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Affiliated with the University of Pittsburgh School of Medicine

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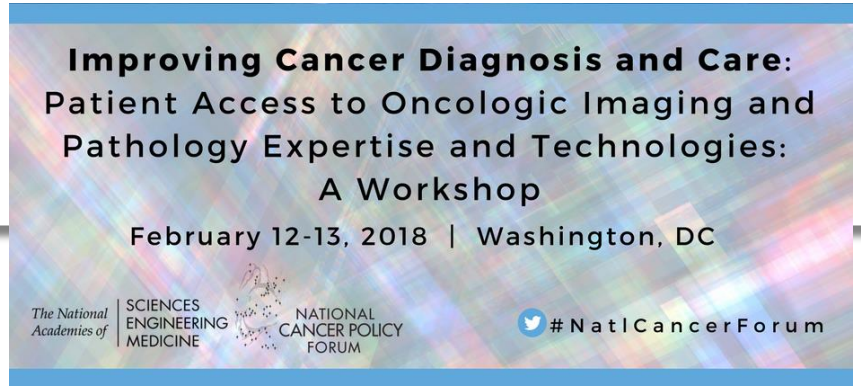
Pathomics, Radiomics and AI Will Enable Informed Cancer Care (if...)

Session 4: Computational Onc & Integrated Diagnostics: Ops for New Tech to Improve Dx Info and Inform Cancer Care

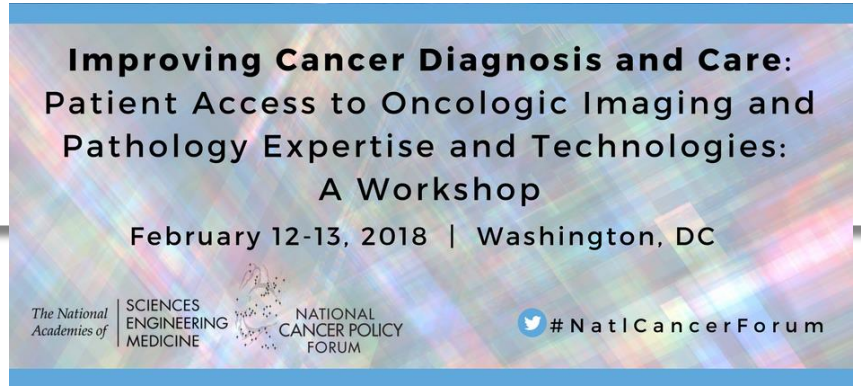
TIES v5 information extraction



NIH NATIONAL CANCER INSTITUTE Informatics Technology for Cancer Research

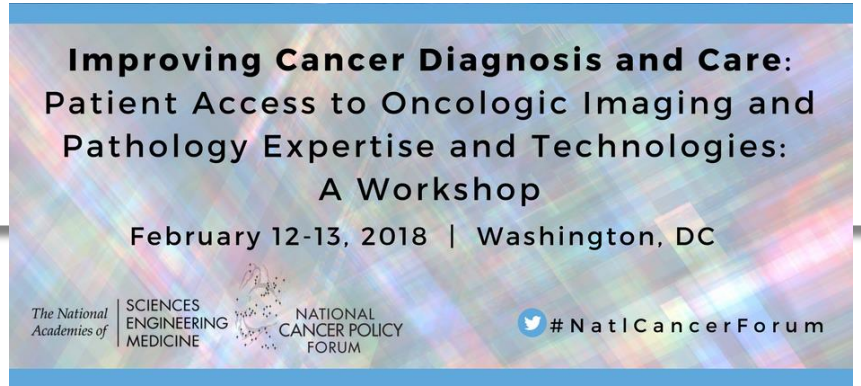
Disclaimers (SFCOI and COI)

- Significant Conflicts of Interest (SFCOI)
  - I have a startup company SpIntellx™ in the computational pathology AI space (**founder equity**)
- Conflicts of Interest (COI)
  - I am funded by three NCI sources – CCSG, ITCR, SPORE (**federal grants**) & CDC, NCATS, NHGRI and NLM.
  - I consult for several cancer centers and biotechnology companies (**consulting fees and honoraria**)



