

# Domain Adaptation

Making Machine Learning Models work Across Datasets

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# Outline



Motivation



Domain Shift and Domain Adaptation



Domain Adaptation Techniques

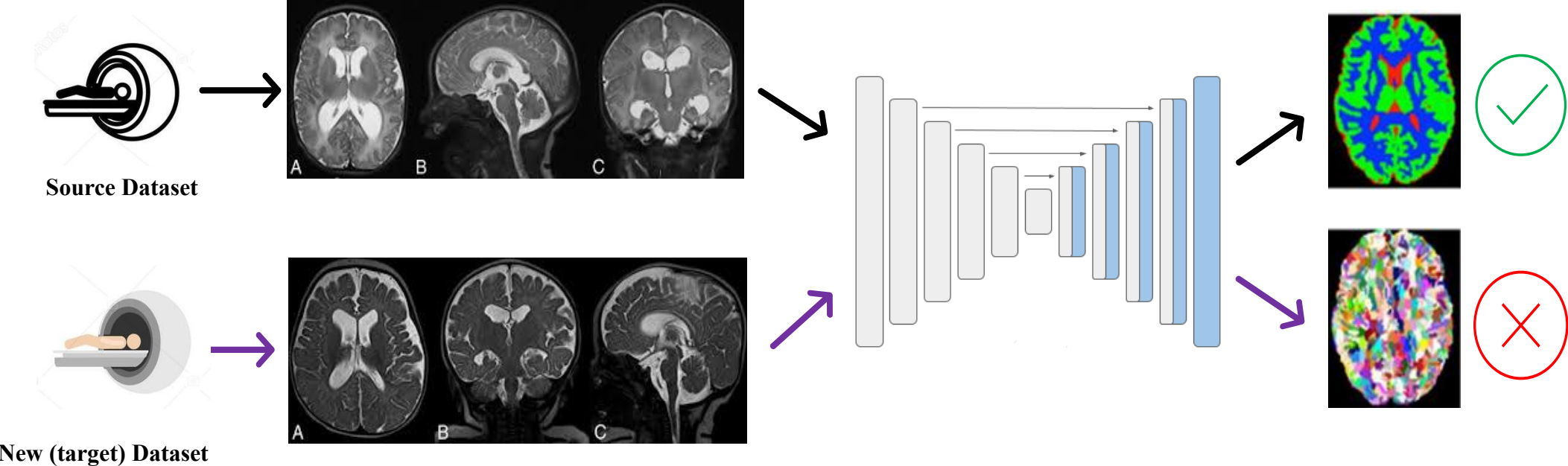


Summary

# Learning Goals

- Learn the basic domain adaptation concepts
- Expose you to different domain adaptation problems
- Get an overview of different domain adaptation approaches

