Technical University of Lodz
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# MAZDA – THE SOFTWARE PACKAGE FOR TEXTURAL ANALYSIS OF BIOMEDICAL IMAGES

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# Functionality

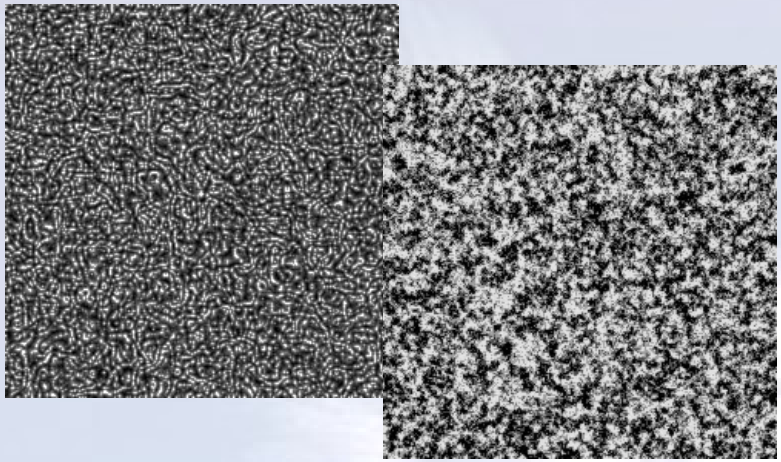

*A MaZda:*

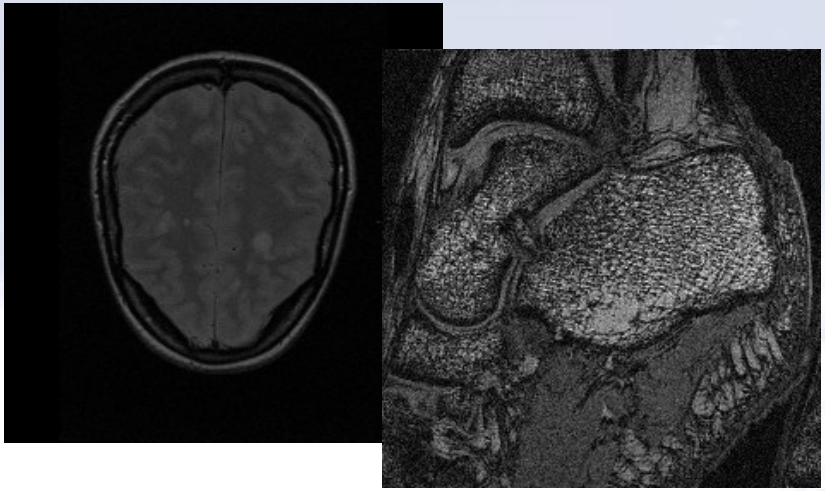
- *is a software package for 2D and 3D image texture analysis*
- *computes a variety of textural features within arbitrarily shaped regions of interest*
- *computes feature maps of images*
- *performs statistical analysis of computed feature sets*
- *aids in image texture classification*

# The long story short

- Development started in 1996 with the Mammo program (Łódź-Warszawa)
- Combining procedures from NMRWin (DKFZ-Heidelberg)
- MaZda – the name derived from Macierz Zdarzeń
- 1998-2002 development within COST B11, 2002-2007 COST B21 project
- aimed at analysis of magnetic resonance images texture

