Photonics / Imaging / Display

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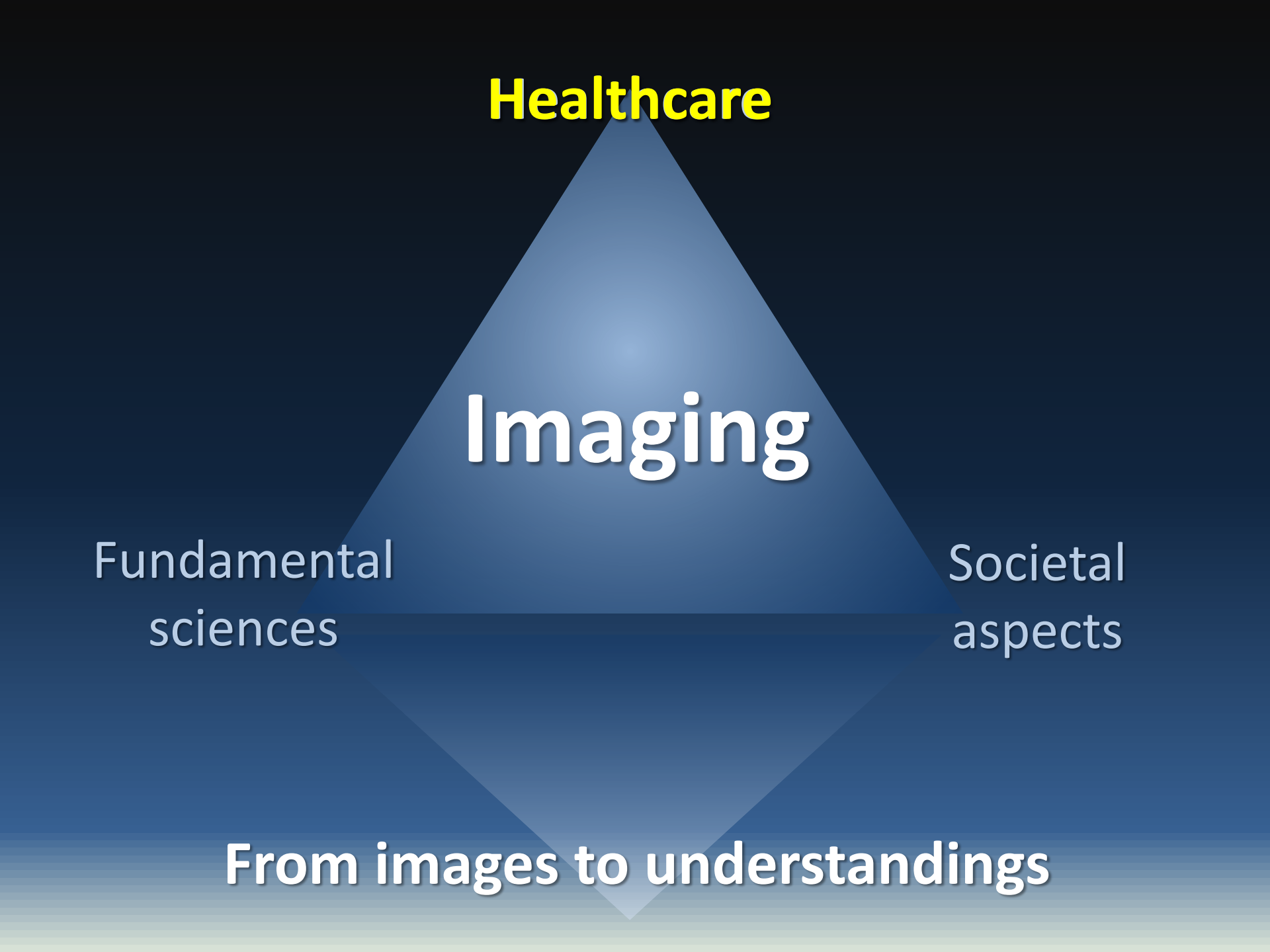
Dr. Kenneth Kin-Yip Wong (HKU)
Prof. Edmund Lam (HKU)
Prof. Yongping Zheng (PolyU)

