Deep Learning for Medical Image Analysis

COMP5423

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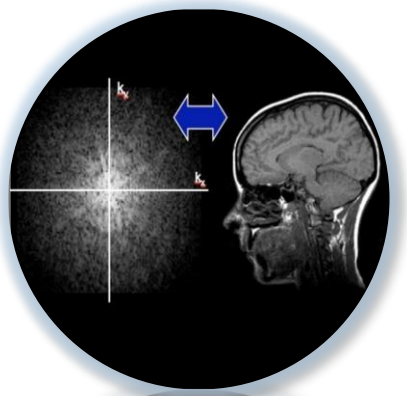
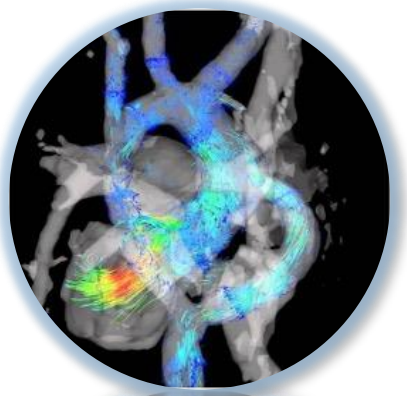
Deep learning shapes medical imaging

From imaging to prognosis

Acquisition



Reconstruction



Visualization (XR)

Analysis & Diagnosis

Treatment & Prognosis

Safer, Faster, Better | See the Invisible, Accurate, Quantitative | Decision Support, Minimize Risk

Syllabus

1. Course Overview
2. Introduction to Medical Image Analysis
3. Fundamentals of Deep Learning
4. Medical Image Classification
5. Medical Image Segmentation
6. Medical Image Registration
7. Label-efficient Learning in MIA
8. Anomaly Detection in MIA
9. Attention Mechanism in MIA
10. Explainability in MIA
11. Domain Adaptation in MIA
12. Federated Learning in MIA
13. Multimodal Learning in Healthcare
14. Review

Grading Scheme

- Assignments (20%)

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

- Final Project (60%)

Final presentation and Project report.

- Final Exam (20%)

All the content covered in class.

Time: 27/5/2024, 4:30PM - 5:30PM (please come 10 min early, i.e., 4:20pm).

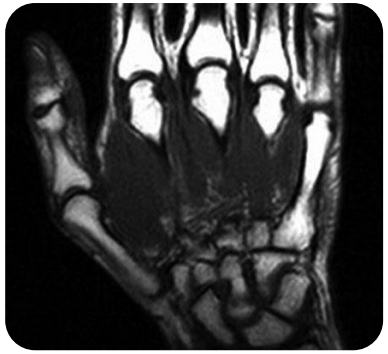
Venue: Rm 2463, Lift 25-26.

Goals for this Course

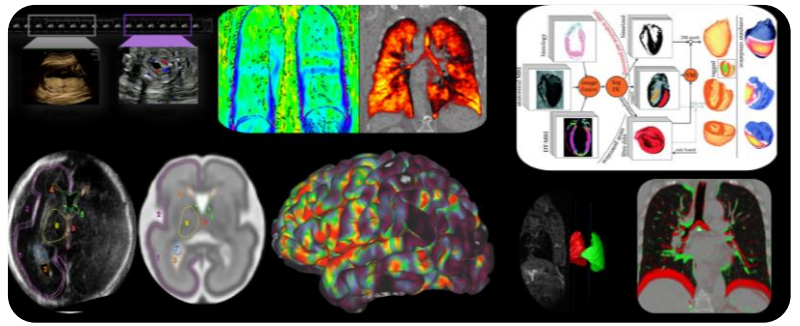
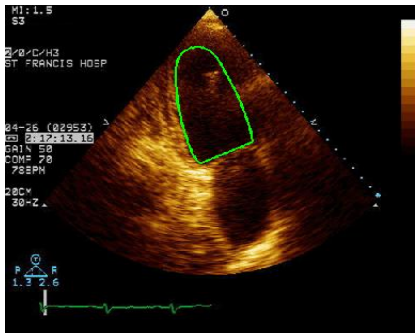
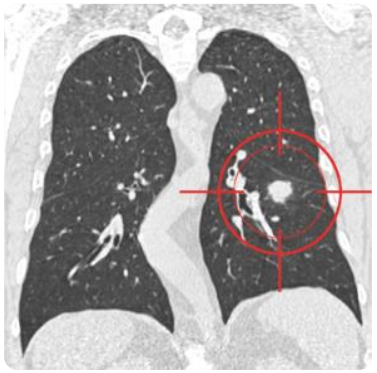
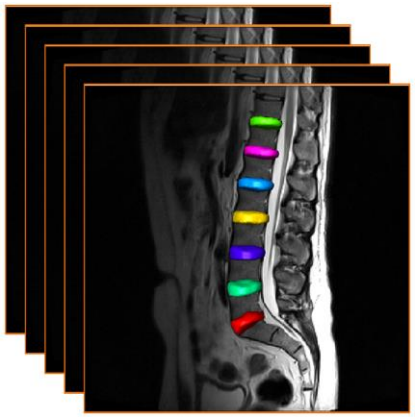
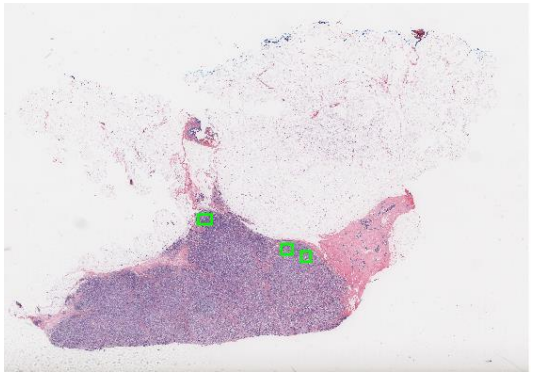
- Obtain the basic knowledge of medical imaging techniques and various medical image analysis tasks.
- Learn the fundamentals in deep learning methods for medical imaging and analysis.
- Master and apply the skills of deep learning technologies in medical image analysis tasks, including computer-aided 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?

