Disclaimer

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Domain Adaptation

Making Machine Learning Models work Across Datasets

Roberto Souza
Assistant Professor
Electrical and Computer Engineering
Schulich School of Engineering

March 2022

Outline

Motivation

Domain Shift and Domain Adaptation

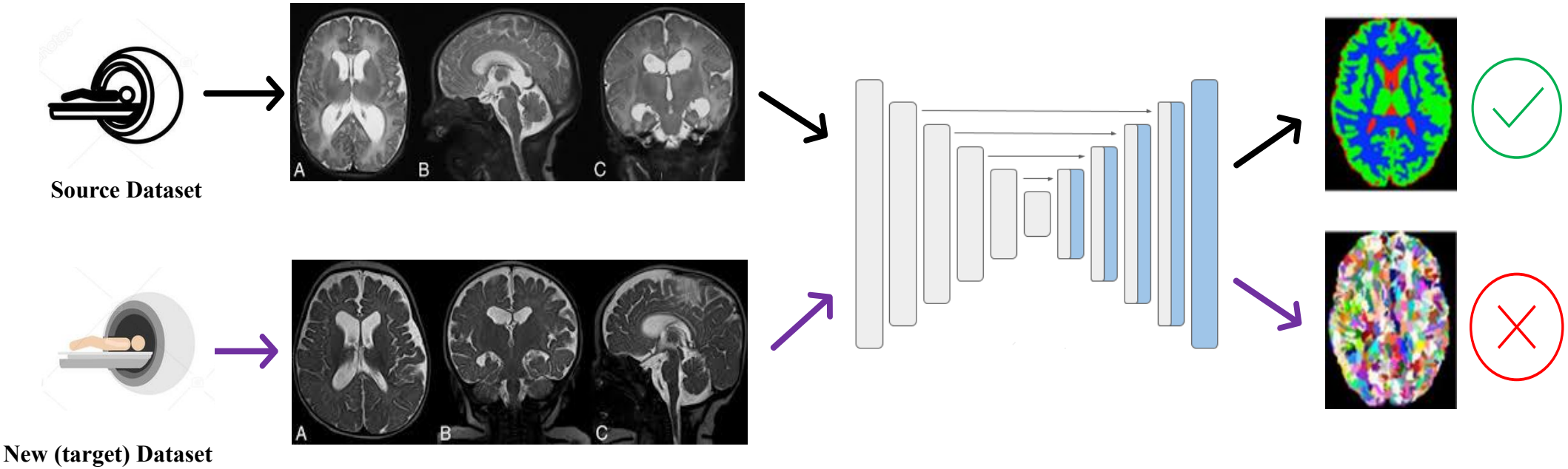
Domain Adaptation Techniques

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



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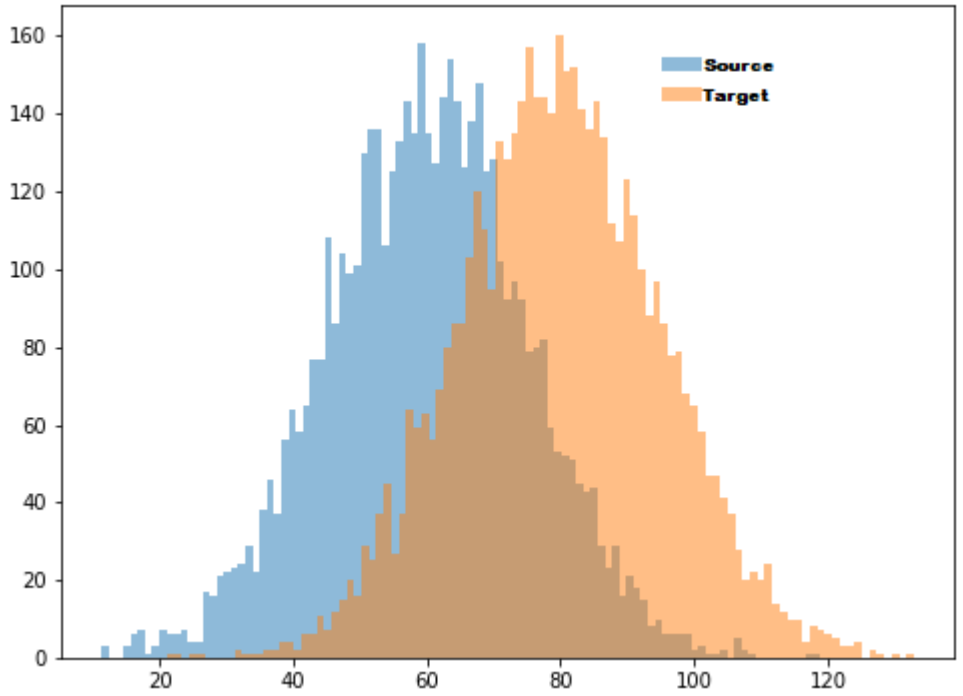
Domain Shift

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

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



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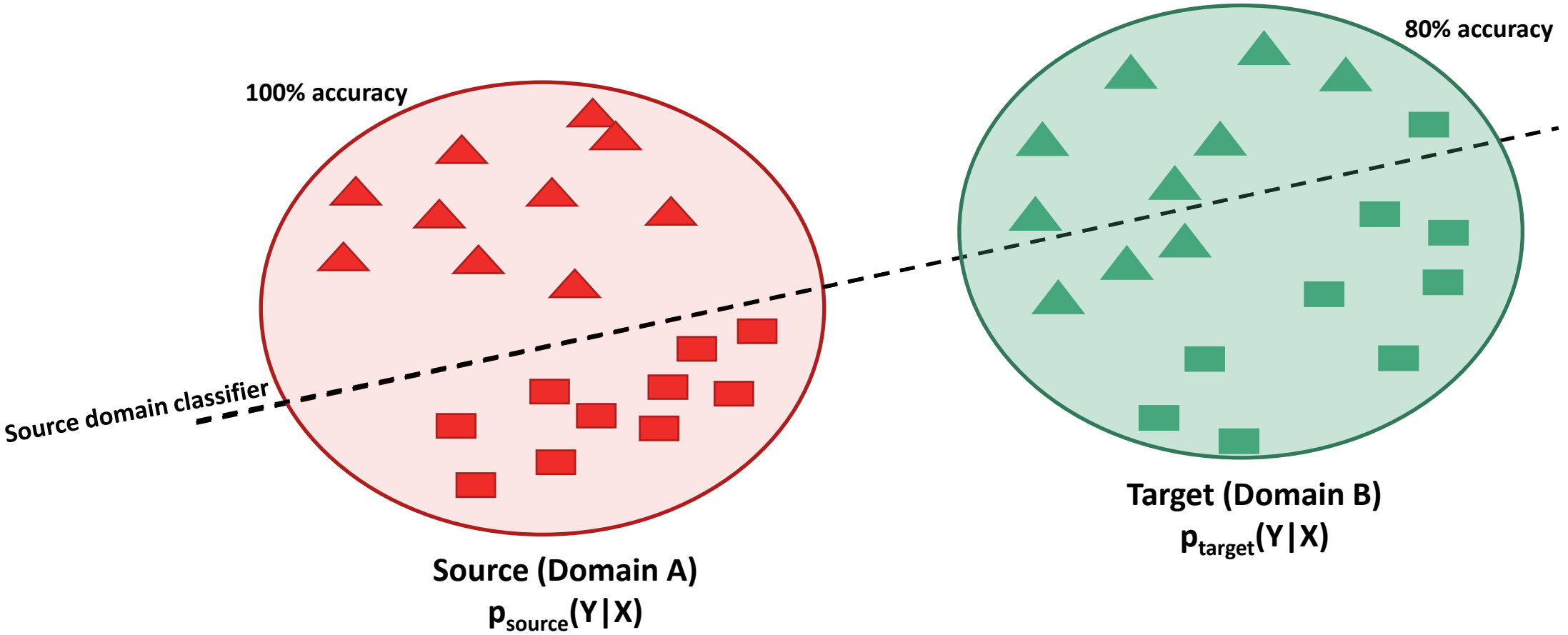
Domain Shift Problem



