

Deep Learning for Medical Image Analysis

COMP5423

Hao CHEN

Dept. of CSE,CBE&LIFS, HKUST

jhc@cse.ust.hk



THE DEPARTMENT OF
COMPUTER SCIENCE & ENGINEERING
計算機科學及工程學系



香港科技大學
THE HONG KONG UNIVERSITY OF
SCIENCE AND TECHNOLOGY

Our Team

- Instructor

Dr. Hao CHEN, Assistant Professor

Email: jhc@cse.ust.hk

Tel: +852-2358 8346

Office: RM 3524 (via lifts 25-26), Dept. of CSE, HKUST



- Teaching Assistant

Ms. Hongmei Wang, PhD student, CSE, HKUST

Email: hwangfy@connect.ust.hk



About me

- Instructor: Dr. Hao CHEN
- Assistant Professor of CSE at HKUST, Director of Smart Lab

<https://cse.hkust.edu.hk/~jhc/>

Research interest:

Trustworthy AI for Healthcare, etc.

- Experience in both academia ([google scholar](#)) and industry (e.g., Siemens and startup).
- Collaboration

If you are interested in medical image analysis, welcome to discuss with me.

COMP5423 DLMIA

- Lecture:

Tue and Thurs, 9:00-10:20am, Rm 5583, Lift 29-30.

Lecture notes will be available online in HKUST Canvas.

- Class Dates:

Feb 1, 2024-May 9, 2024

- Office Hours: by appointment.

- No tutorial/lab sessions.

Pre-requisites

- Basic Math including calculus, linear algebra, geometry, probability, statistics.
- Image Processing and Machine Learning

We will cover some fundamentals, thus no worries.

- Programming Skills

You may use Pytorch or Tensorflow in assignments and Final Project.

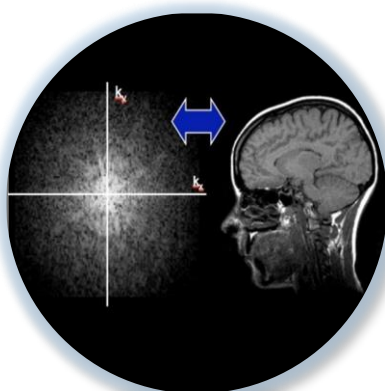
Deep learning shapes medical imaging

From imaging to prognosis



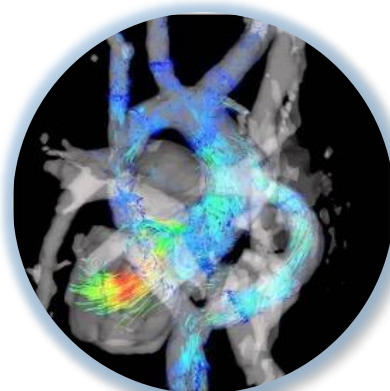
Acquisition

Safer, Faster, Better



Reconstruction

See the Invisible, Accurate, Quantitative



Visualization (XR)



Analysis & Diagnosis

Decision Support, Minimize Risk



Treatment & Prognosis

Syllabus (tentative)

1. Introduction to Medical Image Analysis
2. Fundamentals of Deep Learning
3. Medical Image Classification
4. Medical Image Segmentation
5. Medical Image Registration
6. Label-efficient Learning in MIA
7. Anomaly Detection in MIA
8. Attention Mechanism in MIA
9. Explainability in MIA
10. Domain Adaptation in MIA
11. Federated Learning in MIA
12. Multimodal Learning for Precision Oncology
13. Foundation Models in MIA
14. Advances and Applications

Textbooks

- No official textbooks.
- Some useful books:

Toennies, Klaus D. **Guide to medical image analysis**. Springer London, 2017.

Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. **Deep learning**. MIT press, 2016.

Dhawan, Atam P. **Medical image analysis**. Vol. 31. John Wiley & Sons, 2011.

Zhou, S. Kevin, Hayit Greenspan, and Dinggang Shen, eds. **Deep learning for medical image analysis**. Academic Press, 2017.

Grading Scheme

- Assignments (20%)

2 assignments (each 10%), including paper presentation and survey report, etc.

- Final Project (60%)

Final presentation and Project report.

Details will be released later.

- Final Exam (20%)

All the content covered in class.

Policies

- Late policies

20% penalty per day, maximum of one day.

- Honor academic integrity

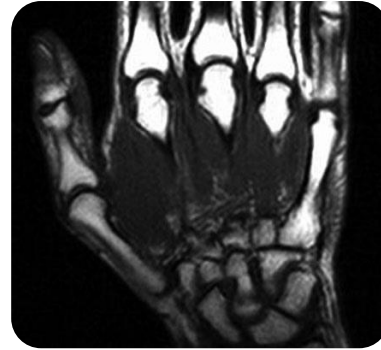
We will follow university's policy for penalty if improper actions identified.

Goals for this Course

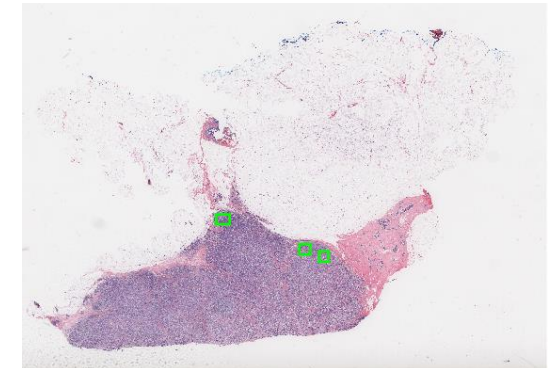
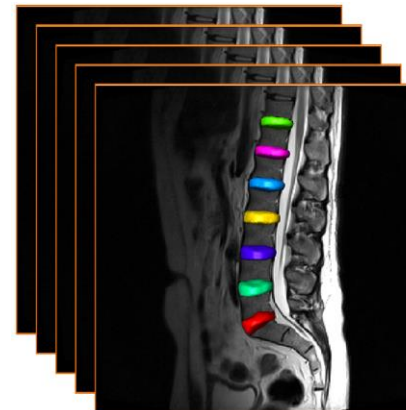
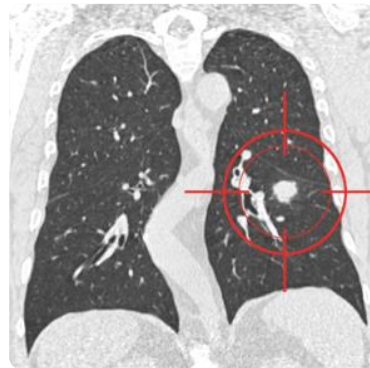
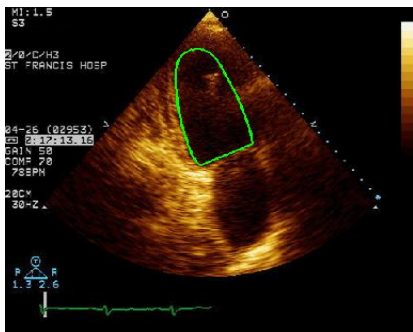
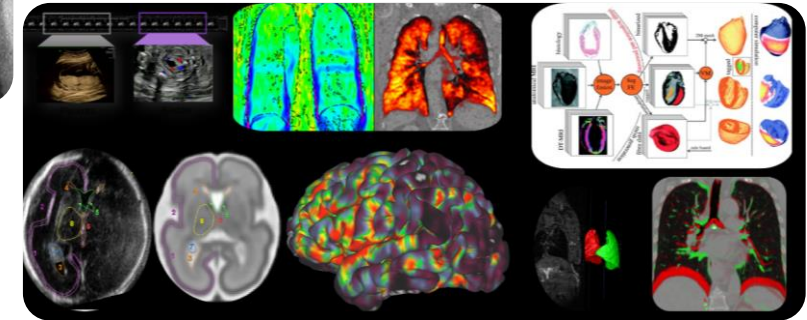
- Obtain the basic knowledge of medical imaging techniques and various medical image analysis tasks.
- Learn the fundamentals in deep learning methods for medical imaging and analysis.
- Master and apply the skills of deep learning technologies in medical image analysis tasks, including computer-aided detection, diagnosis and prognosis, etc.
- Gain the current research and development trends in both academia and industry in the domain of medical imaging and analysis.

