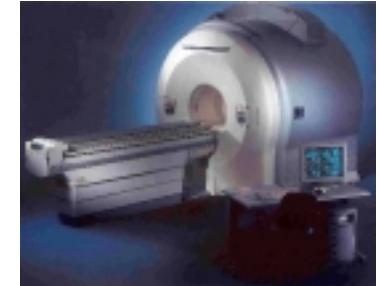


# Introduction to Software Package

---

Andrzej MATERKA,  
Technical University of Lodz, Poland

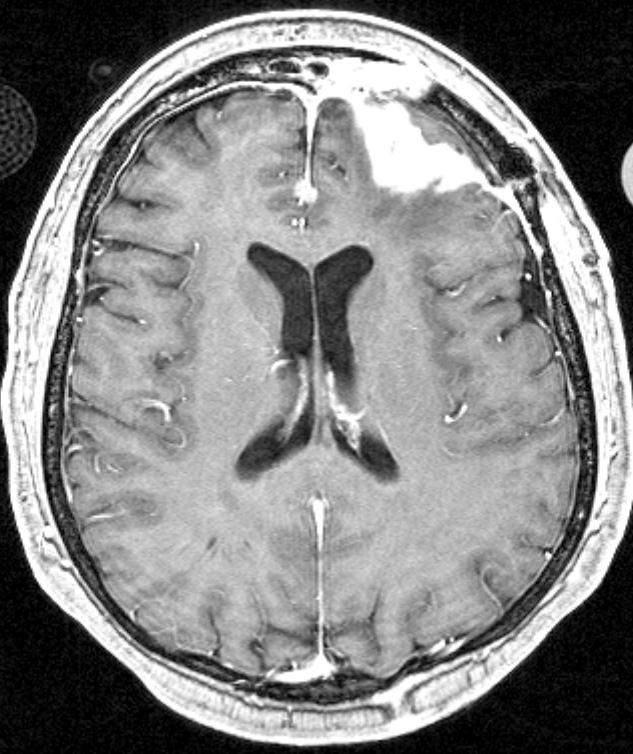
# COST B11: “Software and Statistics” Working Group



## Goals

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

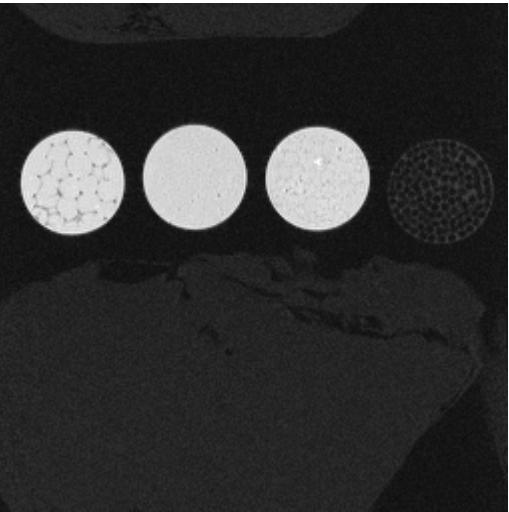
# Material (on CD)



PS + foam + clinical examples

| d:\brussels2000\lothar\* |       |      |
|--------------------------|-------|------|
| Name                     | Ext   | Size |
| ..[..]                   | <DIR> |      |
| [clinical_examples]      | <DIR> |      |
| [phantoms]               | <DIR> |      |

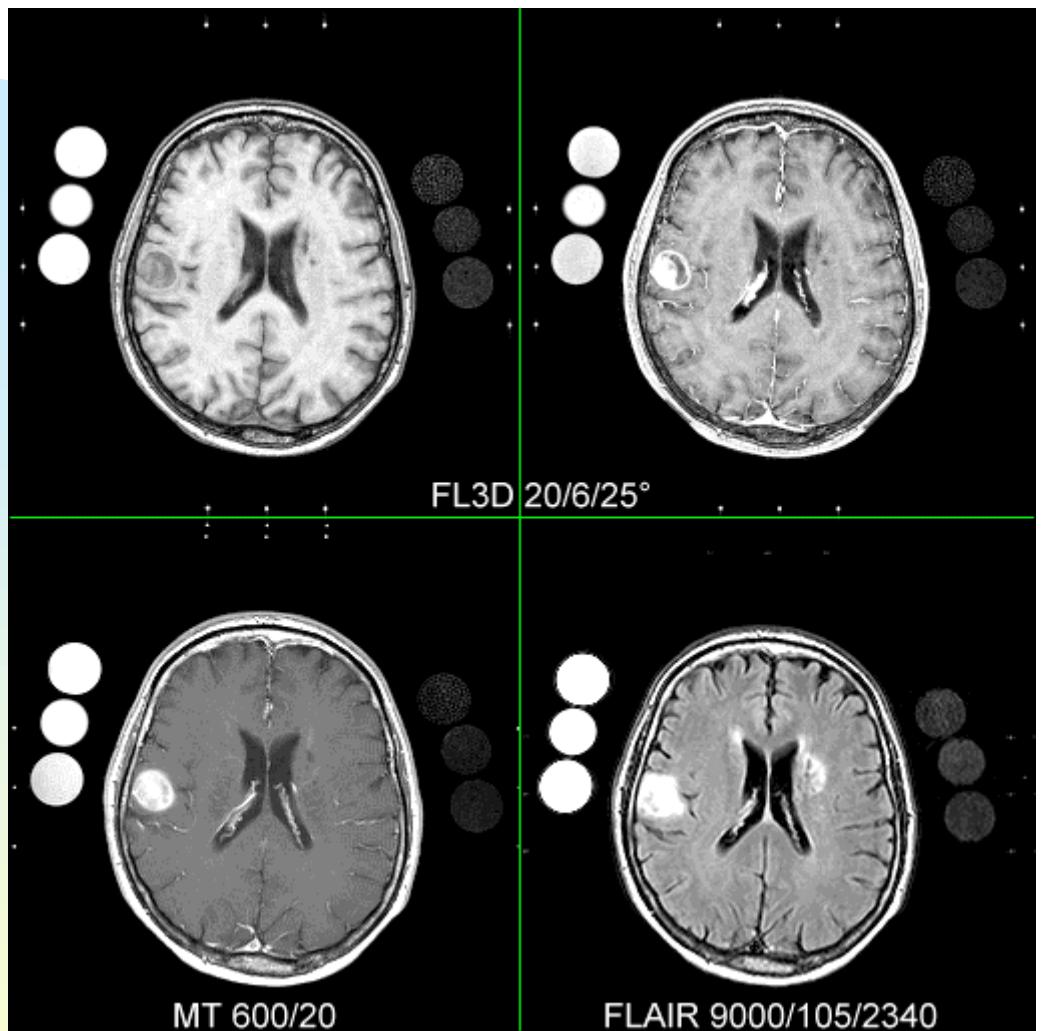
| Name     |
|----------|
| ..[..]   |
| [733-0]  |
| [733-6]  |
| [733-7]  |
| [733-8]  |
| [735-57] |
| [735-6]  |
| [735-61] |
| [735-62] |
| [735-63] |
| [735-64] |
| [737-0]  |
| [737-2]  |
| [737-4]  |
| [737-5]  |
| [737-6]  |
| [763-0]  |
| [763-2]  |
| [763-3]  |
| [763-4]  |
| [771-0]  |
| [771-59] |
| [771-60] |