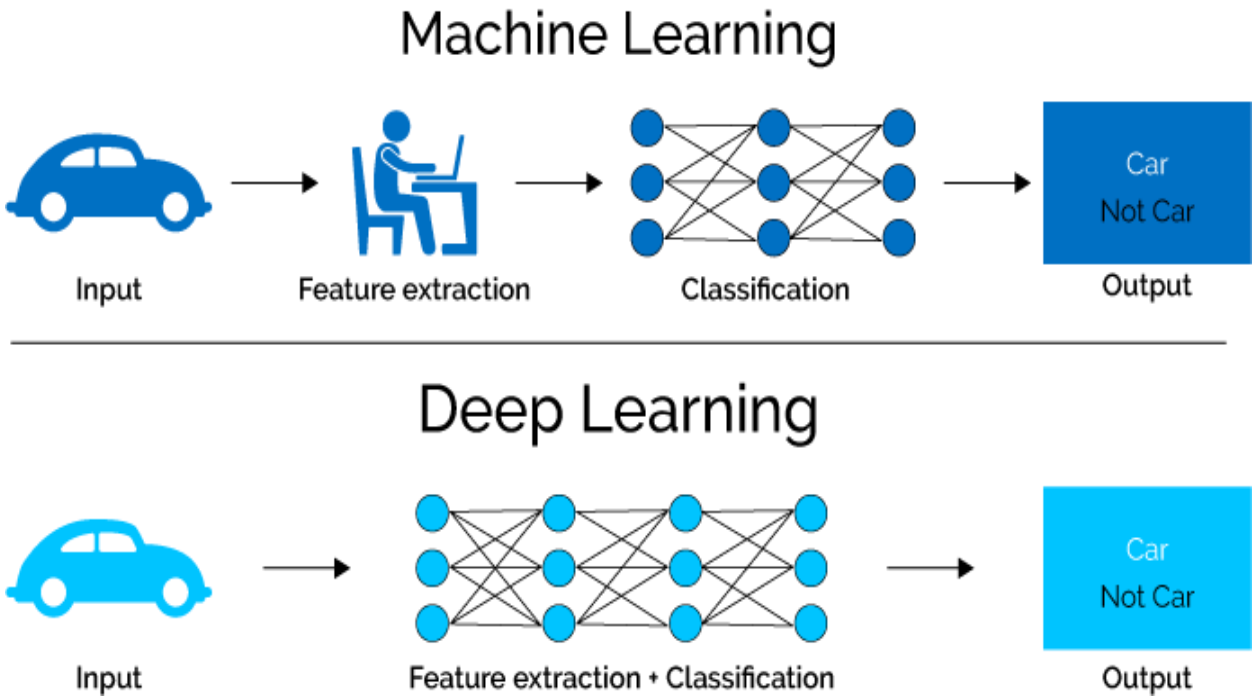




- **Applications** related to medical image analysis.
- Various **medical imaging modalities**.

