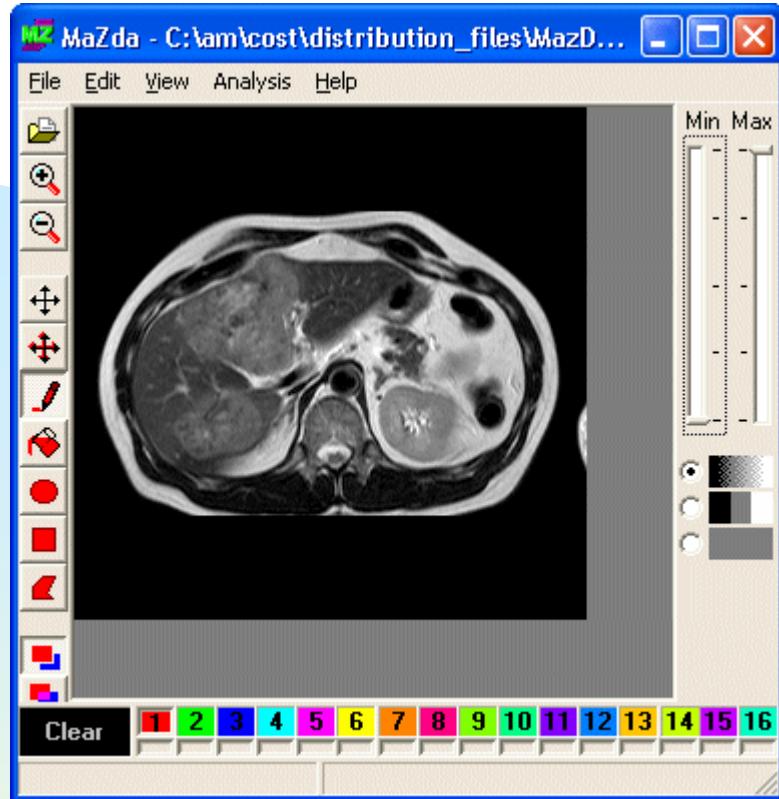


Image normalization





MaZda, ver. 3.08

Feature extraction

Input

images in 12 file formats

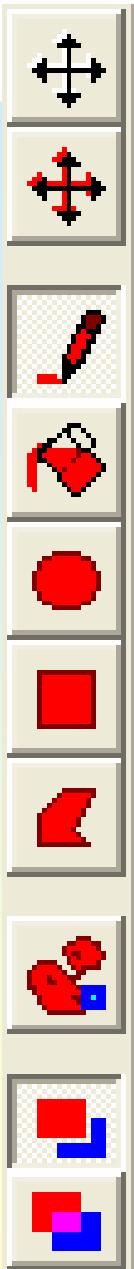
Methods

- histogram
- gradient
- RL matrix
- CO matrix
- AR model
- wavelets

Output

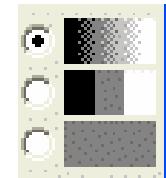
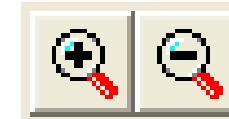
- (*.par, *.sel) text files
- (*.bmp) histograms
- (*.bmp) feature maps



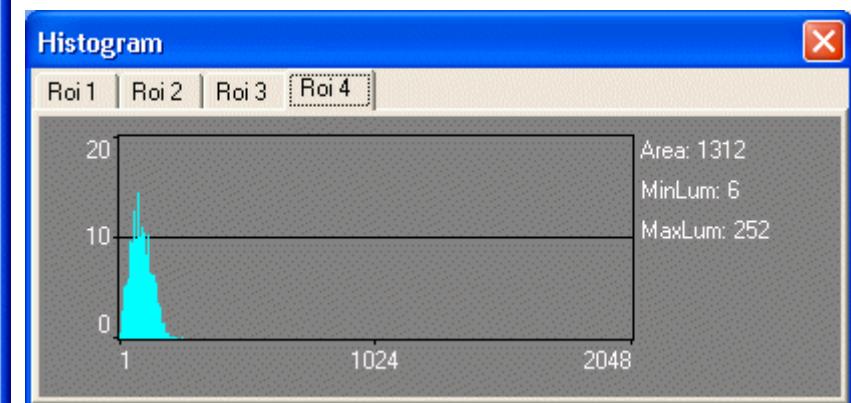
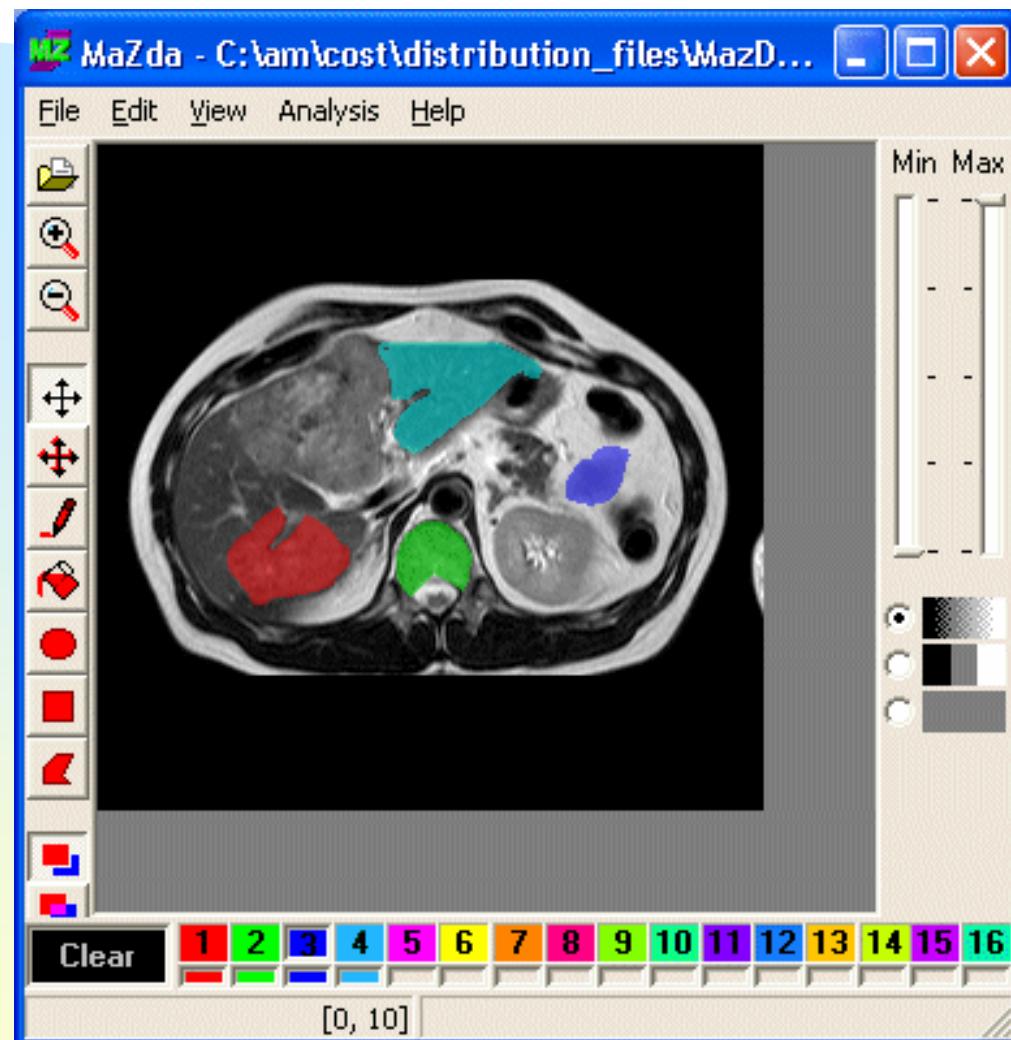