Major Points - Objectives

- Pathomics and Radiomics will fundamentally change diagnostics for precision oncology
- Pathology and Radiology need to partner to accomplish this for Oncology
- Data sharing is key enabler for this transformation



Pathomics: A Definition

- First appeared in mid-2000's attributed to Lawrence Livermore Lab – "...high throughput diagnostics to understand the molecular basis of disease..."
- Today=Computational Pathology (Louis, 2014 & 5)

Computational Pathology

An Emerging Definition

David N. Louis, MD; Georg K. Gerber, MD, PhD; Jason M. Baron, MD; Lyn Bry, MD, PhD; Anand S. Dighe, MD, PhD; Gad Getz, PhD; John M. Higgins, MD; Frank C. Kuo, MD, PhD; William J. Lane, MD, PhD; James S. Michaelson, PhD; Long P. Le, MD, PhD; Craig H. Mermel, MD, PhD; John R. Gilbertson, MD; Jeffrey A. Golden, MD

• Advances in high-throughput laboratory and health information technologies are revolutionizing the disciplines of pathology and laboratory medicine. The ability to extract clinically actionable knowledge using computational methods from complex, high-dimensional laboratory and clinical (digital) data, thereby yielding more precise diagnoses, disease stratification, and selection of patient-specific treatments, will clearly be a significant and important realization in the delivery of health care. Pathologists, who are at the nexus of diagnostic data, models of disease pathogenesis, and clinical correlation, are ideally positioned to provide leadership in the emerging "big data" era of medical care. We thus propose a vision for a new discipline of computational pathology.

(*Arch Pathol Lab Med.* doi: 10.5858/arpa.2014-0034-ED)

We define *computational pathology* as an approach to diagnosis that incorporates multiple sources of raw data (eg, clinical electronic medical records; laboratory data, including "-omics"; and imaging); extracts biologically and clinically relevant information from those data; uses

Louis, et. al. 2014, Arch Path Lab Med

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UCRL-TR-226770

Pathomics: Final Report

K.W. Turteltaub, M. Ascher, R. Langlois, I. Fodor, J. Kercher, K. Mc Laughlin, D. Nelson, W. Colston, F.P. Milanovich

December 13, 2006

Computational Pathology

A Path Ahead

...MD; Michael Feldman, MD, PhD; Alexis B. Carter, MD; Anand S. Dighe, MD, PhD; John D. Pfeifer, MD, PhD; ..., PhD; Jonas S. Almeida, PhD; Joel Saltz, MD, PhD; Jonathan Braun, MD, PhD; John E. Tomaszewski, MD; ..., MD; John H. Sinard, MD, PhD; Georg K. Gerber, MD, PhD, MPH; Stephen J. Galli, MD; Jeffrey A. Golden, MD; ...cich, MD, PhD

asserting that the value propositions for health care systems must include means to incorporate robust computational approaches to implement data-driven methods that aid in guiding individual and population health care; leveraging computational pathology as a center for data interpretation in modern health care systems; stating that realizing the value proposition will require working with institutional administrations, other departments, and pathology colleagues; declaring that a robust pipeline should be fostered that trains and develops future computational pathologists, for those with both pathology and non-pathology backgrounds; and deciding that computational pathology should serve as a hub for data-related research in health care systems. The dissemination of these recommendations to pathology and bioinformatics departments should help facilitate the development of computational pathology.