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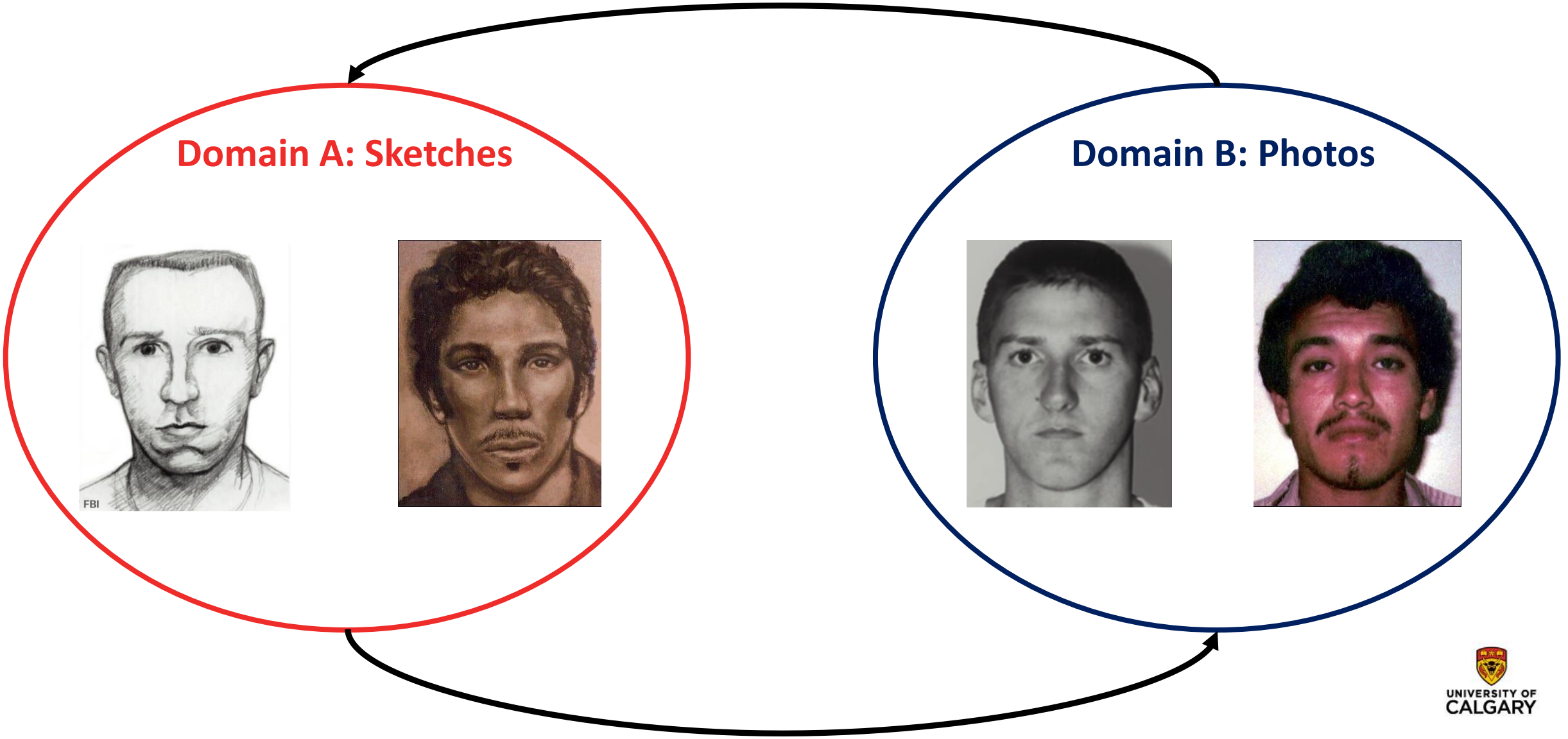
Different Types of Images