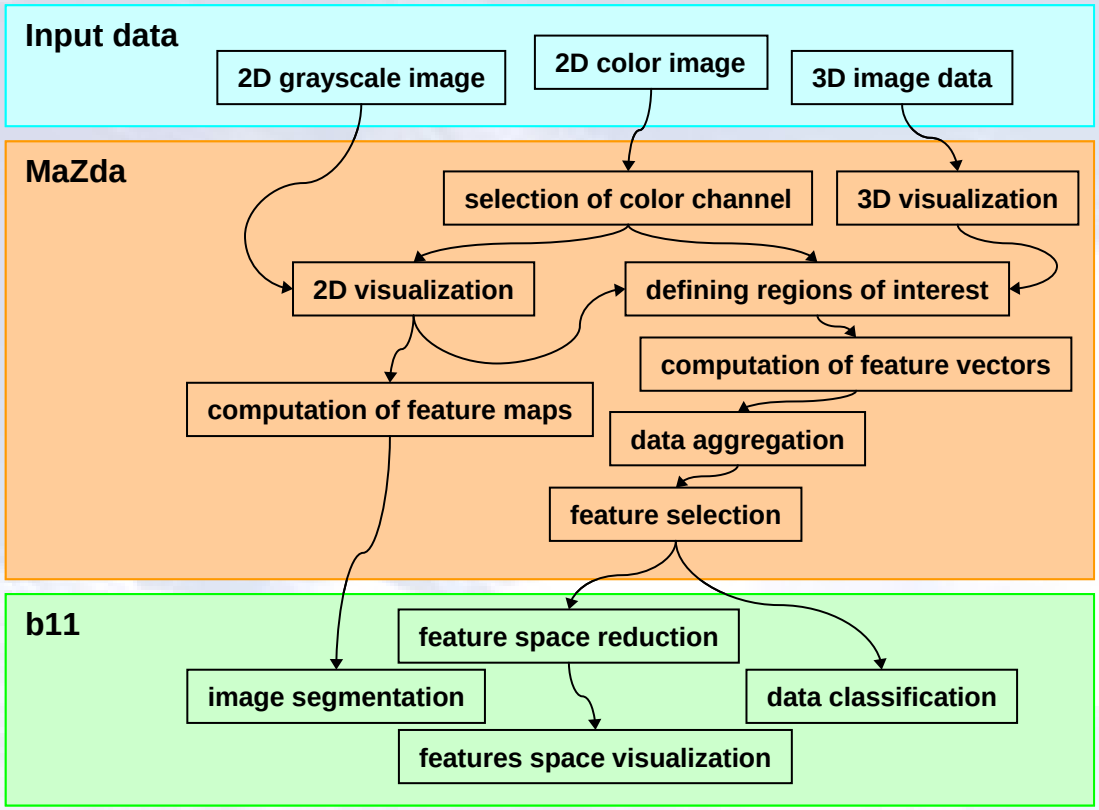
# Texture

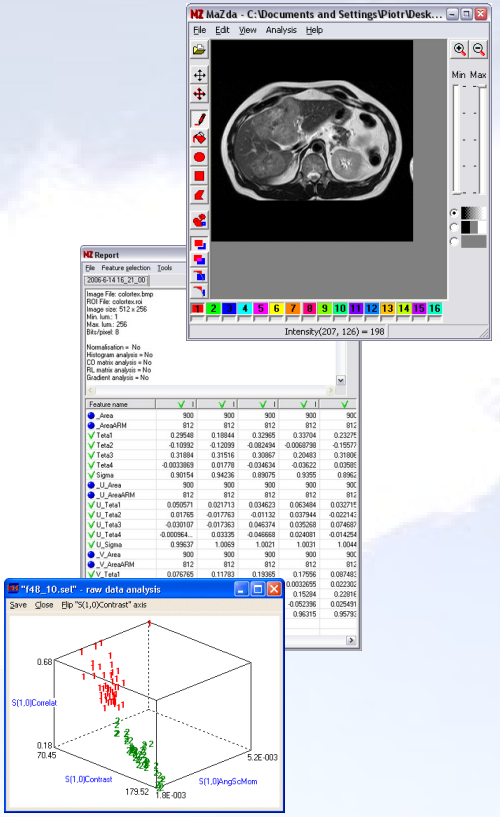




- perceived by humans as complex patterns composed of spatially organized, repeated subpatterns, which have characteristic somewhat uniform appearance
- carries substantial information about the structure of physical objects – analysis is an important issue in image processing and understanding