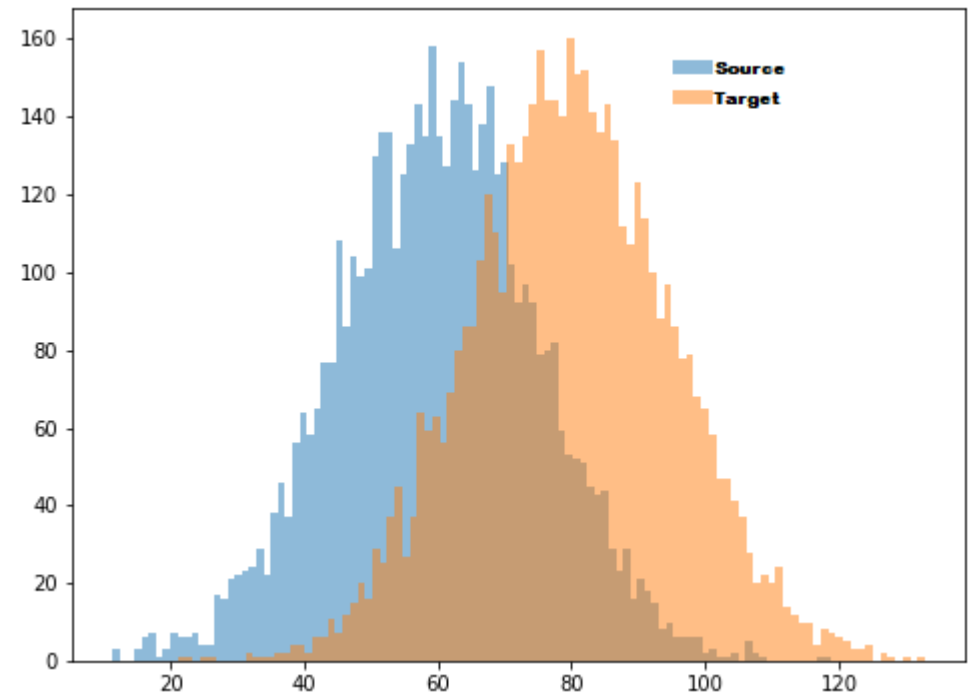
# Motivation



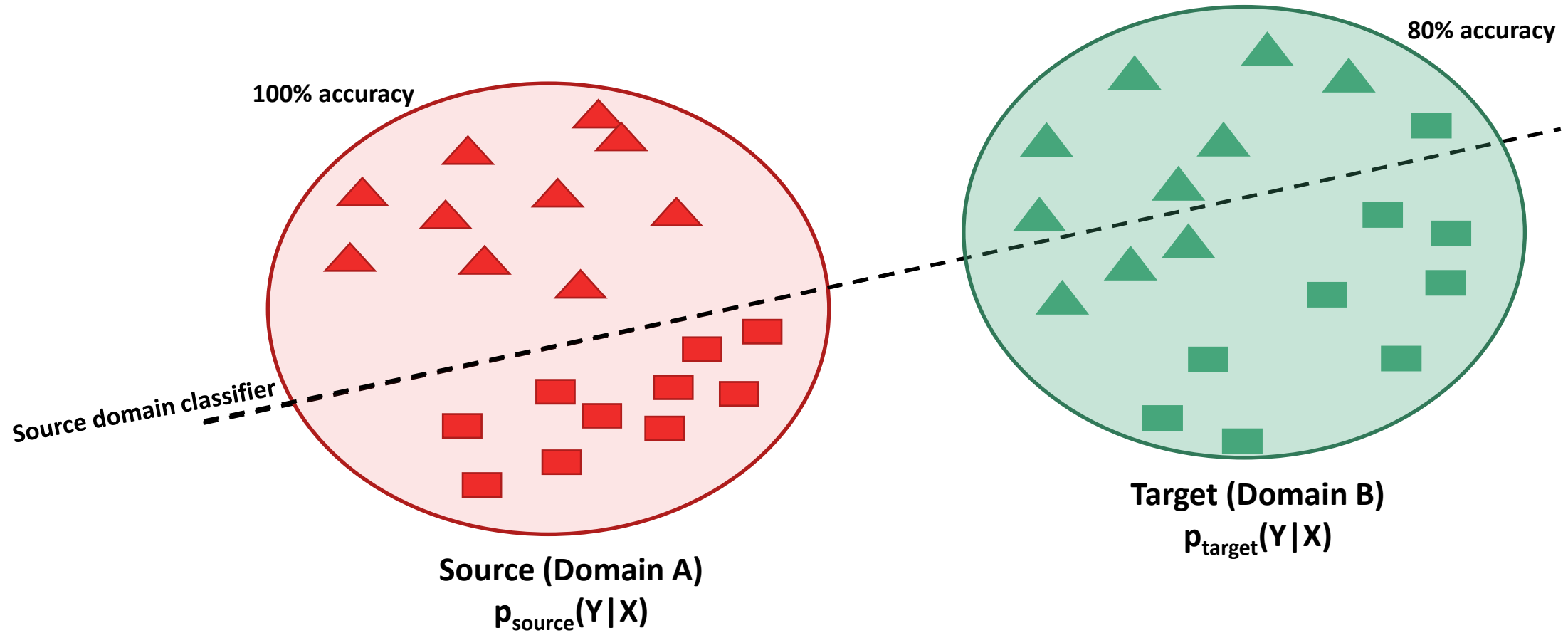
# Domain Shift

- **Domain shift:** refers to the change of data distribution between one dataset (source/reference domain) and another dataset (target domain).