What is new in MaZda 3.08

- integration of MaZda, Convert and B11
- wavelet-derived features
- increased number of ROIs (now 16)
- graphical tools for ROI edition
- new multi-report window + tools for parameter selection
- windows for image viewing (with image enhancement sliders)
- image header window
- feature maps in separate windows
- script-driven automated texture analysis
- ANN classifier testing



MaZda 3.08 windows



Histogram window

Mazda 3.08 windows

MZ Report

File Feature selection Tools

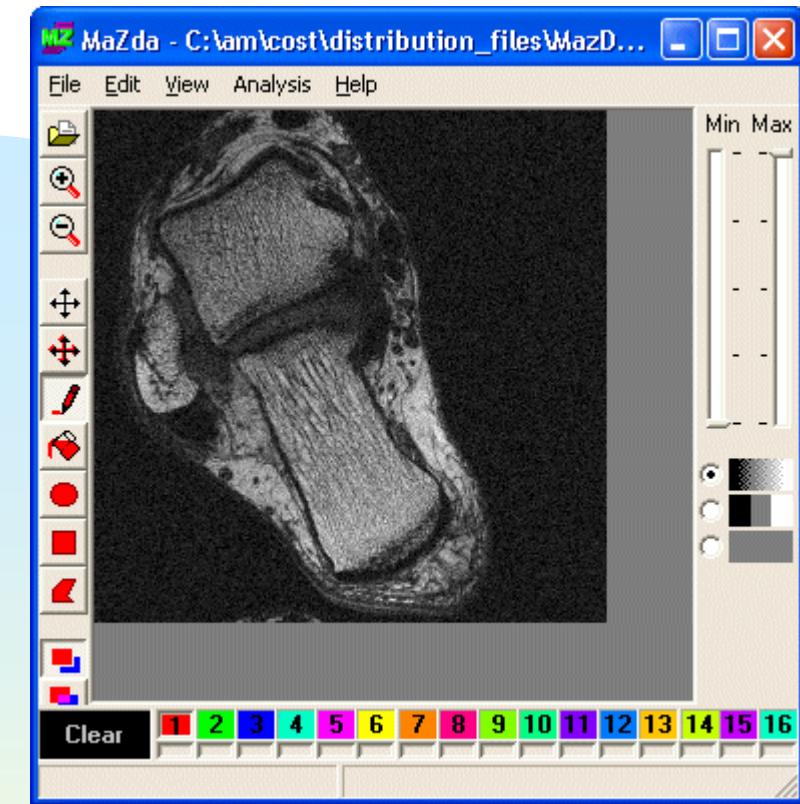
2002-2-14 14:16,52

Image File: text0324.ima
ROI File: newdraw.roi
Image size: 256 x 256
Min. lum.: 1
Max. lum.: 1240
Bits/pixel: 11

Normalisation = 3 sigma
Histogram analysis = No
CO matrix analysis = Yes, Dimensions = 6 x 6, Distances = 1 2 3 4 5
RL matrix analysis = Yes, Dimension = 6
Gradient analysis = Yes, Max pixel value = 64