Theme-based Research Scheme - Research Grants Council
Town Hall Meeting
June 19, 2015

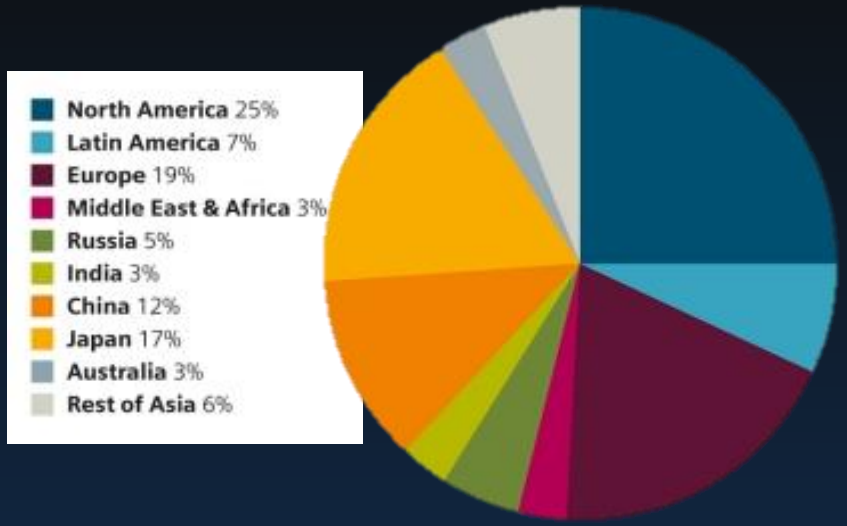

Healthcare
Imaging
Fundamental sciences
Societal aspects
From images to understandings

Diagnostic imaging – Current status

- Global market size:

  $32.3B in 2014 to $49B in 2020.

- China: A rapidly expanding market

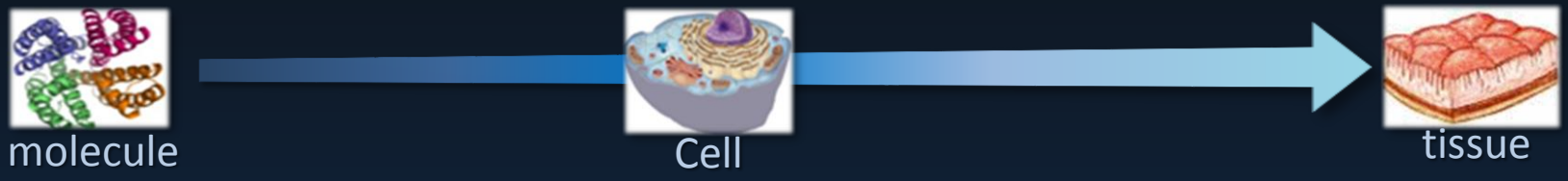


Frost & Sullivan 2013

- Every $385 spent on imaging decreased a patient's hospital stay by one day (saving ~$3000 per patient)
  Molly Beinfeld et. al., Radiology, June 2005.

So far, we have some images, and some understandings

Grand challenge:
From better images to better understandings



...but, image information is extremely heterogeneous:

- **Multiscale**: molecules, cells, tissues, organisms
- **Multidimensional**: 3D + time (dynamics)
- **Complex & quantitative**: molecular, structural, functional