Topic 1: Introduction to MIA

- Why **medical imaging** is unique?

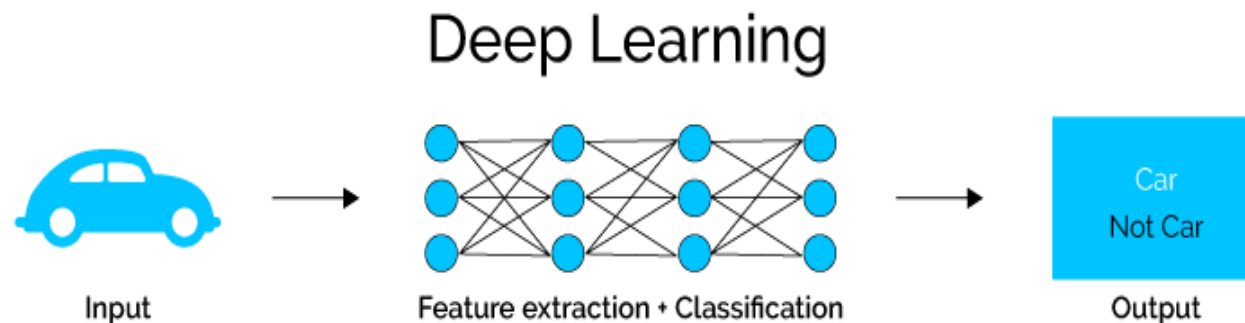
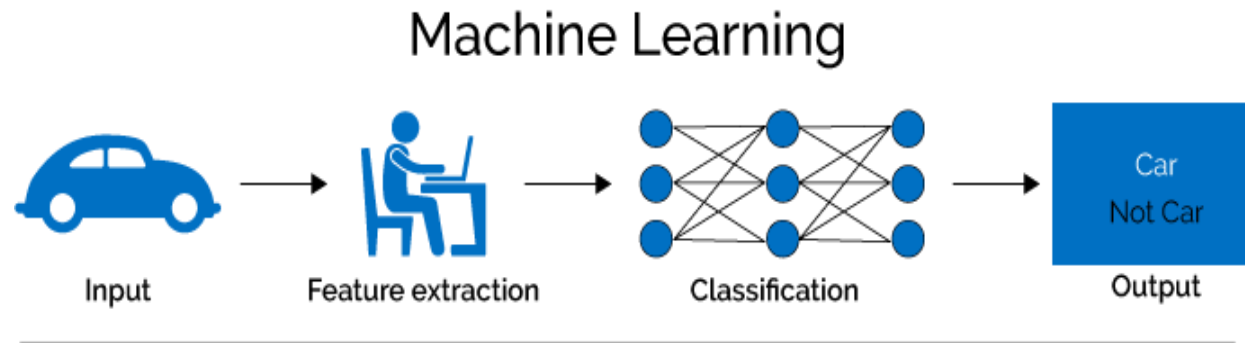


- **Applications** related to medical image analysis.
- Various **medical imaging modalities**.



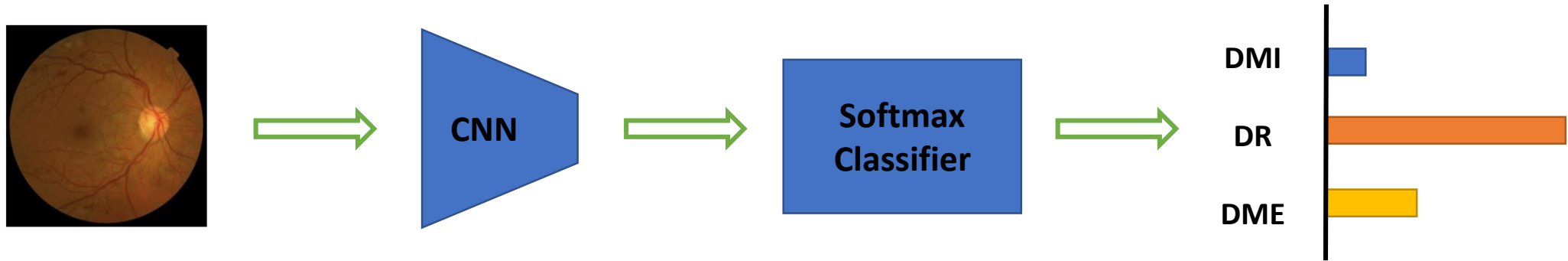
Topic 2: Fundamentals of Deep Learning

- Machine learning basics
- **Deep learning** models and optimization, including CNN, RNN, Autoencoder, etc.