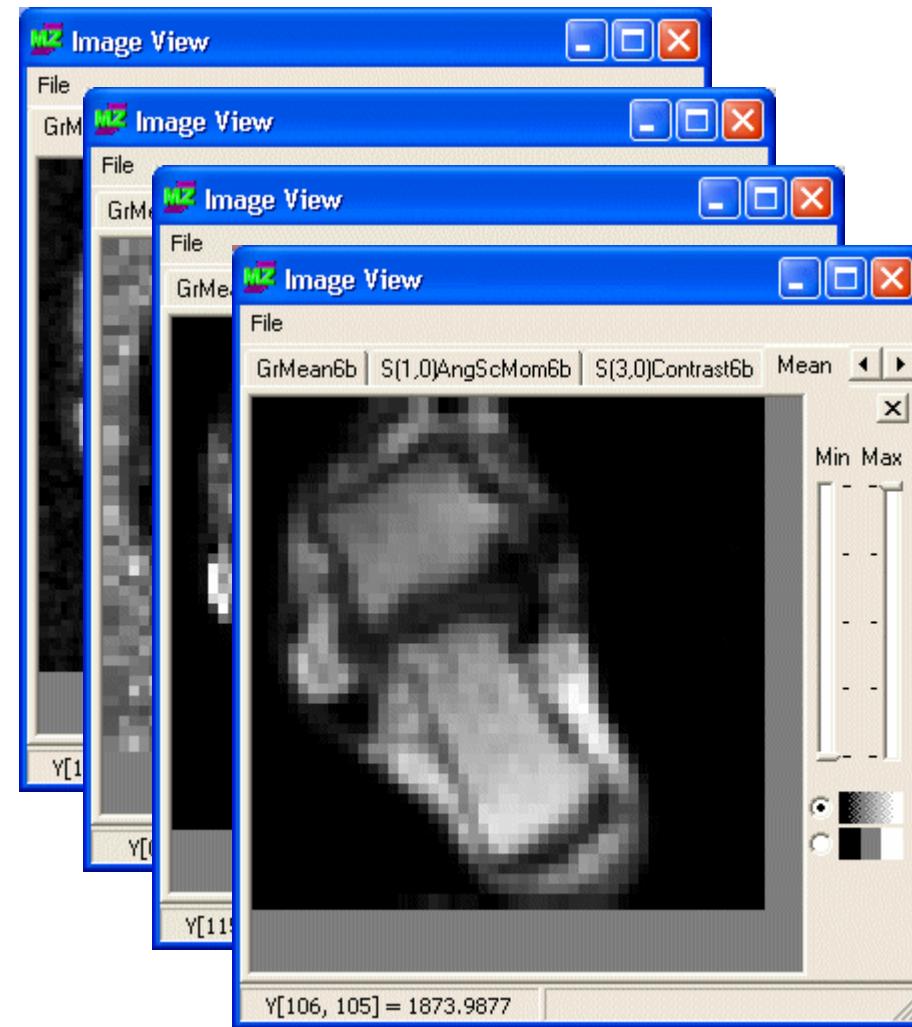
Feature name	X red_roi	✓ 2	✓ 3	✓ 4	5
Area	1336	1343	1208	1312	0
✓ MinNorm	851	929	934	-40	0
✓ MaxNorm	1254	1103	1146	223	0
Area_S(1,0)	2596	2608	2344	2544	0
✓ S(1,0)AngScMom	0.0025745	0.0012741	0.0012777	0.0012058	0
✓ S(1,0)Contrast	109.67	186.66	193.78	152.88	0
✓ S(1,0)Correlat	0.40377	0.044443	0.041113	0.30046	0
✓ S(1,0)SumOfSqs	91.972	97.671	101.05	109.27	0
✓ S(1,0)InvDfMom	0.15312	0.099241	0.087963	0.10185	0
✓ S(1,0)SumAverg	65.279	64.706	65.119	64.554	0
✓ S(1,0)SumVarn	258.21	204.02	210.4	284.21	0
✓ S(1,0)SumEntrp	1.6922	1.7496	1.7529	1.8186	0
✓ S(1,0)Entropy	2.7606	2.9823	2.9813	3.0003	0