# Analysis pathways

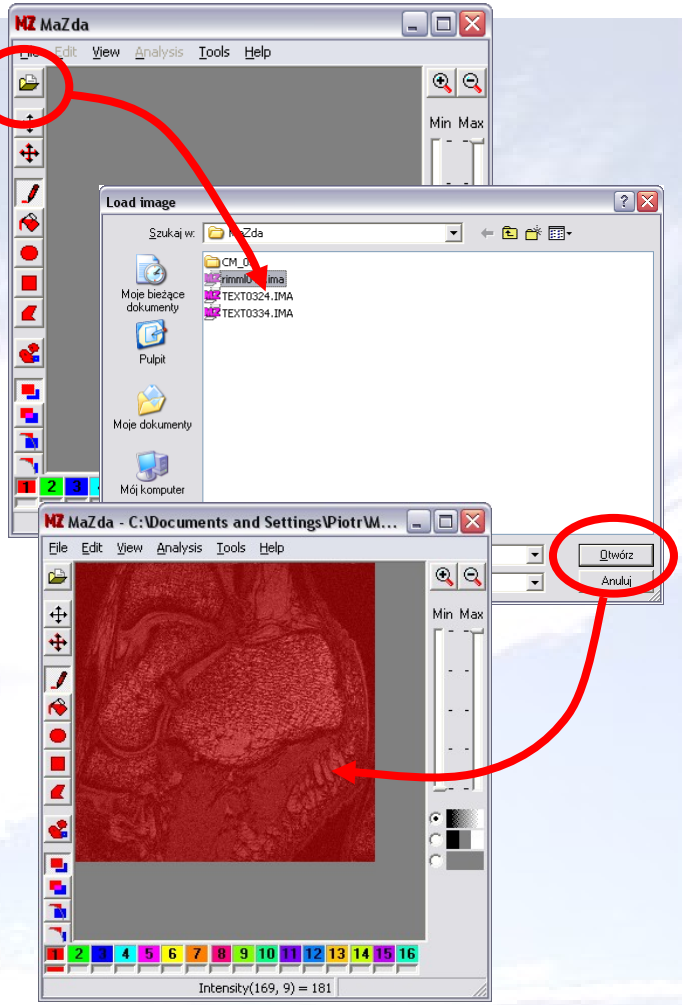


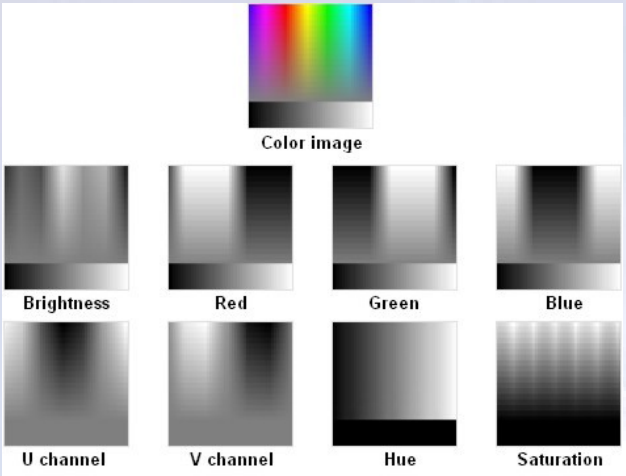
# Image loading

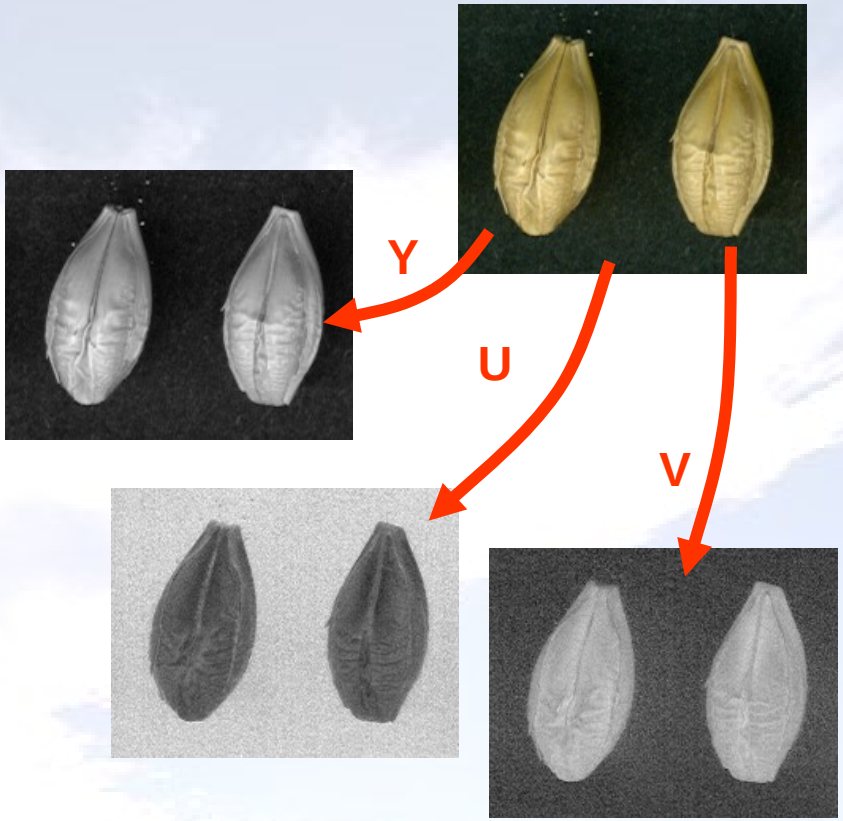
Gray-scale images formats to load:

- Siemens NUMARIS 2 and 3
- Siemens Vision
- ACR NEMA
- GE Advantage
- GE IDBM
- IGE – YMS
- Bruker Aspect 3000
- Picker
- Dicom
- Windows Bitmap
- Unformatted 8 or 16 bits/pixel



# Color image loading




Disadvantage - texture analysis methods for gray-scale image analysis only.

To extract substantial information procedures for color to gray-scale image conversion are implemented.