Topic 3: Medical Image Classification

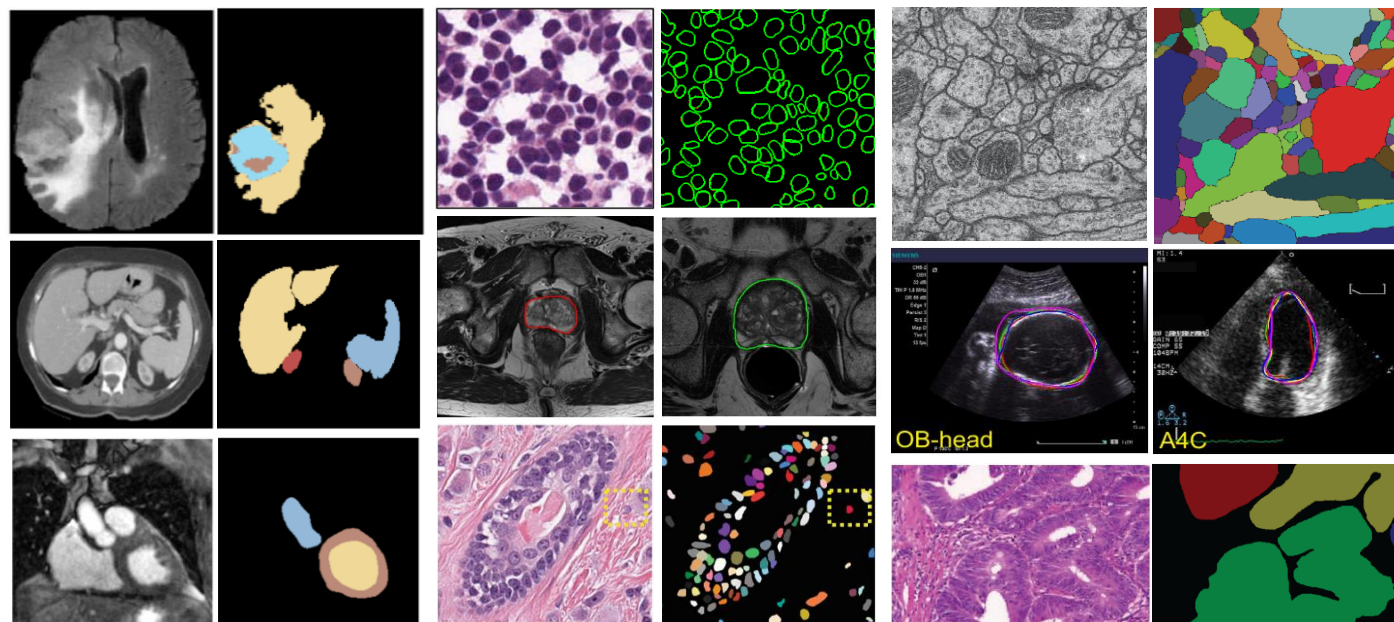
- How to build and evaluate a **medical image classifier** with deep learning?



- Transfer learning with limited medical dataset
- 3D deep learning for volumetric image modality
- Multi-task learning, etc.

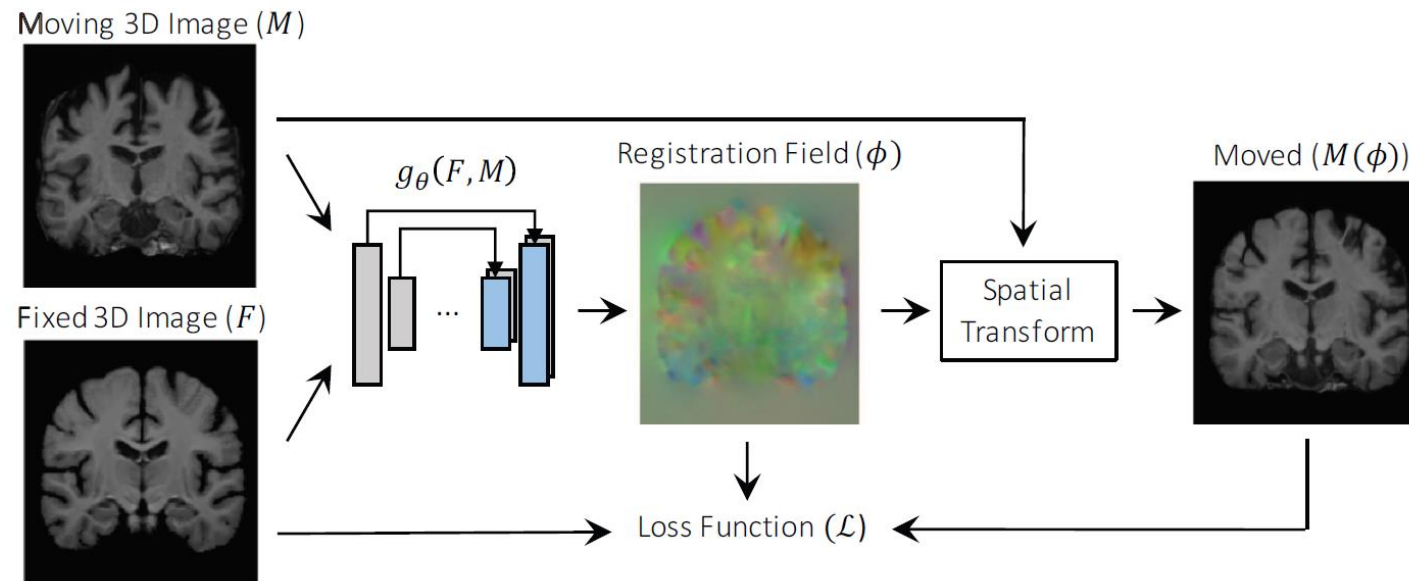
Topic 4: Medical Image Segmentation

- Semantic vs instance segmentation
- Context vs localization
- Volumetric medical image segmentation
- Interactive segmentation
- Challenges and directions



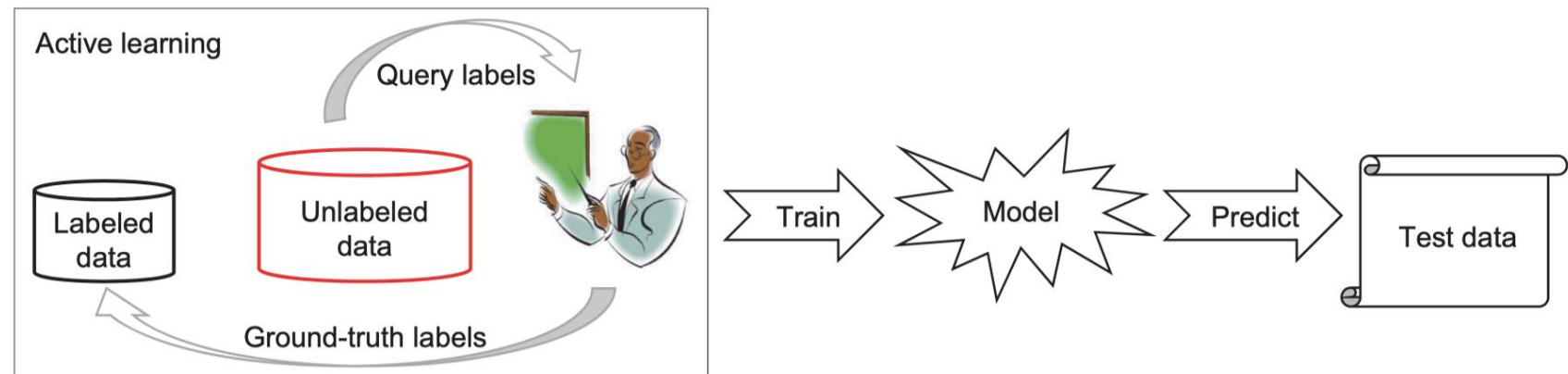
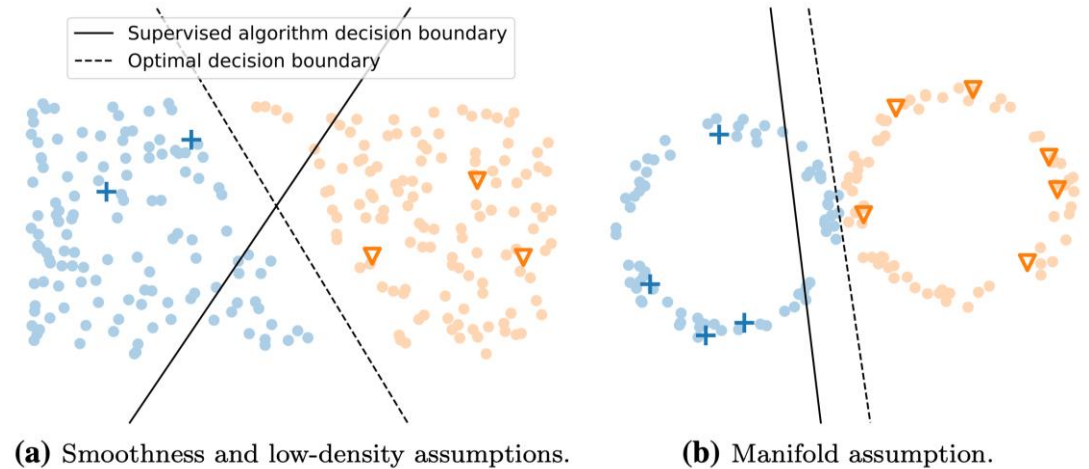
Topic 5: Medical Image Registration