Report window



MaZda 3.08
windows

Image View window



MaZda 3.08 windows

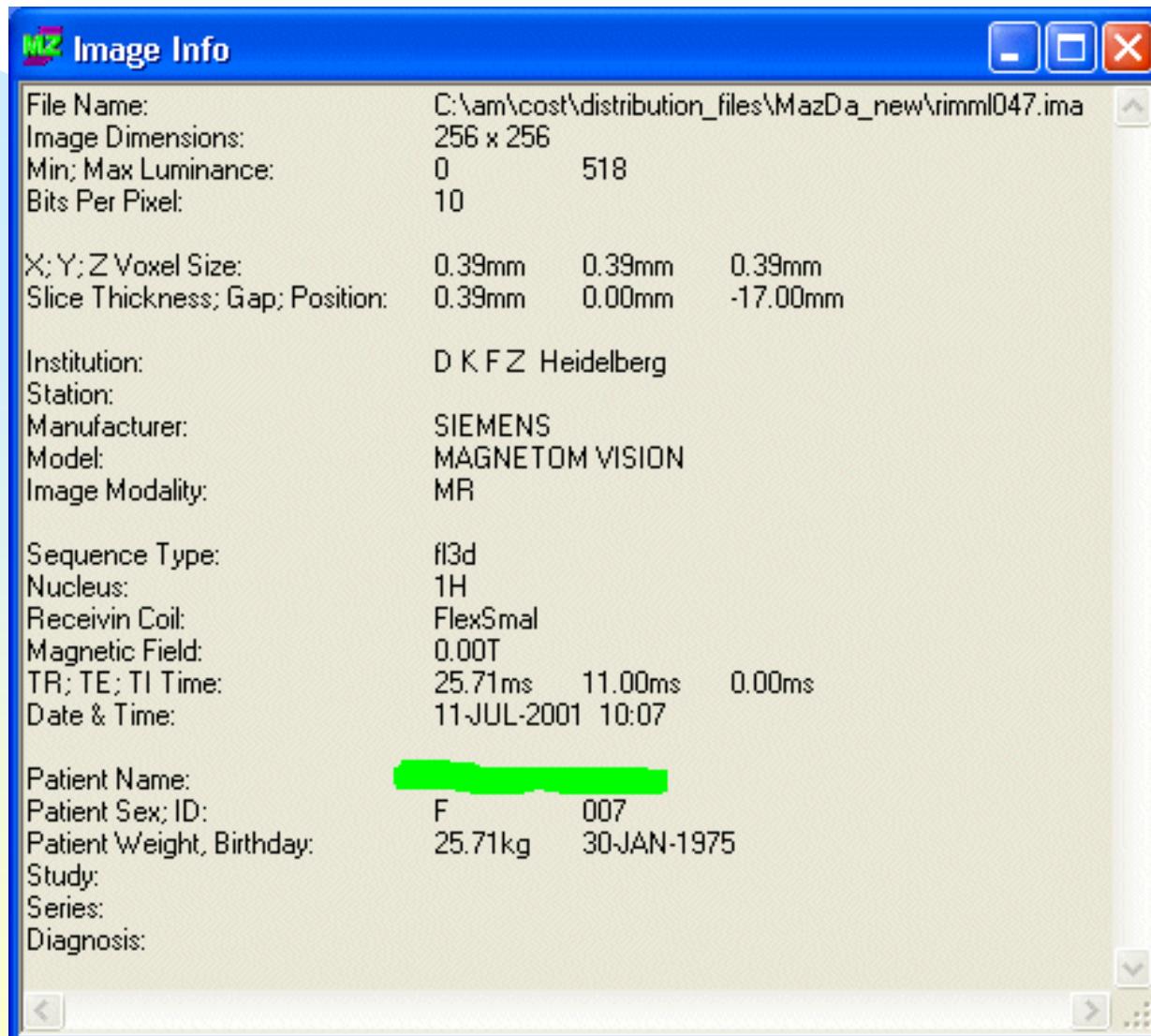
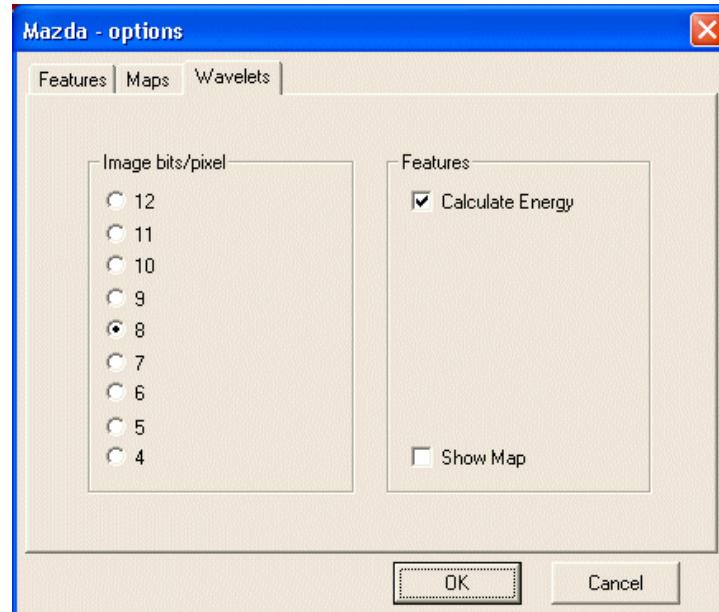
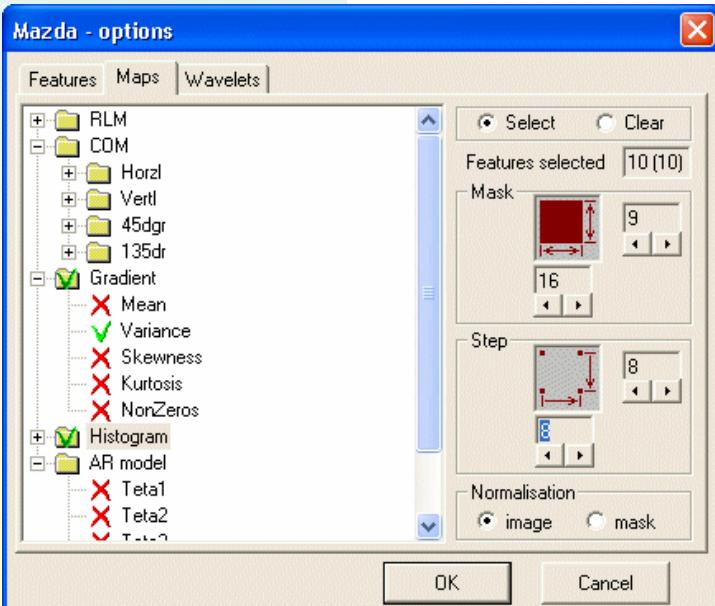
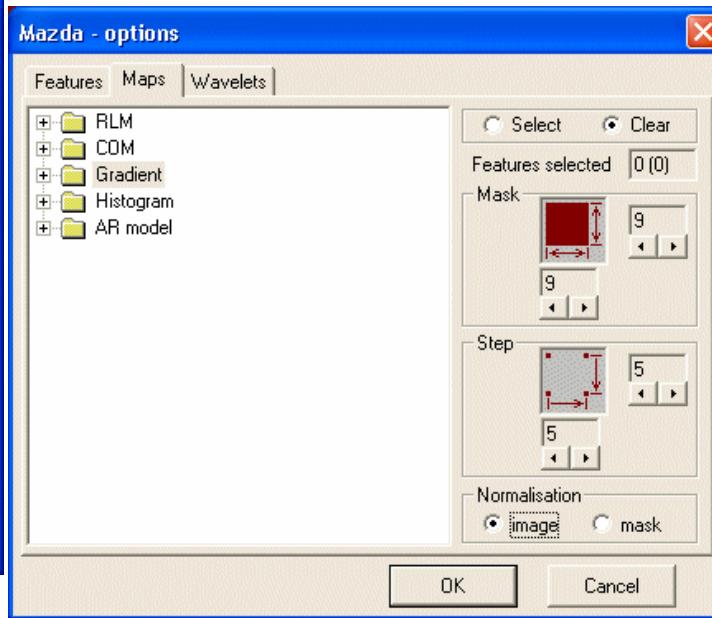
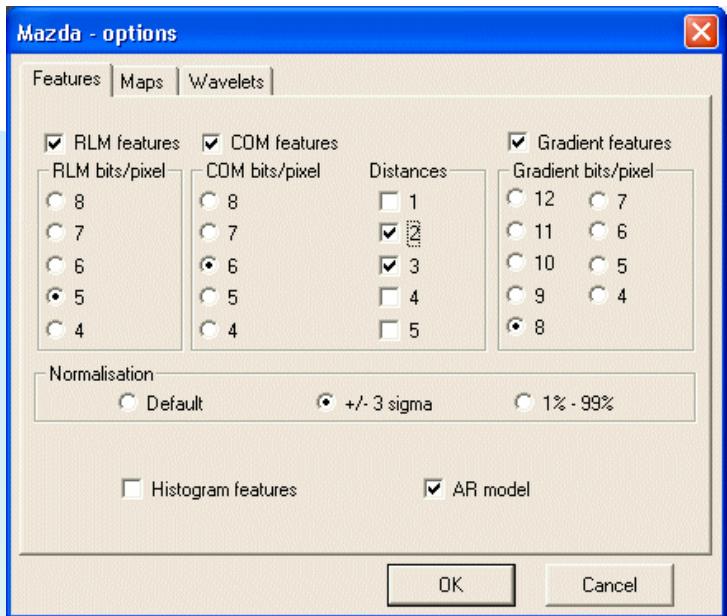