## Phantoms

| Name           |
|----------------|
| ..[..]         |
| [FOV100thick2] |
| [FOV100thick4] |
| [FOV200thick2] |
| [FOV200thick4] |

# Material (on CD)

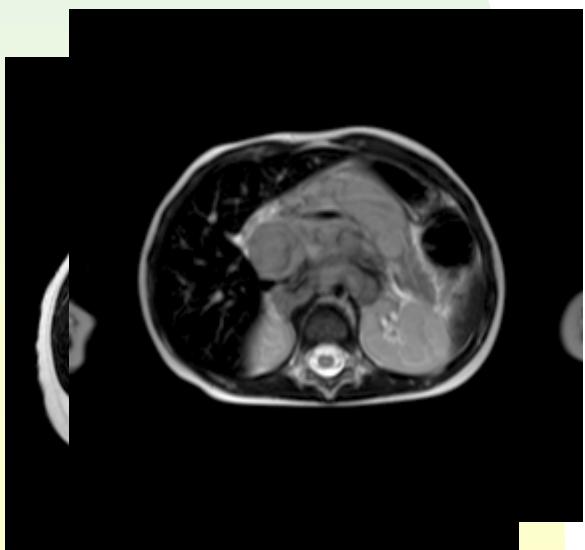
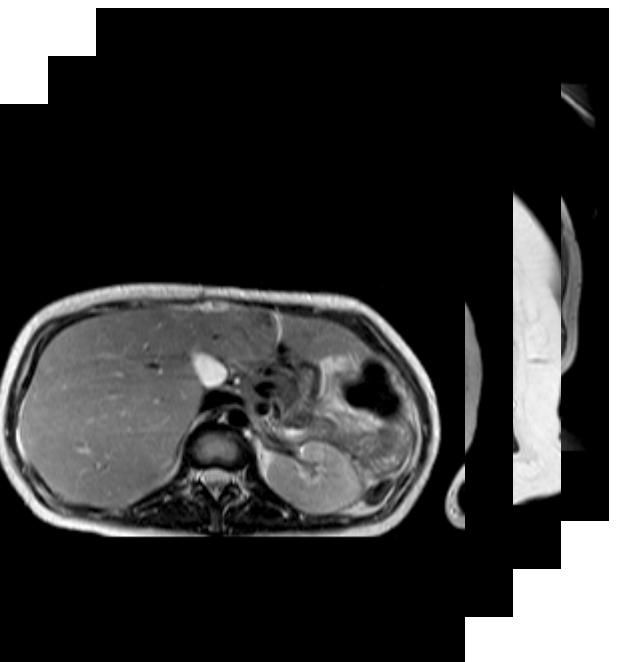
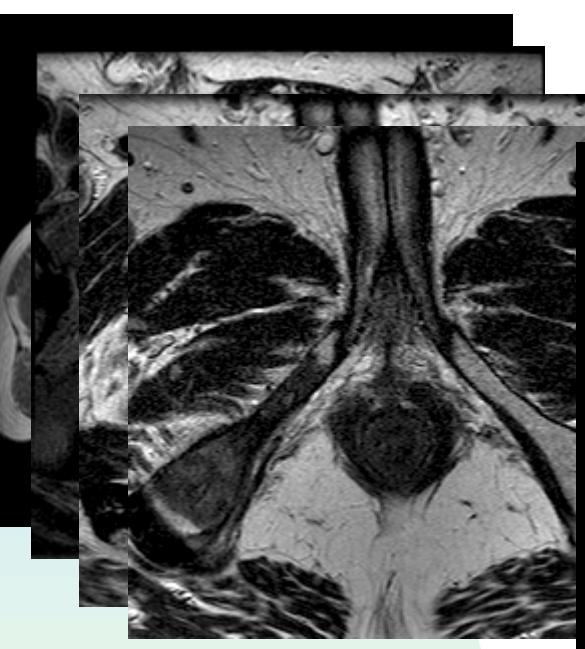


## Patient data

| d:\brussels2000\* |       |      |
|-------------------|-------|------|
| Name              | Ext   | Size |
| t..[.]            | <DIR> |      |
| [phantoms]        | <DIR> |      |
| [heidelberg]      | <DIR> |      |
| [lothar]          | <DIR> |      |
| [software]        | <DIR> |      |

| Name                      | Ext   | Size      |
|---------------------------|-------|-----------|
| t..[.]                    | <DIR> |           |
| [clinical_examples]       | <DIR> |           |
| [phantoms]                | <DIR> |           |
| patient #1                | eml   | 2 728 096 |
| patient #2                | eml   | 2 916 439 |
| patient #3                | eml   | 4 721 313 |
| patient #4 (missed ima..) | eml   | 729 197   |
| patient #4                | eml   | 3 267 032 |
| patient #5                | eml   | 2 728 015 |
| patient #6                | eml   | 3 994 162 |
| patient #7 (last one)     | eml   | 3 994 173 |

