



Biomedical Imaging & Analysis

Lecture 1, Fall 2014

Part 1:

Intro to Biomedical Imaging & its Applications

[*Text: Ch. 1 of Insight into Images edited by Terry Yoo, et al.*]

Prahlad G Menon, PhD

Assistant Professor

Sun Yat-sen University – Carnegie Mellon University (SYSU-CMU)

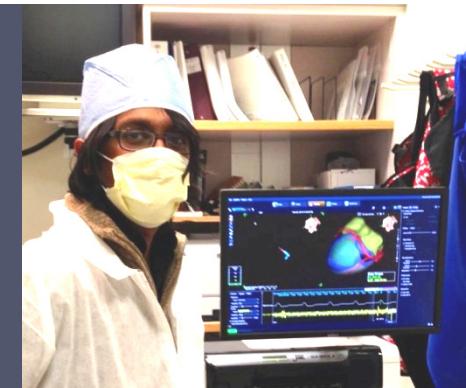
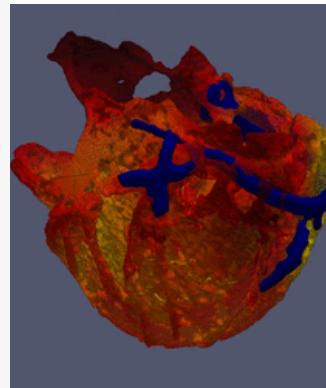
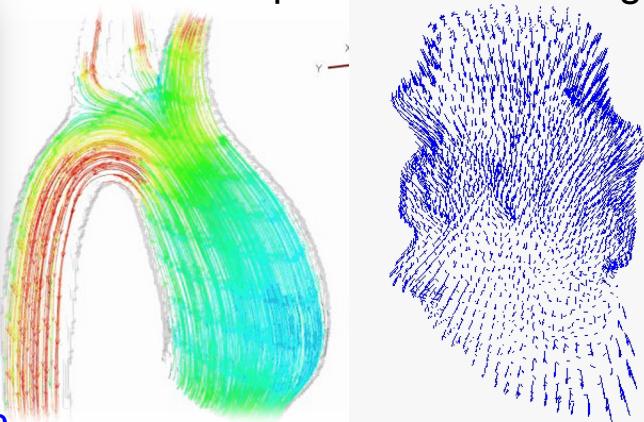
Joint Institute of Engineering



Who is this guy..?

NCBI: <http://www.ncbi.nlm.nih.gov/myncbi/prahlad.menon%20gopalakrishna.1/cv/3610/>

- Director of The MeDCaVE research program (www.justcallharry.com), strategically positioned at the confluence of physics based computational modeling, informatics, radiology, surgical practice.



www.justcallharry.com

Post Doc. Biomedical Informatics,
University of Pittsburgh, 2013-14.

Ph.D. Biomedical Engg.,
Carnegie Mellon University, 2013

M.S. in Mechanical Engg.
Carnegie Mellon University, 2010

B.Tech. Mechanical Engg.
National Institute of Technology
Karnataka, India, 2009

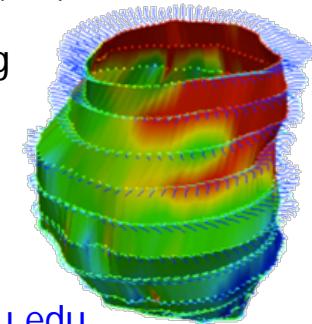
Prahlad G. Menon, PhD | Founder & CEO, QuantMD, LLC
Assistant Professor, Electrical & Computer Engg.

Sun Yat-sen University - Carnegie Mellon University (SYSU-CMU)
Joint Institute of Engg. (JIE) & Joint Research Institute (JRI)

Assistant Professor (Adjunct), Biomedical Engineering
University of Texas at San Antonio (UTSA)

Assistant Professor (Adjunct), Bioengineering
University of Pittsburgh (PITT)

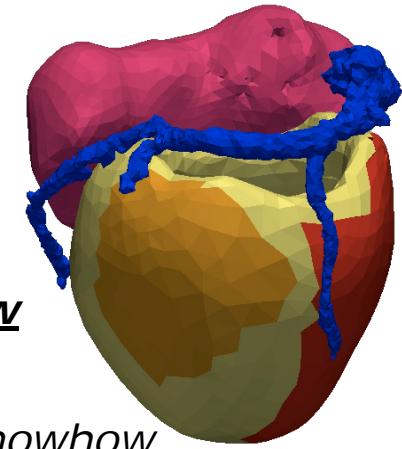
PI: The MeDCaVE | Email: pgmenon@andrew.cmu.edu
Phone: +1 412.259.3031 | Web: www.justcallharry.com





The MeDCaVE

Carnegie
Mellon
University

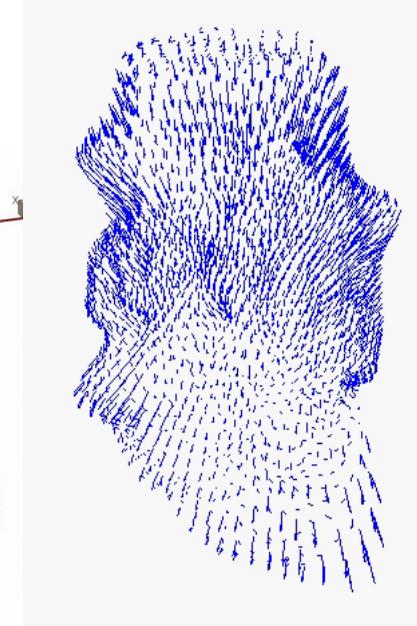


Quantitative imaging based evaluation of :