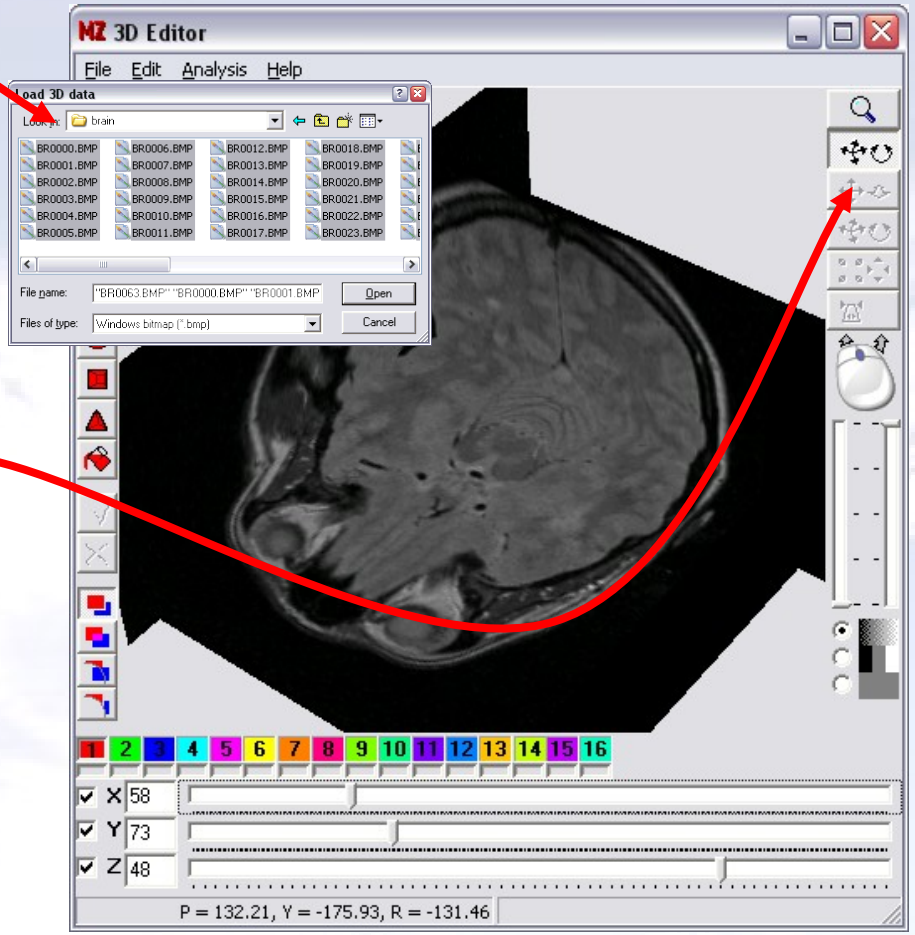
# 3D image loading

Loading:

- Window bitmaps
- 3D Bmf format
- 3D Dicom data

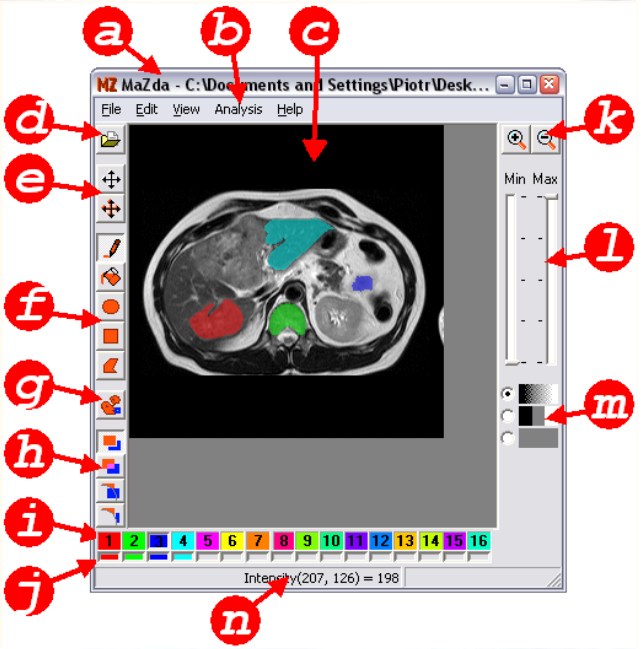
View adjustment:

- cross-sections selection
- adjustment of angles
- zoom
- gray-scale window
- gray-scale thresholds