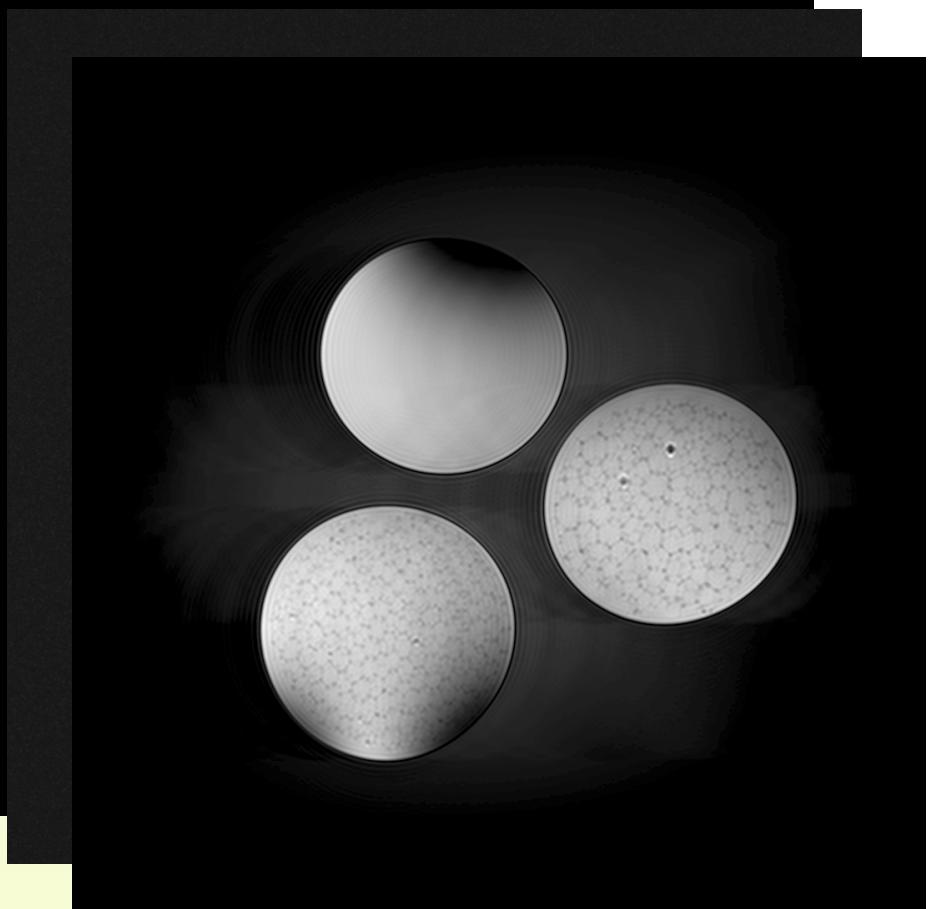
# Material (on CD)



| d:\brussels2000\* |      |       |
|-------------------|------|-------|
| Name              | ↑Ext | Size  |
| ⬆..[..]           |      | <DIR> |
| 📁 [hans]          |      | <DIR> |
| 📁 [heidelberg]    |      | <DIR> |
| 📁 [lothar]        |      | <DIR> |
| 📁 [software]      |      | <DIR> |

| d:\brussels2000\hans\aarhus_cost_ |      |       |
|-----------------------------------|------|-------|
| Name                              | ↑Ext | Size  |
| ⬆..[..]                           |      | <DIR> |
| 📁 [c_prostata.1]                  |      | <DIR> |
| 📁 [c_prostata.2]                  |      | <DIR> |
| 📁 [c_prostata.3]                  |      | <DIR> |
| 📁 [c_prostata.4]                  |      | <DIR> |
| 📁 [l_cirrous]                     |      | <DIR> |
| 📁 [l_cirrous_pancreatitis.1]      |      | <DIR> |
| 📁 [l_cirrous_pancreatitis.2]      |      | <DIR> |
| 📁 [l_cirrous_pancreatitis.3]      |      | <DIR> |
| 📁 [l_tomour]                      |      | <DIR> |
| 📁 [neuroblastom]                  |      | <DIR> |
| 📁 [phantoms]                      |      | <DIR> |
| 📁 [pregnant]                      |      | <DIR> |
| 📁 [ratimages]                     |      | <DIR> |
| readme                            | .txt | 1 401 |

