

Biomedical signal and image processing Master in Medical Informatics FCUP 2012



Tissue Characterization by Image Analysis for Diagnosis Purposes

> J. Miguel Sanches (PhD) Assistant Professor

Institute for Systems and Robotics Bioengineering Department (DBE) Instituto Superior Técnico / Technical University of Lisbon

> email: jmrs@ist.utl.pt home: www.isr.ist.utl.pt/~jmrs



Medical Imaging



Different Biomedical Image Modalities are corrupted and distorted by different types of noise

(IV)US











- Is usually discarded because it is unwanted and purposeless
- Is generated during the acquisition process and/or processing
- Is stochastic and is usually described from a statistical point of view, e.g., first or higher order statistics
- Is difficult to eliminate
- It is usually very difficult to decide what is noise/artifact what what is not

But it can contains useful information about the observed object





Image Distortion and Noise Observation model



Typical effects/models

y = f(x)









Estimate x from y

 $\hat{x} = f^{-1}(y(x)) = g(y(x))$









 $\hat{x} = g(y)$

- Estimating x from y is usually an **ill-posed** inverse problem
- A problem is ill-posed if it is not well-posed.
- The problem is well-posed, according Hadamard, if
 - A solution exists
 - The solution is unique
 - The solution depends continuously on the data







$$Y \approx p(Y, \theta(X)), \qquad Y = \left\{ y_i \right\}$$

- Noise Characterization:
 - Additive/Multiplicative/Other
 - White / Colored
- e.g. White and Gaussian

White:
$$p(Y | \theta(x)) = \prod_{i} p(y_i | \theta_i(x_i))$$

Gaussian: $p(y_i | \theta_i(x_i)) \approx N(x_i, \sigma^2)$







Additive White Gaussian Noise

$$y_i = x_i + \eta_i$$

 $p(\eta_i) \approx N(0, \sigma^2)$

$$p(y_i | \theta_i(x_i)) \approx N(x_i, \sigma^2)$$









Multiplicative White Gaussian Noise









Multiplicative White Rayleigh Noise







- Variance depending on Signal
- Not necessarily multiplicative in the algebraic sense

$$p(y | \theta(x)) \approx Poisson(y, x) \approx \frac{x^y}{y!} e^{-x}$$

The Variance depends of the observation (signal); it is not constant









- Ultrasound images usually present low quality (low SNR)
- Images are corrupted by *speckle* noise (multiplicative)



Processed by José Seabra (Biomedical PhD student)







Medical Information



Speckle Pattern (texture) contains relevant medical information



fatty Liver.



Image Decomposition



- Decompose the image in textural and anatomical/morphological components.
- Characterize the texture/"noise" (speckle).
- Associate the texture characteristics with the disease.
- Classification and Quantification for Detection (Diagnosis) and Quantification (Severity Assessment) of the disease.





Decomposition Examples







Texture Characeterization

Rayleigh Mixture Model(RMM)





Seabra, J.C.; Ciompi, F.; Pujol, O.; Mauri, J.; Radeva, P.; Sanches, J., "Rayleigh Mixture Model for Plaque Characterization in Intravascular Ultrasound," Biomedical Engineering, IEEE Transactions on , vol.58, no.5, pp.1314-1324, May 2011.

Biomedical signal and image processing, Master in Medical Informatics, FCUP, 2012

Speckle Analysis for Diagnostic Purposes

• Liver Steatosis

PÓLO DO I.S.T

- Ricardo Ribeiro (PhD Student)
- Classification and Staging of Chronic Liver Disease from Multimodal Data
 - Ricardo Ribeiro (PhD Student)
- Carotid Atherosclerotic Plaques
 - José Seabra (PhD)
 - David Afonso (PhD Student)
 - Manya Afonso (PhD, Post-Doc)













- Diffuse Liver diseases such as Steatosis and Cirrhosis are mainly textural abnormalities of the hepatic parenchyma
- Today, the assessment is subjectively performed by visual inspection





Steatosis



• Comparison with histological data





Liver Steatosis Local Analysis





Biomedical signal and image processing, Master in Medical Informatics, FCUP, 2012



Classification and Staging of Chronic Liver Disease from Multimodal Data







Clinical Based Classifier (CBC)