- Medical image registration and evaluation
- Deep similarity metric
- Supervised image registration
- Unsupervised image registration
- Challenges and future directions



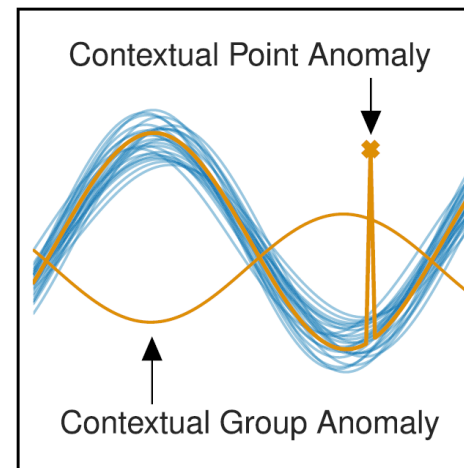
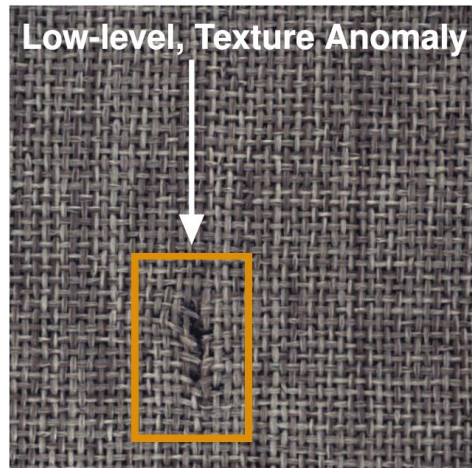
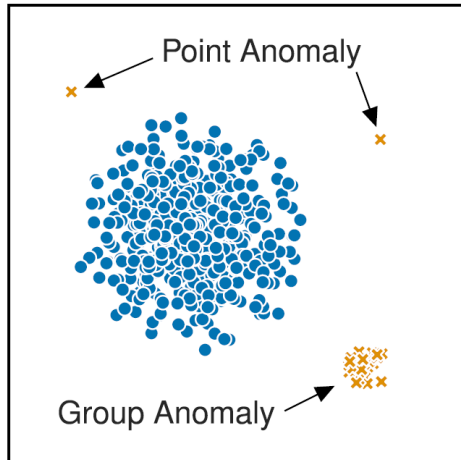
Topic 6: Label-efficient Learning in MIA

- What's label-efficient learning?
- Semi-supervised learning
- Multi-instance learning
- Self-supervised learning
- Active learning
- Annotation-efficient learning
- Future directions



Topic 7: Anomaly Detection in MIA

- What's anomaly detection?
- Reconstruction-based methods
- Self-supervised methods
- Challenge and future direction