Patient-specific ***Morphology, Function and Flow***

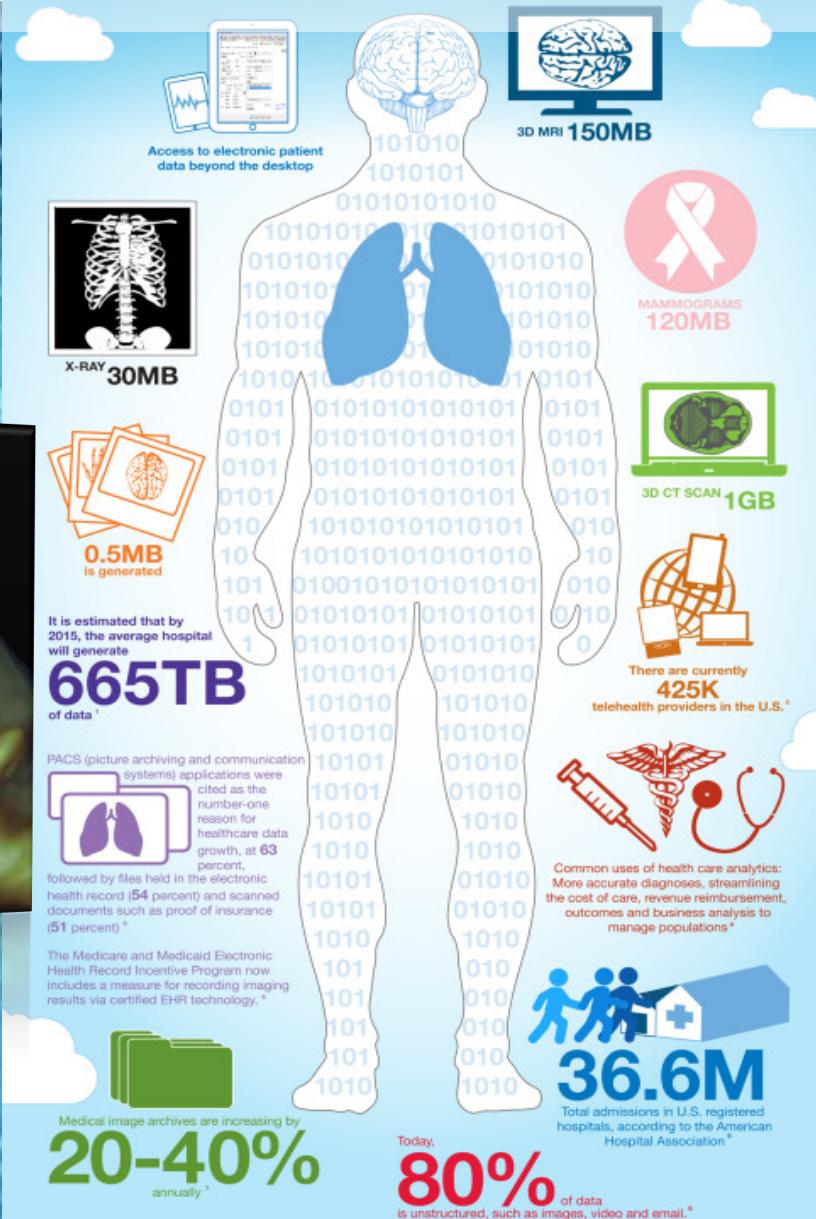
Big Data + Innovative Software + Physics & Clinical knowhow

DRIVING TIMELY INTERVENTION,
PLANNING / GUIDING SURGERY
FOR IMPROVED OUTCOMES

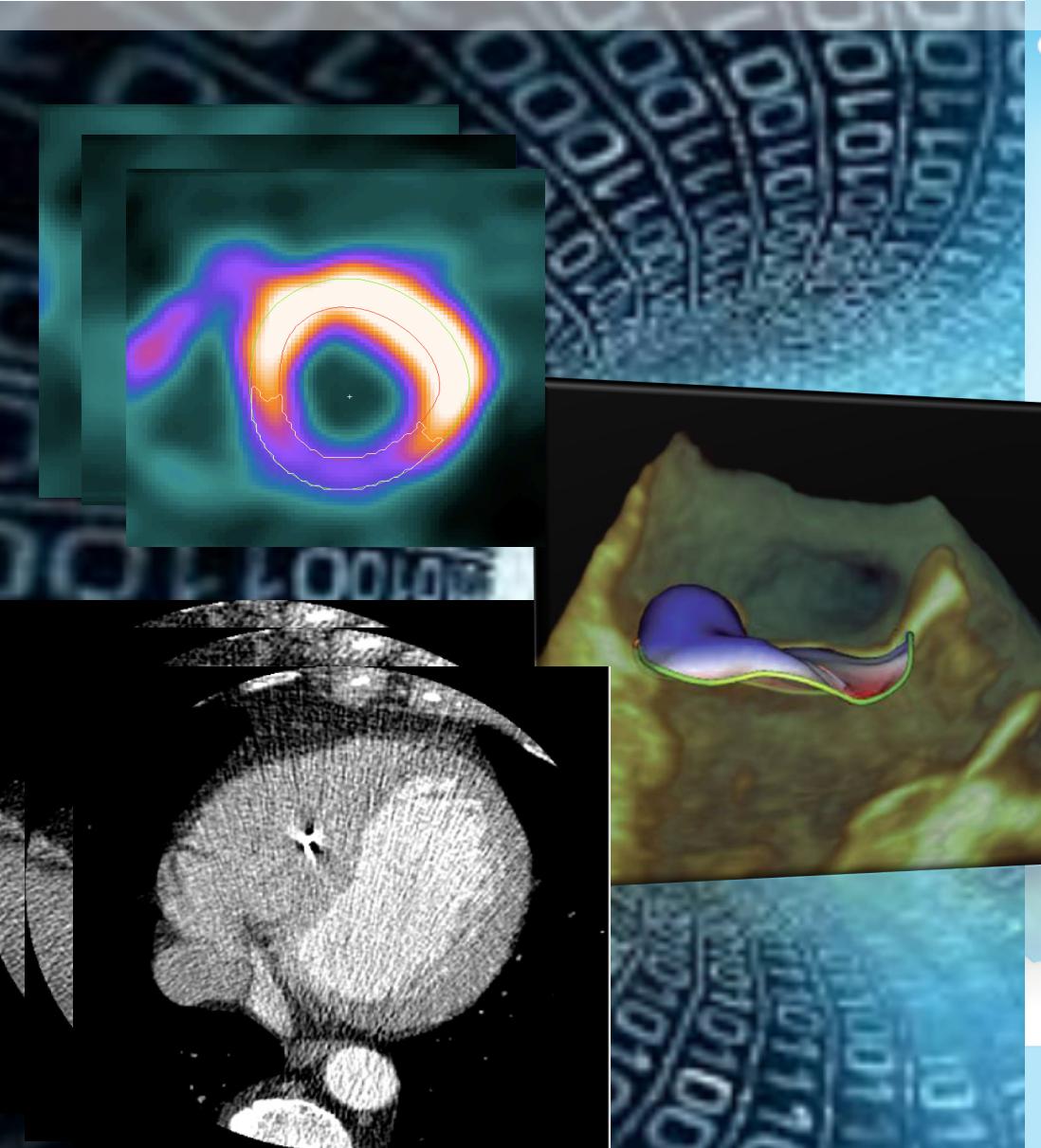


The Body as a Source of Big Data

Today data storage is essential for healthcare providers to see a patient's complete story of care, make the most informed decisions and enhance treatment and outcomes.