Image header window

Mazda 3.08 windows



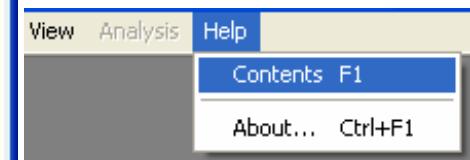
Option windows

Mazda on-line User's Manual

Ukryj Wstecz Drukuj Opcje

- 1. The Mazda package
 - 1.1 Introduction
 - 1.2 Functionality
 - 1.3 Main window
 - 1.4 Histogram window
 - 1.5 Report window
 - 1.6 Image View window
 - 1.7 Image information window
 - 1.8 B11 window
 - 1.9 Options window
- 2. Getting started with Mazda
 - 2.1 Input and output data
 - 2.2 Loading the image
 - 2.3 Editing ROI
 - 2.4 Image analysis
 - 2.5 Parameter selection and reduction
 - 2.6 Analysis automation
- 3. Theoretical background
 - 3.1 Texture analysis methods
 - 3.2 Feature reduction methods
 - 3.3 Texture parameters summary
 - 3.4 References
- 4. B11 program for data analysis and classification
 - 4.1 Introduction
 - 4.2 Input and output data
 - 4.3 Getting started with B11
 - 4.4 Analysis
 - 4.5 Classification
 - 4.6 Options
 - 4.7 References
- 5. Copyright

Mazda 3.08 windows



On-line help
window

MaZda, ver. 3.08

Feature selection



Input

(*.par) files from Mazda

Methods

- Fisher coefficient
- POE+ACC
- manual choice

Output

(*.sel) files

Fisher coefficient	
Feature name	F
S(4,0)AngScMom	312.3768
S(2,0)AngScMom	307.7508
S(3,0)AngScMom	305.4635
S(5,-5)AngScMom	294.7775
S(4,-4)AngScMom	282.1180
S(1,-1)AngScMom	273.8941
S(5,0)AngScMom	271.6925
S(3,-3)AngScMom	268.4229
S(0,2)AngScMom	266.8662
S(4,4)AngScMom	255.2278

POE+ACC	
Feature name	P
Teta3	0.3612
Horzl_RLNonUni	0.3647
S(1,0)Correlat	0.3770
45dgr_GLevNonU	0.3944
Teta1	0.4249
Teta2	0.4389
S(0,3)Correlat	0.4400
Vertl_RLNonUni	0.4408
S(1,0)DiVarnc	0.4541
S(0,3)DiEntrp	0.5000

Feature name	ps1	ps2	p
Area	1584	1584	1584
MinNorm	10	-4	-7
MaxNorm	72	71	9
Mean	41.944	33.573	37.62
Variance	106.69	157.99	361.0
Skewness	0.30804	0.21075	0.3160
Kurtosis	0.49048	-0.1714	-0.5503
Perc.01%	19	8	1

Automation

Analysis automation

```
// This is an example of macro file for MaZda software  
  
LoadImage siem2.dcm  
LoadROI testroi.roi  
  
LoadOptions opcje1.ini  
RunAnalysis  
  
SaveReport wynik1.par  
SaveMap mapa3.bmf  
CloseMap  
SaveMap mapa2.bmf  
CloseMap  
SaveMap mapa1.bmf  
CloseMap
```



