影像處理與統計應用
生物影像統計學
(BIS: Bio-Image Statistics)

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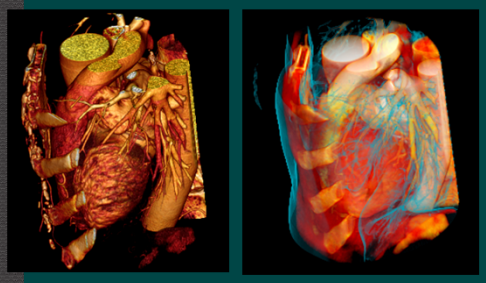
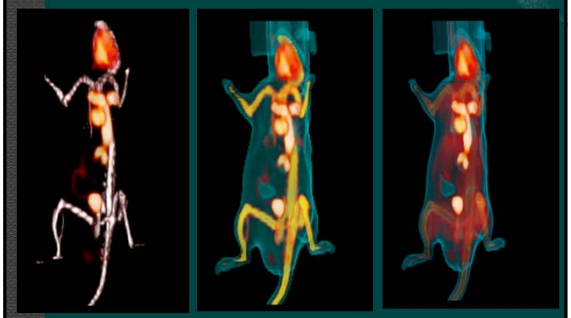
3D Cardiac Volume Rendering



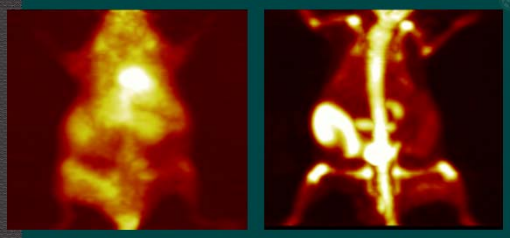
2

3D Mice Volume Rendering



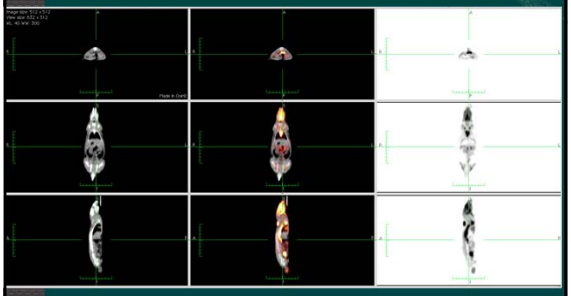
3

3D Maximum Intensity Projection



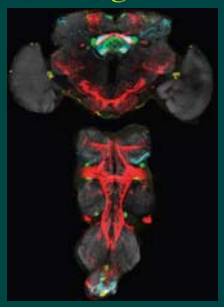
4

Mice PET+CT and Image Fusion



5

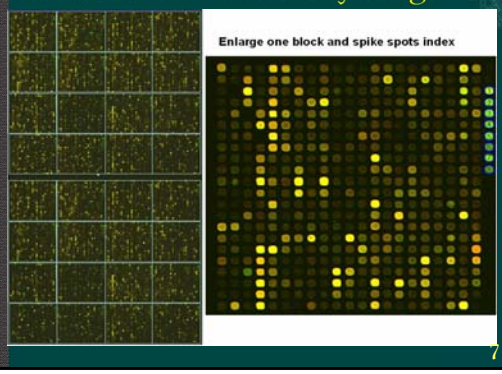
3D Registered Image



3D registered and overlaid neuronal patterns of multiple fruit fly central complexes (top) and thoracic ganglia (bottom). Hanchuan Peng, 2008.