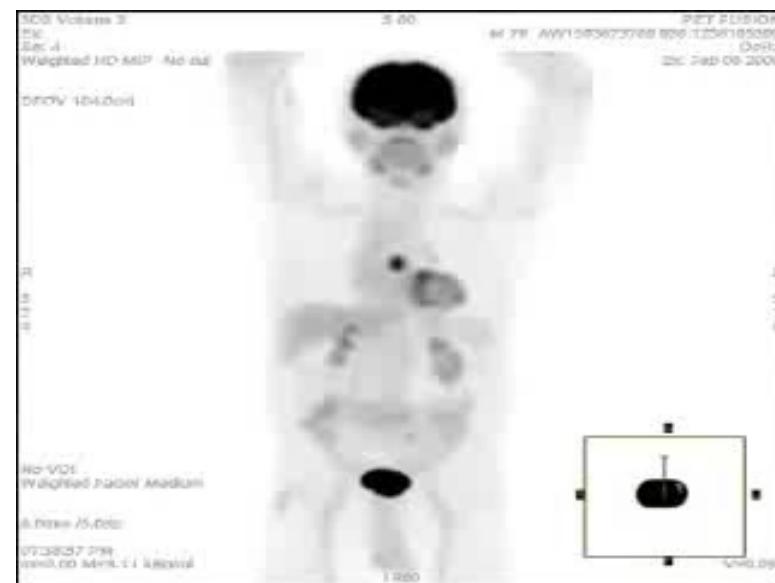
The Biggest Big Data



More Examples of Biomedical Imaging

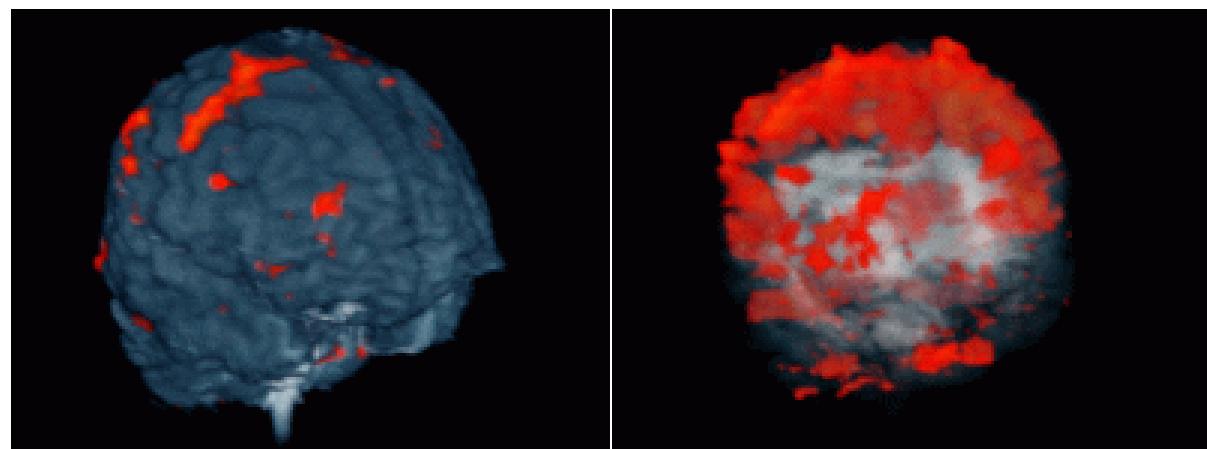


3D rendering of tumor for surgical planning (MRI)



Tumor Metastasis localization (PET)

fMRI of whole brain activation :