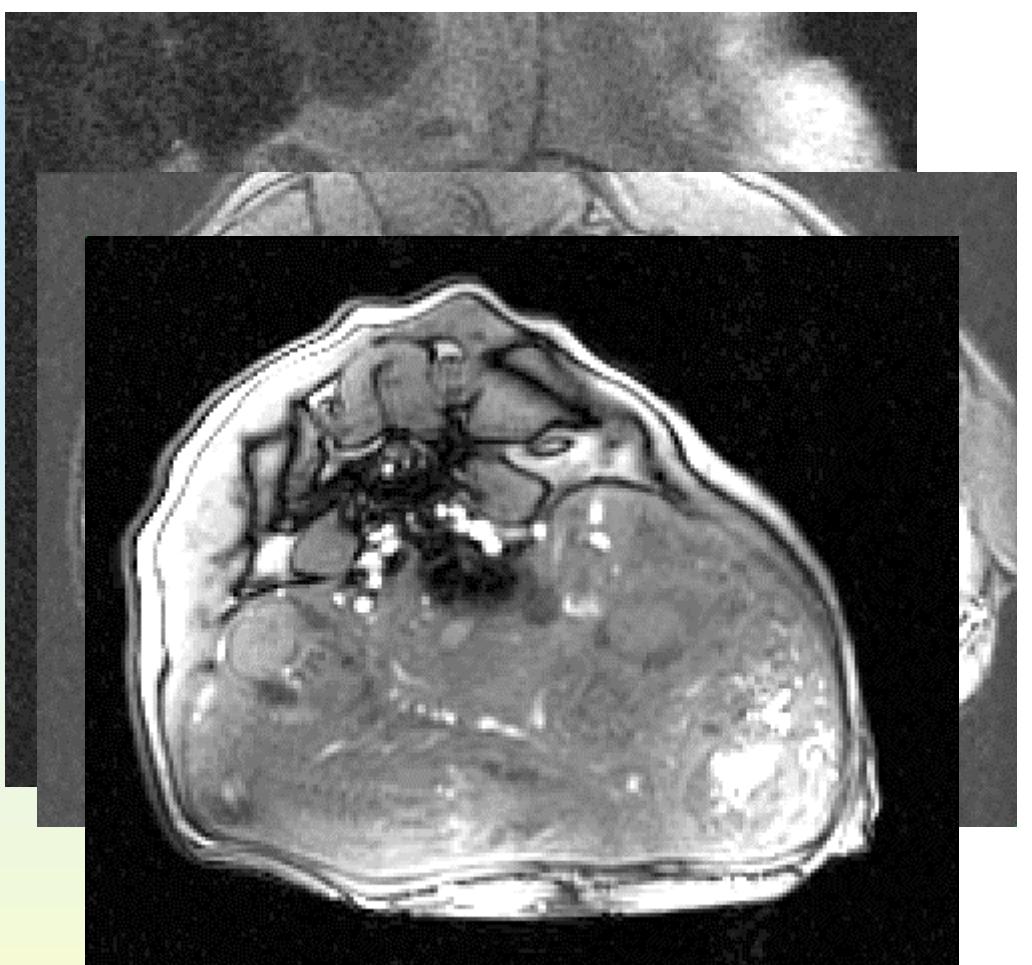
# Material (on CD)



| d:\brussels2000\* |     |       |
|-------------------|-----|-------|
| Name              | Ext | Size  |
| t..[...]          |     | <DIR> |
| [hans]            |     | <DIR> |
| [heidelberg]      |     | <DIR> |
| [lothar]          |     | <DIR> |
| [software]        |     | <DIR> |

| d:\brussels2000\hans\aarhus_cost_ |     |       |
|-----------------------------------|-----|-------|
| Name                              | Ext | Size  |
| t..[...]                          |     | <DIR> |
| [c_prostata.1]                    |     | <DIR> |
| [c_prostata.2]                    |     | <DIR> |
| [c_prostata.3]                    |     | <DIR> |
| [c_prostata.4]                    |     | <DIR> |
| [l_cirrous]                       |     | <DIR> |
| [l_cirrous_pancreatitis.1]        |     | <DIR> |
| [l_cirrous_pancreatitis.2]        |     | <DIR> |
| [l_cirrous_pancreatitis.3]        |     | <DIR> |
| [l_tomour]                        |     | <DIR> |
| [neuroblastom]                    |     | <DIR> |
| [phantoms]                        |     | <DIR> |
| [pregnant]                        |     | <DIR> |
| [ratimages]                       |     | <DIR> |
| readme                            | txt | 1 401 |

# Material (on CD)



| d:\brussels2000\* |     |       |
|-------------------|-----|-------|
| Name              | Ext | Size  |
| t..[...]          |     | <DIR> |
| [hans]            |     | <DIR> |
| [heidelberg]      |     | <DIR> |
| [lothar]          |     | <DIR> |
| [software]        |     | <DIR> |

| d:\brussels2000\hans\aarhus_cost_ |     |       |
|-----------------------------------|-----|-------|
| Name                              | Ext | Size  |
| t..[...]                          |     | <DIR> |
| [c_prostata.1]                    |     | <DIR> |
| [c_prostata.2]                    |     | <DIR> |
| [c_prostata.3]                    |     | <DIR> |
| [c_prostata.4]                    |     | <DIR> |
| [l_cirrous]                       |     | <DIR> |
| [l_cirrous_pancreatitis.1]        |     | <DIR> |
| [l_cirrous_pancreatitis.2]        |     | <DIR> |
| [l_cirrous_pancreatitis.3]        |     | <DIR> |
| [l_tomour]                        |     | <DIR> |
| [neuroblastom]                    |     | <DIR> |
| [phantoms]                        |     | <DIR> |
| [pregnant]                        |     | <DIR> |
| [ratimages]                       |     | <DIR> |
| readme                            | txt | 1 401 |