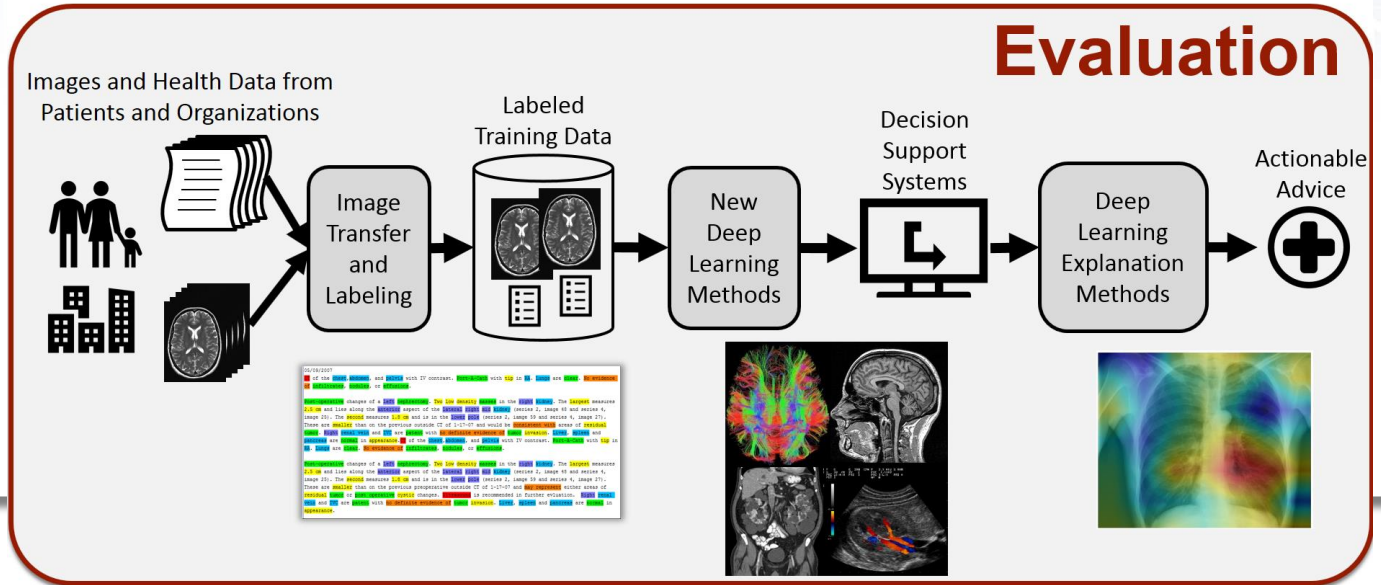
(*Arch Pathol Lab Med.* doi: 10.5858/arpa.2015-0093-SA)

Louis, et. al. 2015, Arch Path Lab Med

Radiomics: A Definition

- **Radiomics** is a field of medical study that aims to extract large amount of quantitative features from medical images using data-characterization algorithms. These features, termed **radiomic** features, have the potential to uncover disease characteristics that fail to be appreciated by the naked eye.

Deep Learning Research in Radiology



From: Artificial Intelligence to Enhance Radiology Image Interpretation - Curtis P. Langlotz, MD, PhD

Pathomics + Radiomics = Dx Power$^{\infty}$

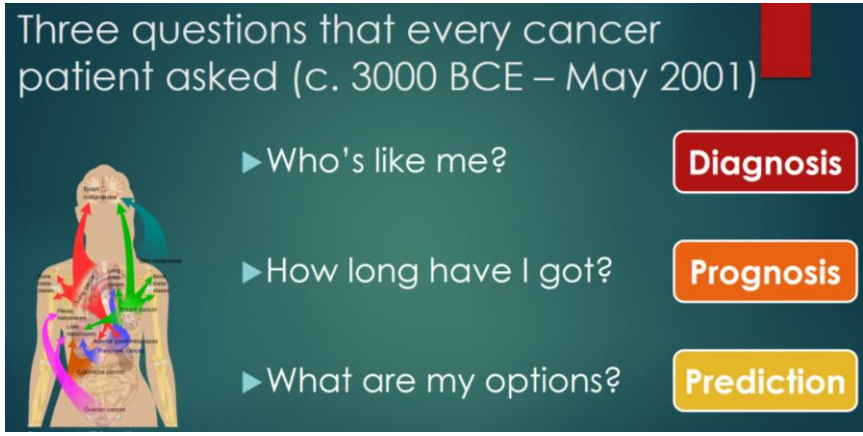
- Both Pathomics and Radiomics are making great strides in combining Genomics in computational algorithms for Dx, Px and Prediction
  - Pathogenomics and Radiogenomics are key
- Validation: Industry AI Rad/Path startups booming!
  - Pathomics Funding - Paige.AI (Fuchs) = $25M, PathAI = $15M, Fimmic = $11M
  - Radiomics Funding – Zebra Medical Vision = $20M, Arterys = $14M, AiDoc Medical = $11M, plus 30 radiology AI companies at RSNA in 2017

https://medium.com/@DrHughHarvey/the-a-z-guide-to-radiology-ai-companies-showcasing-at-rsna-2017-8c9976db90df

From Genomic Standards and Knowledge Bases for Decision Support = Jeremy Warner M.D., M.S.