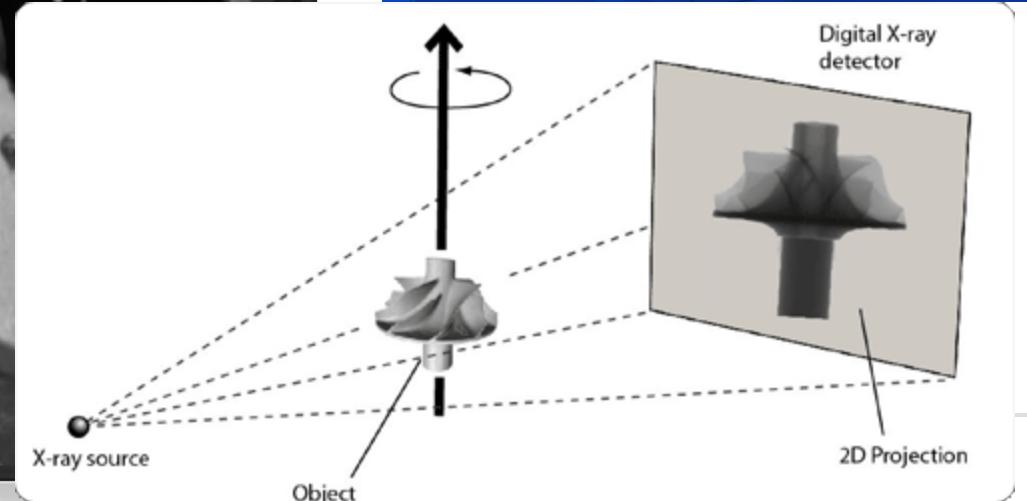
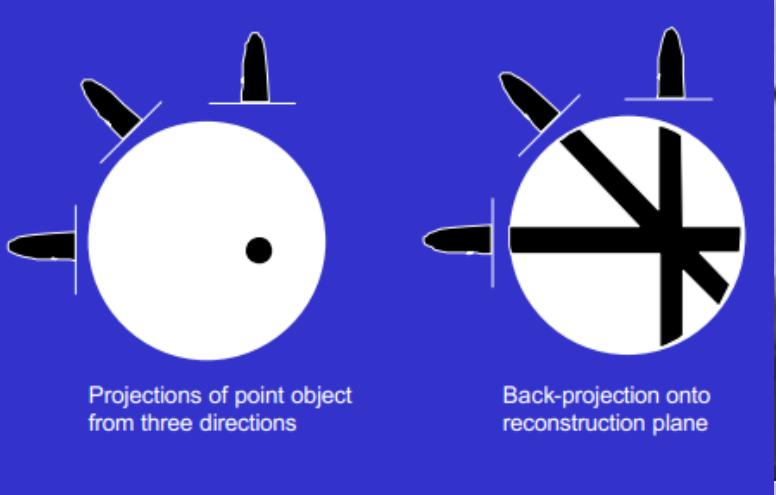
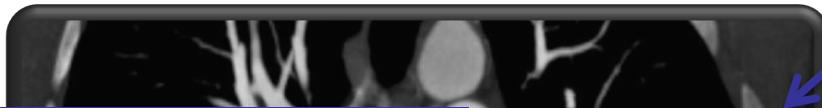
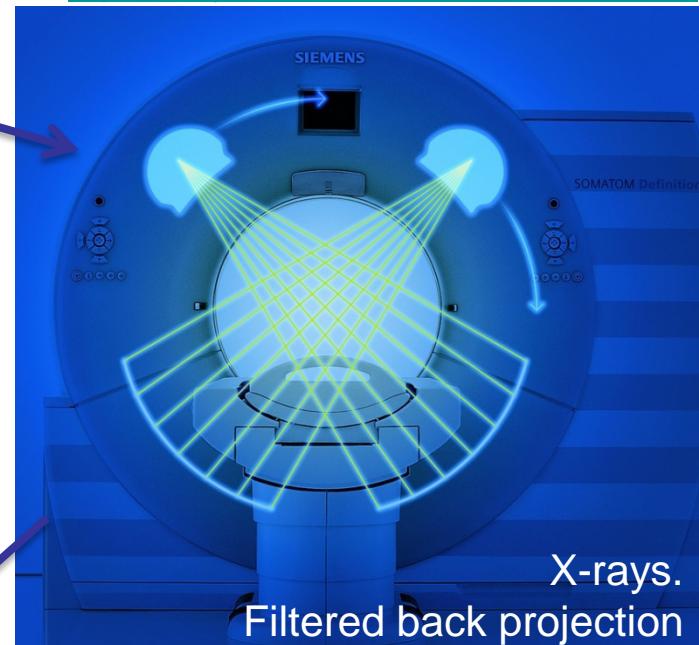


Abundance of Medical Imaging Data

CT: Physics meets Clinic (Part I): Doing more for clinicians.



<http://www.youtube.com/watch?v=ra7sw0kNvTw>

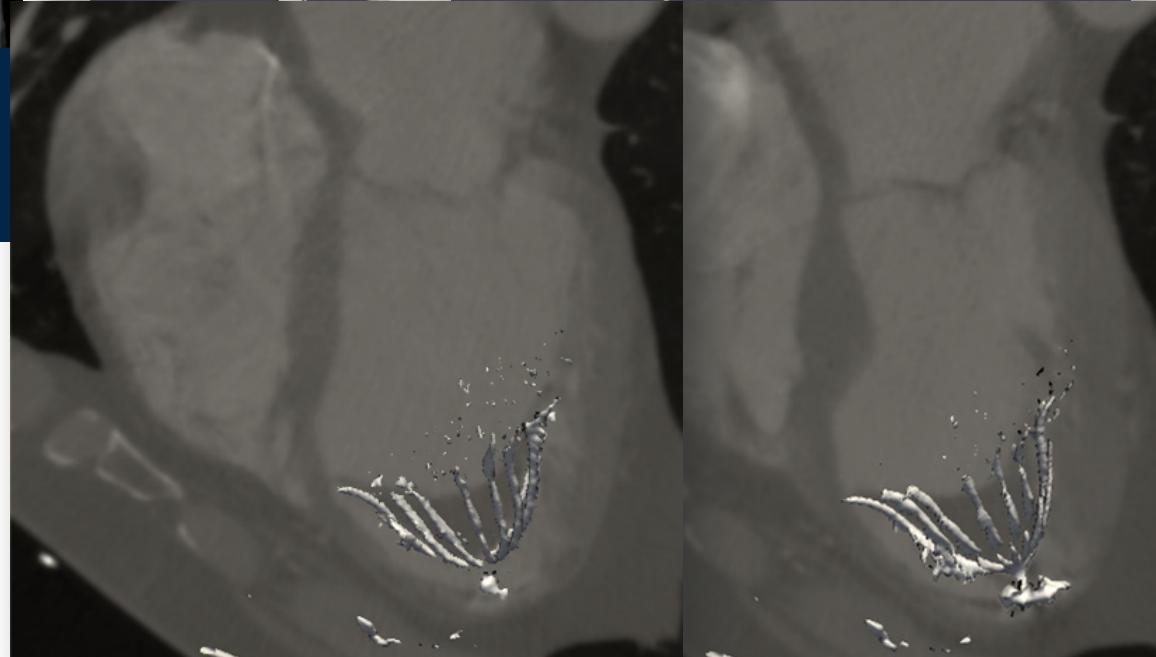


What CT Image data look like ..?

Short-axis slice



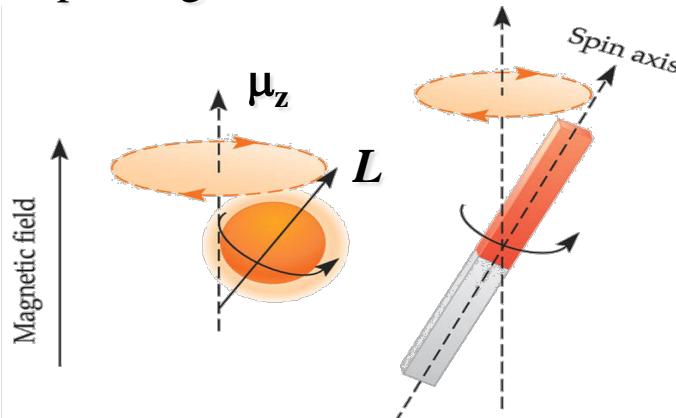
Horizontal slice



How are these images formed..?