$$p_{\text{source}}(Y|X) \neq p_{\text{target}}(Y|X)$$



# Domain Shift Problem

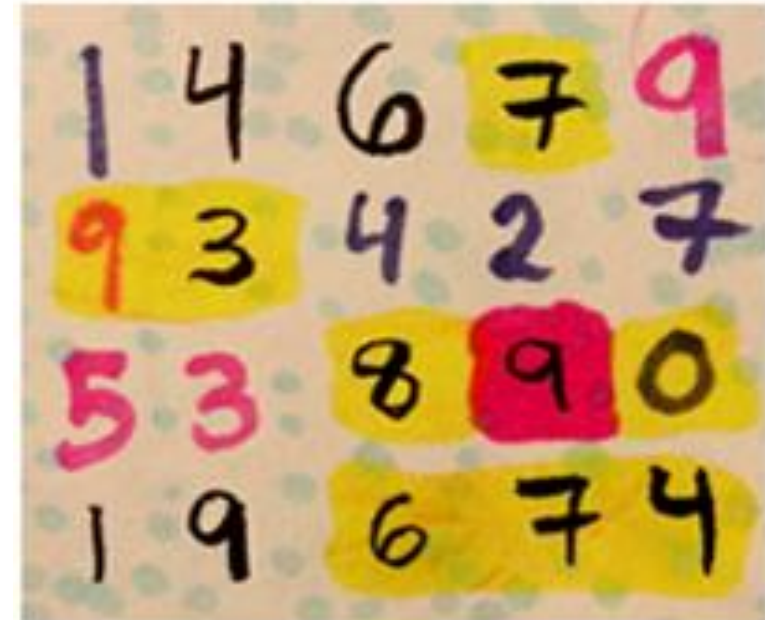


# Different Types of Images

Domain A

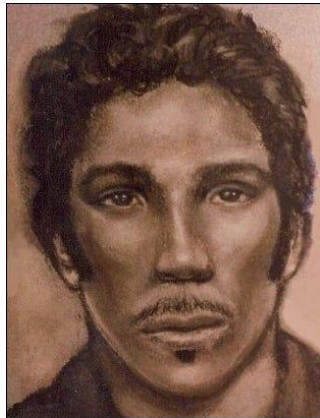


Domain B

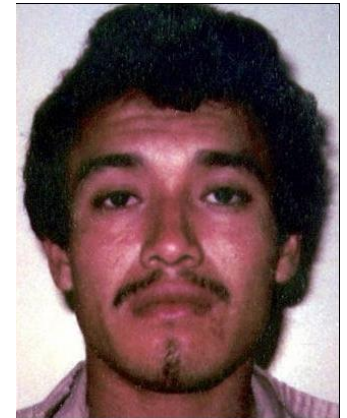


# Different Types of Images: Sketches and Photos

**Domain A: Sketches**



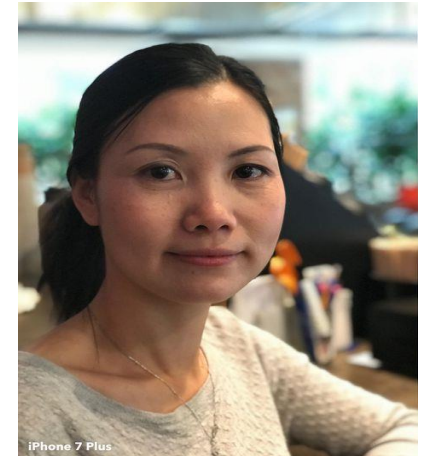
**Domain B: Photos**





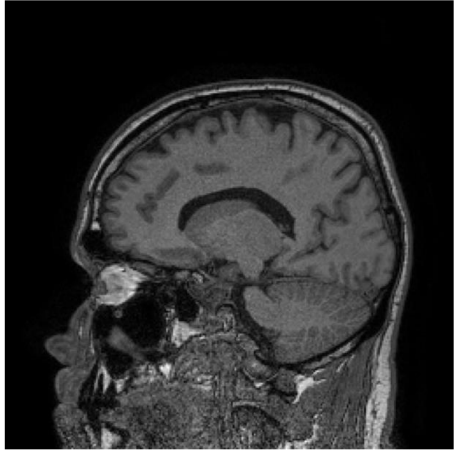