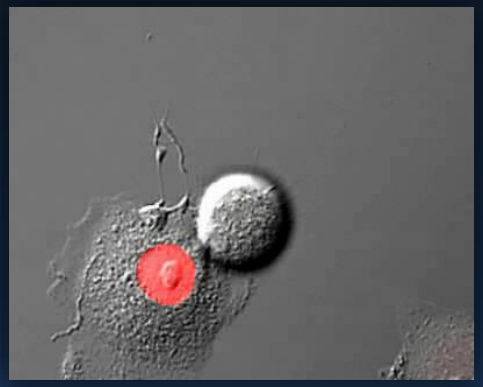
Regenerative medicine

Neuroscience

Cancer diagnostics

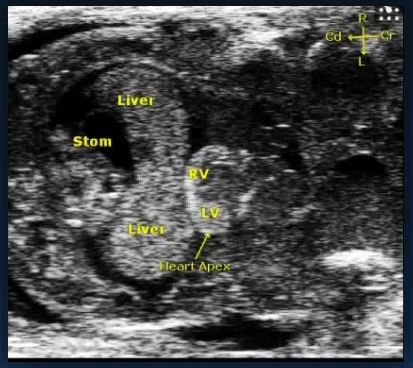
Redefine imaging: What is missing?

Imaging platforms | Image analytics | Image visualization



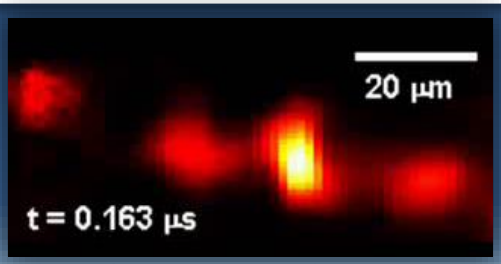
Video-rate live-cell imaging

Olympus: Microscopy resource center



Clinical ultrasound

Nature 521 520 (2015)

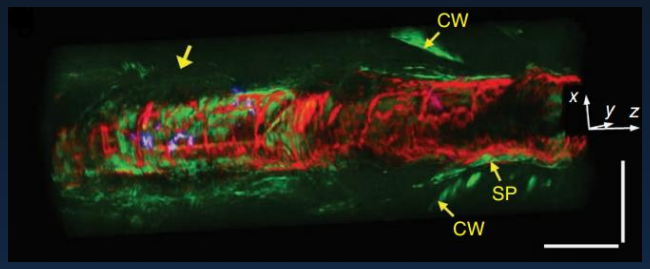


Ultrafast optical imaging

Nature 458, 1145 (2009)

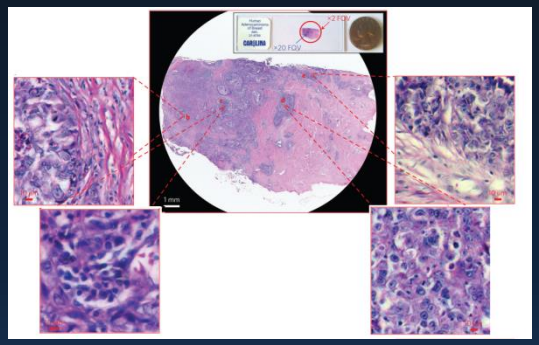
Redefine imaging: What is missing?

Imaging platforms | Image analytics | Image visualization



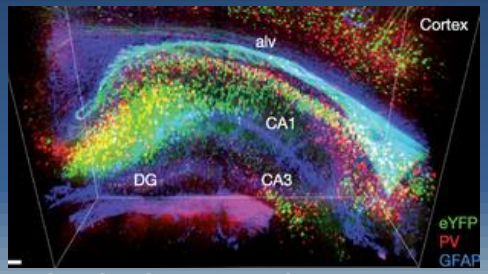
Functional ultrasound + photoacoustic imaging

Nature Medicine 18, 1297 (2013)



Digital pathology

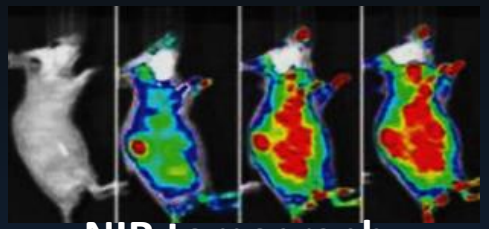
Nature Photonics 7, 739 (2013)



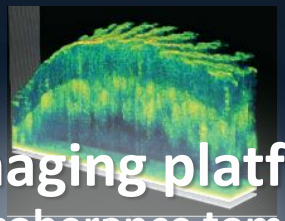
Whole brain phenotypes

Nature 497, 332 (2013)