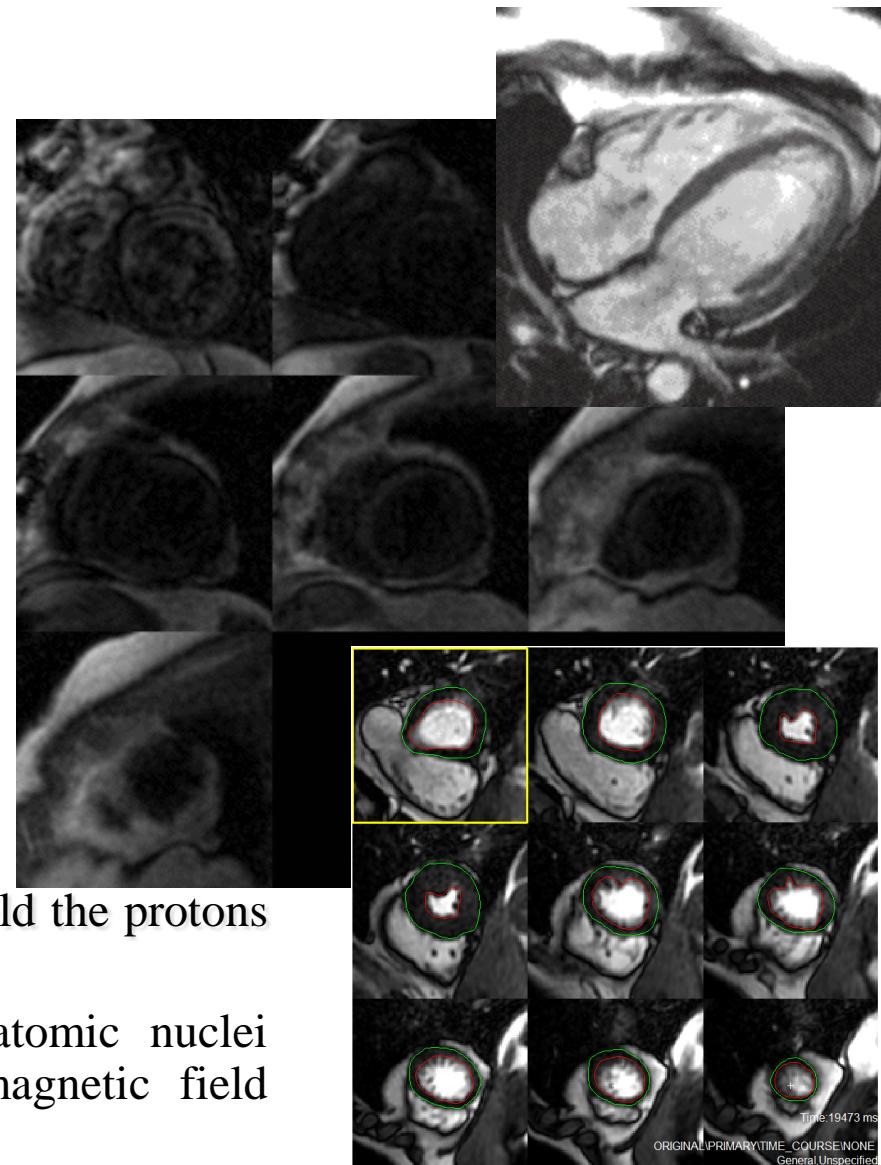
MRI: Physics meets Clinic (Part II)

The proton has mass and an angular momentum \mathbf{L} when it is spinning.



An Introduction to MRI Physics and Analysis Michael Jay Schillaci, PhD

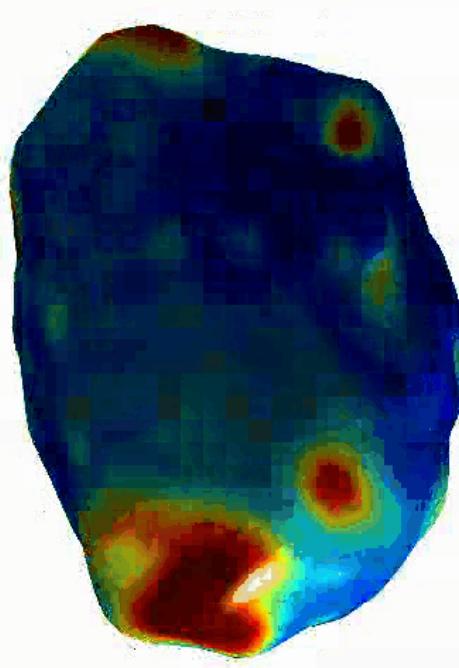
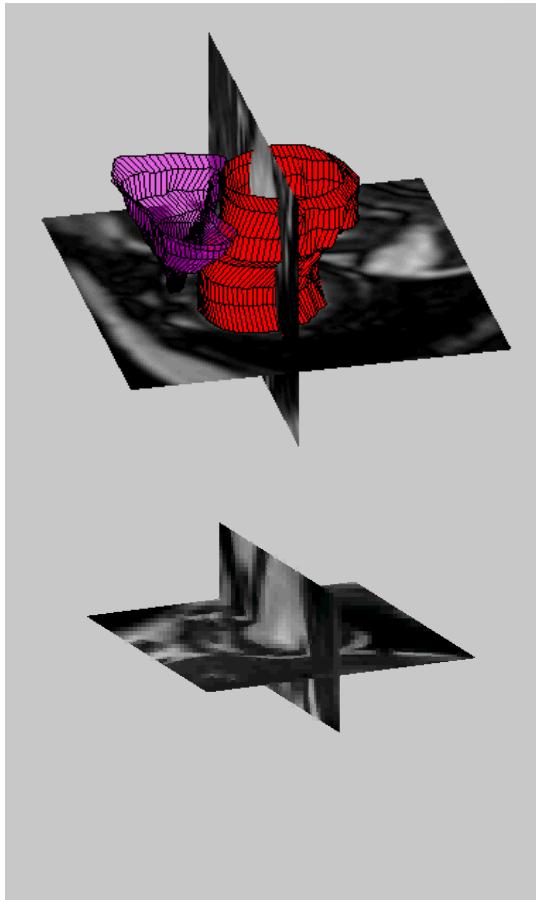
- The electric charge of the proton creates a small current loop since the proton is constantly in motion and this generates a magnetic moment μ = current times the area of the loop.
 - In the presence of a static external magnetic field the protons try to align (or anti-align) with the applied field.
 - MR measures the net *magnetization* of atomic nuclei which can be manipulated by changing the magnetic field environment.