# Technology Differences and Evolution

Camera comparison images: Low light/night mode

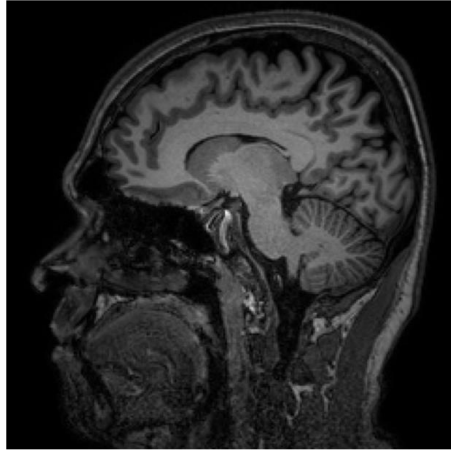


# Hardware and Software Differences

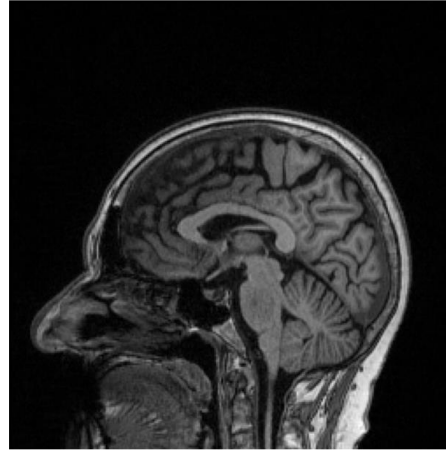
philips\_15



philips\_3



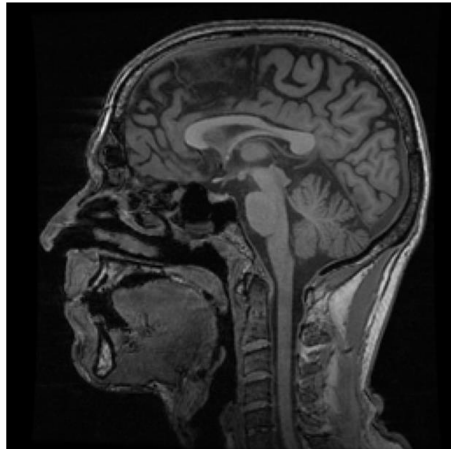
siemens\_15



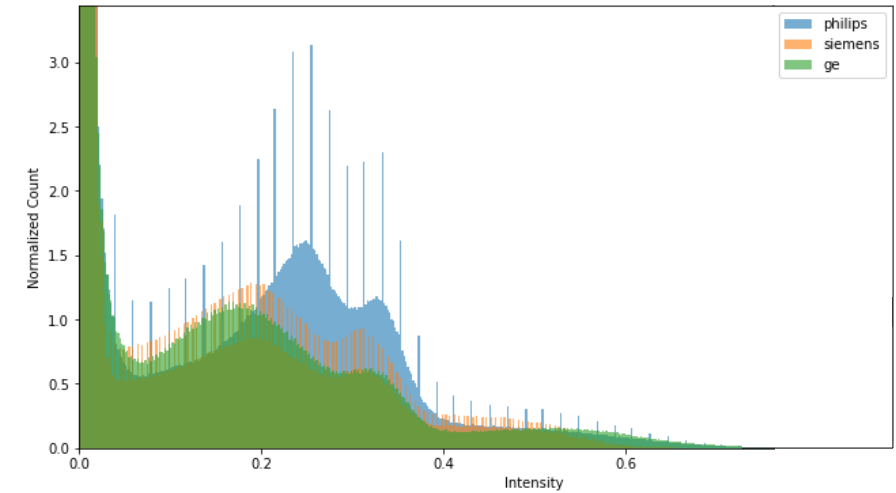
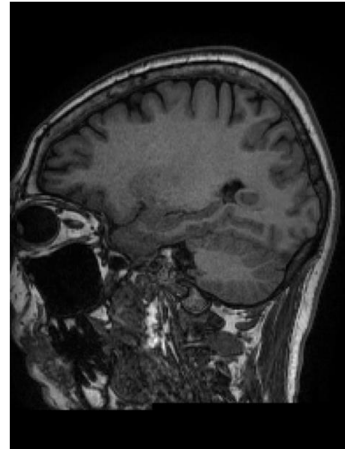
siemens\_3