Domain A

Domain B

Different Types of Images: Sketches and Photos



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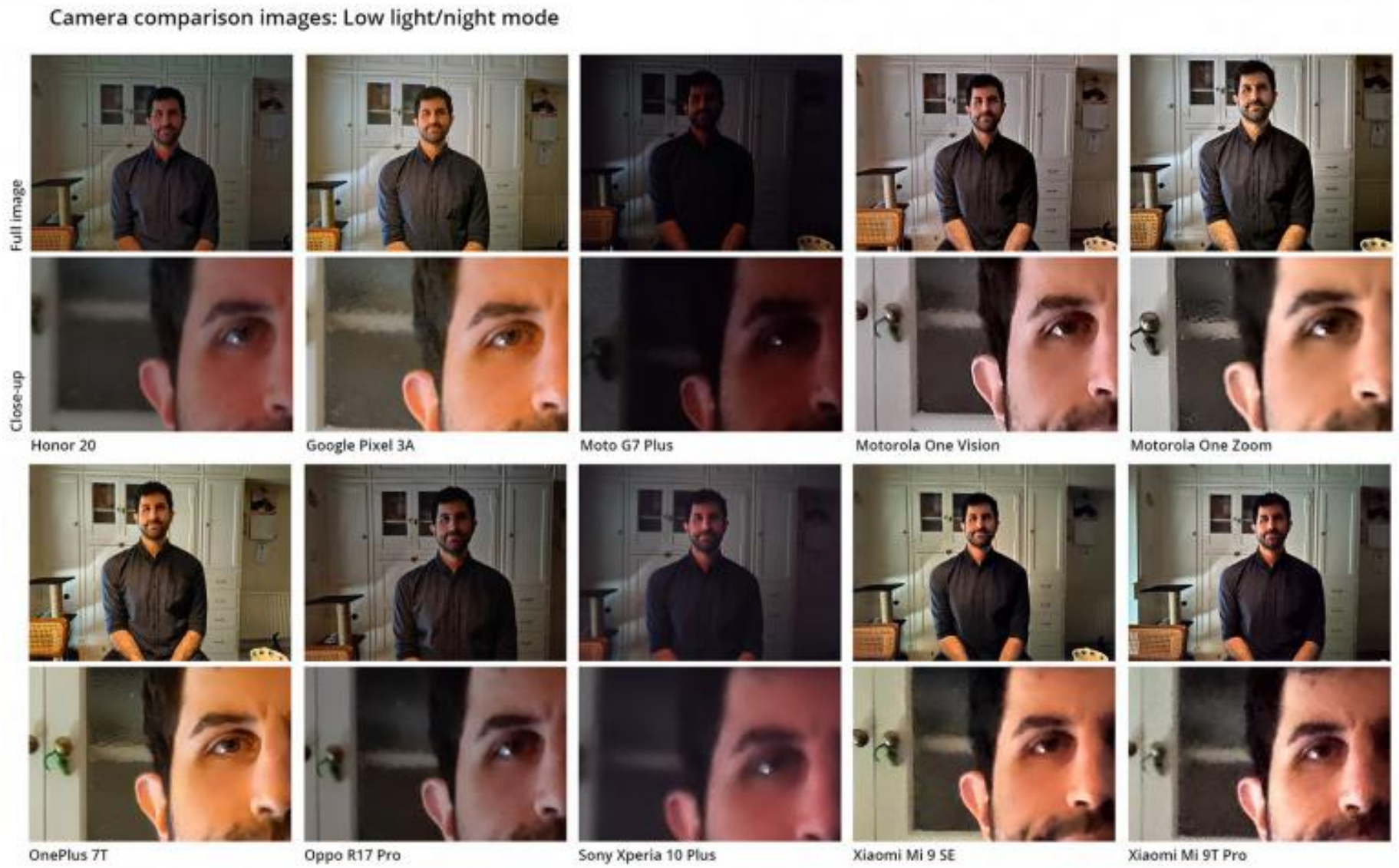
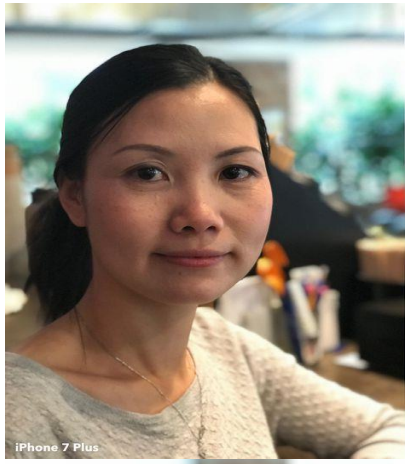
Technology Differences and Evolution





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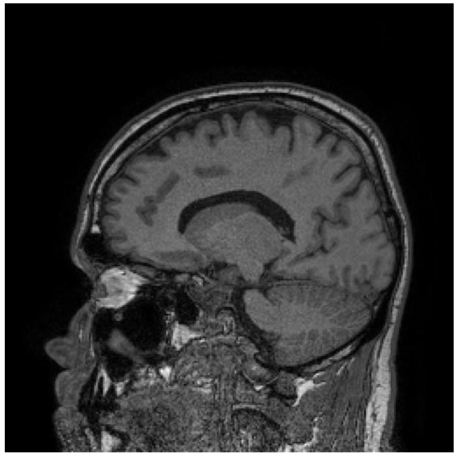
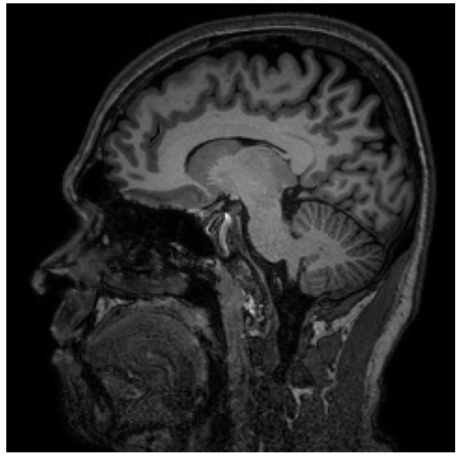
Hardware and Software Differences

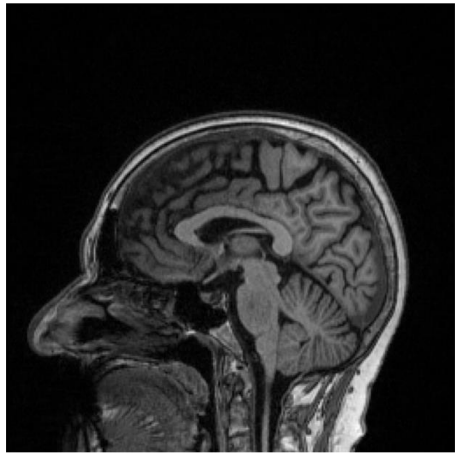
philips_15



philips_3



siemens_15



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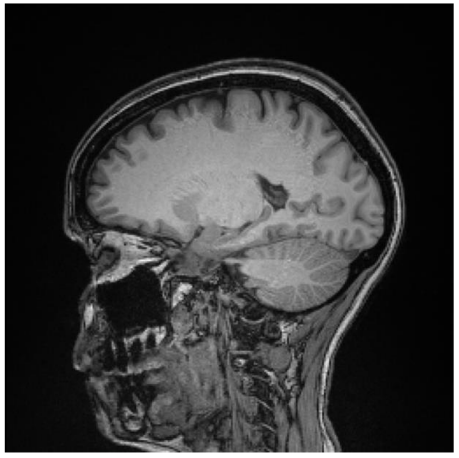
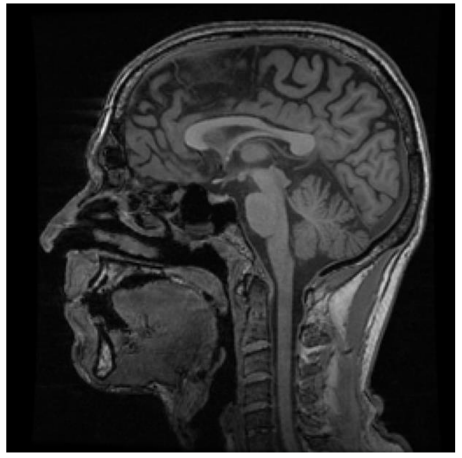