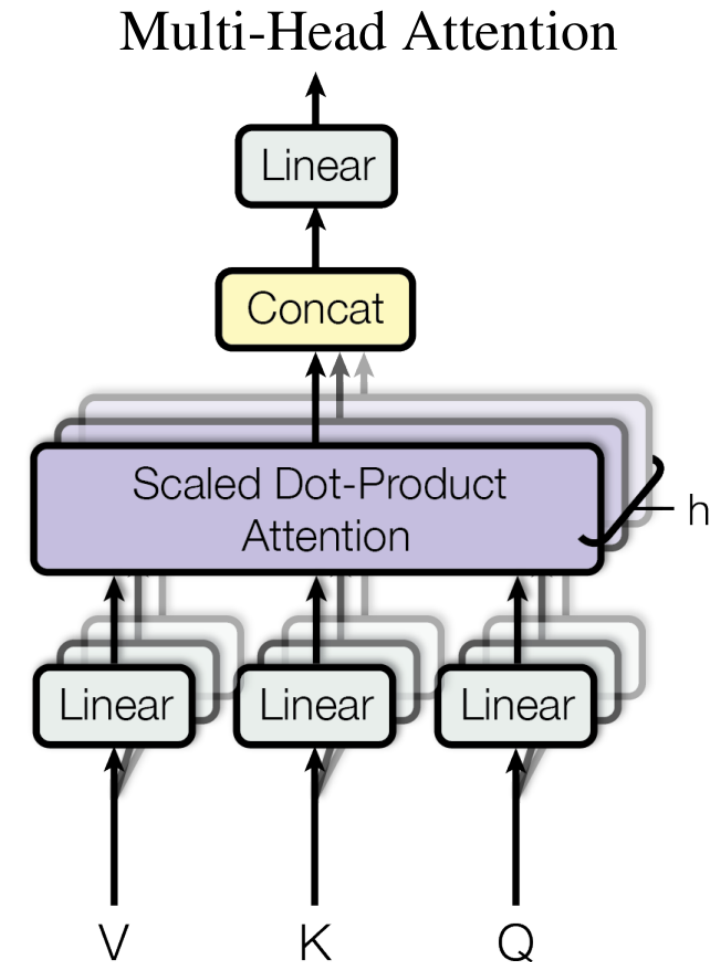


High-level, Semantic Anomaly



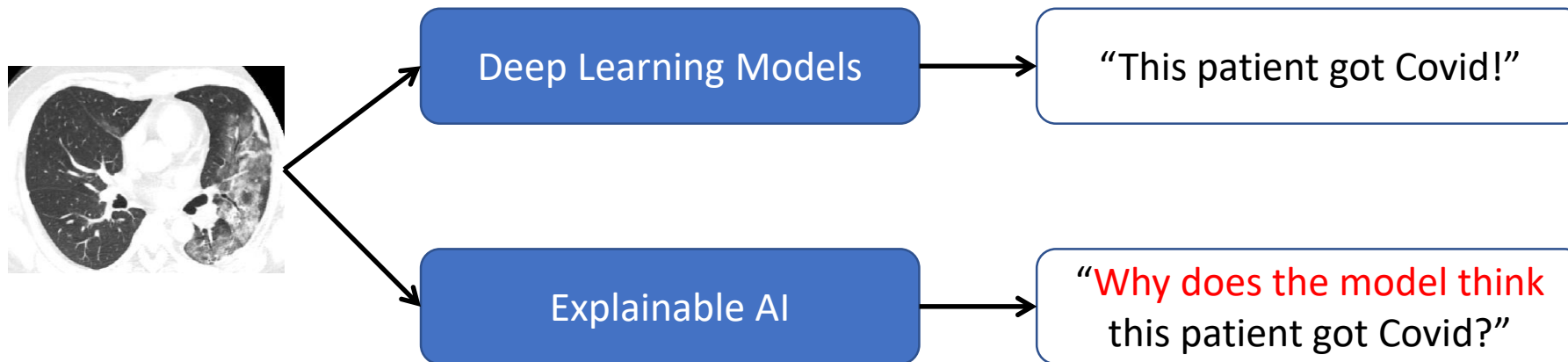
Topic 8: Attention Mechanism in MIA

- What's attention?
- Spatial and channel attention
- Transformer
- Challenge and future direction



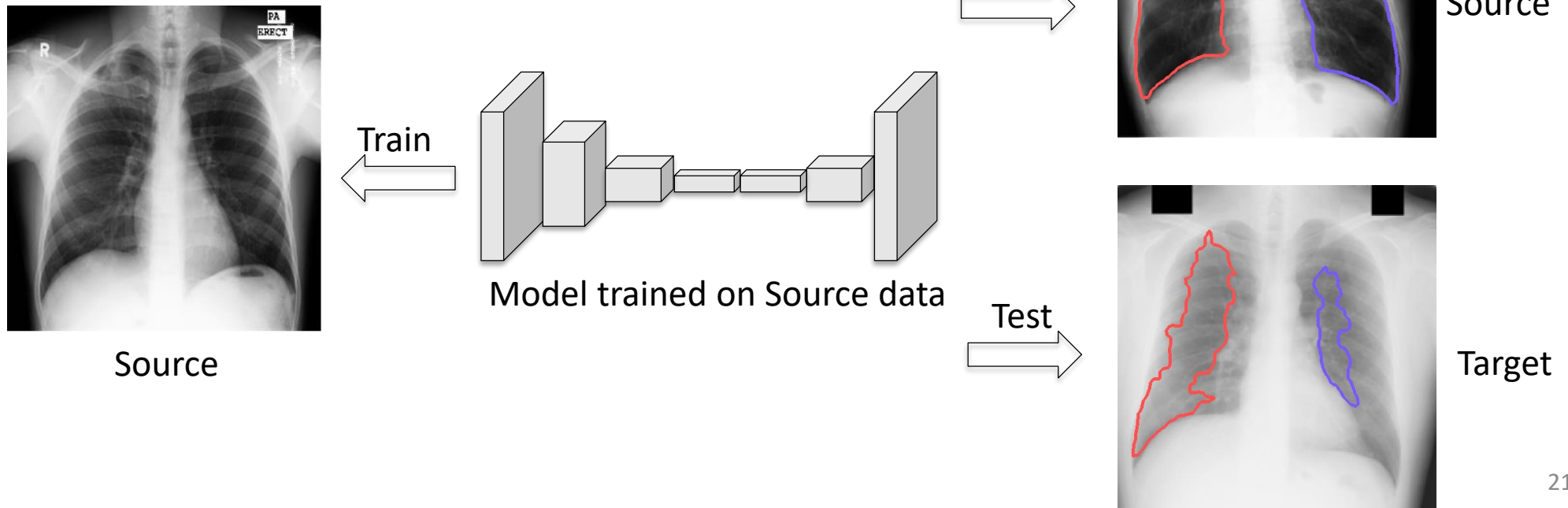
Topic 9: Explainability in MIA

- What's explainability?
- Categories of explainable AI
- Ante-hoc vs Post-hoc methods



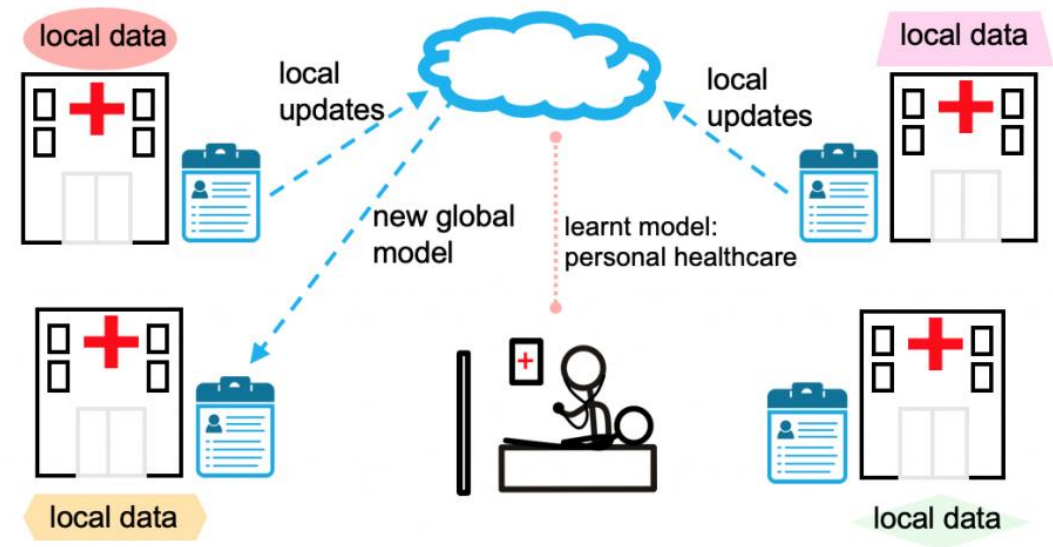
Topic 10: Domain Adaptation in MIA

- What's domain adaptation?
- Shallow domain adaptation
- Deep domain adaptation
- Challenge and future direction