MaZda scripts

Exploratory data analysis, classification

b11 - m25.sel

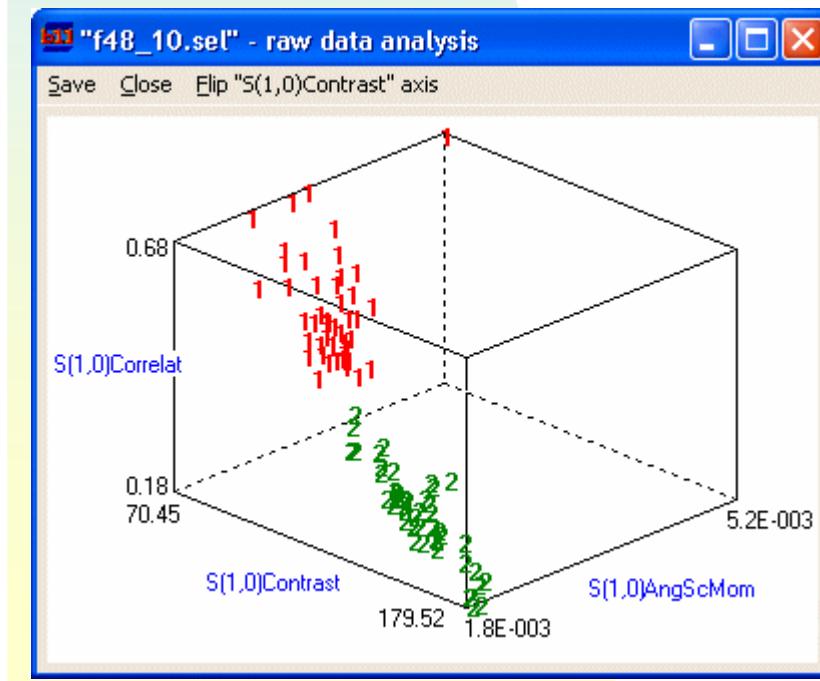
File Options Analysis Classification About Exit Help

Input (data)

```
*label
AR model, phantom image analysis
*features
1 teta1
2 teta2
3 teta3
4 teta4
5 sigma
*categories
1 Large-size bubbles
2 Glass beads
3 Medium-size bubbles
4 Small-size bubbles
5 Background noise
*data
 1 1 3.004e-1 -5.460e-2 4.466e-1 4.10
  2 1 2.936e-1 -4.150e-2 4.428e-1 7.44
  3 1 3.630e-1 -7.520e-2 4.042e-1 5.02
  4 1 3.140e-1 -9.010e-2 4.068e-1 8.18
```

Output (report)

```
* b11 report file [raw data analysis]
* Data file name: "m25.sel"
* Selected features [5 out of 5]
teta1 [#1/#1]; p.mean= 1.35928E-001, p.std= 4.1560E-002, p.stdev= 4.1560E-002, p.min= 1.35928E-001, p.max= 4.1560E-002, p.sum= 2.79588E-001, p.sumsq= 2.06920E-002, p.var= 9.08444E-001, p.varsq= 8.18888E-002
Feature vector standardized: NO
* Results [raw data analysis]
> Fisher coefficient, F = 40.0
> 1-NN classification of raw data
Missclassified data vectors: 4/25 [or 16.0%]
Sample No: 4; Category: 1; ClassResult: 1
Sample No: 5; Category: 1; ClassResult: 1
Sample No: 10; Category: 2; ClassResult: 2
Sample No: 20; Category: 4; ClassResult: 4
```



Methods

- PCA, LDA, NDA
- k-NN, ANN

Feature standardization

Feature selection box

- teta1
- teta2
- teta3
- teta4
- sigma

Neural network parameters

1st hidden layer <1..10>	3
2nd hidden layer <2..4>	2
backprop eta <0.01-0.99>	0.15
backprop iter. limit <50k..1M>	200000
optimization iter. limit <1..1000>	50