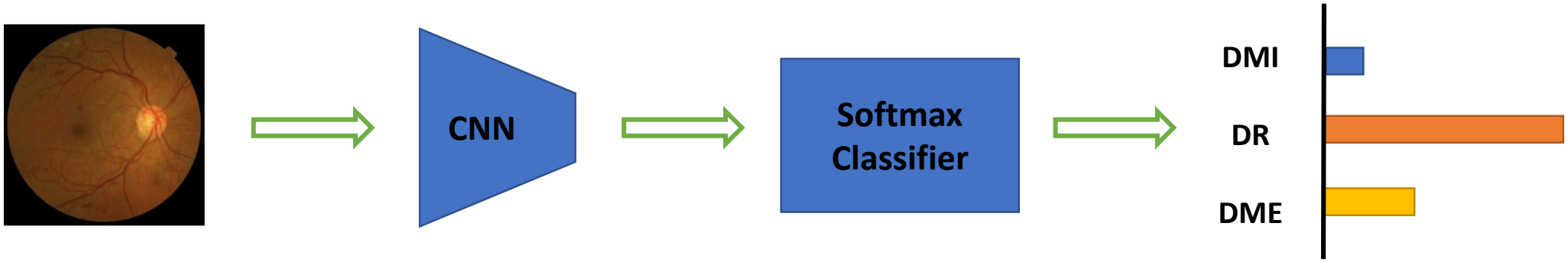
Topic 2: Fundamentals of Deep Learning

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



Topic 3: Medical Image Classification

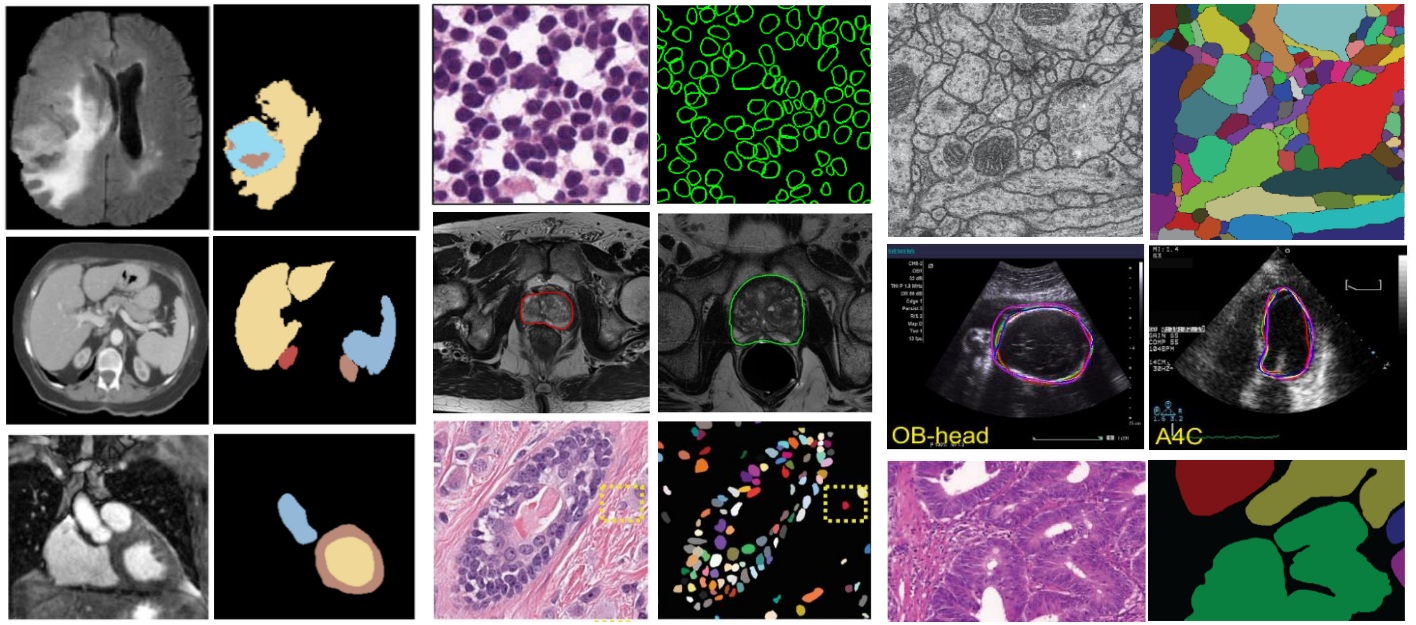
- How to build and evaluate a **medical image classifier** with deep learning?