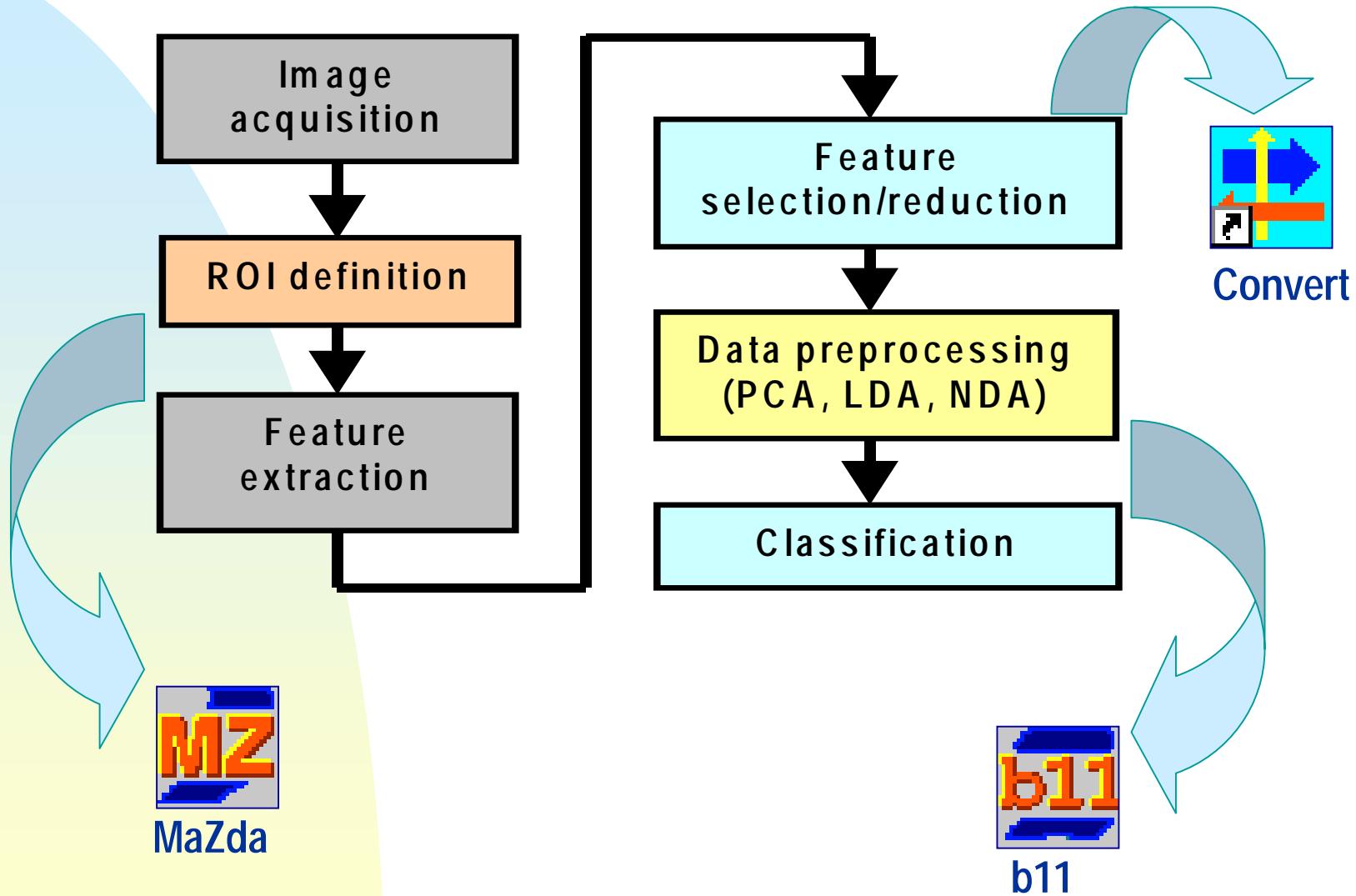
# Material (on CD)

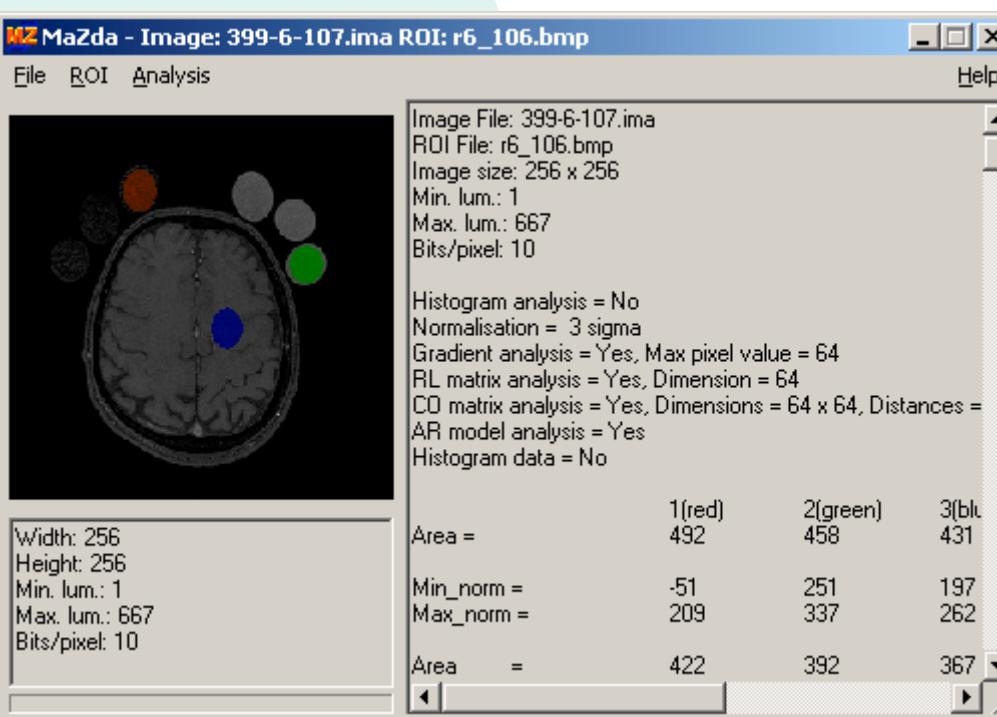


| d:\brussels2000\* |     |       |
|-------------------|-----|-------|
| Name              | Ext | Size  |
| t..[.]            |     | <DIR> |
| [hans]            |     | <DIR> |
| [heidelberg]      |     | <DIR> |
| [lothar]          |     | <DIR> |
| [software]        |     | <DIR> |

| d:\brussels2000\hans\aarhus_cost_ |     |       |
|-----------------------------------|-----|-------|
| Name                              | Ext | Size  |
| t..[.]                            |     | <DIR> |
| [c_prostata.1]                    |     | <DIR> |
| [c_prostata.2]                    |     | <DIR> |
| [c_prostata.3]                    |     | <DIR> |
| [c_prostata.4]                    |     | <DIR> |
| [l_cirrous]                       |     | <DIR> |
| [l_cirrous_pancreatitis.1]        |     | <DIR> |
| [l_cirrous_pancreatitis.2]        |     | <DIR> |
| [l_cirrous_pancreatitis.3]        |     | <DIR> |
| [l_tomour]                        |     | <DIR> |
| [neuroblastom]                    |     | <DIR> |
| [phantoms]                        |     | <DIR> |
| [pregnant]                        |     | <DIR> |
| [ratimages]                       |     | <DIR> |
| readme                            | txt | 1 401 |

# Methods





# MaZda, ver. 2.21

## Feature extraction

Input: images in 11 file formats

## Methods

histogram, gradient, CO matrix,  
AR model (total of 259 features)

