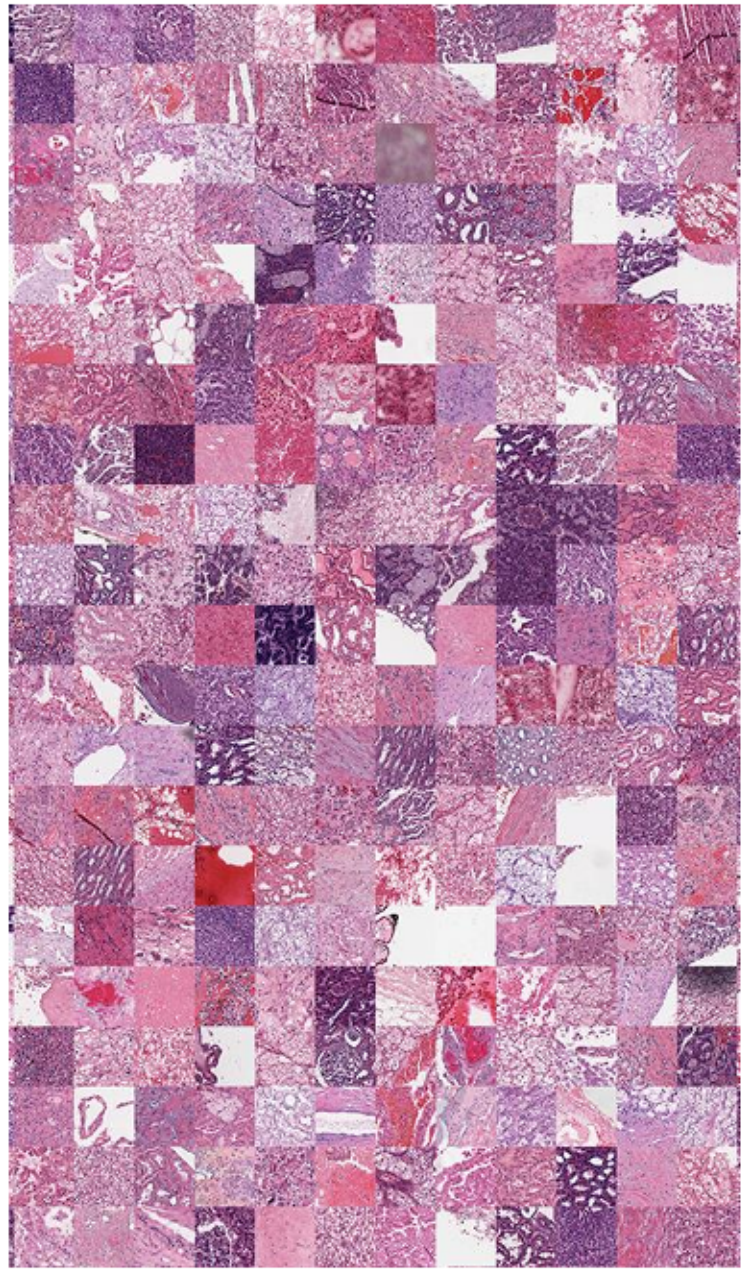
Artificial Intelligence Applied to Pathology
UofL / UofL Health Experience

Dibson Dibe Gondim, MD
Associate Professor of Pathology
Director, Pathology Informatics
Department of Pathology and Laboratory Medicine
University of Louisville School of Medicine

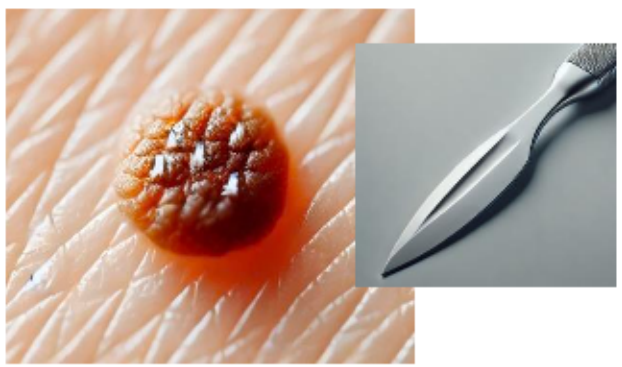


Topics

- Pathology
- Digital Pathology
- AI In Pathology
- No Reimbursement For Digital Pathology/AI
- UofL Health Implementation AI In Pathology
- How Large Datasets Are Essential To Advance In AI In Pathology