Classification

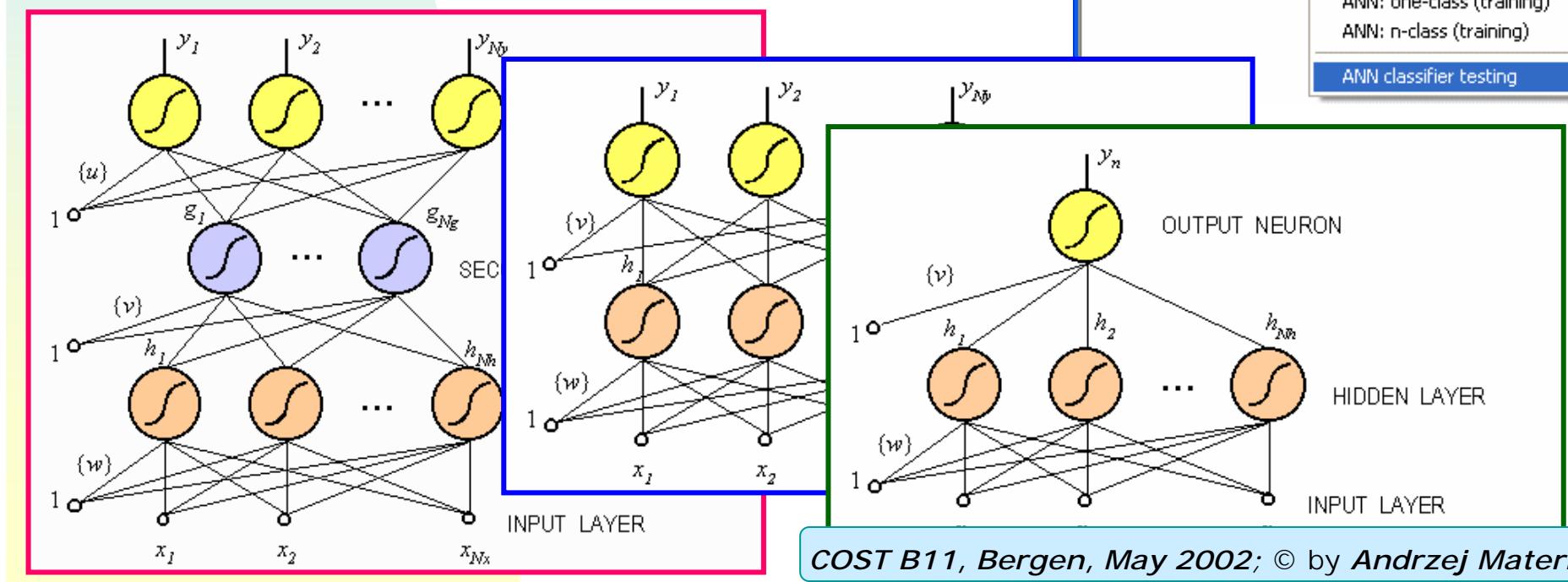
Selected category

texture data analysis

Options Analysis Classification About Exit

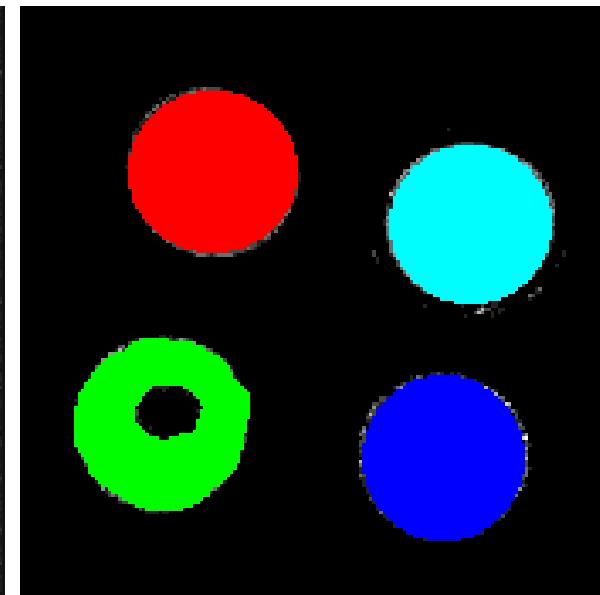
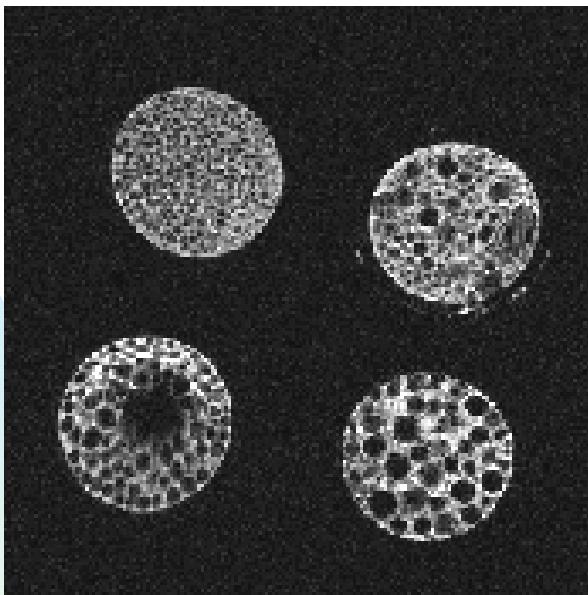
1_NN
ANN: one-class (training)
ANN: n-class (training)
ANN classifier testing

**ANN
classifier
testing**



Example - PS phantom image analysis

22 images



- class 1
- class 2
- class 3
- class 4



MaZda → 22 (*.par) files, ~300 texture parameters

MaZda → 2 (*.sel) files, 10 parameters each (F, POE)