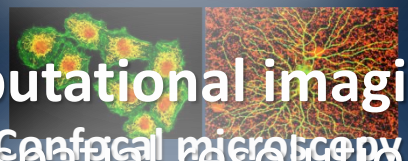
Photonics Imaging: A New Paradigm



NIR tomography



Optical coherence tomography (OCT)



Confocal microscopy

Super-resolution microscopy

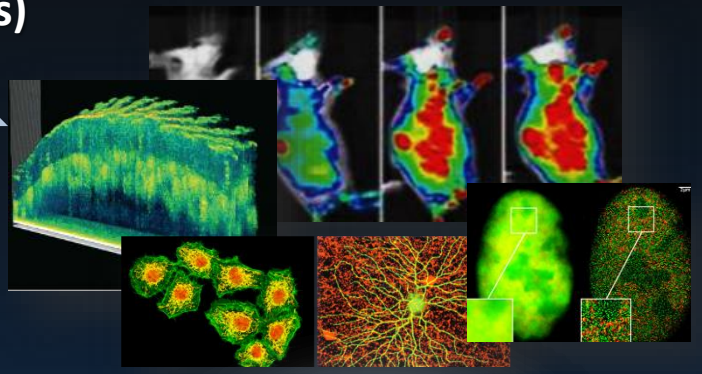
Length (m) Time (s)

10^{-1} 10^{1}

10^{-3} 10^{-3}

10^{-6} 10^{-7}

10^{-9} 10^{-9}



New imaging platforms:

Go multimodal

Computational imaging:

High spatial resolution + large-scale

New imaging platforms:

High spatiotemporal resolution

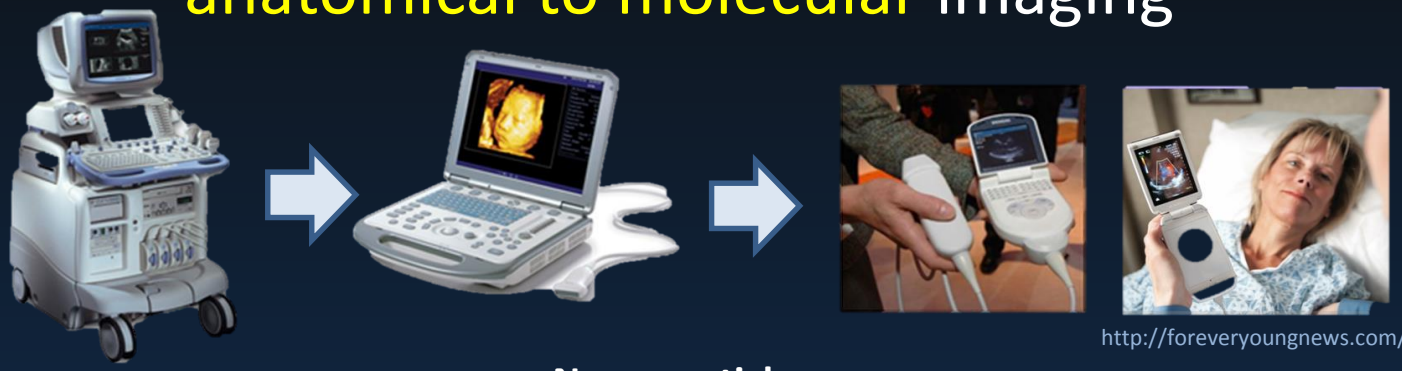
Computational imaging:

Single-pixel imaging

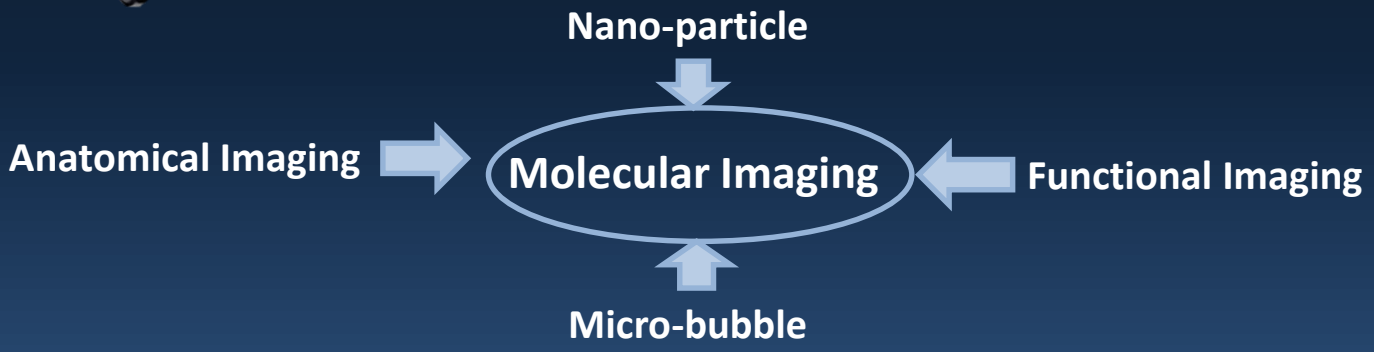
Complex and Big Image Data Analytics

New Era of Biomedical Ultrasound Imaging

Moving machine to patient to provide
anatomical to molecular imaging



http://foreveryoungnews.com/



Moving ultrasound machine to patient instead of moving patient to machine

- **Clinical needs and feasibility clearly demonstrated, BUT**
- **Resolution and functionality to be improved with breakthrough developments**
- **Breakthroughs needed in ultrasound transducer techniques and 3D image formation**
- **Functional imaging, e.g. elasticity imaging, high resolution Doppler flow**
- **More effective use of images via big data analysis and cloud computing**

Display of Volumetric Images in 3D Media

Quantum Dots
Size Dependent
Emission

http://en.wikipedia.org/wiki/Quantum_dot

Challenge

Excite quantum dots with focused laser to create lighting voxel with colors, resolution, and frame rate to be comparable to 2-D display.

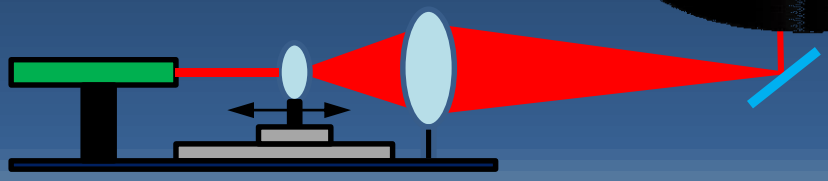
3D Blood Flow Visualization (whole heart 4D flow MRI)

3D Volumetric Image

Nanoparticle Doped Polymeric
3D Display in Freeform Shape

Scattering Voxel

Laser Beam with Focal Point
Modulation in z-axis



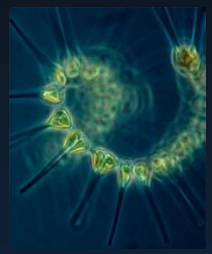
Heart Image http://thevirtualheart.org/

MEMS Scanning
Micro-mirror for
Steering in x- and y-
axes

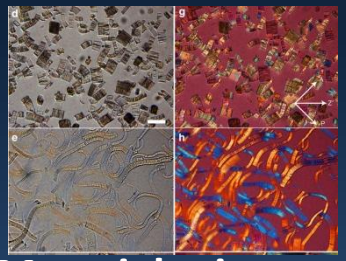
https://www.youtube.com/watch?v=1ORpeB6j0gc

Examples of Existing Strengths in Hong Kong

Imaging platforms | **Image analytics** | **Image visualization**



Plankton ecology



Material sciences

Ultrafast OCT
3D image visualization
Optogenetic functional MRI
THz spectroscopy & imaging
Biometric Security and Recognition
Computational imaging and analytics
Ultrahigh-throughput single-cell imaging
Label-free nonlinear optical microscopy
Imaging for neural recording/stimulation
Molecular/functional ultrasound imaging
....

Autonomous vehicles

Biometric Security

Fundamental sciences

Societal aspects