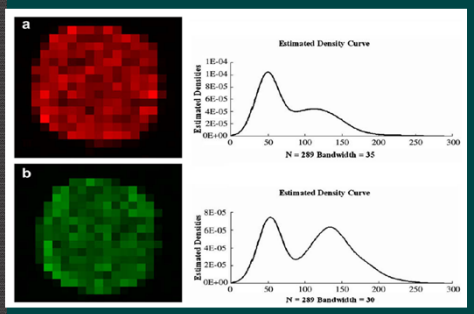
6

Bioinfomatics: MicroArray Image



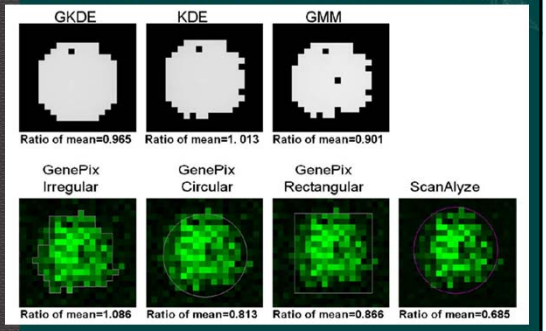
7

Segmentation a Spot of MicroArray Using Kernel Density



8

Feature Calculation for MicroArray



9

Evaluation Accuracy of Segmentation Methods for Spike Spots

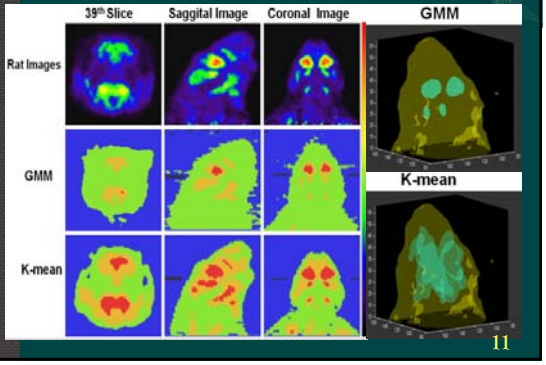
The comparisons of SSREs obtained by GMM, GKDE, KDE, ScanAlyze, and GenePix 6.0 for spike genes are listed

Array	Sum of square of relative errors							Relative performance		
	GKDE	KDE	GMM	ScanAlyze	GenePix irregular	GenePix circular	GenePix rectangular	GKDE	KDE	GMM
1	85.482	82.495	85.482	243.383	301.408	320.264	258.886	64.878	66.105	64.878
2	55.009	45.899	55.025	117.817	152.598	123.584	128.127	53.310	61.042	53.296
3	80.421	77.148	80.421	286.480	317.267	303.845	317.147	71.928	73.070	71.928
4	29.861	28.021	30.170	36.042	31.277	34.409	35.664	4.528	10.409	3.539
5	10.401	7.908	10.410	15.256	20.094	16.070	19.737	31.823	48.161	31.765
6	7.605	7.729	7.647	53.392	57.603	55.068	58.491	85.757	85.525	85.678
7	60.911	59.383	60.916	90.118	115.513	115.779	114.534	32.411	34.106	32.405
8	110.991	101.908	110.992	163.735	219.798	196.928	207.335	32.213	37.761	32.213
1s	33.005	31.740	32.980	130.681	147.429	132.150	132.289	74.744	75.712	74.763
2s	26.900	27.211	26.905	32.285	31.157	33.630	37.984	13.662	12.664	13.640
3s	149.074	130.196	149.739	244.790	286.494	261.726	272.590	39.101	46.813	38.830
4s	675.010	648.212	674.388	769.750	826.411	761.916	767.239	11.406	14.923	11.488
5s	12.202	12.106	12.222	16.525	23.215	14.541	17.244	16.086	16.745	15.950
6s	6.781	6.550	6.786	94.839	107.370	101.951	104.794	92.850	93.093	92.845
7s	12.705	12.425	12.739	29.883	53.558	44.113	45.079	57.484	58.419	57.371
8s	9.910	10.025	9.997	17.570	25.496	21.485	24.715	43.599	42.942	43.105
Average relative performance								45.283	48.593	45.231

Array 1s is obtained by swapping the dyes of Array 1. Relative improvement is specified by (Min{GenePix,ScanAlyze} – Methods)/Min{GenePix,ScanAlyze} as a percentage

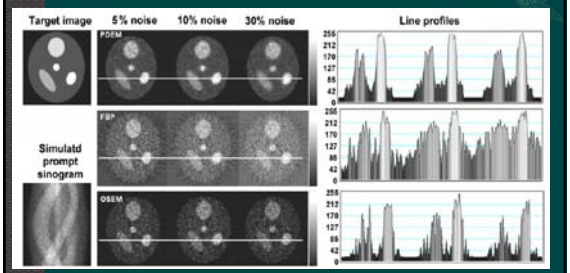
10

3D Image Segmentation



11

Image Reconstruction and Analysis



12

What is bio-image statistics?