# Region of interest

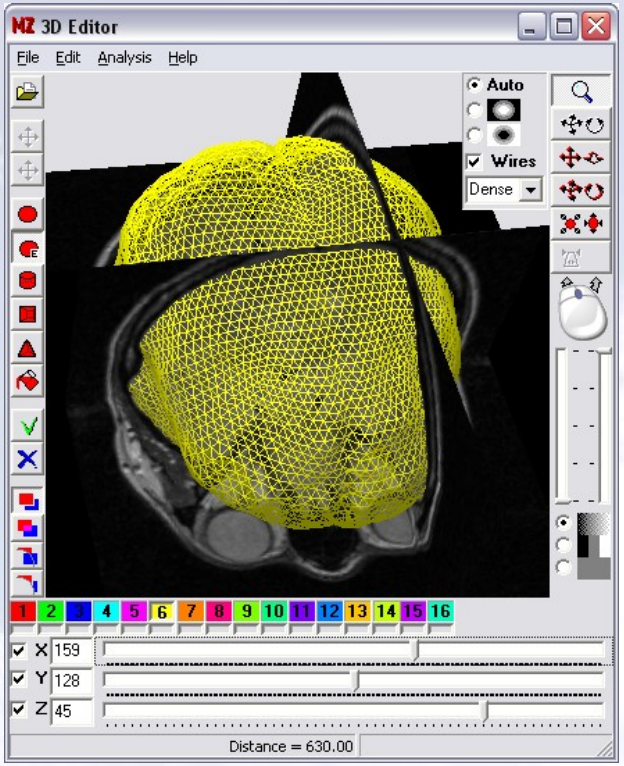
- Region of interest (ROI) is a set of pixels in 2D image or voxels in 3D image selected for processing.
- ROIs concentrate computation effort on image fragment that is relevant to a goal of computation and thus helps avoid processing of unnecessary image fragments.

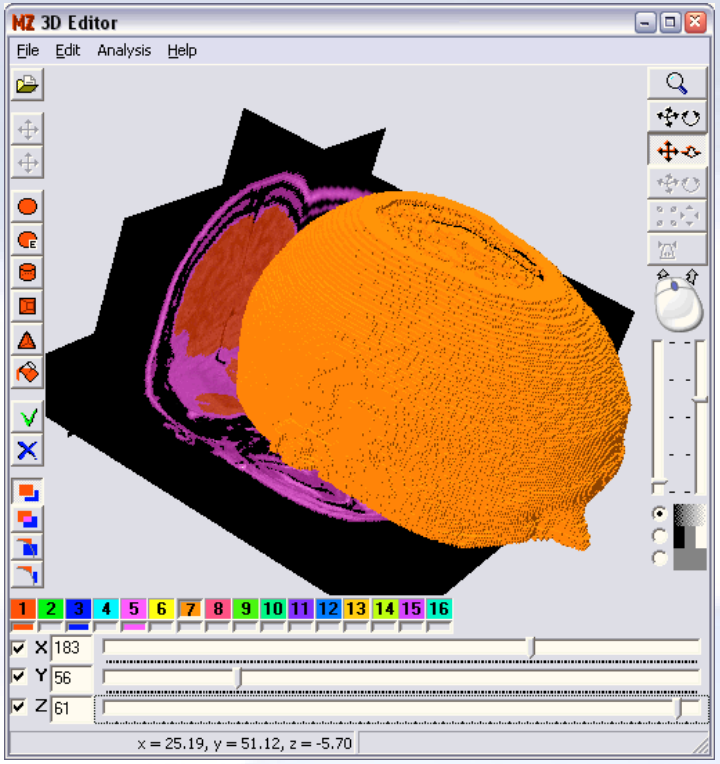



*2D ROI Editor in MaZda*

a) window title bar, b) menu bar, c) image panel, d) load file button, e) copy and move buttons, f) graphics toolbar for ROI edition, g) morphological tools for ROI edition, h) drawing mode selection buttons, i) ROI color selector, j) ROI on/off switches, k) zoom in/out buttons, l) sliders for adjustment of grey-scale palette, m) image view mode selector, n) status bar