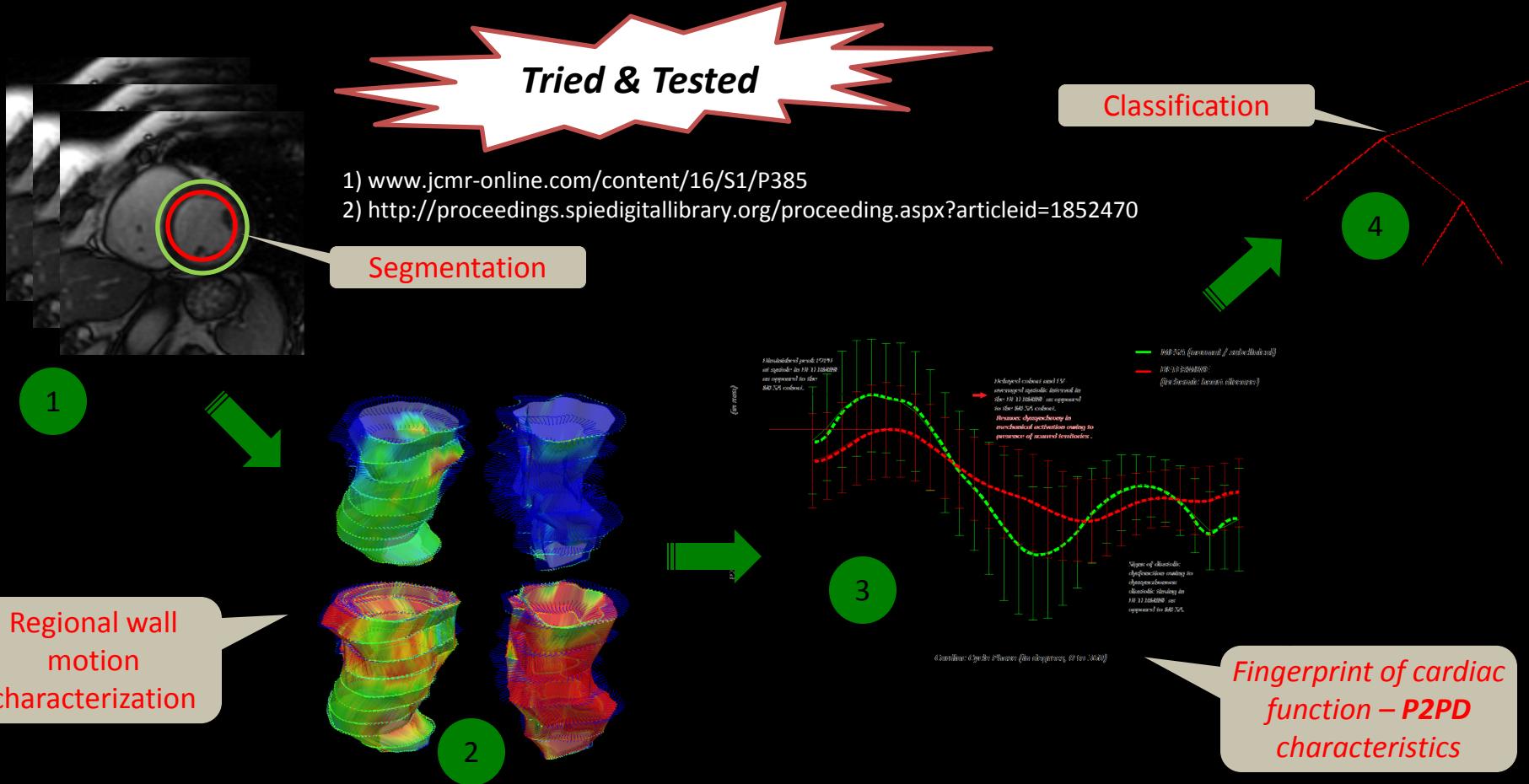
Decision Support

CONFLUENCE OF QUANTITATIVE
ANALYSIS AND RADIOLOGY



STARTING WITH STANDARD IMAGING
SHAPE-DRIVEN FUNCTION ANALYTICS
4 D STRAIN, DISPLACEMENT, DYSSYNCHRONY

Stratifying Heart Disease based on Wall Motion Function



Carnegie Mellon

Menon Medical Diagnostics & CardioVascular Engineering
700 Technology Drive, Pittsburgh, PA:15219, Tel: +1 (412) 259-3031

 Electrical & Computer
ENGINEERING

CONTACT:

pgmenon@andrew.cmu.edu
www.justcallharry.com

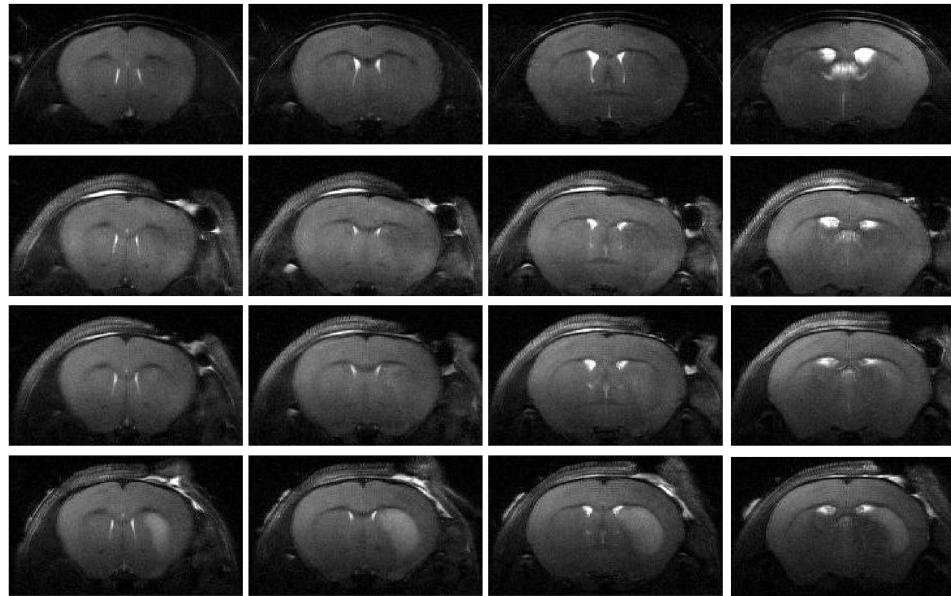
Prahlad G Menon, Ph.D : Assistant Professor