- Five image types of features:
  - Pixel **statistics (max, min,...)**
  - Textures (Entropy, histogram,...)
  - Polynomial decompositions
  - High contrast features (e.g. object number, spatial distribution, size, shape, ..., etc.)
  - Standard **image** transforms (Fourier, wavelet, Chebyshev)

13

What is bio-image statistics?

- A good understanding of mathematics and statistics and an interest in mastering the biological/biochemical/bio-image/Optical images background is essential.

14

Main Goal

- In recent years (after 2000 B.C.), new state-of-art scanning machines like nano-PET/CT, naon-SPECT/CT, micro-MR,…,and etc bring imaging science into investigation of super micro details inside live animal.
- This course is designed to understand how to analyze the feature and interesting of bio-image by using statistical tools.

15

Tool

- Statistics
- Feature extraction and selection
- Segmentation
- Registration
- Clustering, classification and annotation
- Indexing and retrieval
- Visualization

16

Resources

- ***BioImage Suite*** is an integrated image analysis software suite developed at Yale University. BioImage Suite has been extensively used at different labs at Yale since about 2001. The last stable version is 2.6.1 which was released on April 6th, 2009. http://www.bioimagesuite.org/

17

Resources

- ***Center for Bio-Image Informatics***: The UCSB Bio-Segmentation Benchmark dataset consists of 2D/3D images and time-lapse sequences that can be used for evaluating the performance of novel state of the art computer vision algorithms. Tasks include segmentation, classification and tracking. For each class of problem, at least one ground truth dataset is available. We also provide performance metrics for comparing the results of the algorithms with the ground truth. Additional ground truth data will be posted as they become available. http://www.bioimage.ucsb.edu/

18

Statistics

- Smoothing: Gaussian, Median, Mean,...
- Classification: Gaussian mixture model, Bayesian approach,...
- Correlation: Pearson, Kendall, Spearman
- Relevant Test: Chi-test, Kappa,...
- Prediction: Spatial statistics, Regression, General linear model,...

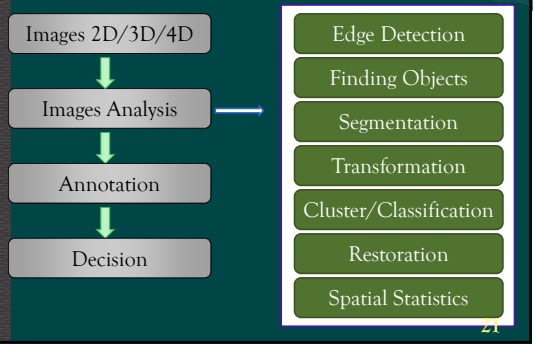
19

Feature extraction and selection

- ROI-Based Analysis
- Feature extraction: Size, Shape, Geometric, Area, Volume, Distance,...
- Pixel intensity
- Clustering and Classification

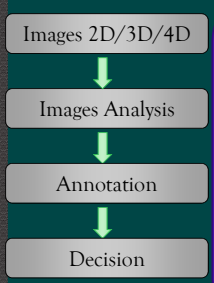
20

Frame Work between Statistics and Image Analysis



21

什麼是醫學影像定量?



影像定量分析: 透過數學或統計方法找出影像特徵並與疾病進行關連分析的一種技術。

目的: 建立客觀量化數據(資訊),提升(輔助)定(質)性判讀結果。

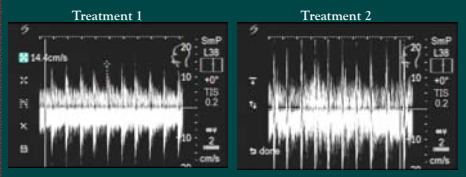
重點: 如何從影像上找出影像特徵??