ge\_3



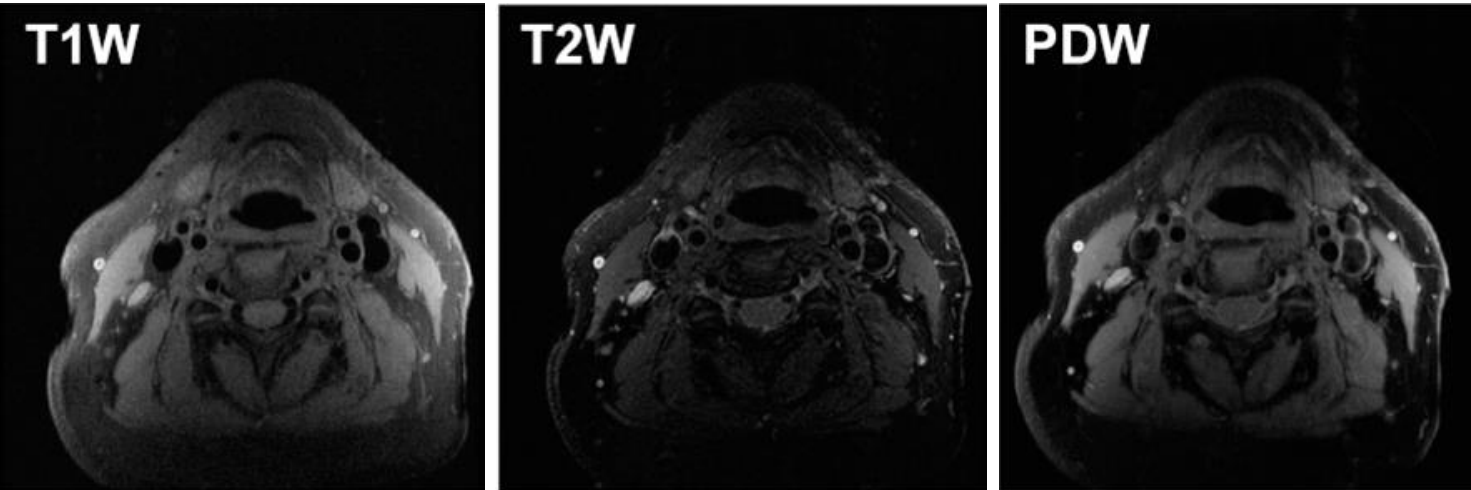
ge\_15





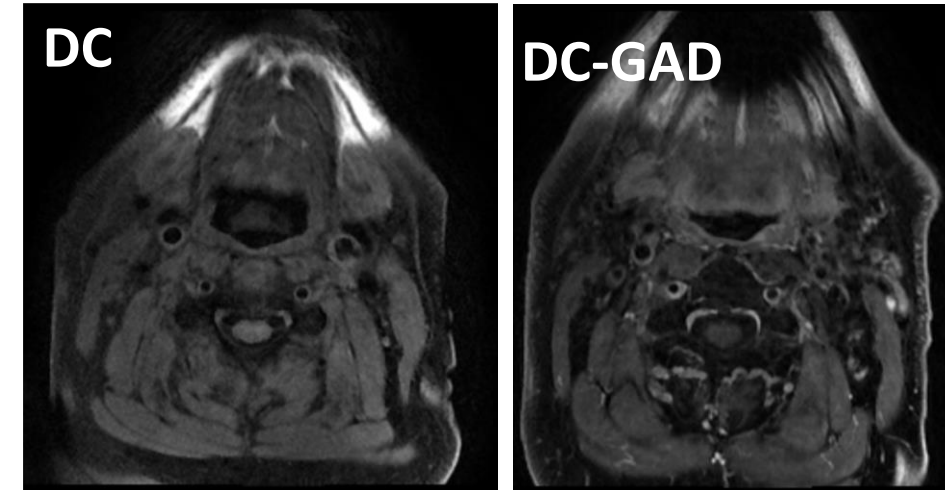
# Hardware and Software Differences

## AIM-HIGH Study



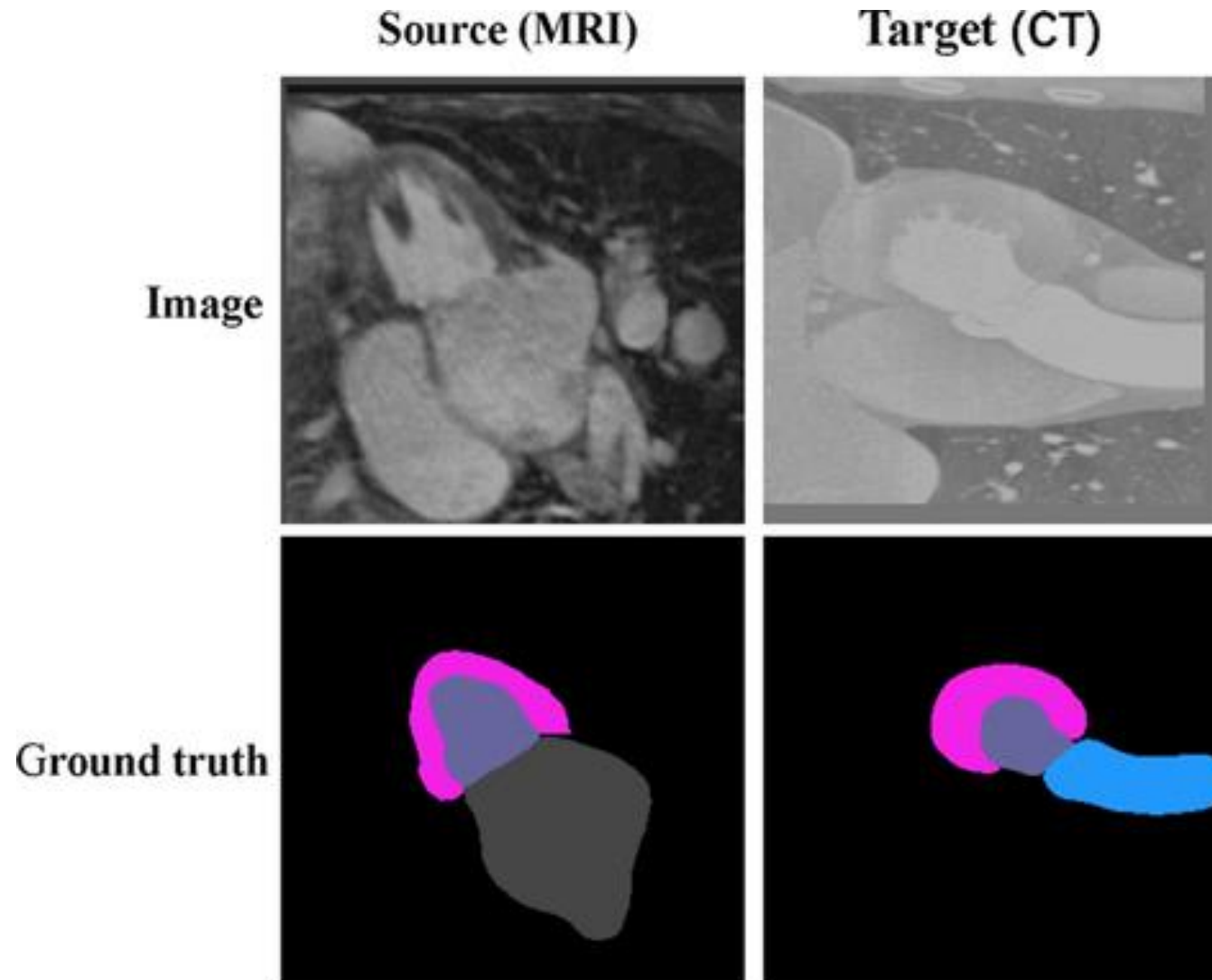
- The carotid arteries were manually annotated at the time of the study

## CARDIS Study



- Leverage AIM-HIGH annotated data to create a segmentation model for the data being collected at CARDIS study