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

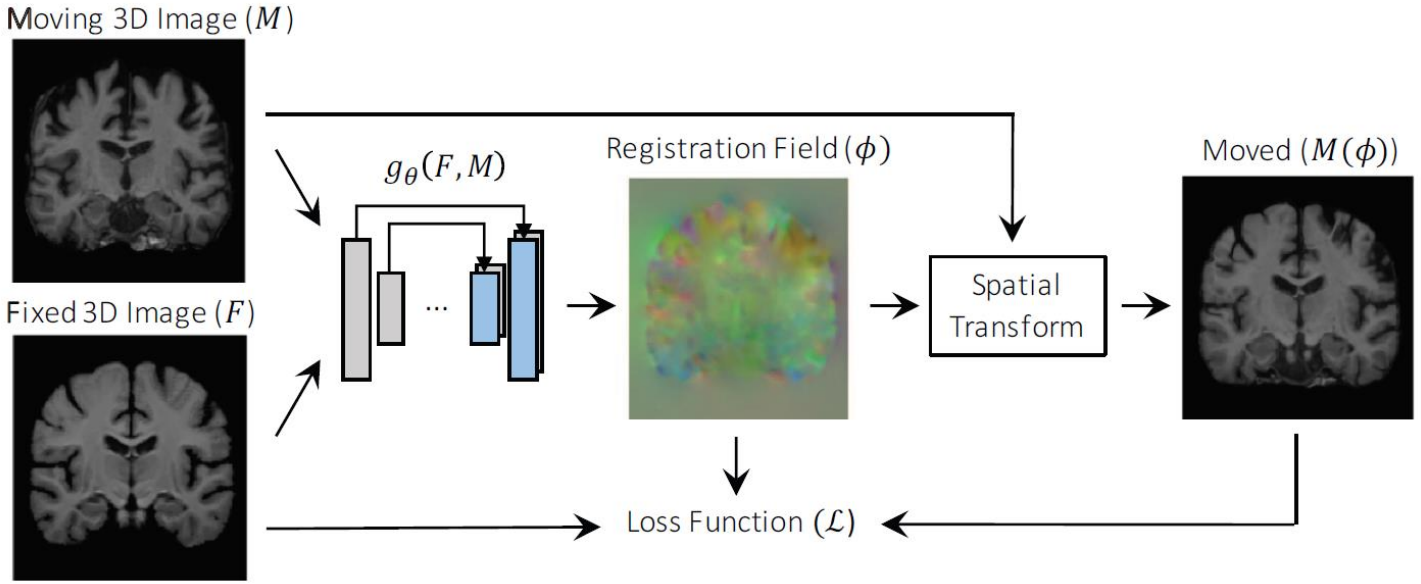
Topic 4: Medical Image Segmentation

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



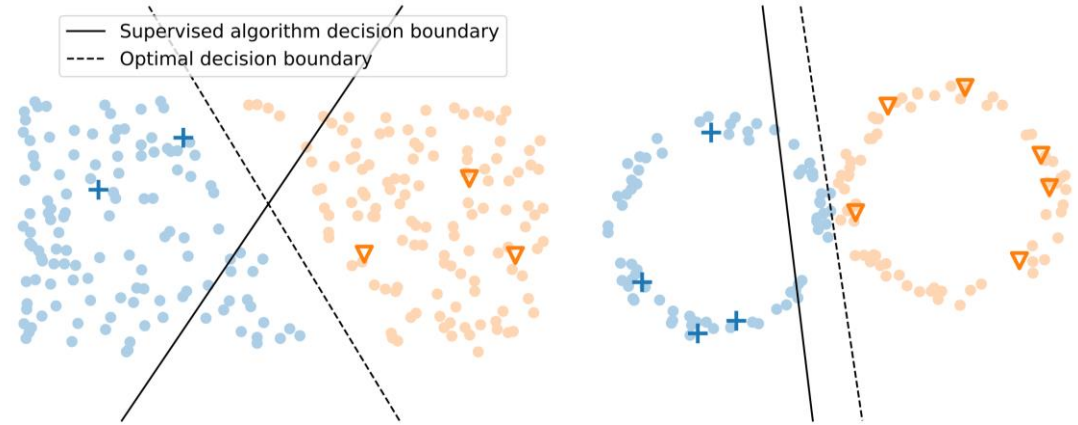
Topic 5: Medical Image Registration

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

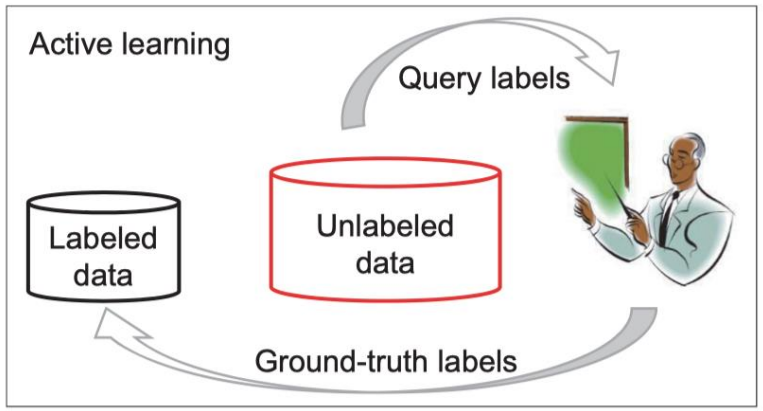


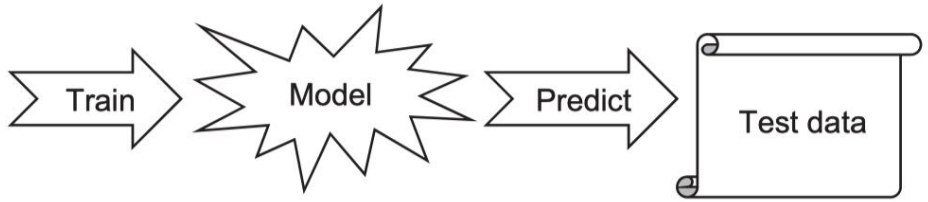
Topic 6: Label-efficient Learning in MIA