SMART on FHIR Genomics: facilitating standardized clinico-genomic apps

Gil Alterovitz[1,2,3,*], Jeremy Warner[4,5,*], Peijin Zhang[6,*], Yishen Chen[7], Mollie Ullman-Cullere[8], David Kreda[2], Isaac S. Kohane[1,2,3]



Precision Oncology at Scale Leverages Computation (AI)

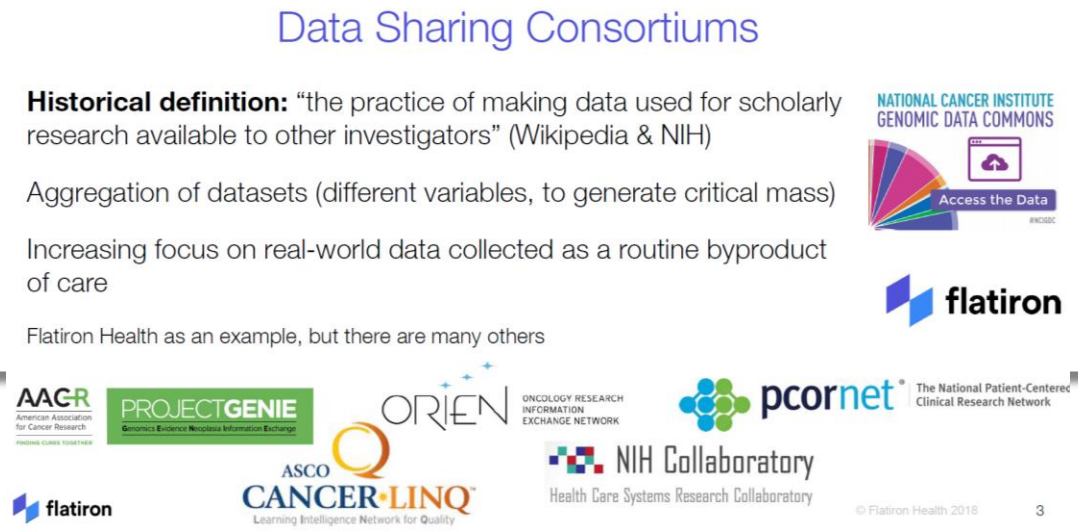
- Imaging data is multidimensional (complex) and multi-modal (weighted images, tracers, color, fluorescence, etc...)
- Deeper understanding of imaging data is facilitated by AI to see what is not visible by human cognition alone (e.g. “fundamental theorem” Friedman, et al.)

Figure 1. A “Fundamental Theorem” of informatics.

Data Sharing is key to get there

- Data sharing will be key to AI for Oncology
- Needed for R&D, validation and implementation
- Training sets for the next generation of pathologists and radiologists – need to get involved
- FAIR data (Findable, Accessible, Interoperable and Reusable) and Academic/Industry partnership is key!

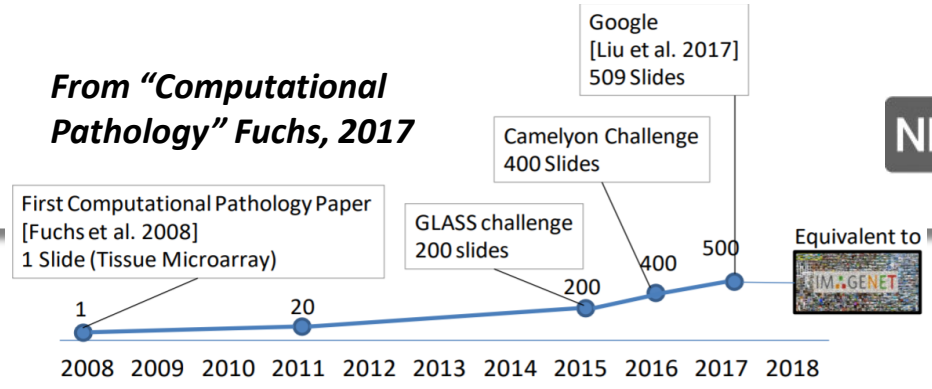
Data Sharing Consortiums and Large Datasets to Inform Cancer Diagnosis - Amy Abernethy, M.D.