22

Examples

23

Two Treatments of Doppler Ultrasound Images

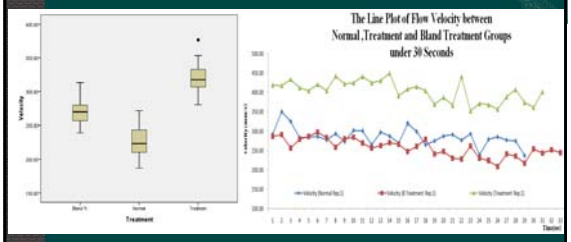


Q: What are different features between these images?

A: (1). Time interval of Peaks (2). Maximum value of peaks (3). Distance between positive and negative peaks.

24

Data Analysis and Model

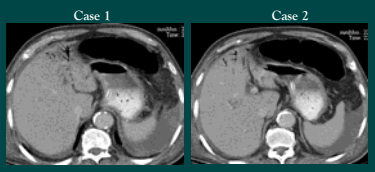


Analytic Model

$$\text{Velocity} = \mu + \text{Treatmeat} + \text{Replication} + \text{Observation} + \text{Treatmeat}*\text{Replication} + \text{Treatmeat}*\text{Observation} + \text{Replication}*\text{Observation} + \text{Treatmeat}*\text{Replication}*\text{Observation} + \text{Error}$$

25

Two Computed Tomography of Human Livers



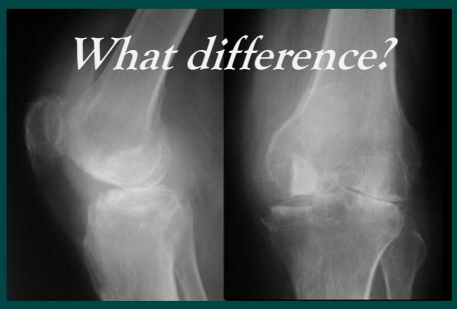
Q: (1) Are these images the same?
(2) Where are difference between these images?

A(1,2): No. Pixel intensity and sharp are different.

Q: (3) How long will show serious (bad) images?

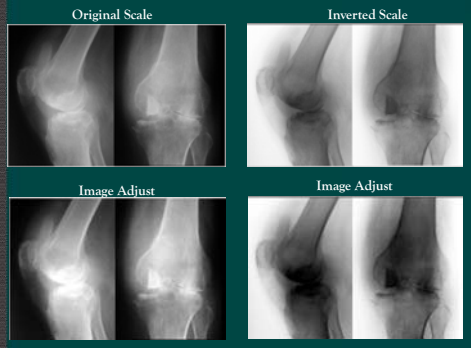
26

Two X-ray Images Human Knee



27

Inverted Gray Scale Image

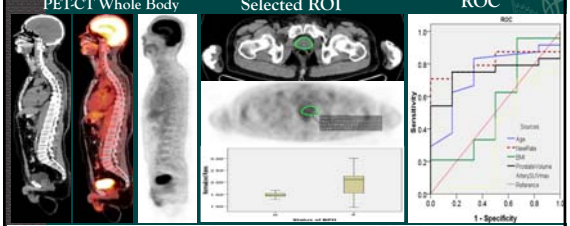


28

PET-CT : Benign Prostate Hyperplasia

- PET: the metabolic information was estimated from PET images, including SUV of arteries, iliac arteries, kidney, skin, whole body, and etc.
- CT: The rate of prostate volume
- Analysis
  - ROC (Receiver Operating Characteristic), AUC (Area under ROC), Pearson's correlation, and ANOVA

29



Sources	Status of BPH	Average	95% CI L.Bound	95% CI U.Bound
NewRate	N	1.48	1.34	1.61
	P	1.95	1.74	2.17
Age	N	50.50	45.28	55.72
	P	56.00	52.85	59.15
ArterySUVmax	N	1.78	1.42	2.14
	P	1.58	1.48	1.69