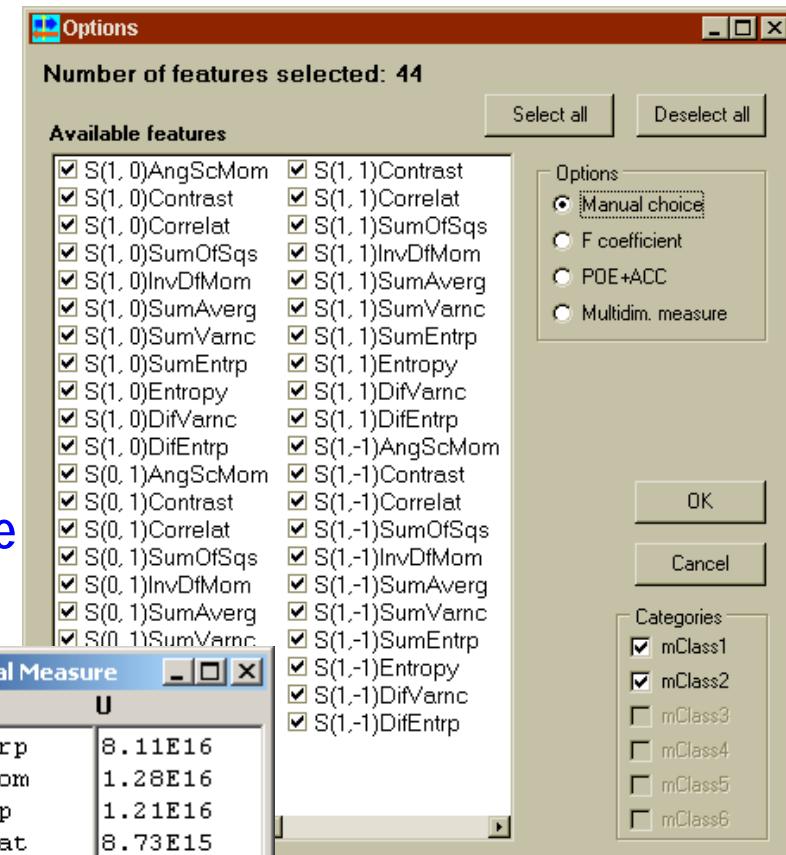
## Output:

- (\*.par) text file,
- (\*.bmp) histograms
- (\*.bmp) feature maps

# Convert



## Feature selection



Input: (\*.par) files from Mazda

Methods: Fisher coefficient, POE+ACC,  
multidimesional analysis of variance, manual choice

Output: (\*.sel) files

Three windows are shown side-by-side. The left window, titled 'F Fisher coefficient', lists features with their F values. The middle window, titled 'P POE+ACC', lists features with their POE+ACC values. The right window, titled 'U Multidimensional Measure', lists features with their U values. All three windows have columns for 'Feature name' and either 'F', 'POE+ACC', or 'U'.

| Feature name    | F     |
|-----------------|-------|
| S(1, 1)Correlat | 44.00 |
| S(0, 1)Correlat | 43.52 |
| S(1, 0)Correlat | 37.59 |
| S(1, 1)SumVarnc | 36.19 |
| S(0, 1)Contrast | 35.72 |
| S(1, 0)Contrast | 33.66 |
| S(1, 1)Contrast | 33.01 |
| S(1, 0)DifEntrp | 31.47 |
| Sigma           | 29.65 |
| S(1,-1)Correlat | 27.96 |

| Feature name    | POE+ACC |
|-----------------|---------|
| GrMean          | 0.00    |
| S(0, 1)SumVarnc | 0.02    |
| S(4, 4)DifVarnc | 0.06    |
| Teta4           | 0.10    |
| S(0, 5)Correlat | 0.10    |
| S(4,-4)SumAverg | 0.10    |
| S(5, 0)DifVarnc | 0.11    |
| S(1, 0)DifEntrp | 0.10    |
| S(1, 0)SumVarnc | 0.12    |
| S(1,-1)InvDfMom | 0.12    |

| Feature name    | U       |
|-----------------|---------|
| S(0, 1)SumEntrp | 8.11E16 |
| S(0, 4)AngScMom | 1.28E16 |
| 45dgr_ShrtREmp  | 1.21E16 |
| S(4,-4)Correlat | 8.73E15 |
| S(4, 0)Entropy  | 6.63E15 |
| S(0, 4)DifEntrp | 6.42E15 |
| S(5,-5)InvDfMom | 4.63E15 |
| S(0, 4)InvDfMom | 3.43E15 |
| S(4, 0)AngScMom | 3.38E15 |
| S(1,-1)SumEntrp | 3.24E15 |

**b11 - m25.txt**

Files 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 3.004e-1 -5.460e-2 4.466e-1 4.100e-2 8.:
1 2.936e-1 -4.150e-2 4.428e-1 7.440e-2 8.:
1 3.630e-1 -7.520e-2 4.042e-1 5.020e-2 7.:
```

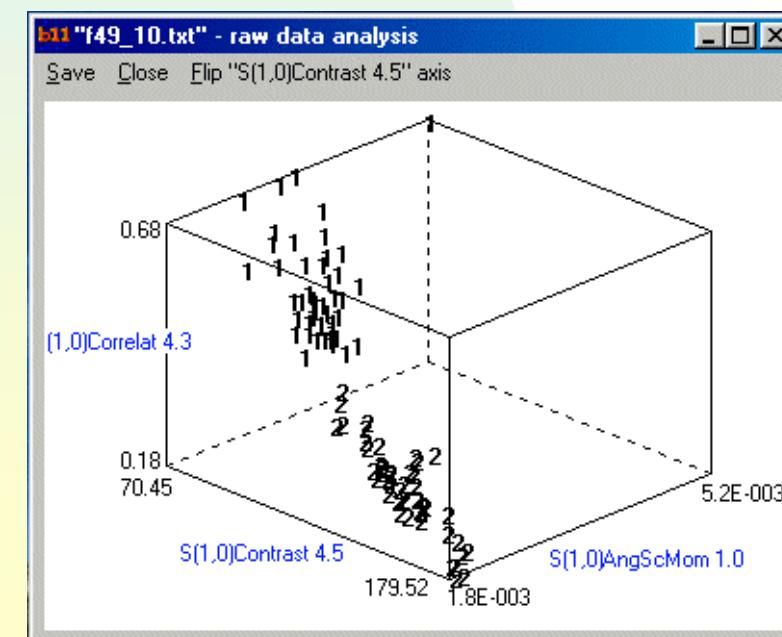
**Output (report)**