Building Data Sharing Platforms Pathology and Radiology Can Share

- Text Information Extraction System (TIES) Cancer Research Network (TCRN) shares de-identified pathology and radiology reports and images which are searchable and FAIR
- Supported by NCI's Information Technology for Cancer Research (ITCR) program and links to The Cancer Image Archive (TCIA)
- Soon supporting datathons and hackathons

TIES v5 information extraction



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Conclusions

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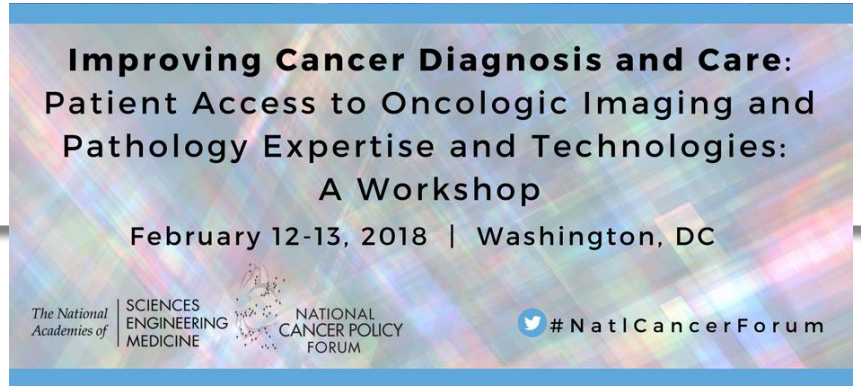
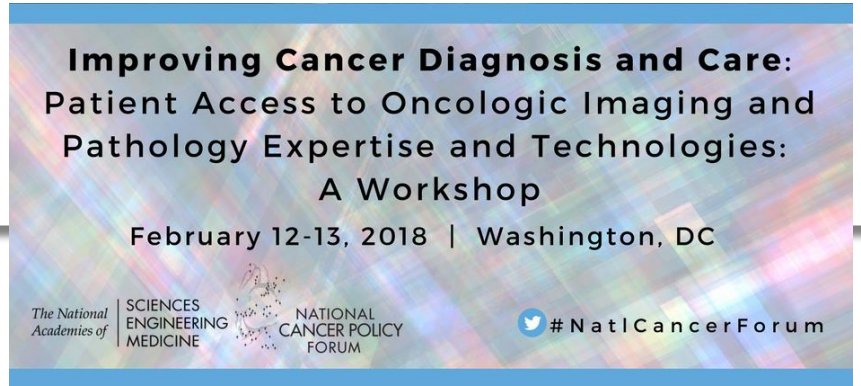


Questions to Address

- **How will artificial intelligence (AI) and machine learning change the practice of radiology, pathology, and other forms of diagnostic imaging?**
- **How should clinical training be transformed so future physicians are prepared to use AI and machine learning systems in daily practice?**
- **As we adopt AI, machine learning, and other information systems to improve diagnostic information and inform cancer care, what are the opportunities and challenges?**
- **What practice model is likely to derive the most benefit from AI and machine learning? (e.g. academic vs. community care setting, or urban vs. rural setting)**



Questions to Address

- **Is artificial intelligence and machine learning more likely to bring radiology and pathology together as a single specialty, or to keep them as separate disciplines?**
- **What role can AI, machine learning, and other information technologies play in enhancing radiology reports, pathology reports, and other forms of physician/patient communication?**
- **What are the best methods to produce large datasets that inform cancer diagnosis? What are the challenges in creating and using such data sets?**