b11 → Exploratory data analysis and classification

Example - PS phantom image analysis

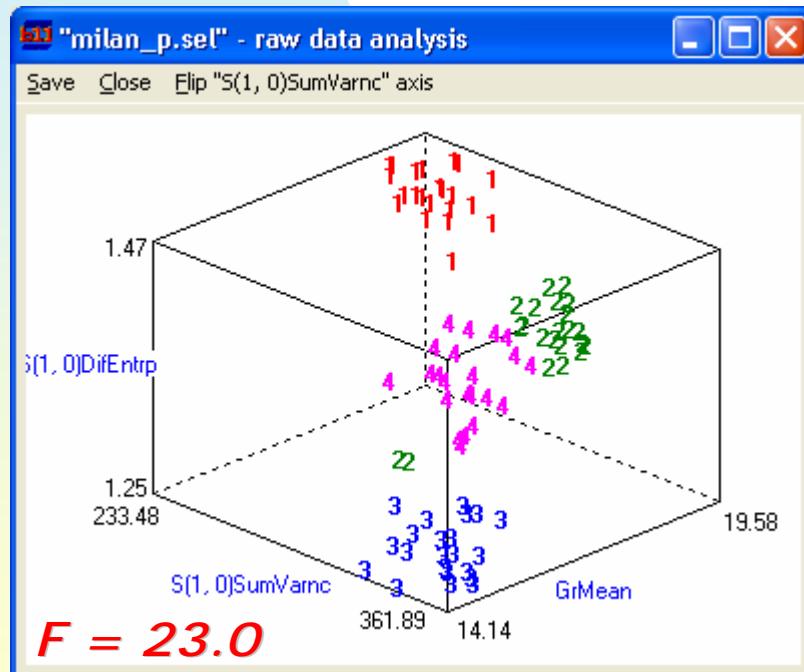


b11



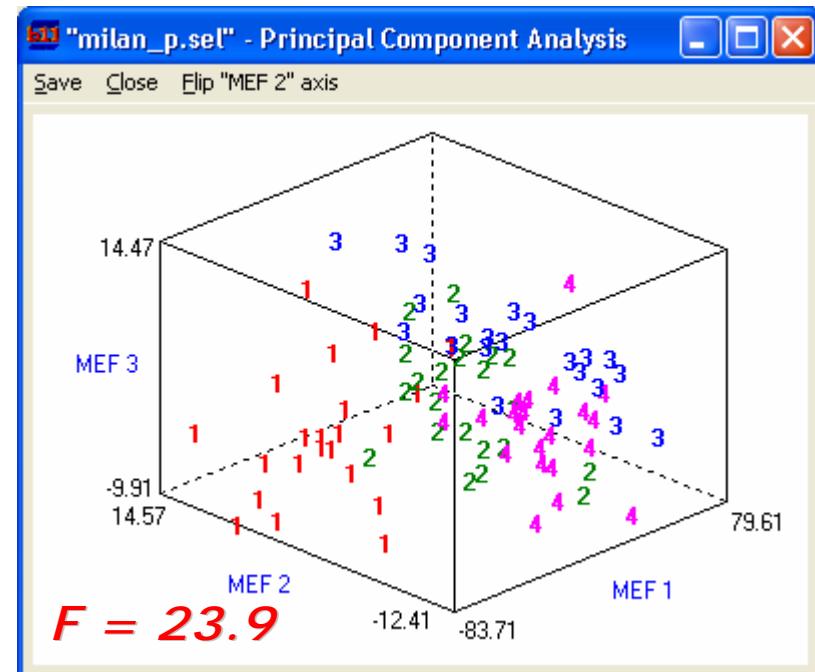
Exploratory data analysis and classification

Raw data



1-NN: 8 classification errors

First 3 PCAs



1-NN: 10 classification errors

Example - PS phantom image analysis

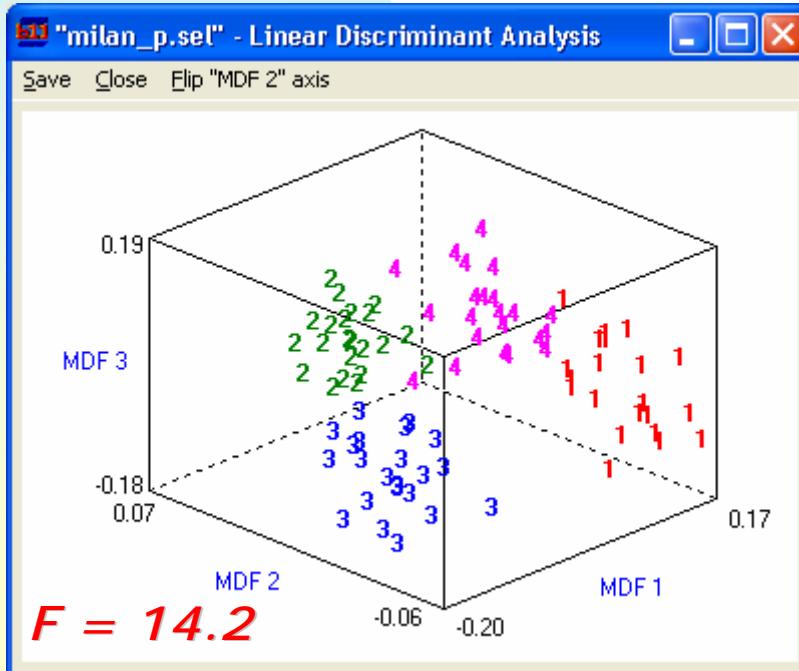


b11



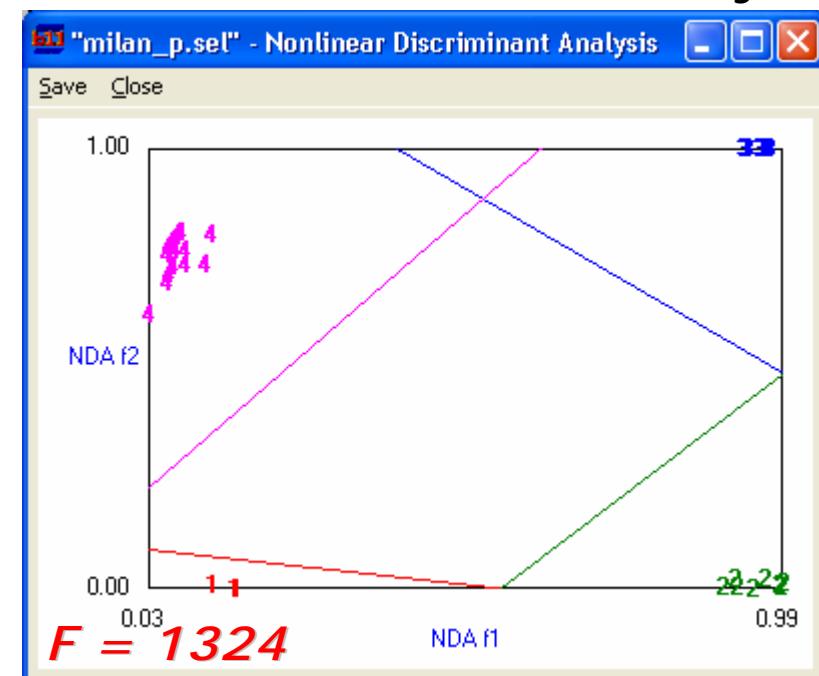
Exploratory data analysis and classification

Linear Discriminant Analysis



1-NN: 0 classification errors

Nonlinear Discriminant Analysis



1-NN: 0 classification errors

Summary



- *MaZda* allows computation of almost all texture parameters known up to date.
- It is a unique tool for quantitative analysis of image texture.
- *MaZda* report files can be further studied using *Matlab*®, *Excel*®, *Statistica*®, etc.
- It supports 12 image file formats.
- The program is being extensively tested worldwide (> 300 download requests).
- Shareware version will be launched soon.