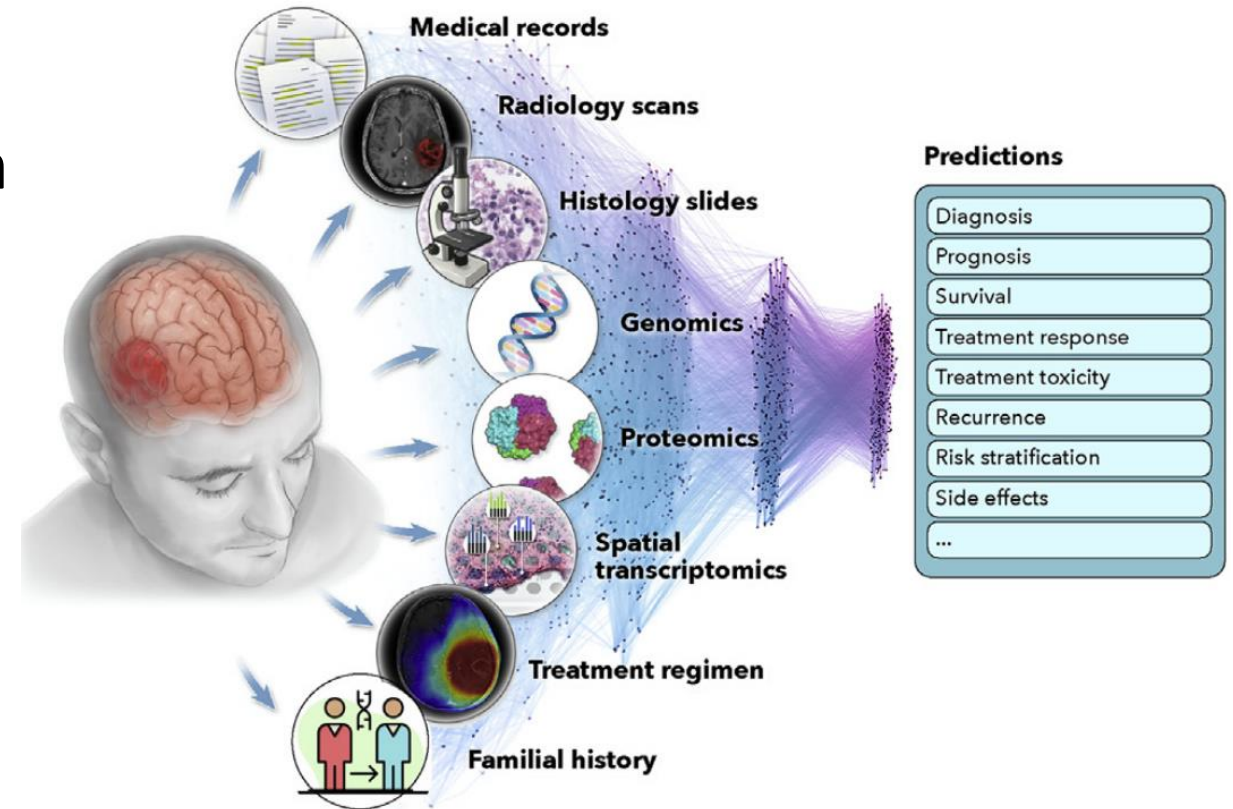
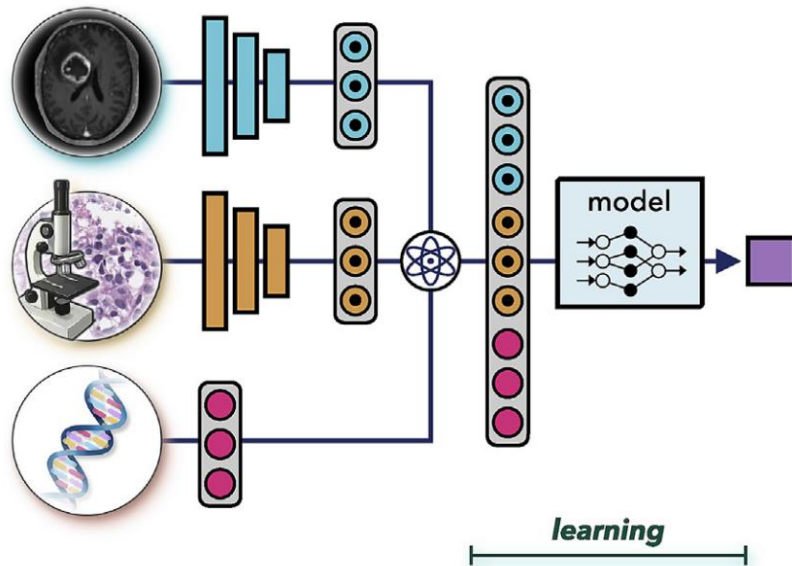
Topic 11: Federated Learning in MIA

- What's federated learning?
- Federated learning for predicting clinical outcomes
- Federated domain generalization
- Federated semi-supervised learning
- Challenge and future direction



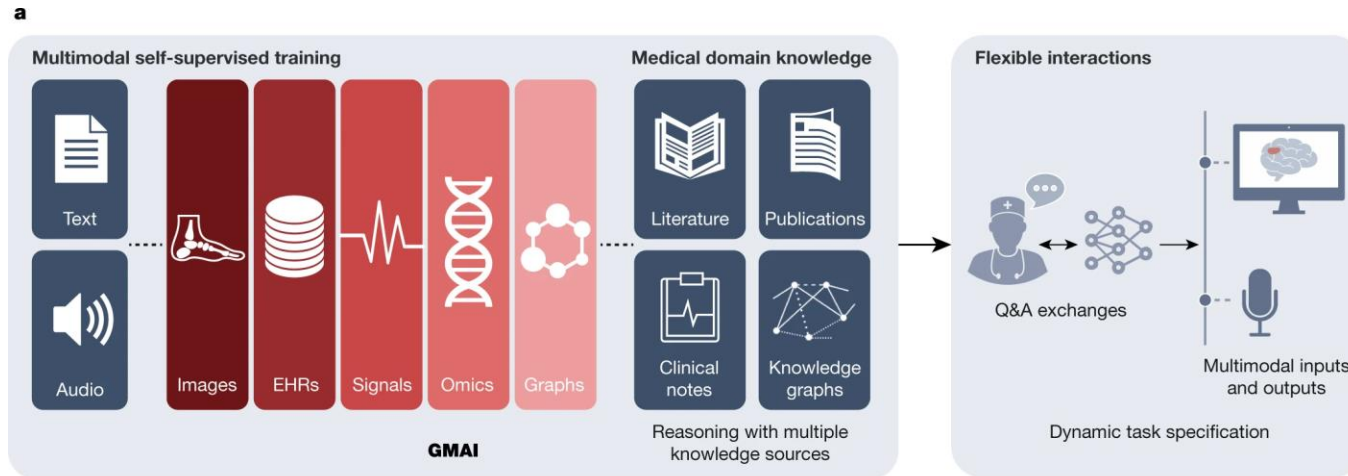
Topic 12: Multimodal Learning for Precision Oncology

- What's multimodal learning?
- Multimodal information fusion
- Multimodal data interconnection
- Challenge and clinical adoption