Pathology

- Fundamental for Diagnostic Confirmation
- Diagnostic possibility – Confirmed or Modified by Pathology
- Accurate and prompt pathology diagnosis
  - **Cornerstone of a successful treatment**

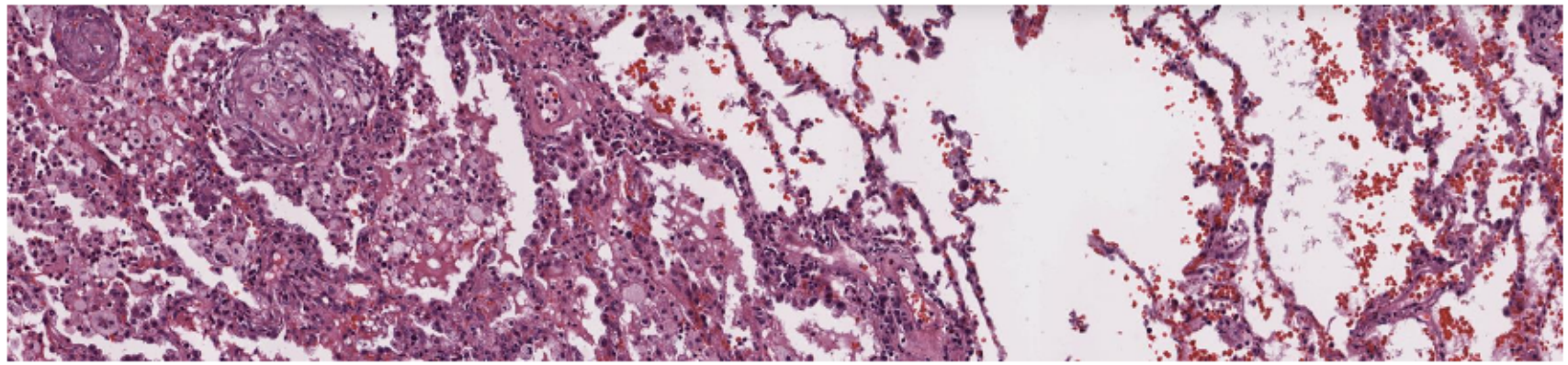


Pathology Report

Benign

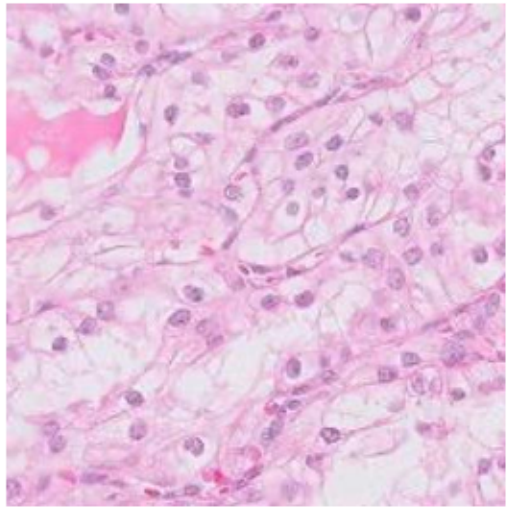
Malignant → **Cancer Treatment**

A GLIMPSE INTO THE WORLD OF PATHOLOGY

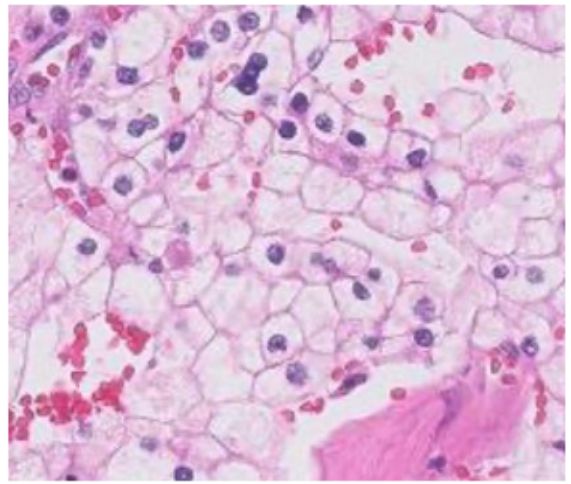


Lung Cancer

Normal Lung



Patient #1 - Kidney tumor
Clear Cell Papillary Renal Cell Tumor
BENIGN



Patient #2 - Kidney tumor
Clear Cell Renal Cell Carcinoma
MALIGNANT

Abdeltawab H, Khalifa F, Ghazal M, Cheng L, Gondim D, El-Baz A. A pyramidal deep learning pipeline for kidney whole-slide histology images classification. Scientific reports. 2021 Oct 12;11(1):20189.

Digital Pathology

- Traditionally, pathology glass slide images examined with a microscope
- Slide scanners capture digital images at high resolution
- Digitalization facilitates:
  - Efficient workflows
  - Specialized consultations
  - Multidisciplinary conferences
  - AI

Glass Slide

Slide Scanner

Digital Images

State of Digital Pathology in US

- Digitization is needed for AI
- Estimated that <10% of pathology labs in the US are fully digital
- Leaders in Digital Pathology and AI
  - University of Louisville
    - Initiated transformation to DP in 2021
    - Validated and deployed first pathology AI application in 2021
    - Completed full digitization in 2022
  - The Ohio State University
  - Memorial Sloan Kettering, NYC

https://klasresearch.com/report/us-digital-pathology-2023-a-deep-dive-into-early-clinical-adopters-successes-and-lessons-learned/3215

THE DARK REPORT
Since 1995, Reliable Business Intelligence for Clinical Laboratories, Pathology Groups and Laboratory Diag

DIGITAL PATHOLOGY ROLLOUT WAS 'BIG BANG' AT UNIVERSITY OF LOUISVILLE