ge_3



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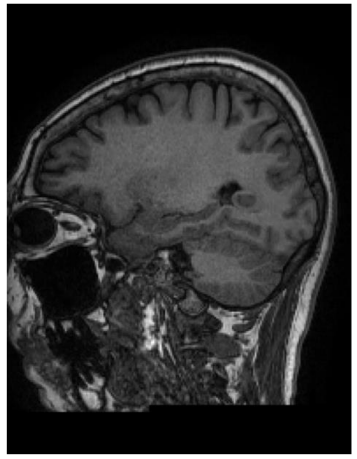

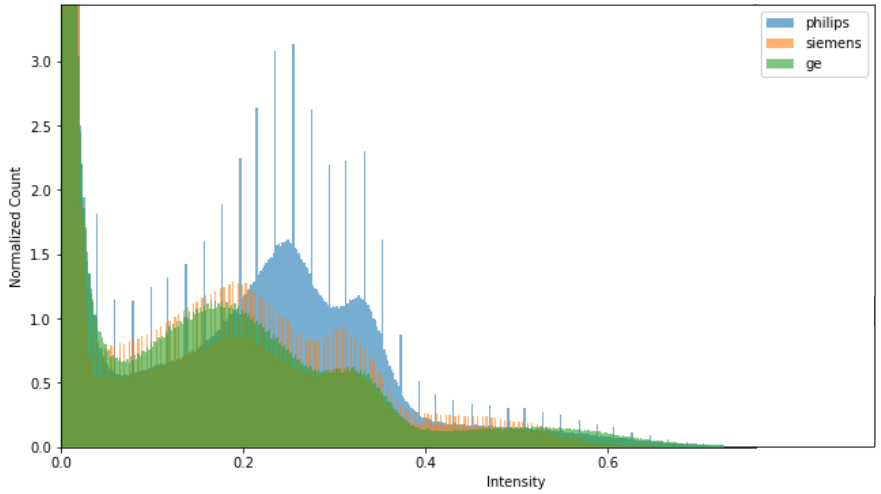

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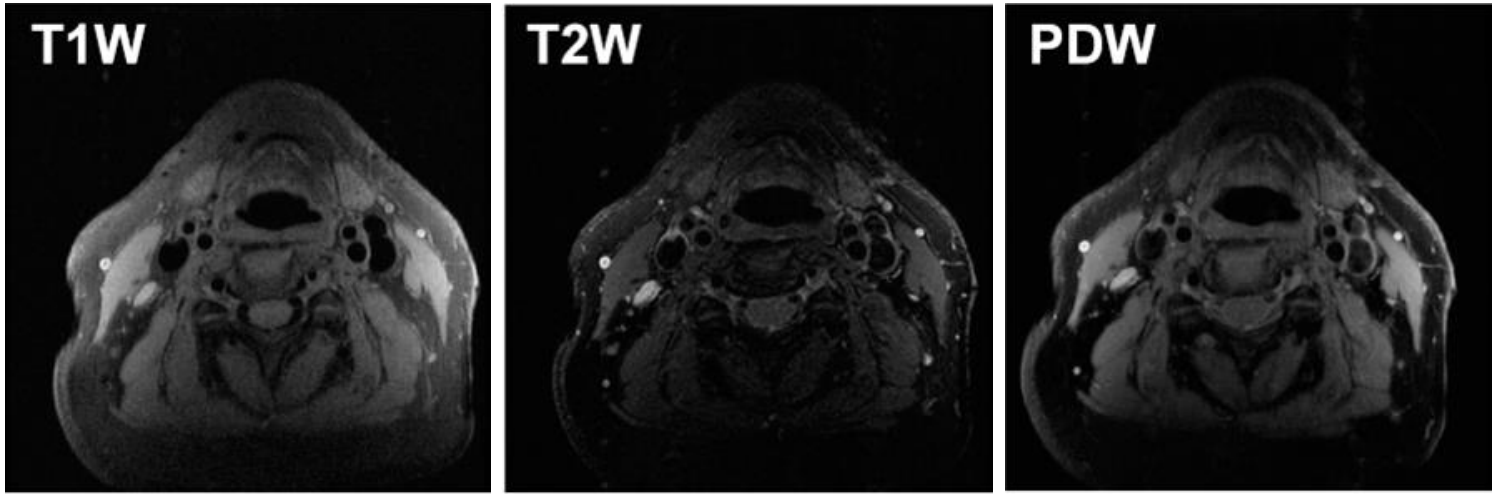
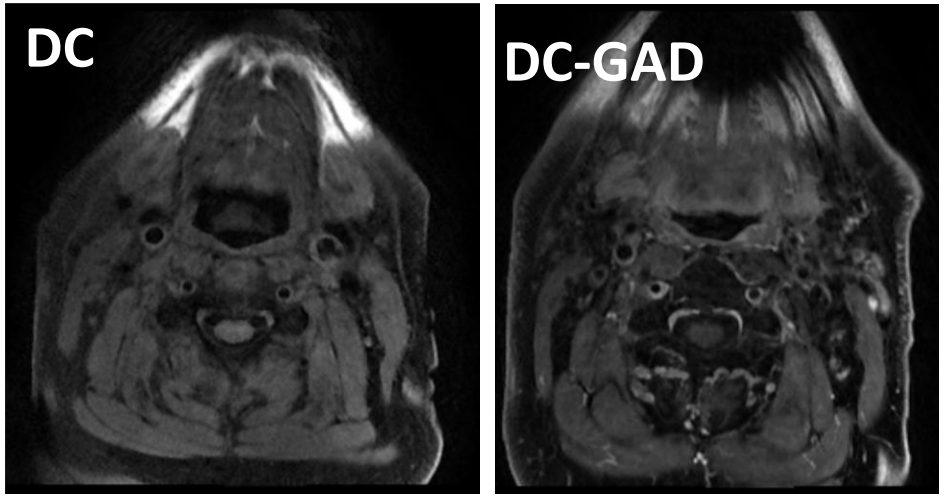
Hardware and Software Differences