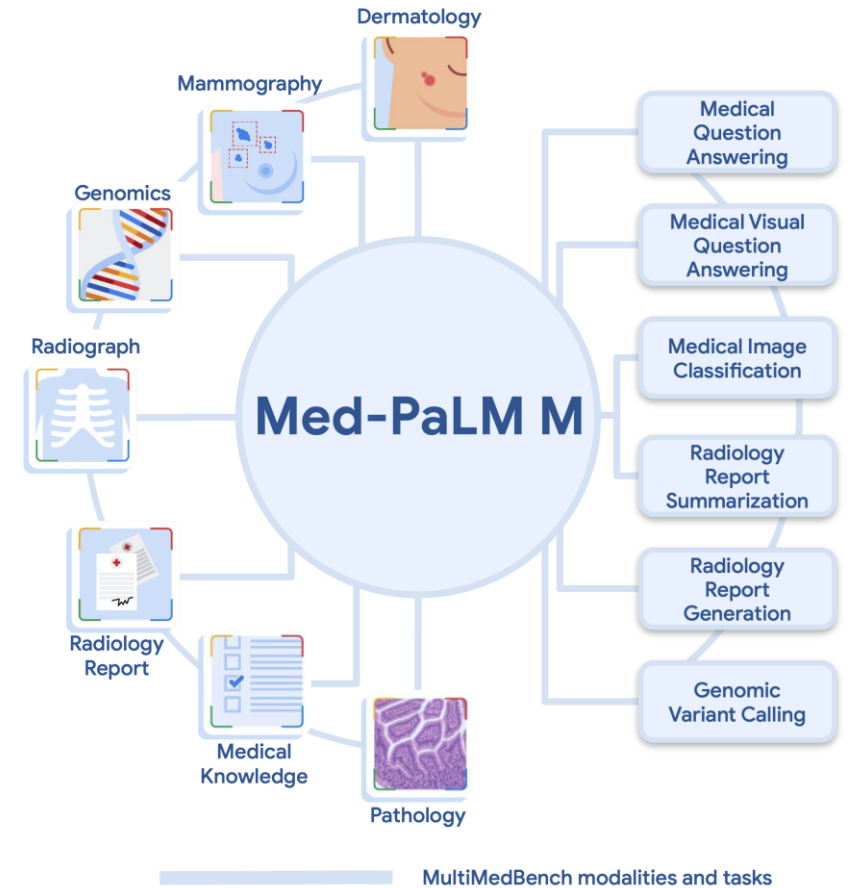


Topic 13: Foundation Models in MIA

- What's foundation model?
- Foundation model pre-training
- Foundation model adaption

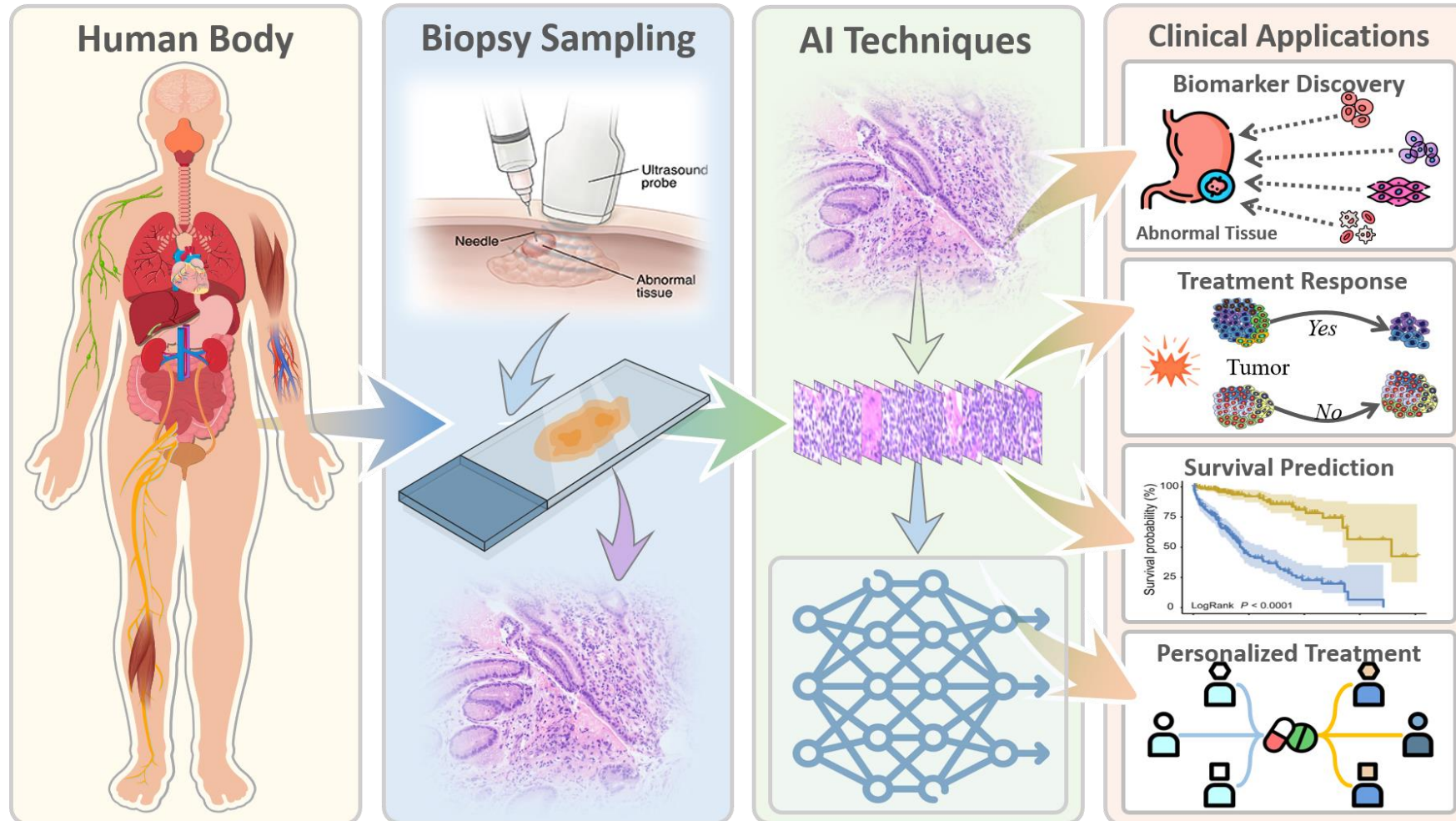


Regulations: Application approval; validation; audits; community-based challenges; analyses of biases, fairness and diversity