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



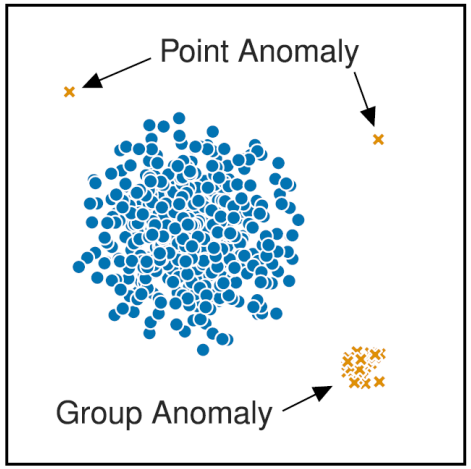
(a) Smoothness and low-density assumptions. **(b)** Manifold assumption.

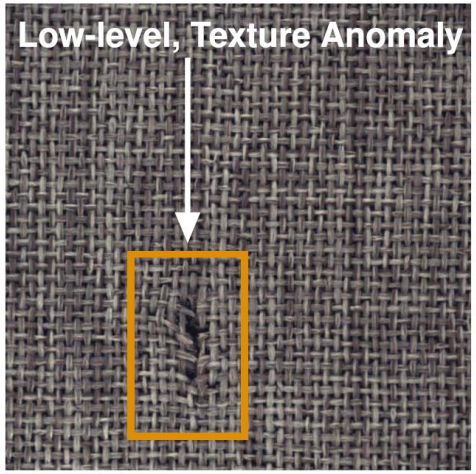


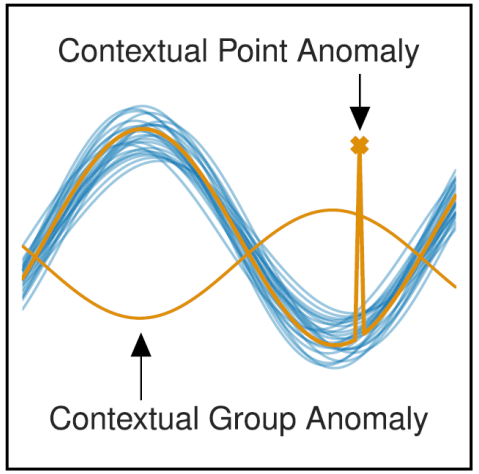


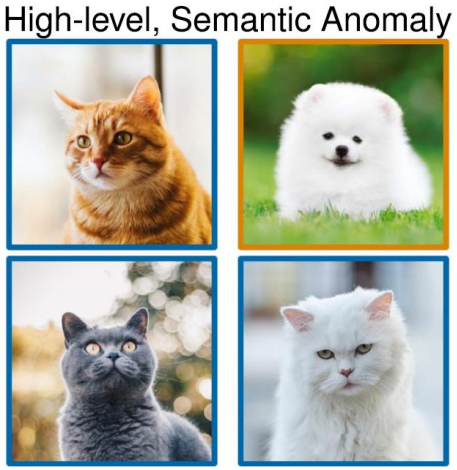
Topic 7: Anomaly Detection in MIA

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



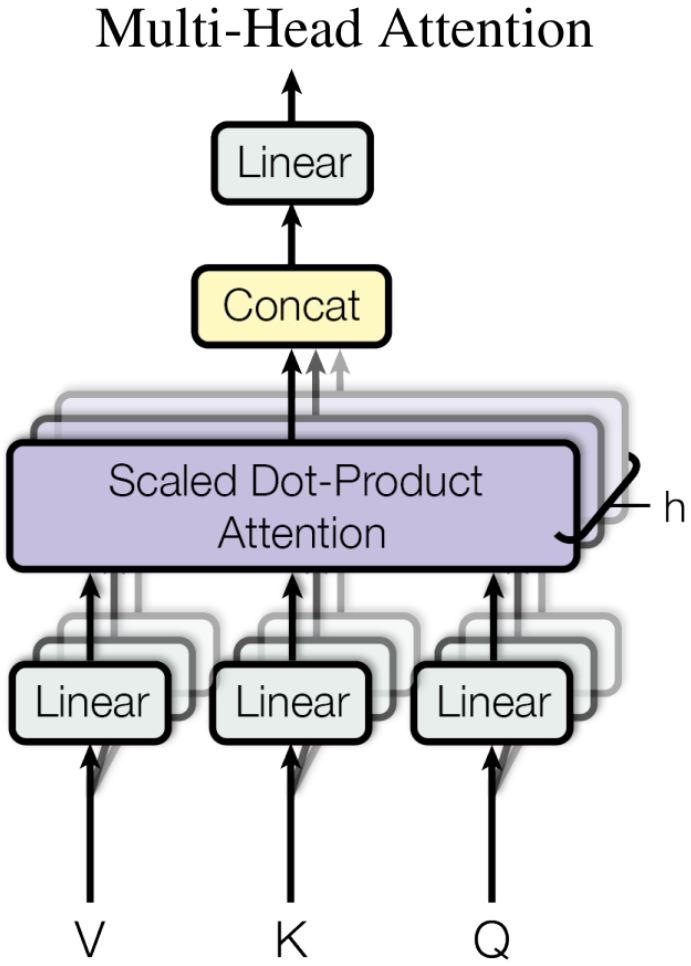






