

Technical University of Lodz Institute of Electronics

MAZDA – THE SOFTWARE PACKAGE FOR TEXTURAL ANALYSIS OF BIOMEDICAL IMAGES

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ICCMA, Łódź 2007



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

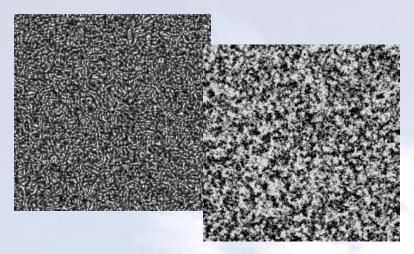


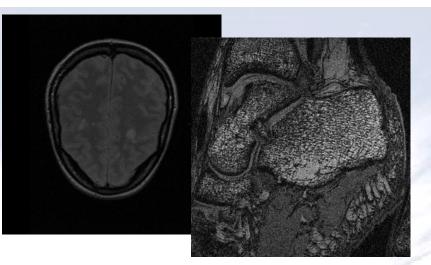
The long story short

- 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

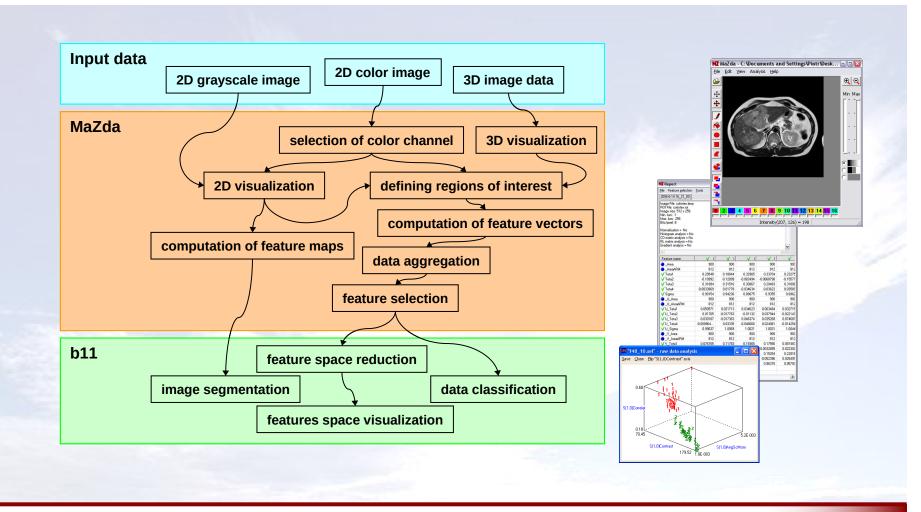




- perceived by humans as complex patterns composed of spatially organized, repeated subpatterns, which have characteristic somewhat uniform appearance
- carries substantial information about the structure of physical objects – analysis is an important issue in image processing and understanding



Analysis pathways

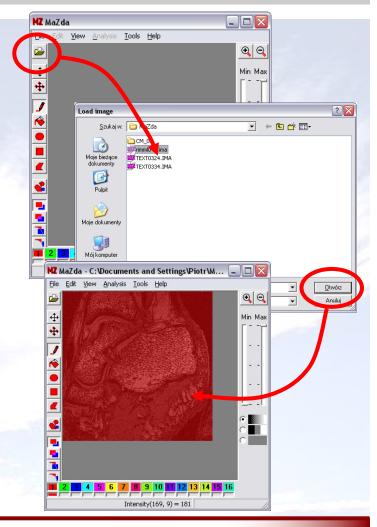


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Image loading

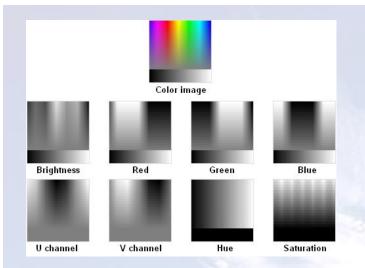
Gray-scale images formats to load:

- 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



<u>Disadvantage</u> - texture analysis methods for gray-scale image analysis only.