```
* b11 report file [raw data analysis]
* Data file name: "m25.txt"
* Selected features [5 out of 5]
teta1 [#1/#1]; p.mean= 1.35928E-001, p.std= 1
teta2 [#2/#2]; p.mean=-4.31560E-002, p.std= 6
teta3 [#3/#3]; p.mean= 2.79588E-001, p.std= 1
teta4 [#4/#4]; p.mean= 2.06920E-002, p.std= 3
sigma [#5/#5]; p.mean= 9.08444E-001, p.std= 7
Feature vector standardized: NO
* Results [raw data analysis]
> Fisher coefficient, F = 40.0
```

**B11**

**Input**  
- (\*.sel) files

**Output**  
- text files,  
- BMP graphs



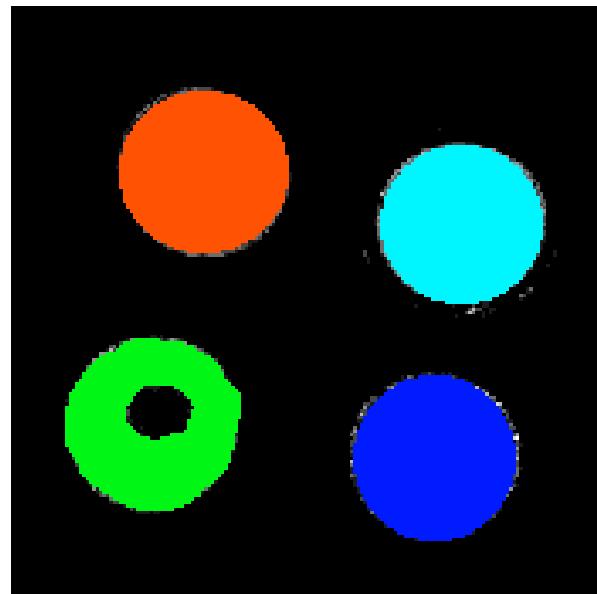
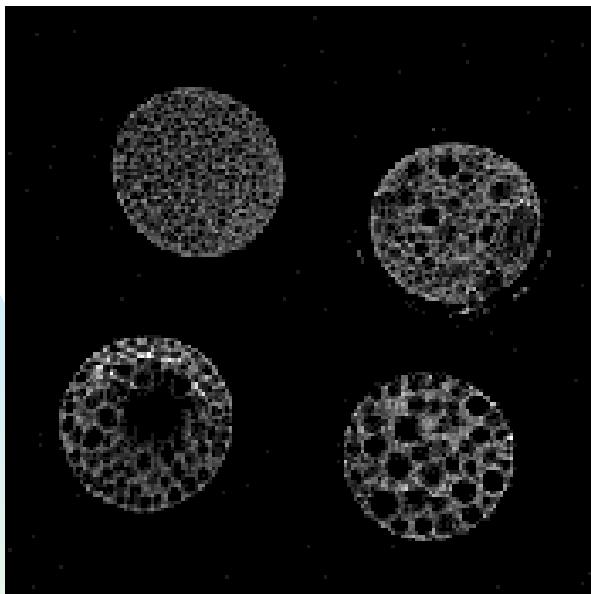
**Analysis,  
classification**

**Methods**

- data analysis: raw, PCA, LDA, NDA
- classification: k-NN, neural network

# Example - PS phantom image analysis

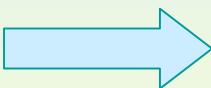
22 images



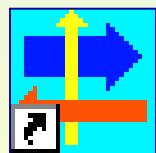
- class 1
- class 2
- class 3
- class 4



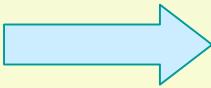
MaZda



22 (\*.par) files, each contains 259 texture parameters



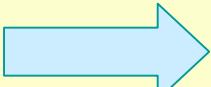
Convert



2 (\*.sel) files, each of 10 parameters (F, POE)



b11