Academic pathology department's goal was full implementation, including primary diagnosis

By Scott Wallask > From the Volume XXX, No. 11 - July 31, 2023 Issue

← OIG: Billing Code 81408 Is at 'Risk of Improper Payment' 2022 Ranking of the World's Top 12 IVD Corporations →

CEO SUMMARY: It took less than one year to achieve full implementation of whole slide imaging and digital pathology at the University of Louisville's Department of Pathology. One decision was to scan slides in a central location to promote efficient workflows. Integrating digital pathology with the pathology LIS and artificial intelligence software proved to be ...

https://www.darkintelligencegroup.com/the-dark-report/digital-pathology/digital-pathology-rollout-was-big-bang-at-uofl/

AI for Pathology Images

PRIMARY OUTPUTS

- Image segmentation
  - e.g. Cells, structures (vessels)
- Regression prediction
- Categorization

APPLICATIONS

- Quality control
- Triage
- Diagnosis
- Molecular alteration prediction
- Treatment recommendation
- Search engines

UofL AI experience in Pathology

- Paige Prostate AI (implemented)
  - Prostate cancer is second most type of cancer in men
  - AI as **quality control** system for prostate biopsies
- Paige MSI detection for colon cancer (under validation)
  - AI can **predict genetic alteration** based on pathology images
- Paige Pan Cancer Detection (pre-validation implementation)
  - **Triage** pathology cases based on likelihood of cancer

Paige Prostate AI validation

- Initial Dataset: 1220 prostate biopsy digital images
- Diagnosis of interest: Benign and Prostate Cancer
- Excluded: Precursor lesions, non-definitive cancer
- Final Dataset: 1141

- **Sensitivity:** 0.9798 (97.98%)
- **Specificity:** 0.9810 (98.10%)
- **Positive Predictive Value (PPV):** 0.9344 (93.44%)
- **Negative Predictive Value (NPV):** 0.9943 (99.43%)
- **Accuracy:** 0.9807 (98.07%)