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

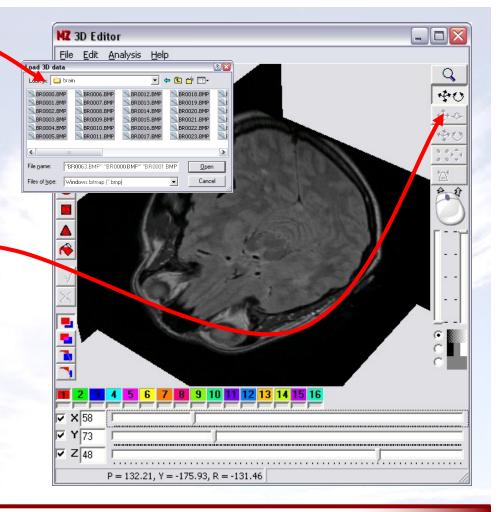
3D image loading

Loading:

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

View adjustment:

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



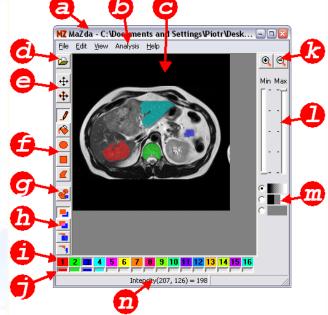


Region of interest

- 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.

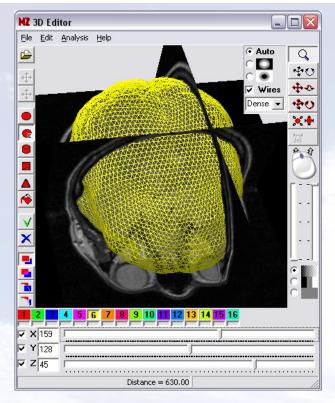
2D ROI Editor in MaZda

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

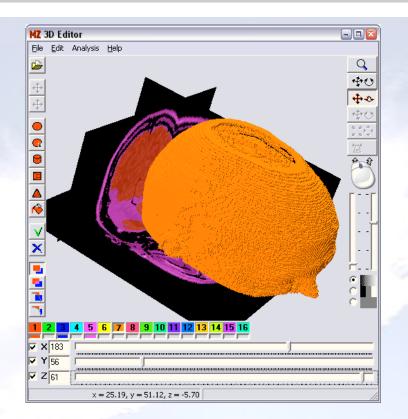




3D ROIs



3D ROI Editor in MaZda a) Defining ROI with interactive tool of elastic surface



b) ROI found with flood-fill algorithm

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Textural features computation

	Mazda - options 🛛 🔀
2	Features Maps Wavelets Geometry
	Image: RLM features Image: COM features Image: Gradient features RLM bits/pixel COM bits/pixel Distances Gradient features RLM bits/pixel COM bits/pixel Distances Gradient bits/pixel 0 7 7 1 1 0 6 Image: Standard Standar
t image 3D) with	b) Options for the analysis (selection of feature groups to compute, algorithms parameters, image normalization options, etc.)

File Feature selection	Tools				
	-	5 46 2007-9-1	8 12 /6 /0		
1	JU7-3-10 12_40	_40 _2001 0 1	0 12_40_40		_
Image File: B03.bmp R01 File: newdraw.roi Image size: 256 x 256 Min. lum.: 1 Max. lum.: 218 Bits/pixel: 8 Normalisation = 1 percen Histogram analysis = Yes.					
CO matrix analysis = Yes,		6 x 6, Distances	=13		
RL matrix analysis = Yes, Gradient analysis = No	Dimension = 6				
				>	~
Feature name	✓ 1	✓ 2	√ 3	✓ 4	
O_Area	33027	9512	12953	10044	_
_MinNorm	1	2	6	2	_
_MaxNorm	135	193	191	179	_
V Mean	28.656	107.26	77.421	105.4	_
Variance	1523.9	2205.5	3016.4	2388.3	
V Skewness	1.2352	0.023104	0.40637	-0.42005	
V Kurtosis	0.35029	-0.97895	-1.1601	-0.86054	
V Perc.01%	1	2	6	2	
V Perc.10%	1	49	17	33	
V Perc.50%	92	110 173	150	111	
✓ Perc.90% ✓ Perc.99%	92 136	173	192	165	
	65128	194	25658	19926	
_Area_S(1,0) S(1,0)AngScMom	0.30849	0.0040141	0.009213	0.0050203	
✓ S(1,0)Contrast	6.061	5.1411	2.197	5.6434	
V S(1,0)Correlat	0.99076	0.9892	0.99685	0.99058	
V S(1,0)SumOfSqs	327.96	237.98	348.67	299.4	
V S(1,0)InvDfMom	0.78719	0.53221	0.67186	0.56983	
V S(1,0)SumAverg	27.06	70.813	49.736	74.943	
V S(1,0)SumVarnc	1305.8	946.79	1392.5	1192	
V S(1,0)SumEntrp	1.2083	2.029	1.9873	2.0277	
V S(1,0)Entropy	1.4711	2.5712	2.3462	2.542	
✓ S(1,0)DiVarnc	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	
	0.30834	0.0039362	0.008407	0.0048616	
√S(0.1)AnaScMom					
✓ S(0,1)AngScMom ✓ 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)