# 3D ROIs



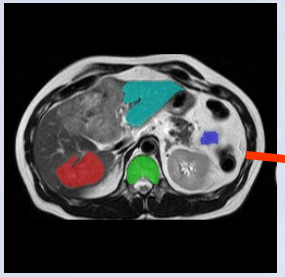



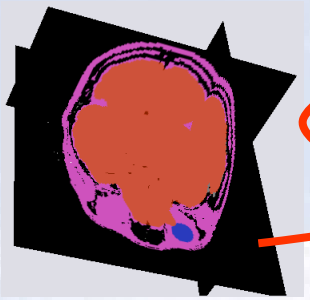

*3D ROI Editor in MaZda*

a) Defining ROI with interactive tool of elastic surface

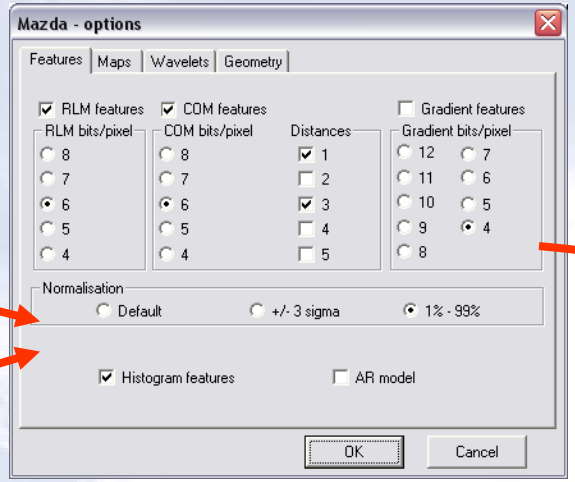
b) ROI found with flood-fill algorithm

# Textural features computation

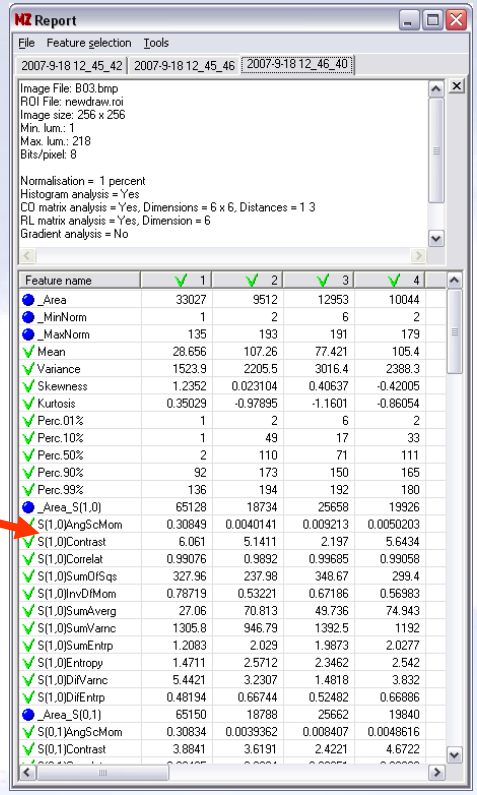




a) Input image (2D or 3D) with the defined ROIs




b) Options for the analysis (selection of feature groups to compute, algorithms parameters, image normalization options, etc.)




| Feature name | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| _Area | 33027 | 9512 | 12953 | 10044 |
| _MinNorm | 1 | 2 | 6 | 2 |
| _MaxNorm | 135 | 193 | 191 | 179 |
| Mean | 28.656 | 107.26 | 77.421 | 105.4 |
| Variance | 1523.9 | 2205.5 | 3016.4 | 2388.3 |
| Skewness | 1.2352 | 0.023104 | 0.40637 | -0.42005 |
| Kurtosis | 0.35029 | -0.97895 | -1.1601 | -0.86054 |
| Perc.01% | 1 | 2 | 6 | 2 |
| Perc.10% | 1 | 49 | 17 | 33 |
| Perc.50% | 2 | 110 | 71 | 111 |
| Perc.90% | 92 | 173 | 150 | 165 |
| Perc.99% | 136 | 194 | 192 | 180 |
| _Area_S(1,0) | 65128 | 18734 | 25658 | 19926 |
| S(1,0)AngScMom | 0.30849 | 0.0040141 | 0.009213 | 0.0050203 |
| S(1,0)Contrast | 6.061 | 5.1411 | 2.197 | 5.6434 |
| S(1,0)Correlat | 0.99076 | 0.9892 | 0.99685 | 0.99058 |
| S(1,0)SumOfSqs | 327.96 | 237.98 | 348.67 | 299.4 |
| S(1,0)InvDfMom | 0.78719 | 0.53221 | 0.67186 | 0.56983 |
| S(1,0)SumAverg | 27.06 | 70.813 | 49.736 | 74.943 |
| S(1,0)SumVarnc | 1305.8 | 946.79 | 1392.5 | 1192 |
| S(1,0)SumEntrp | 1.2083 | 2.029 | 1.9873 | 2.0277 |
| S(1,0)Entropy | 1.4711 | 2.5712 | 2.3462 | 2.542 |
| S(1,0)DifVarnc | 5.4421 | 3.2307 | 1.4818 | 3.832 |
| S(1,0)DifEntrp | 0.48194 | 0.66744 | 0.52482 | 0.66886 |
| _Area_S(0,1) | 65150 | 18788 | 25662 | 19840 |
| S(0,1)AngScMom | 0.30834 | 0.0039362 | 0.008407 | 0.0048616 |
| S(0,1)Contrast | 3.8841 | 3.6191 | 2.4221 | 4.6722 |