Electrical & Computer Engineering, Carnegie Mellon University

Advantage of Most Bio-imaging v/s tissue analysis ? **NON-INVASIVE!**

Mice subjected to 30 min of stroke:

- Assessed using MRI before and 3-24h after.



Histology: Tissue is fixed, cut into slices, then subjected to a dye. The resulting sections are then analyzed.

Imaging advantages

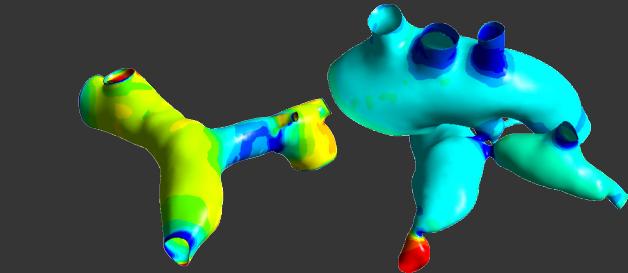
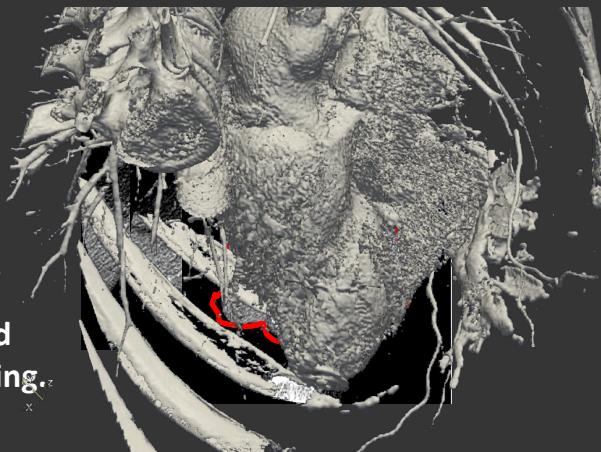
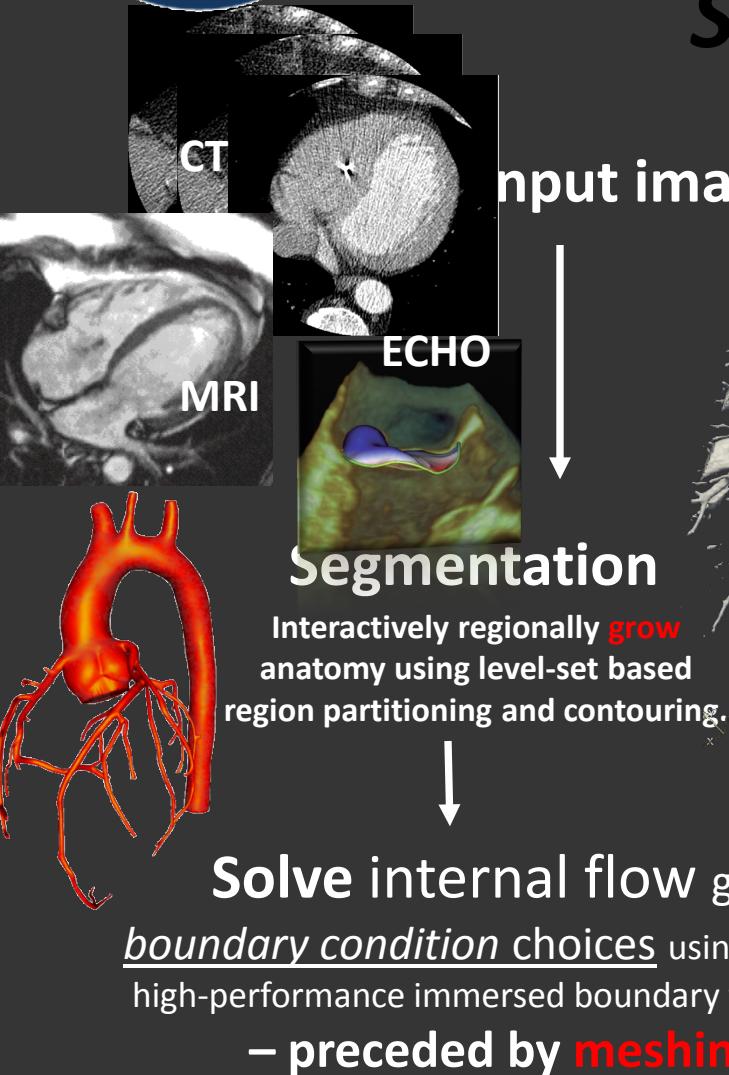
Relative to histology or invasive tissue analysis

- 1.Rapid acquisition of the information
- 2.Non-destructive, i.e. minimal perturbation
- 3.In situ or in vivo
- 4.Repetitive (longitudinal) studies possible

Ultrasound of mouse heart



More than Quantitative VIRTUAL PHYSICS SIMULATION!



 **ParaView**

 
tecplot
Master the View

Custom Plugins – open source! for post-processing flow structures.

Write output files

Compatible with range of commercial & open-source visualization tools.