- 1441 slides
- **AI contributions = 6/1441 slides = diagnostic correction 0.4%**
- 2 slides called benign changed for cancer
- 4 slides called cancer changed to benign
- **AI distractions**
- 17 slides mistakenly called cancer
- 4 slides mistakenly called benign

Layered Approach
Higher Diagnostic Quality

- 1st Layer - Pathologist read (No AI bias)
- 2nd Layer - AI
- 3rd Layer - Adjudicating pathologist/AI discrepancies

- What is the impact of 0.4% diagnostic correction?
- Impact on the lives of the individuals is meaningful
- AI has the potential to set new acceptable standards
- Aviation 2023: 1 accident every 1.26 million flights

Challenges for DP/AI

- Digital Pathology Transition
  - Expensive
  - Requires expertise (Pathology Informatics and IT)
  - No specific reimbursement (Category III CPT codes – Statical Purposes)
- Cost effective solution for large systems
  - Norway, England => Towards National Level
- Smaller/Rural organizations
  - Risk of DP/AI gap

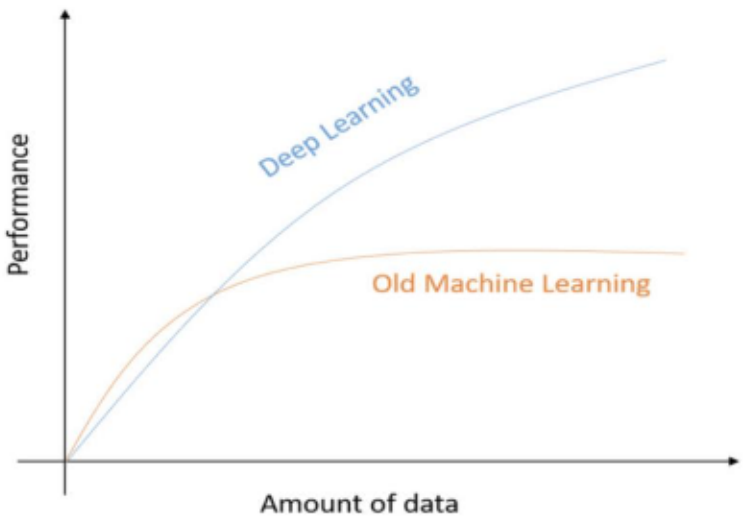
When was the breakthrough?

- 2012 – AlexnetNet
  - **DEEP LEARNING**
  - Successful implementation for image classification
- 2021 – Paige Prostate AI - First FDA approved algorithm for pathology
- Complex biologic systems of cells and tissues
  - High variability
  - Large number of objects (> 1 million cells in a single slide)
  - Color variability due to staining

Alom, Md Zahangir, et al. "The history began from alexnet: A comprehensive survey on deep learning approaches." *arXiv preprint arXiv:1803.01164* (2018).
Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." *Advances in neural information processing systems*25 (2012).

Alexnet 2012

- #1 Large neural networks (Deep Learning)
  - Powerful to extract semantic feature of images
- #2 Large dataset
- #3 Computations GPU (high performance computing)