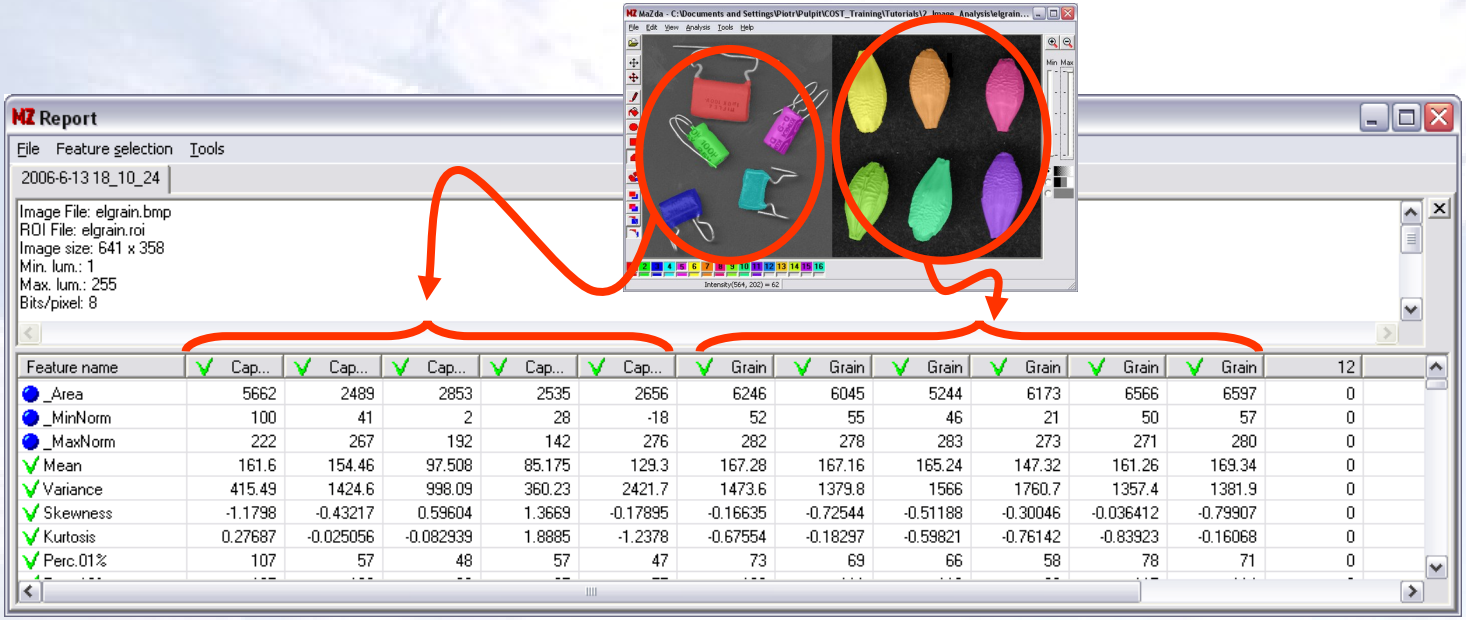
c) Resulting list of textural features (columns of the report correspond with the defined ROIs)

# Feature lists analysis

A Goal:
Finding a way
of texture classification

Tools:

- Combining reports for further analysis
- Defining class names of regions (columns)
- Selection of most discriminative features



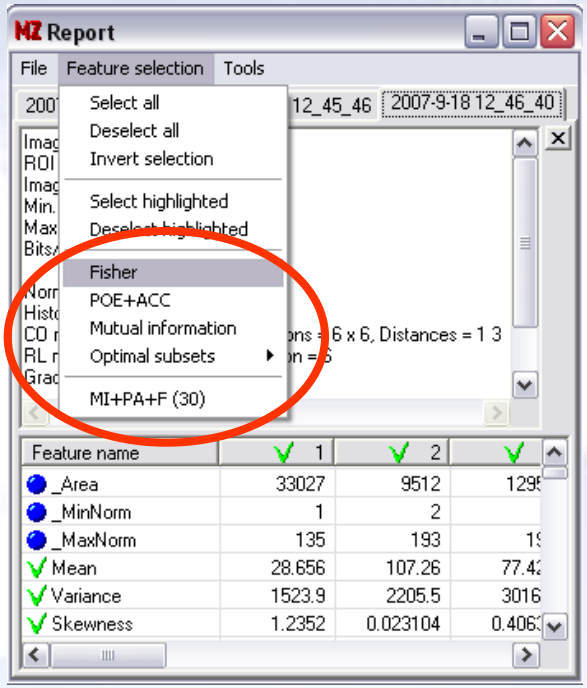

| Feature name | Cap... | Cap... | Cap... | Cap... | Cap... | Grain | Grain | Grain | Grain | Grain | Grain | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| _Area | 5662 | 2489 | 2853 | 2535 | 2656 | 6246 | 6045 | 5244 | 6173 | 6566 | 6597 | 0 |
| _MinNorm | 100 | 41 | 2 | 28 | -18 | 52 | 55 | 46 | 21 | 50 | 57 | 0 |
| _MaxNorm | 222 | 267 | 192 | 142 | 276 | 282 | 278 | 283 | 273 | 271 | 280 | 0 |
| Mean | 161.6 | 154.46 | 97.508 | 85.175 | 129.3 | 167.28 | 167.16 | 165.24 | 147.32 | 161.26 | 169.34 | 0 |
| Variance | 415.49 | 1424.6 | 998.09 | 360.23 | 2421.7 | 1473.6 | 1379.8 | 1566 | 1760.7 | 1357.4 | 1381.9 | 0 |
| Skewness | -1.1798 | -0.43217 | 0.59604 | 1.3669 | -0.17895 | -0.16635 | -0.72544 | -0.51188 | -0.30046 | -0.036412 | -0.79907 | 0 |
| Kurtosis | 0.27687 | -0.025056 | -0.082939 | 1.8885 | -1.2378 | -0.67554 | -0.18297 | -0.59821 | -0.76142 | -0.83923 | -0.16068 | 0 |
| Perc.01% | 107 | 57 | 48 | 57 | 47 | 73 | 69 | 66 | 58 | 78 | 71 | 0 |