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

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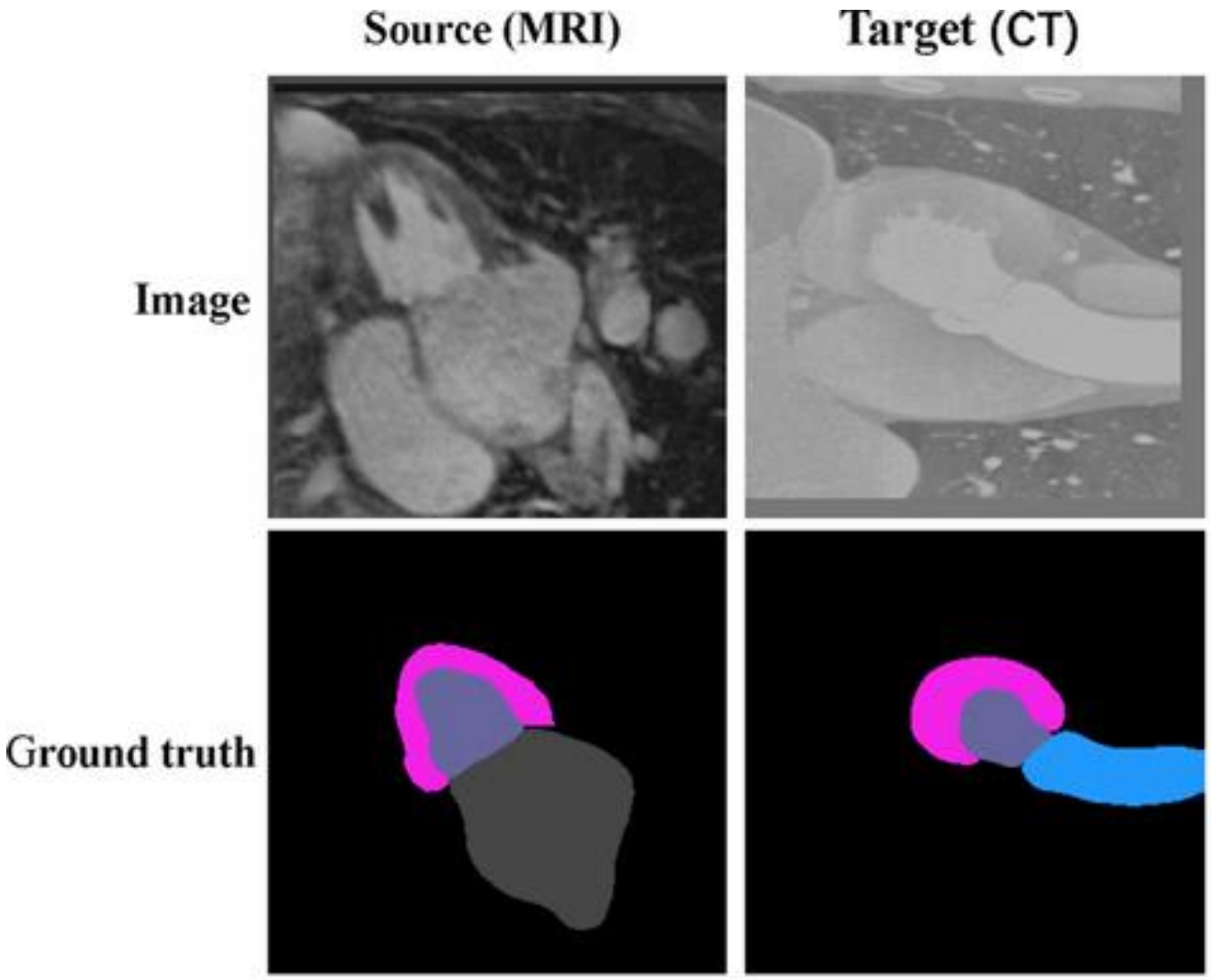
Different Technologies



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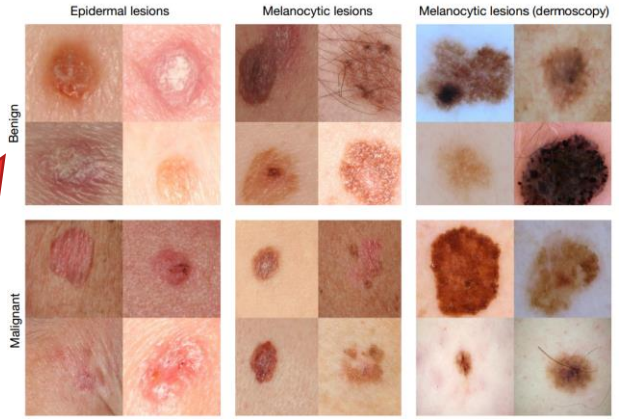
Degree of Domain Shift

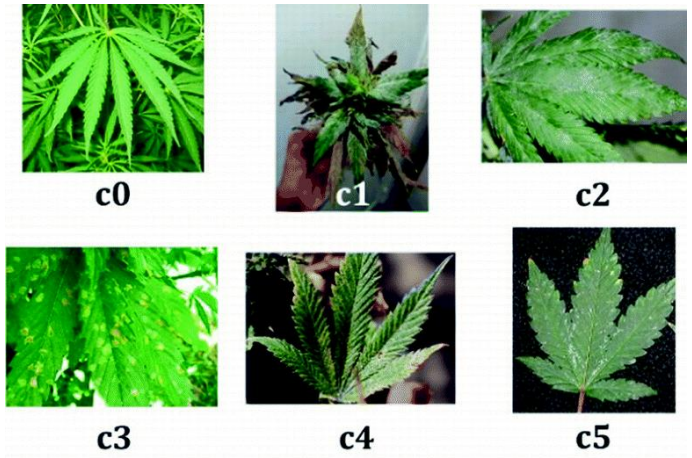
- **Degree of domain shift** is a measure of how much the distributions of the source and target domains are different

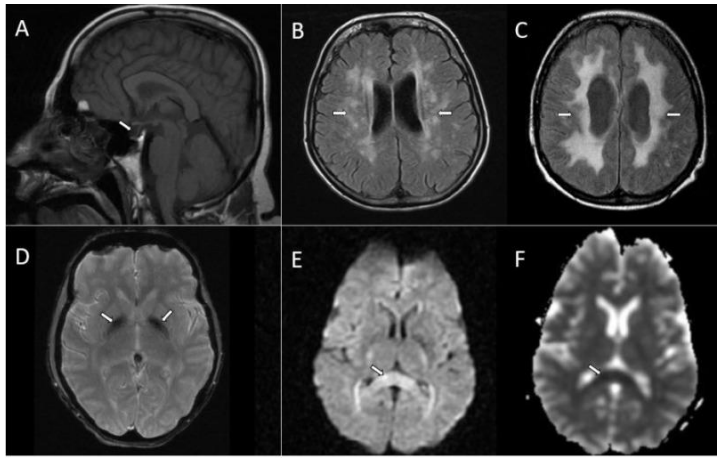
- Previous studies have revealed that the test error generally increases in proportion to the degree of domain shift.