Healthy



CS	FS	Class	Best Performance					
0.5	15	Class	DR (%)	OA (%)	J	Classifier		
I	Α	Normal	97.92	98.67	0.97	kNN		
		Pathologic	99.02			k=1		
	В	Normal	100.00	98.00	0.97	SVM _{polynomial}		
		Pathologic	97.06	20.00	0.27	d=1		
п	Α	СН	73.33	86.00	0.65	kNN		
		Cirrhosis	91.43	80.00	0.05	k=1		
	В	СН	70.00	80.39	0.55	SVM _{polynomial}		
		Cirrhosis	84.72	00.55	0.55	d=3		
ш	Α	CC	97.14	01.67	0.84	Batter		
		DC	86.49	91.07	0.04	Dayes		
	В	CC	88.57	90.27	0.80	Bayes		
		DC	91.89	20.27	0.00			

Biomedical signal and image processing, Master in Medical Informatics, FCUP, 2012



Atherosclerotic Plaques Carotid



24







Tissue Characterization

from Intra Vascular US (IVUS)





Collaboration with the **Centre de Visió per Computador**, Universitat Autònoma de Barcelona, Prof^a Petia Radeva



Plaque IVUS



Decomposition



Classification





Plaque B-Mode





(a) original







• Freehand

PÓLO DO I.S.T

Mechanical











3D Diagnosis



Global and local analysis





0.53



Enhanced Activity Index (EAI) Architecture



PÓLO DO I.S.T

Plaque featu

70dB/C 3

Persist Off 2D Opt:FSCT Fr Rate:Targ SonoCT® XRes™

nic Plaque Analysis - version 1.

Hypoechogenic area (HA





Enhanced Activity Index (EAI) Prototype



31

🛃 menu_PatientData 📃 🗖 🔀	🧈 menu_PlaqueFeatures	_ 🗆 🔀
Patient Data ID FC-240310-LC Name FC Date (dd/mm/yy) 24/03/10 Age 67 Gender (M/F) M Carotid side • Left • Carotid side • CVA major • Carotin infarction • ves • Carotin infarction • ves • Carotin infarction • ves • Diabetes • ves • Diabetes • Anti-hypertensive • Diabetes • Anti-platelet • Diabetes • anti-platelet • Angor • Beta blockers • Angor • CEls/ARAs	Plaque Morphology Echogen Texture heterogeneous echo Type II SD 34 Area 1.267 cm2 P40 36 Length 3.345 cm Mean 54 Stenosis (%) 73 Mean 54 Stenosis (%) 73 Observati Mean 54 Location juxta-luminal w/o FQ Pixel dim Mean 54 % EA 29.056 Save Save Save	icity genic echolucent overall 7.0 17.0 37.0 1.6 16.0 34.1 3.2 89.0 53.0 1.4 20.0 44.4 Normalized ons Activity Index 78 78 78 78 100 Normal No

Biomedical signal and image processing, Master in Medical Informatics, FCUP, 2012



Computer Aided Diagnosis

$A the ros Risk^{\mathsf{TM}}$



				. (1) Save		Exit	
Patient ID Name			Plaque Morphology	B-Mode			
a 102HG-RC2.tif a jsanches0003.bmp a Jena.jpg AR_control.bmp IMA255.jpg		_	Heterogeneity		(2)	Doppler Display	F
			Stenosis (%)	0	Proce	Normalization	
-History Left Right	Risk Factors	-Medication	Surface Disruption		(3)	Commentation	l P L P
asympt 🔽	Hypertension	AH drugs	Thickness (mm)	0	(4)	Segmentation	
AF 🗆 🗆	Diabetes 🔽	_	Fibrous Cap (FC)		(5)	RF	
		Statins	EC thickness (r	nm) 0	(6)	De/Speckle	F
m str ROI selection			C/Plaqu	e 0	(7)	Compute Ftr	Г
CEA Select plaque contour (ENTER do accept, ESC to A	Abort)	area (H	A)	(8)	Load Class Par	
CAS INST.CAR	DVASC.LISBOA	L7-4 CVasci	/car		(9)	EAI 0	
ICA d		100 C 100 C 100 C	al/centr	al w/FC	(10)	Save Images	Г
CAD 170/B/C2	Concession of the local division of the loca	Con a	aque	0			
Advent Persist Low				A		Display Features	
Lumen 2D Opt:FSCT						Save Features	
Fr Rate Surv			and the second			Display Histogram	
SonoCDR			Contraction of the local distance of the loc			Display Acc Hist	1
SonoCTi∂ XRes™	Concession in the		Statement of Street Stree				
SonoCTR XRes™						Dispaly RMM	1





THANKS