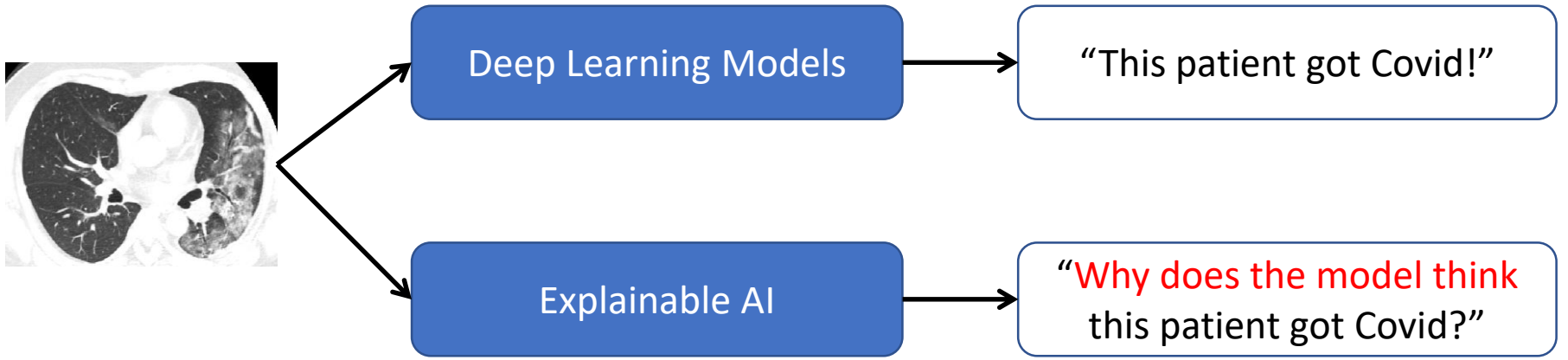
Topic 8: Attention Mechanism in MIA

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



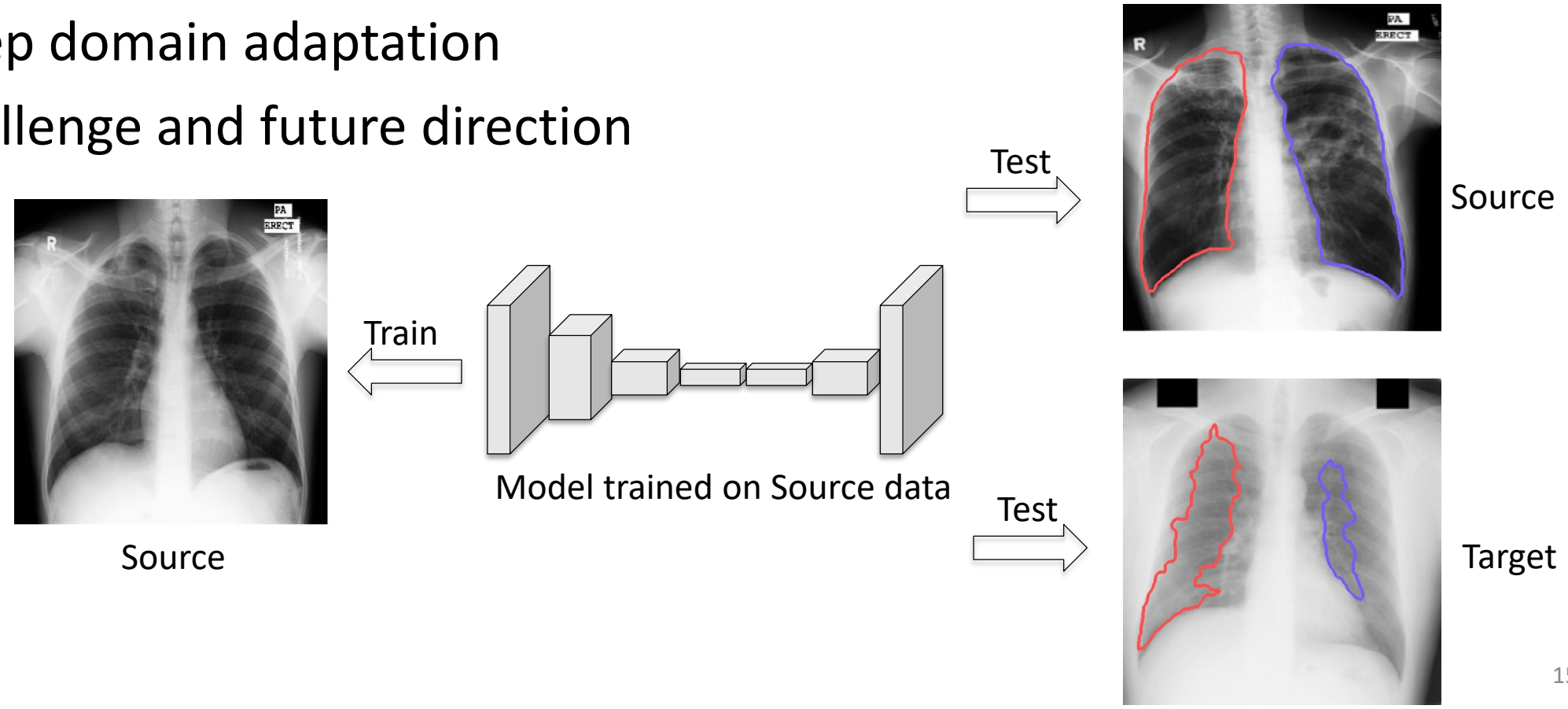
Topic 9: Explainability in MIA

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



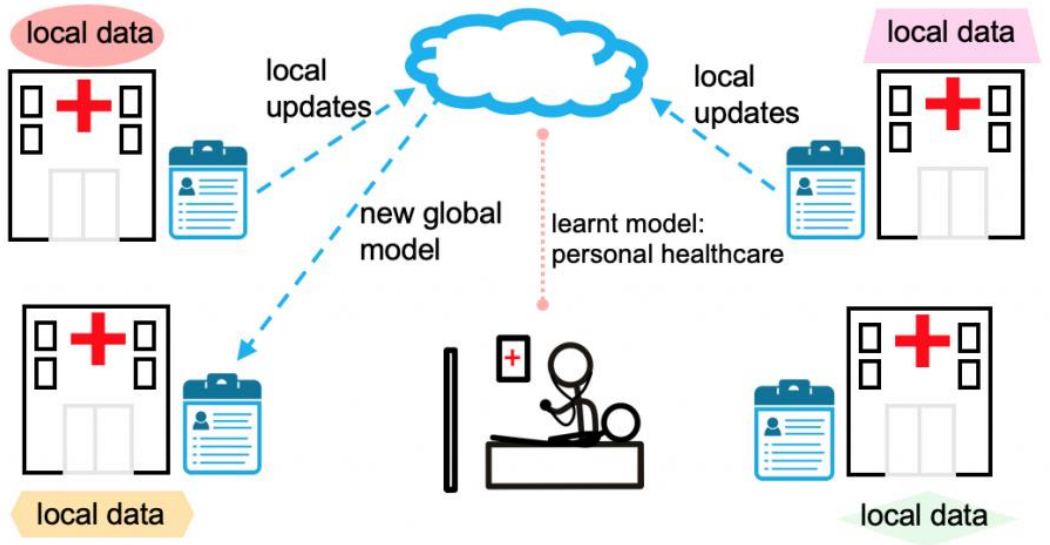
Topic 10: Domain Adaptation in MIA

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



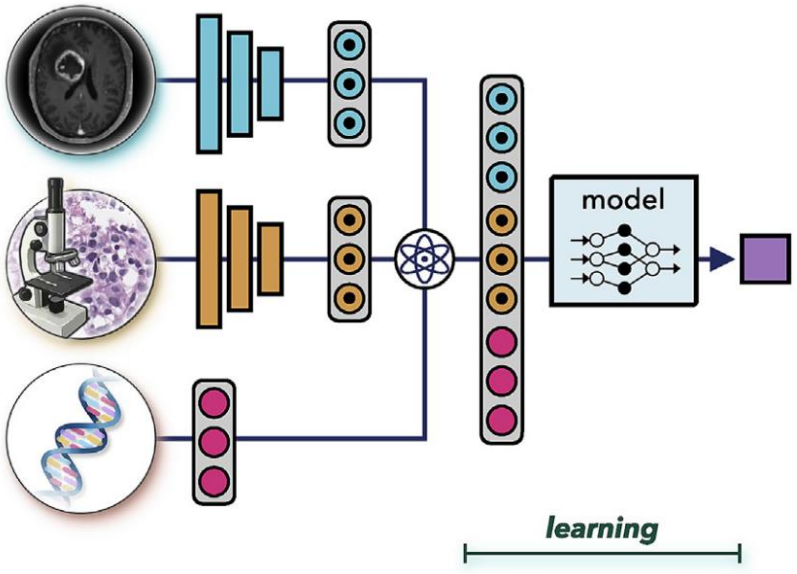
Topic 11: Federated Learning in MIA