# Feature selection

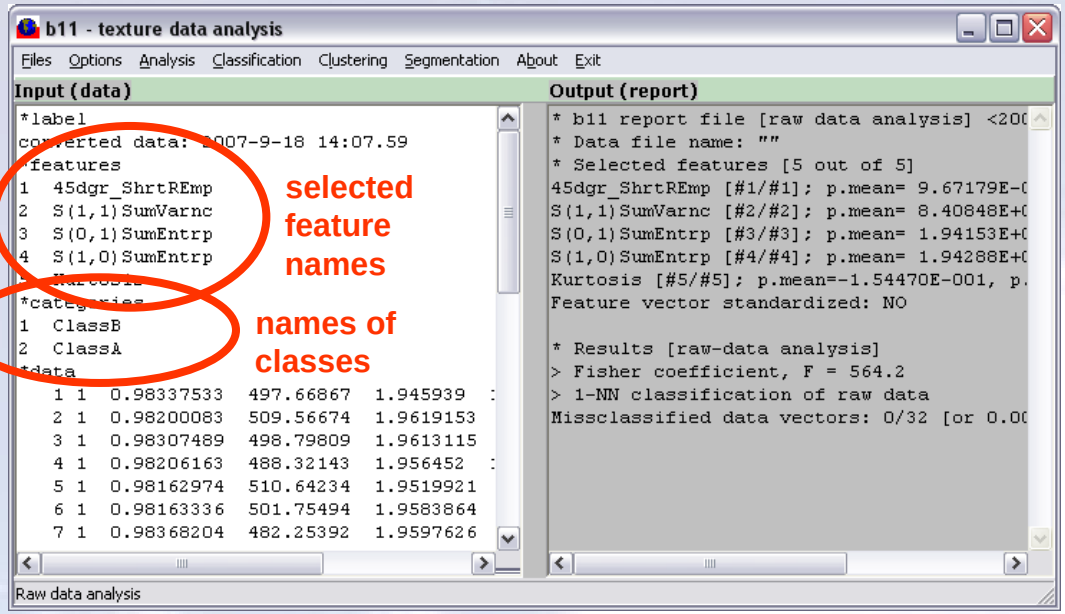
1.The number of features computed by MaZda may reach several-hundred per region, which is difficult to handle.
2.The several-hundred features turns into the problem of analysis of a several-hundred-dimensional space => time consuming, inefficient or even not feasible.
3.Usually only a limited number of features carry relevant information needed for texture discrimination.

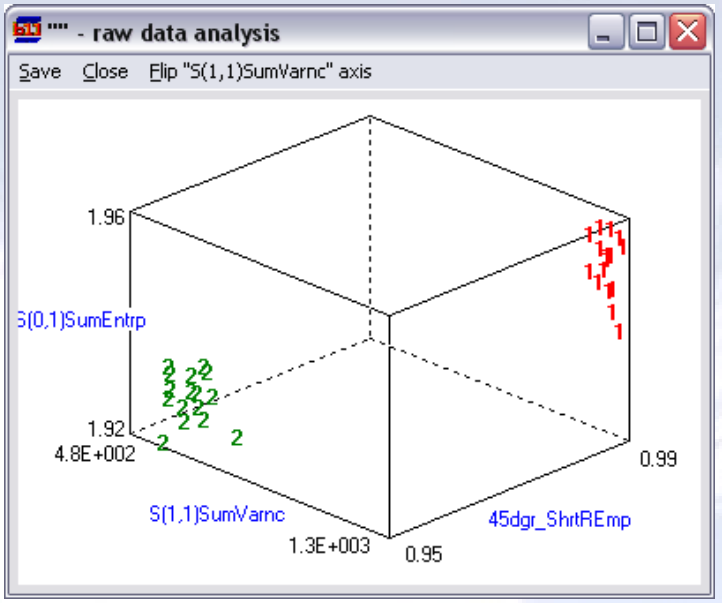
<u>MaZda allows for selection of most effective features and rejection of the others.</u>

Four methods for feature selection are implemented, which use different mathematical criteria:
1.Fisher coefficient
2.classification error combined with correlation coefficient
3.mutual information
4.optimal subsets with minimal 1-NN classification error



# Feature space visualization




List of selected features loaded into B11 module. The features are computed for textures of two different classes.

Visualization of feature space in B11 module.