Degree of Domain Shift

Small or large shift?

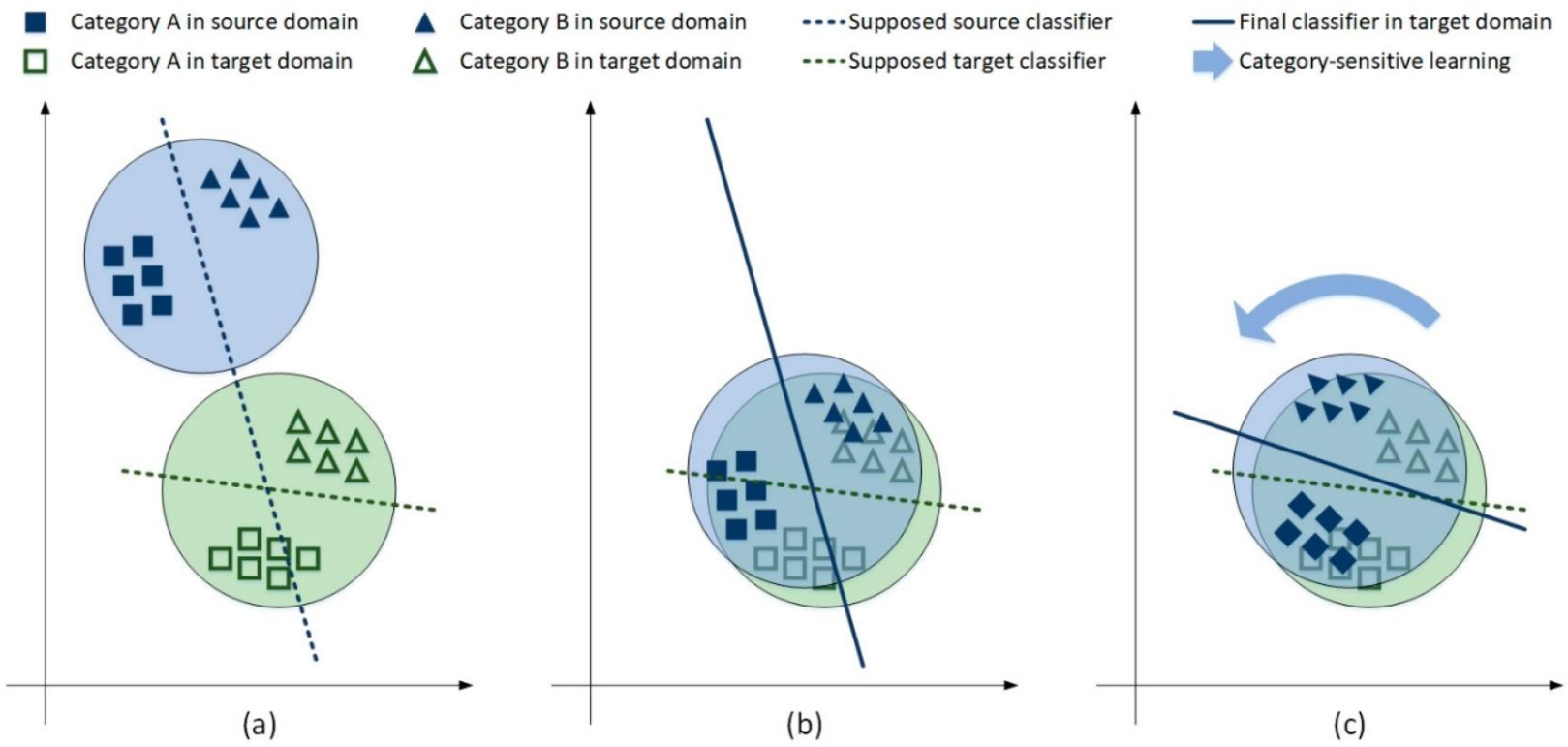






Domain Adaptation

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



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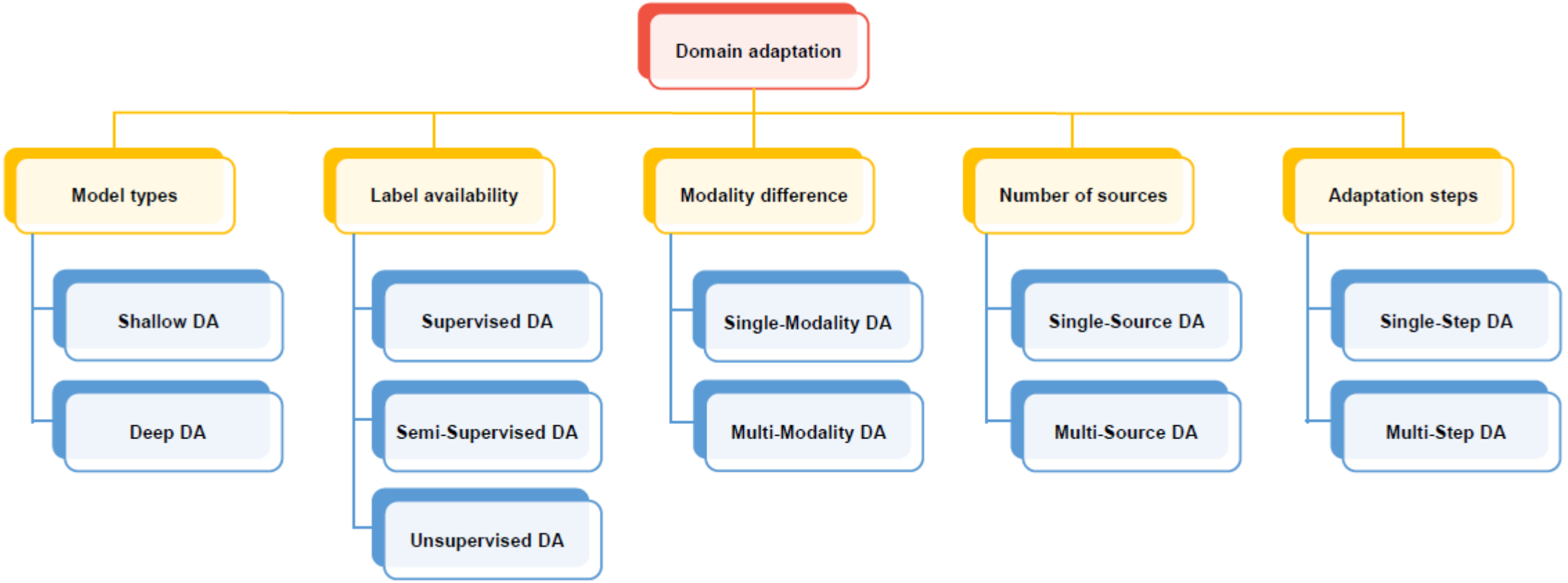
What is the difference between domain adaptation and transfer learning?