Exploratory data analysis and classification

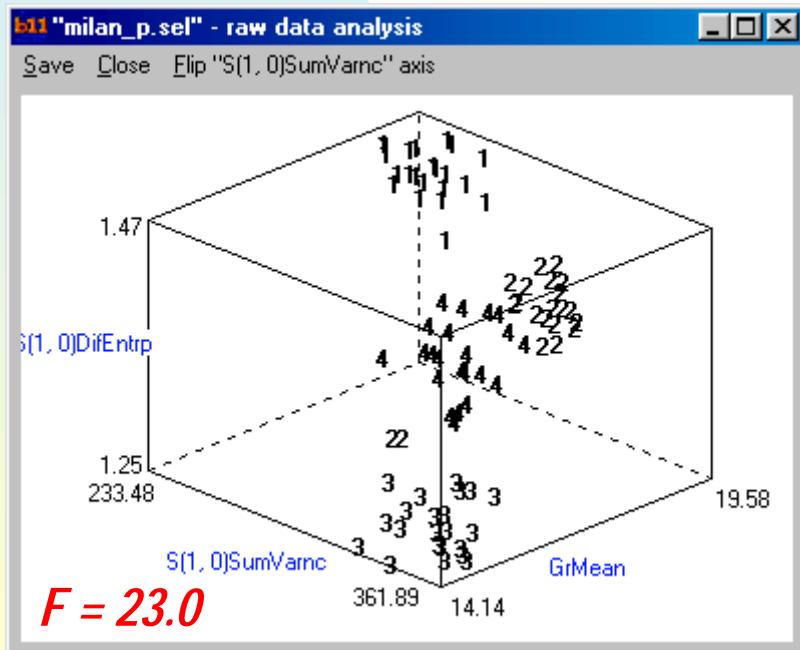
# Example - PS phantom image analysis



b11

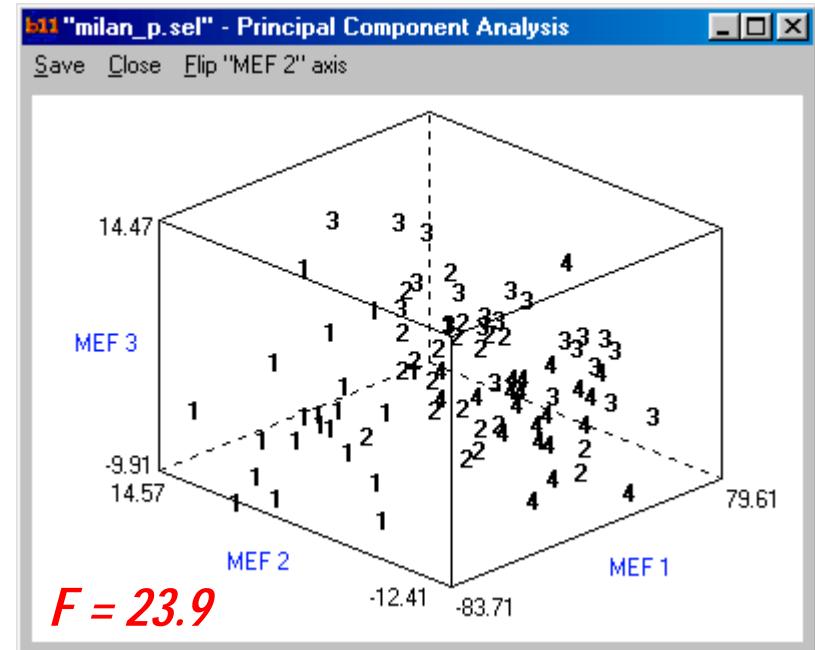
Exploratory data analysis and classification

Raw data



1-NN: 8 classification errors

First 3 PCAs



1-NN: 10 classification errors

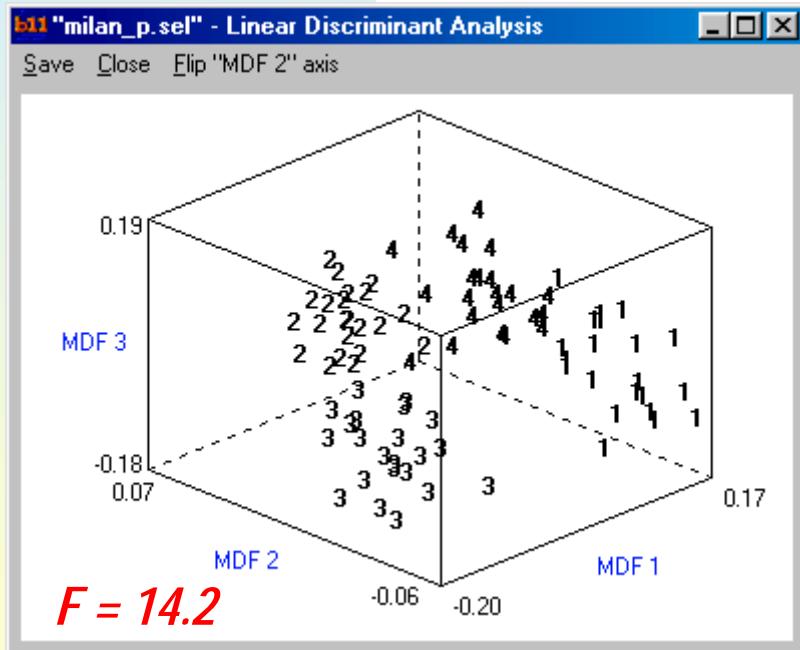
# Example - PS phantom image analysis



b11

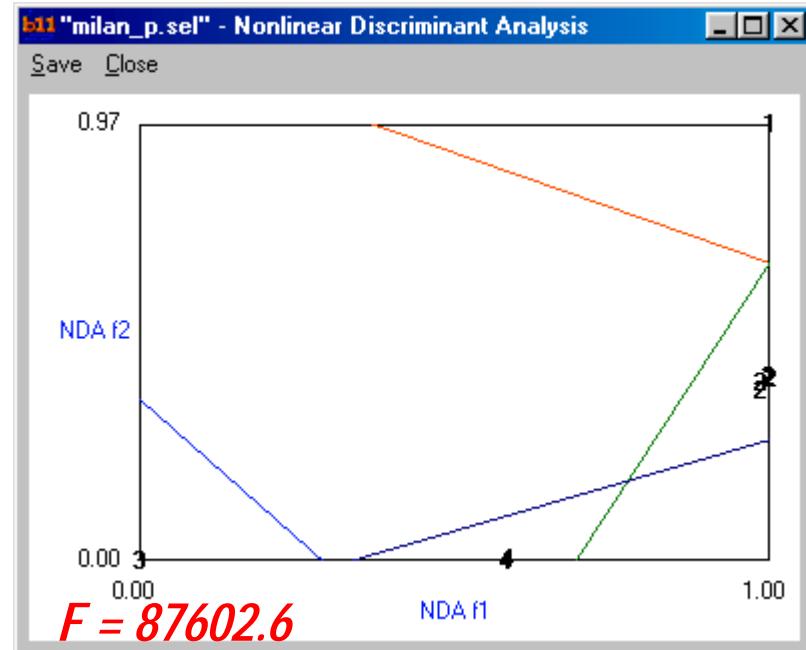
Exploratory data analysis and classification

## Linear Discriminant Analysis



1-NN: 0 classification errors

## Nonlinear Discriminant Analysis



0 classification errors

## Projects under way



- MaZda: ROI editor (to replace MS Paint).
- MaZda: new texture features (wavelets and mathematical morphology).
- MaZda: reading header of image files, supporting new image file standards.
- MaZda: image brightness scaling (optionally manual/auto).
- MaZda: integration of tools (ROIEdit, BMPView).
- Convert: feature reduction and selection techniques.
- B11: testing on separate data sets (PCA, LDA, ANN).
- Extensive experiments using test object and biological MRI.