Performance comparison based on amount of data for AI and ML Algorithms

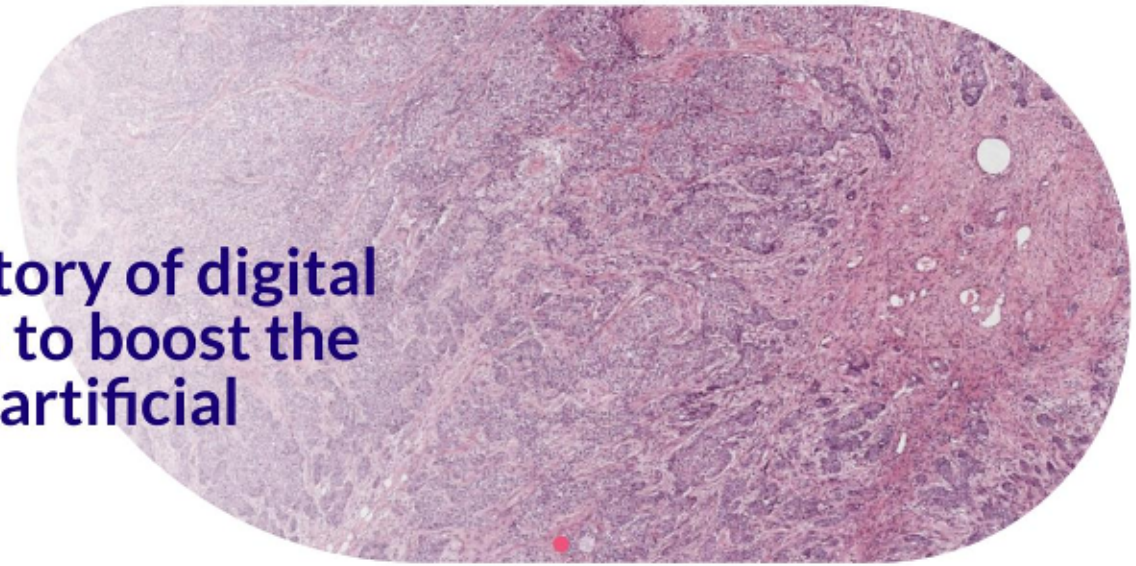
Large Pathology Datasets is Essential
To Advance AI Performance

European Efforts to Develop AI in Pathology

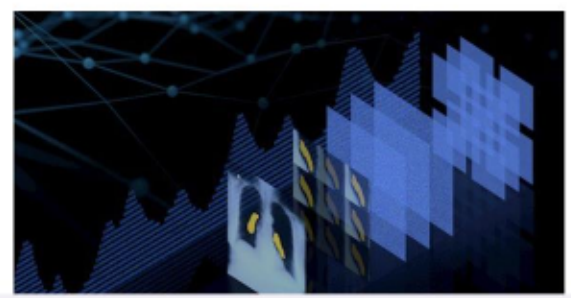
- Project BIGPICTURE
- Repository of 3 million images
- Pharmaceutical Companies: 10
- Universities, Research Organizations: 24
- Small and Mid-sized Companies: 11

bigpicture

ABOUT US OUR WORK OUR TEAM NEWS COMMUNITY

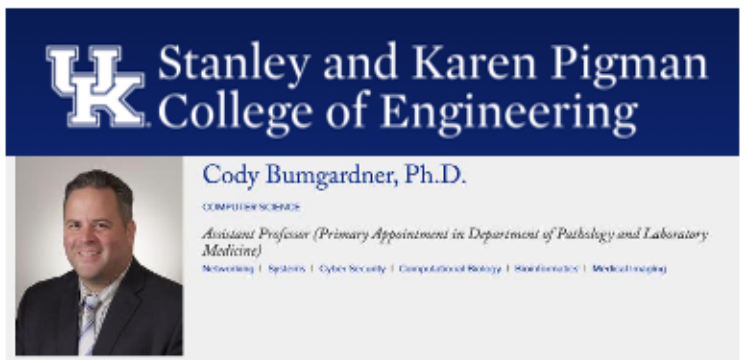


A central repository of digital pathology slides to boost the development of artificial intelligence



Regional Digital Pathology Repository for Research

- University of Louisville
- University of Kentucky
- Over 300,000 images
- Example of integration of clinical and research workflows



Summary

- Digital pathology transition is a basic requirement for AI
- No reimbursement for Digital pathology /AI
- <10% pathology labs in the US are fully digital
- Small laboratories/rural institutions are risk of having an DP/AI gap
- Infrastructure to compile massive pathology datasets will be needed to develop a new generation of AI tools
- Some countries are building DP/AI infrastructure at the national level

Thank you!

UNIVERSITY OF LOUISVILLE
SCHOOL OF MEDICINE

- Dibson D Gondim, MD
  +1 (502) 587-4210
- dibson.gondim@louisville.edu

CONTACT

louisville.edu/medicine/departments/pathology