What is the difference between domain adaptation and transfer learning?

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

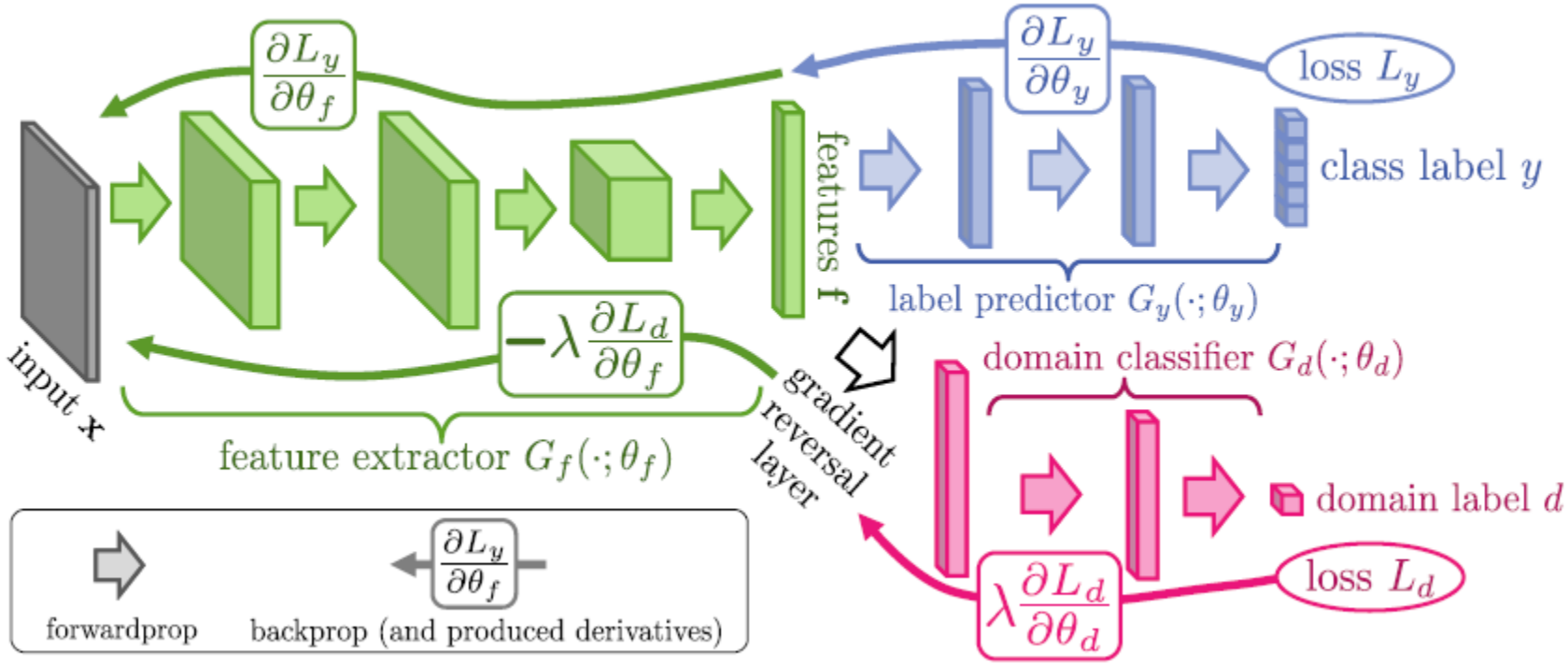
Domain Adaptation Categories



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

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

Unlearning of Dataset Bias for Harmonisation and Confound Removal

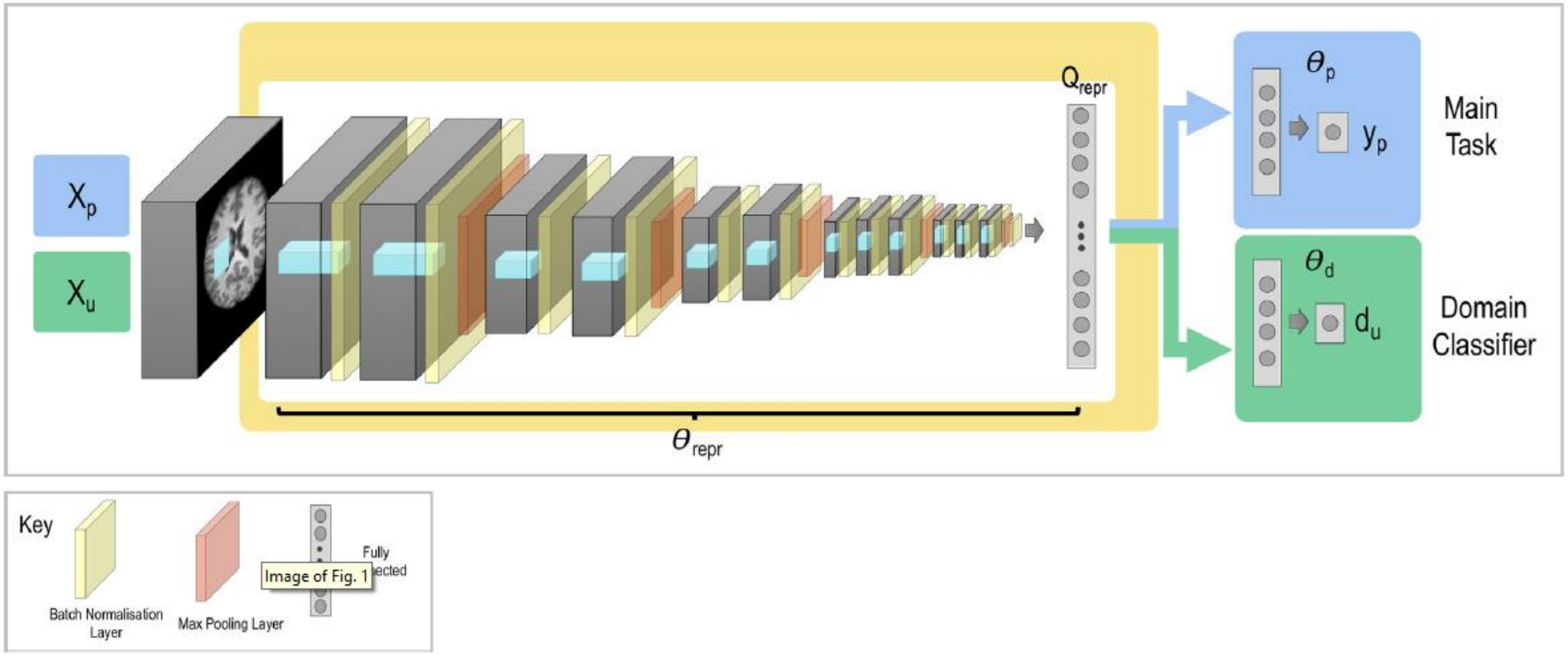


Fig. 1. General network architecture. The network is formed of three sections: the feature extractor with parameters Θ_{repr}, the label predictor with parameters Θ_p, and the domain classifier with parameters Θ_d. X_p represents the input data used to train the main task with labels y_p, and X_u represents the input data used to train the steps involved in unlearning scanner with labels d.

*Dinsdale et al., NeuroImage, 2021

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Unlearning of Dataset Bias for Harmonisation and Confound Removal

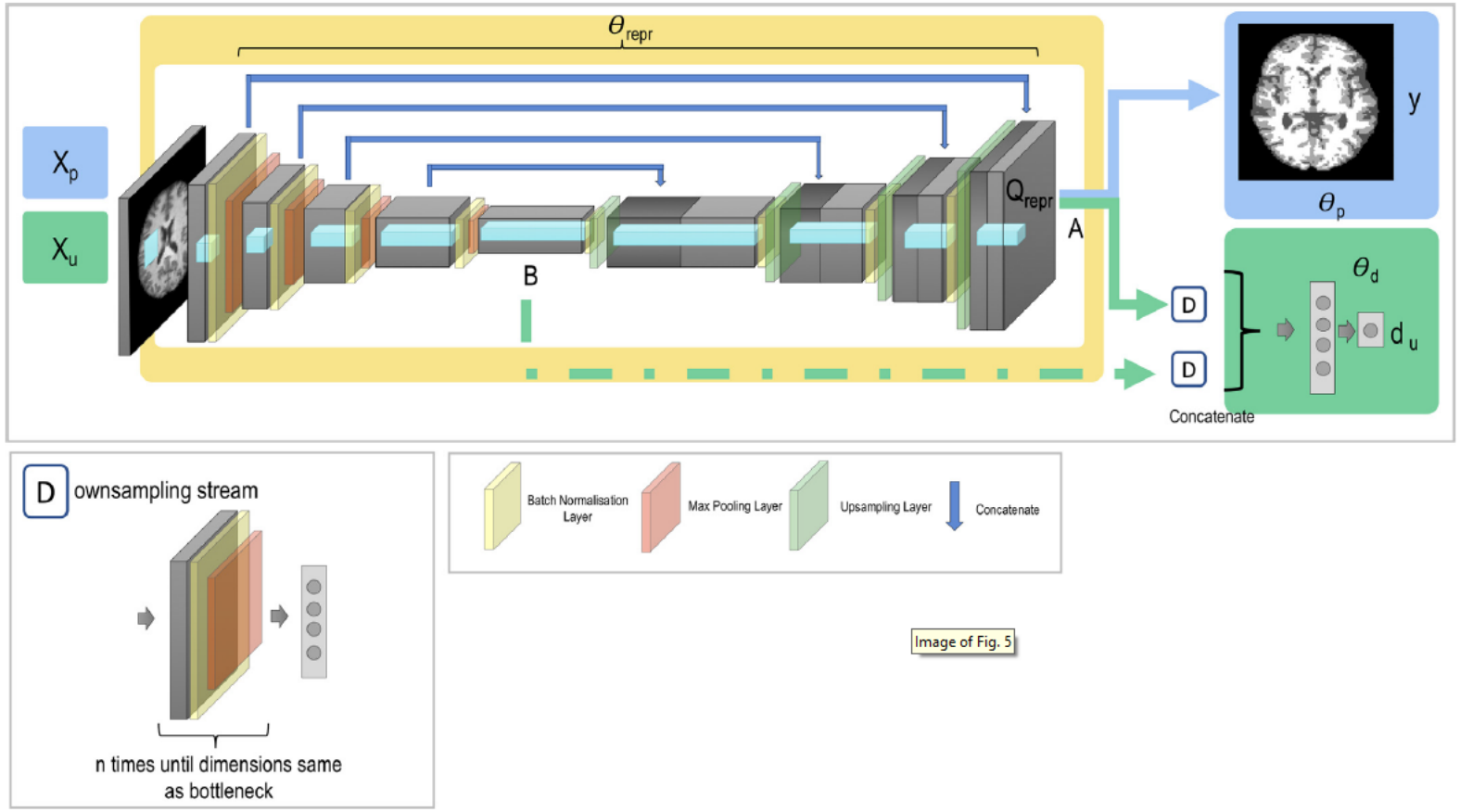

Fig. 5. Network architecture used for unlearning with segmentation. X_p represents the input images used to evaluate the primary task with y being the main task label segmentations. X_u are the input images used for unlearning scanner information with domain labels d_u. The domain discriminator for unlearning can be attached from A, B or the two in combination. If it is attached from A and B together, the first fully connected layers (the output of the two downsampling branches D) are concatenated together to produce a single feature representation.

*Dinsdale et al., NeuroImage, 2021

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Summary

- Machine learning models may not generalize well in the presence of domain shifts across datasets
- Domain adaptation techniques can be used to improve model generalization by harmonising the data and removing confounders
  - Supervised
  - Unsupervised

Assignment 03

- **Assignment 03 (choose one)**
  - Building a classification model
  - Implementing a domain adaptation method for an image classification problem
  - ~~Implementing a signal denoising model~~
  - Implementing a generative adversarial model/auto-encoder
  - **Due:** Noon - 01 April 2022 | **Delivery method:** GitHub repository

Thank you!

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