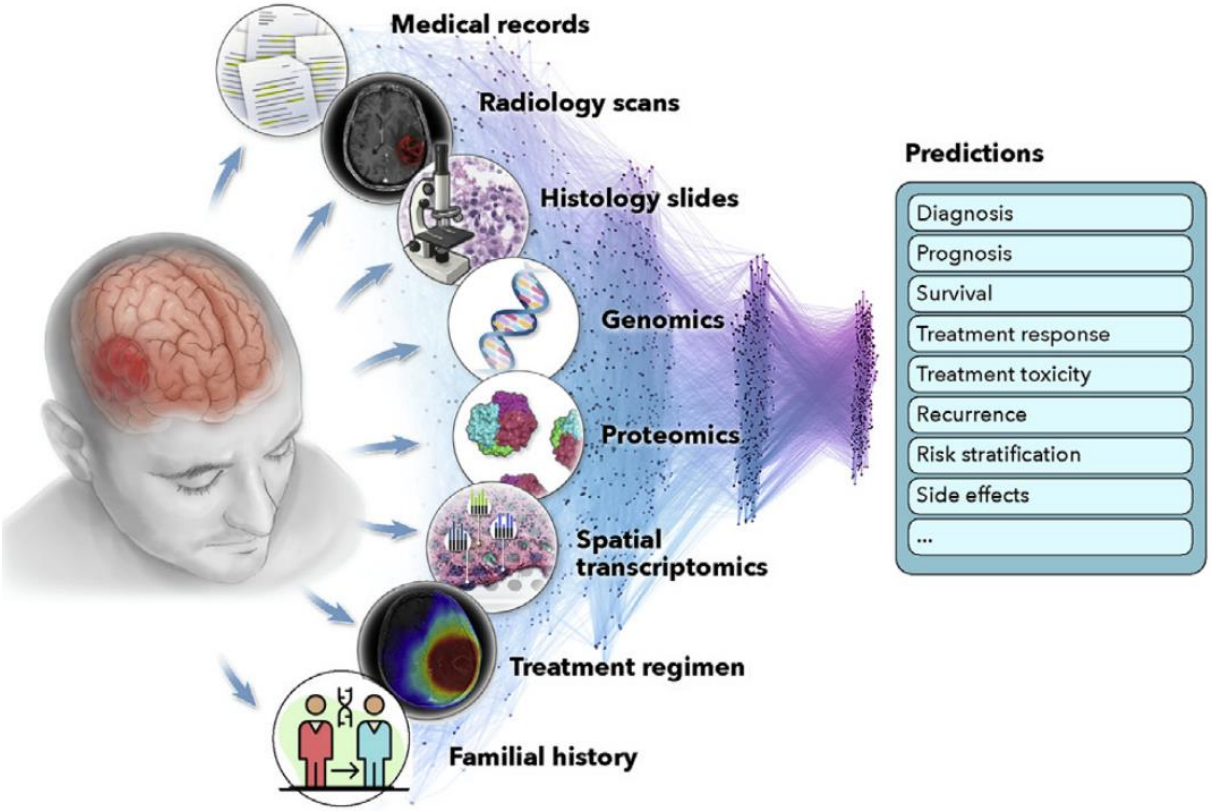
- What's federated learning?
- Federated learning for predicting clinical outcomes
- Federated domain generalization
- Federated semi-supervised learning
- Challenge and future direction



Topic 12: Multimodal Learning in Healthcare

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





Some Future Directions to Note

- **Medical Foundation Models/GPT?**

Vision-language Pre-training.

Medical Visual Foundation Model.

Large Language Model.

- **Multimodal Precision Medicine**

Missing Modality, Information Fusion, Association Analysis, etc.

- **Trustworthy ML for Healthcare**

XAI, Privacy Prediction, etc.

Last thing

- Student Feedback Questionnaire (SFQ) Survey

https://survey.ust.hk/hkust/

- Email Feedback:

jhc@cse.ust.hk

Any questions?

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

Develop trustworthy AI models for healthcare!