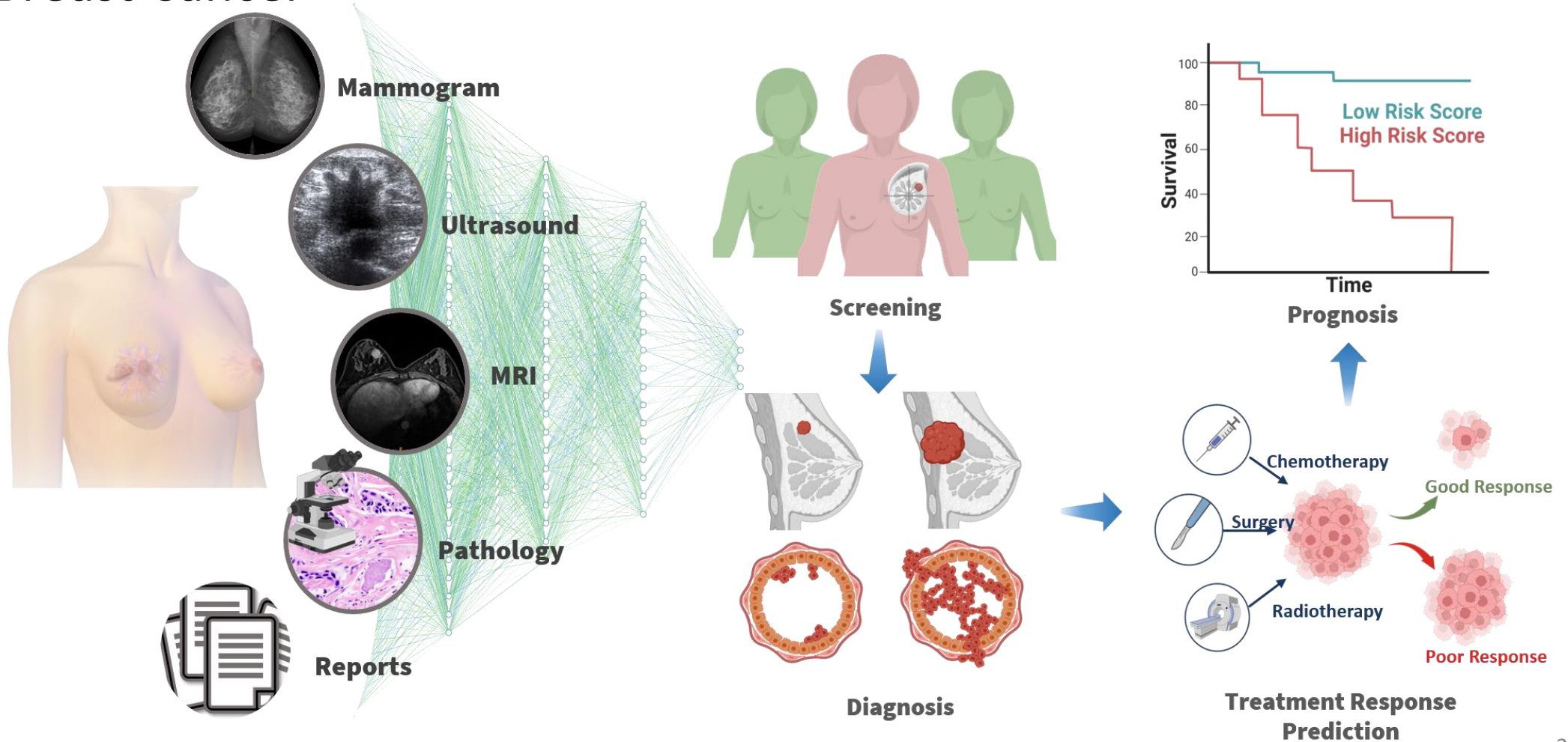
Topic 14: Advances and Applications

- Computational Pathology



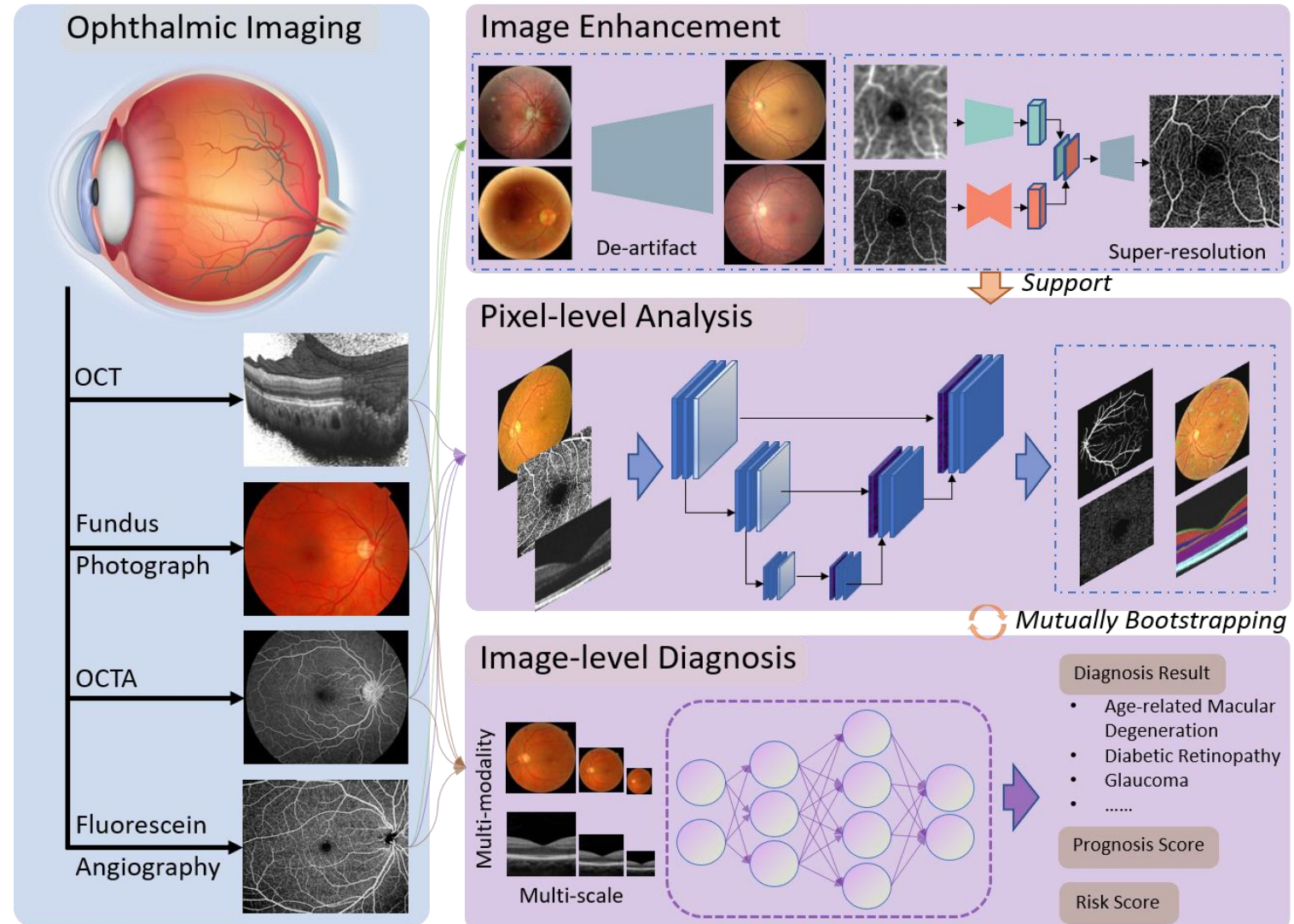
Topic 14: Advances and Applications

- Breast Cancer



Topic 14: Advances and Applications

- Ophthalmology



Any questions?

**Learn state-of-the-art technologies
and get hands on a practical project!**