How is the course organized

- **Image Formation**
- **Basic Image Processing**
 - Applications in Machine Vision & Feature Extraction
 - Feature Classification
- **Advanced Image Processing Topics**
 - Shape Analysis, Registration, Mutual Information
 - Optical Flow & Physics based image processing / Regularization
 - Shape and Appearance Models

TEXT BOOKS

- *Basic: Machine Vision by Wesley E. Snyder & Hairong Qi*
- *Advanced: Insight into Images edited by Terry Yoo, et al.*

Image Formation Topics

- Signal to Noise v/s Contrast to Noise
- System's model of an Imaging Device.
- X-ray & CT
 - Tomographic Reconstruction Techniques
- Fluoroscopy
- MRI
- Optical Imaging
 - Resolution limits
 - Point Spread Functions

Basic Image Processing Topics

- Linear Operators for image Enhancement
- Coding
 - Compression
- Restoration
 - “Fix” an image
 - Requires model of image degradation
- Image Segmentation & 3D Reconstruction

Applications: Machine Vision



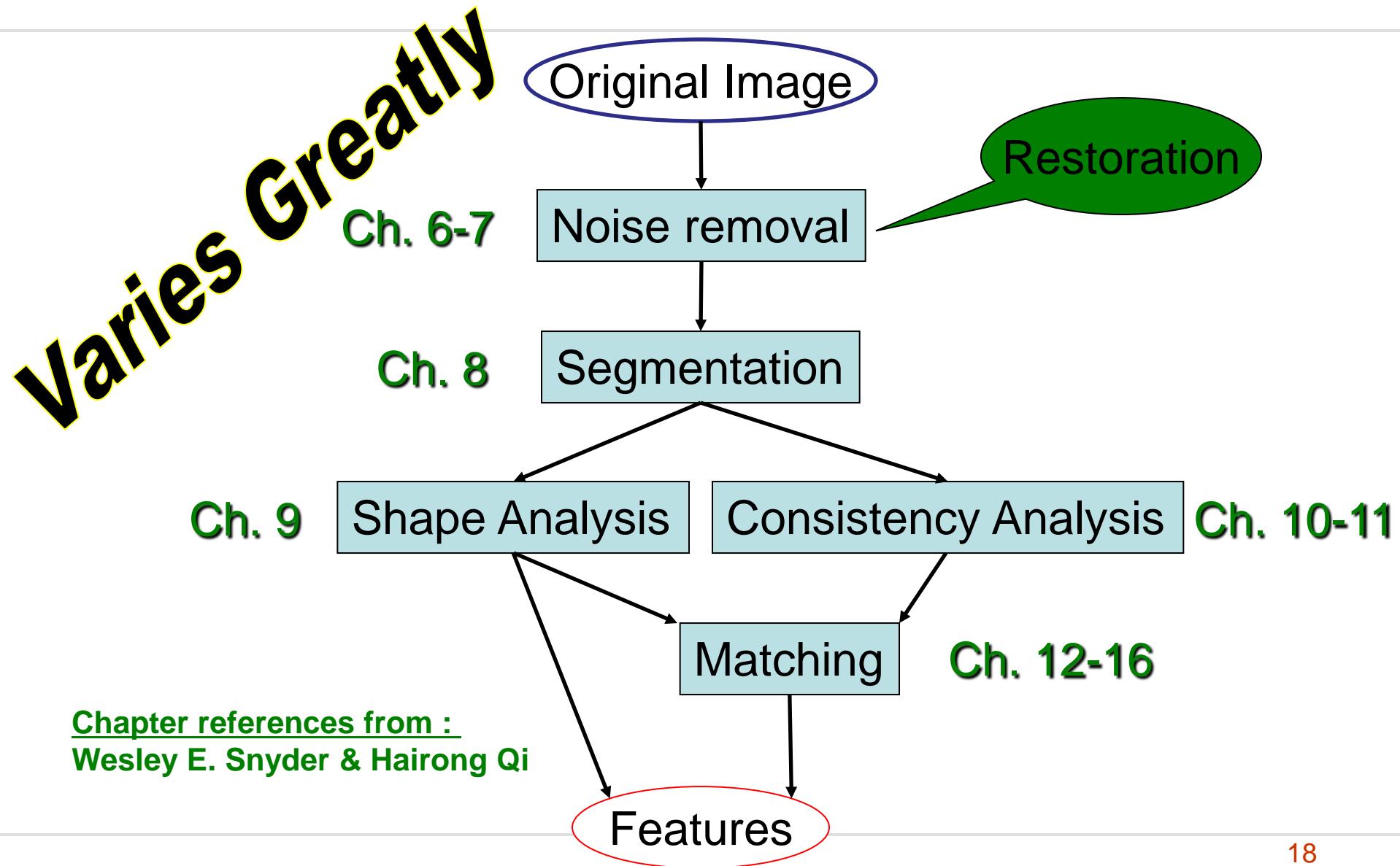
- **AKA:**
 - Computer vision
 - Image analysis
 - Image understanding
- **Pattern recognition:**
 1. **Measurement of features**

Features characterize the image, or some part of it
 2. **Pattern classification**

Requires knowledge about the possible classes

Our Focus

Sample Feature Recognition Pipeline



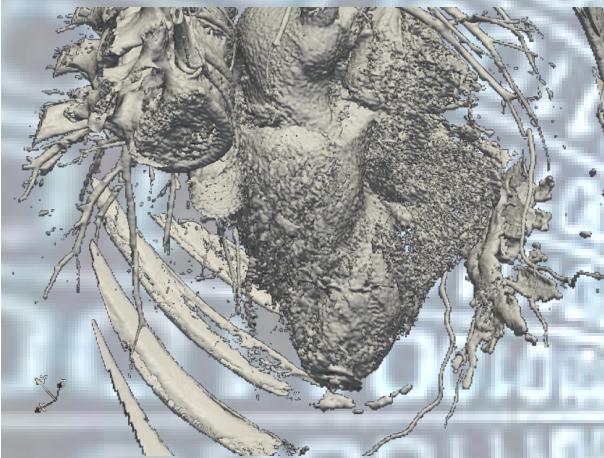
Advanced Image Processing Topics

- Image Registration
 - Mutual Information
 - Physics-based methods & Regularization
- Shape / Morphology Characterization
 - Spherical Harmonics
 - Laplace Eigen Modes & PCA
- Active Shape & Appearance Models



BIA 2014

Carn
Mello
Unive



Prahlad G Menon, PhD
www.justcallharry.com
+1 412-259-3031
pgmenon@andrew.cmu.edu