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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

		1	-		Be Edt yew ⊕ +	Analysis Look Heb	20		Iysis lelgrain	1			
🛿 Report												_	
File Feature selection	<u>T</u> ools						1						
2006-6-13 18_10_24						N 🔊	\geq						
Image File: elgrain.bmp ROI File: elgrain.roi Image size: 641 x 358 Min. lum.: 1 Max. lum.: 255 Bits/pixel: 8			Ļ			6 7 8 7 10 10 12 Intensty(564, 202) = 62		Y					
<													>
Feature name	V Cap	√ Cap	✓ Cap	V Cap	V Cap	V Grain	V Grain	V Grain	V Grain	V Grain	V Grain	12	2
	✓ Cap 5662	✓ Cap 2489	✓ Cap 2853	✓ Cap 2535	✓ Cap 2656	✓ Grain 6246	✓ Grain 6045	✓ Grain 5244	✓ Grain 6173	✓ Grain	✓ Grain 6597	12	<u>></u>
🔴 _Area						_				_			<u>></u>
⊖_Area ⊖_MinNorm	5662	2489	2853	2535	2656	6246	6045	5244	6173	6566	6597	0	
🔴 _Area 🔴 _MinNorm	5662 100	2489 41	2853 2	2535 28	2656 -18	6246 52	6045 55	5244 46	6173 21	6566 50	6597 57	0	
●_Area ●_MinNorm ●_MaxNorm ✔ Mean	5662 100 222	2489 41 267	2853 2 192	2535 28 142	2656 -18 276	6246 52 282	6045 55 278	5244 46 283	6173 21 273	6566 50 271	6597 57 280	0 0	
●_Area ●_MinNorm ●_MaxNorm ✔ Mean	5662 100 222 161.6	2489 41 267 154.46	2853 2 192 97.508	2535 28 142 85.175	2656 -18 276 129.3	6246 52 282 167.28	6045 55 278 167.16	5244 46 283 165.24	6173 21 273 147.32	6566 50 271 161.26	6597 57 280 169.34	0 0 0 0	
●_Area ●_MinNorm ●_MaxNorm √ Mean √ Variance	5662 100 222 161.6 415.49	2489 41 267 154.46 1424.6	2853 2 192 97.508 998.09	2535 28 142 85.175 360.23	2656 -18 276 129.3 2421.7	6246 52 282 167.28 1473.6	6045 55 278 167.16 1379.8	5244 46 283 165.24 1566	6173 21 273 147.32 1760.7	6566 50 271 161.26 1357.4	6597 57 280 169.34 1381.9	0 0 0 0 0	
●_Area ●_MinNorm ●_MaxNorm ✔ Mean ✔ Variance ✔ Skewness	5662 100 222 161.6 415.49 -1.1798	2489 41 267 154.46 1424.6 -0.43217	2853 2 192 97.508 998.09 0.59604	2535 28 142 85.175 360.23 1.3669	2656 -18 276 129.3 2421.7 -0.17895	6246 52 282 167.28 1473.6 -0.16635	6045 55 278 167.16 1379.8 -0.72544	5244 46 283 165.24 1566 -0.51188	6173 21 273 147.32 1760.7 -0.30046	6566 50 271 161.26 1357.4 -0.036412	6597 57 280 169.34 1381.9 -0.79907	0 0 0 0 0	



Feature selection

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

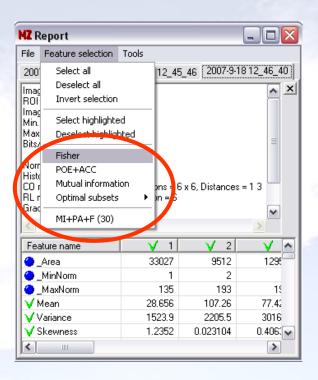
MaZda allows for selection of most effective features and rejection of the others.