# Different Technologies



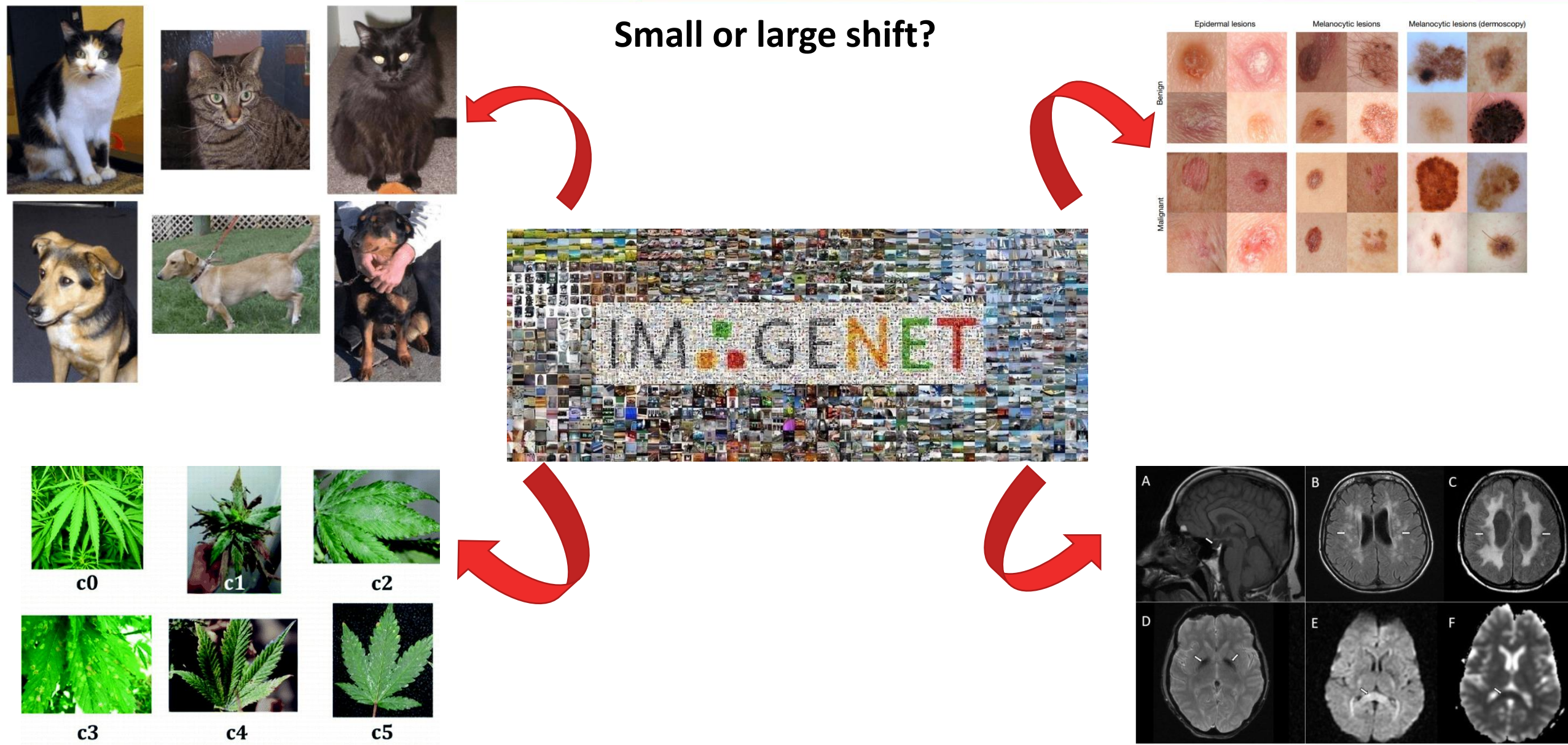
# Degree of Domain Shift

- **Degree of domain shift** is a measure of how much the distributions of the source and target domains are different
- Previous studies have revealed that the test error generally increases in proportion to the degree of domain shift.