One-way ANOVA

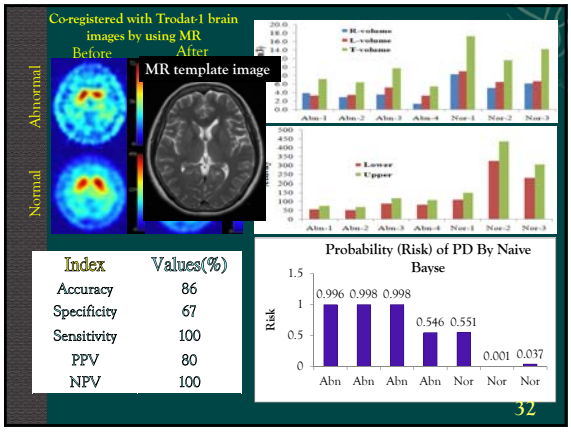
Sources	Items	SS	DF	MS	F	P-value
ArterySUVmax	Between Groups	.22	1	.22	4.66	.040
	Within Groups	1.30	28	.05		
	Total	1.52	29			
NewRate	Between Groups	1.08	1	1.08	4.97	.034
	Within Groups	6.09	28	.22		
	Total	7.18	29			
Age	Between Groups	145.20	1	145.20	2.91	.099
	Within Groups	1399.50	28	49.98		
	Total	1544.70	29			

30

SPECT : The Parkinson Diseases

- Trodat-1 Imaging
  - The functional activity volume of corpus stratum was varying depend on the progress of PD
- MR/CT/SPECT (Normal)
  - Realignment, Normalization
- Evaluation risk of PD by statistical model
  - Naïve Bayes, Logistic Regression,....,etc.

31

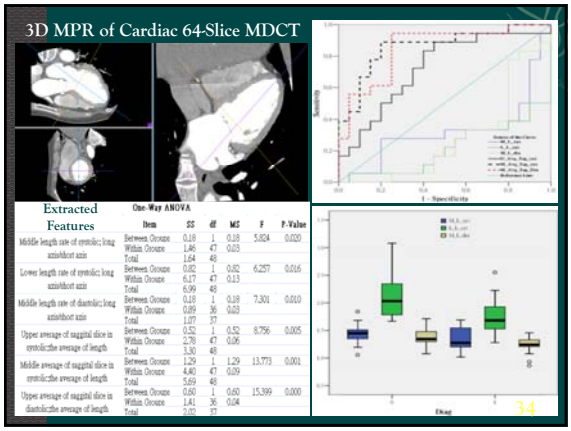


32

Cardiac 64-Slice MDCT

- 64-Slice MDCT
  - Dedicate Anatomical Information of Cardiac Coronary Artery Disease (CAD)
- Extracted Physical Information
  - Long axis, Short Axis, Intensity Values, …, etc.
- Statistical tools
  - ROC (Receiver Operating Characteristic), AUC (Area under ROC), Pearson's correlation, and ANOVA

33

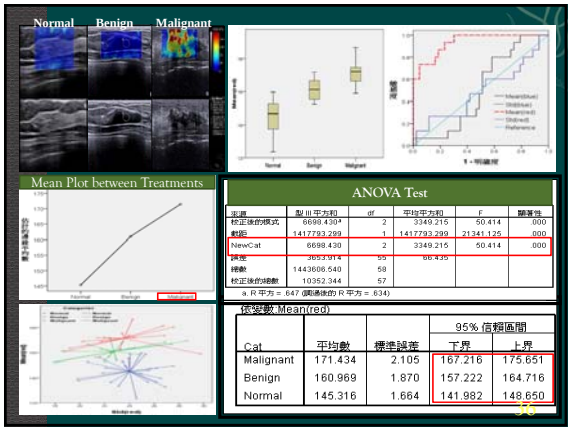


34

Ultrasound: Elastogram

- Elstogram
  - Visualized the elasticity of Breast Cancer by RGB
  - Avoiding embarrassing and keeping privacy
- Extracted Color Information
  - Intensity of Red/Blue channel
  - Computing characteristic of ROI
- Statistical tools
  - ROC (Receiver Operating Characteristic), AUC (Area under ROC), Pearson's correlation, Logistic Regression, ANOVA,…, and etc.

35



36

The Future

- An integrated project union together with interdisciplinary
  - Imaging/Images
  - Information Science
  - Bioinformatics
  - Integrated Medical Information and Biological Images for Personal Medicine

37

Acknowledgement

- Thank all students for their efforts in projects
- Thank E-DAH and VGHKS for providing images
- Thank Prof. Hung, Ding, Du, MD Lu, MD Chen, and other related experts/technological radiologist for their support and comments in projects

Thanks for Your Attention

39