Four methods for feature selection are implemented, which use different mathematical criteria:

1. Fisher coefficient

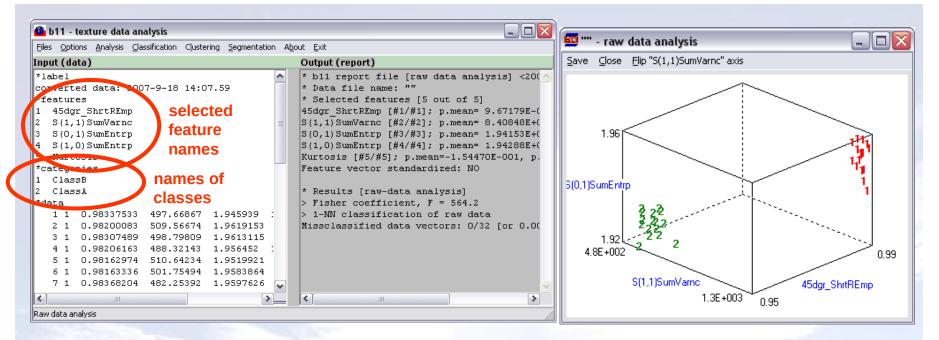
2.classification error combined with correlation coefficient 3.mutual information

4.optimal subsets with minimal 1-NN classification error





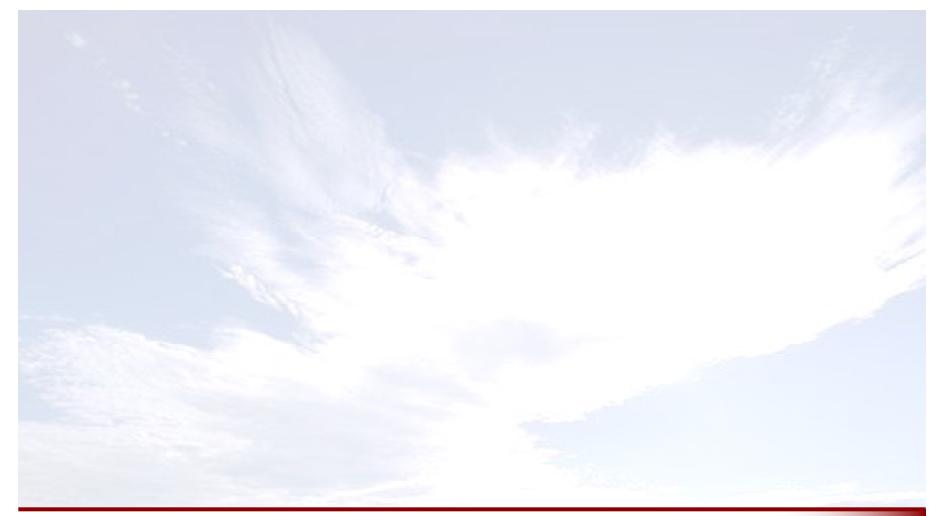
Feature space visualization



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

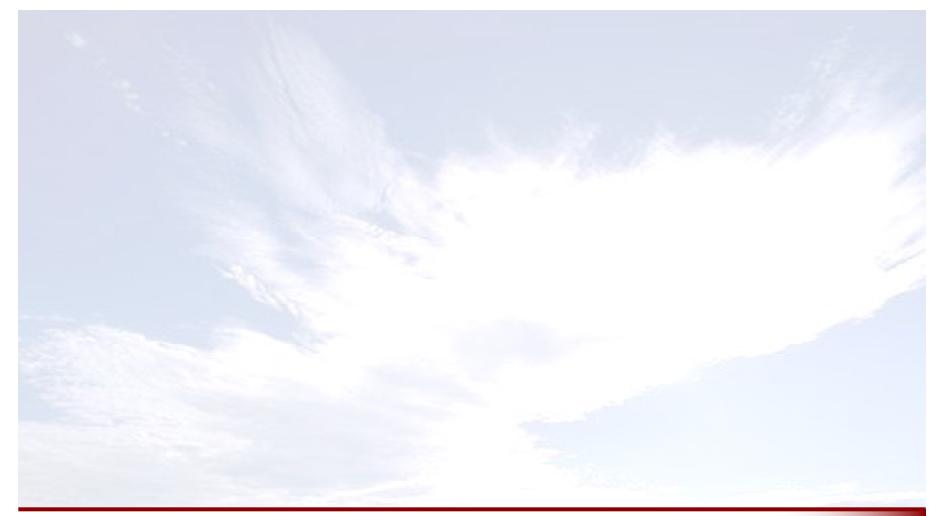
Visualization of feature space in B11 module.





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