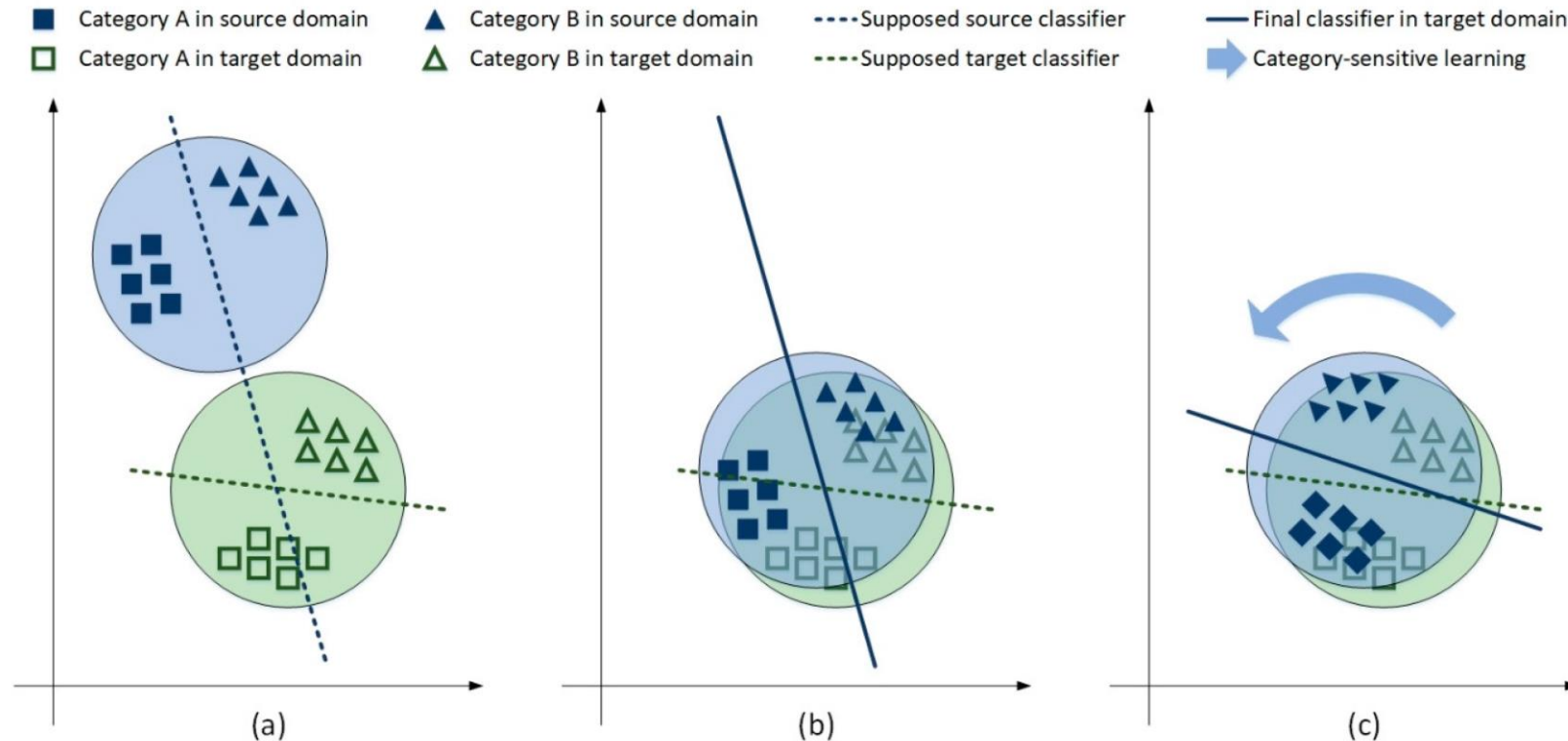
# Degree of Domain Shift

Small or large shift?



# Domain Adaptation

- **Domain adaptation:** domain adaptation refers to adapting a model trained in one or more source domains to a different one or more target domains.



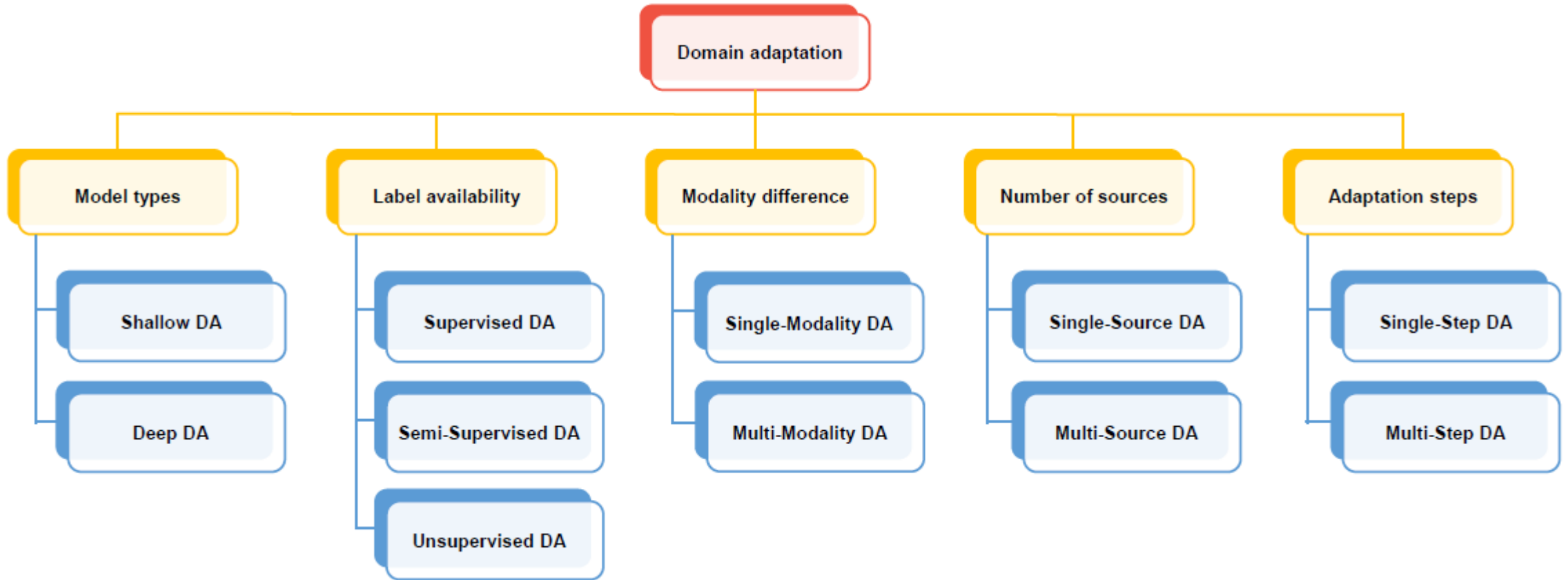
**What is the difference  
between domain  
adaptation and transfer  
learning?**



# What is the difference between domain adaptation and transfer learning?

- In domain adaptation the task in the source and target domains are the same

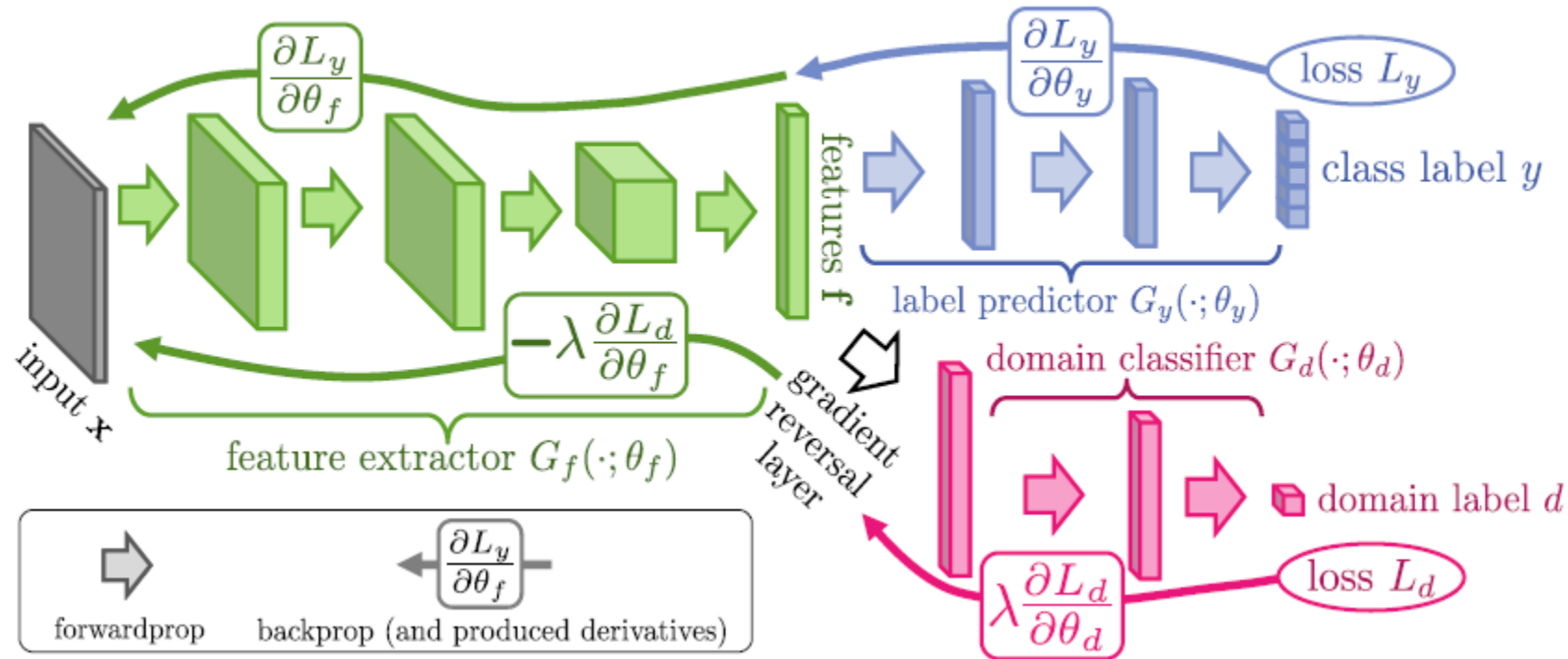
# Domain Adaptation Categories



# Supervised Domain Adaptation

- Essentially transfer learning
  - Fine-tune all layers
  - Fine-tune initial layers
  - Fine-tune final layers

# Domain-Adversarial Training of Neural Networks (Unsupervised)



\*Ganin et al., JMLR, 2016

$$E(\theta_f, \theta_y, \theta_d) = \frac{1}{n} \sum_{i=1}^n \mathcal{L}_y^i(\theta_f, \theta_y) - \lambda \left( \frac{1}{n} \sum_{i=1}^n \mathcal{L}_d^i(\theta_f, \theta_d) + \frac{1}{n'} \sum_{i=n+1}^N \mathcal{L}_d^i(\theta_f, \theta_d) \right)$$

# Thank you!