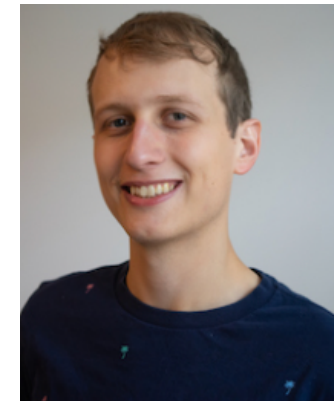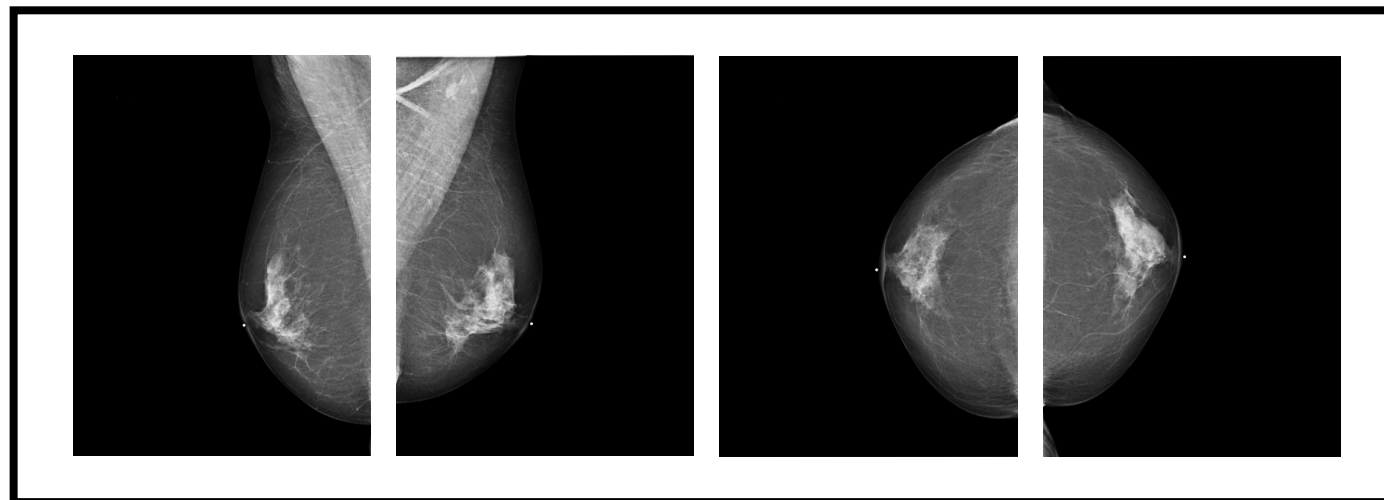# Improving the Ability of
Deep Neural Networks to Use Information from
Multiple Views in Breast Cancer Screening
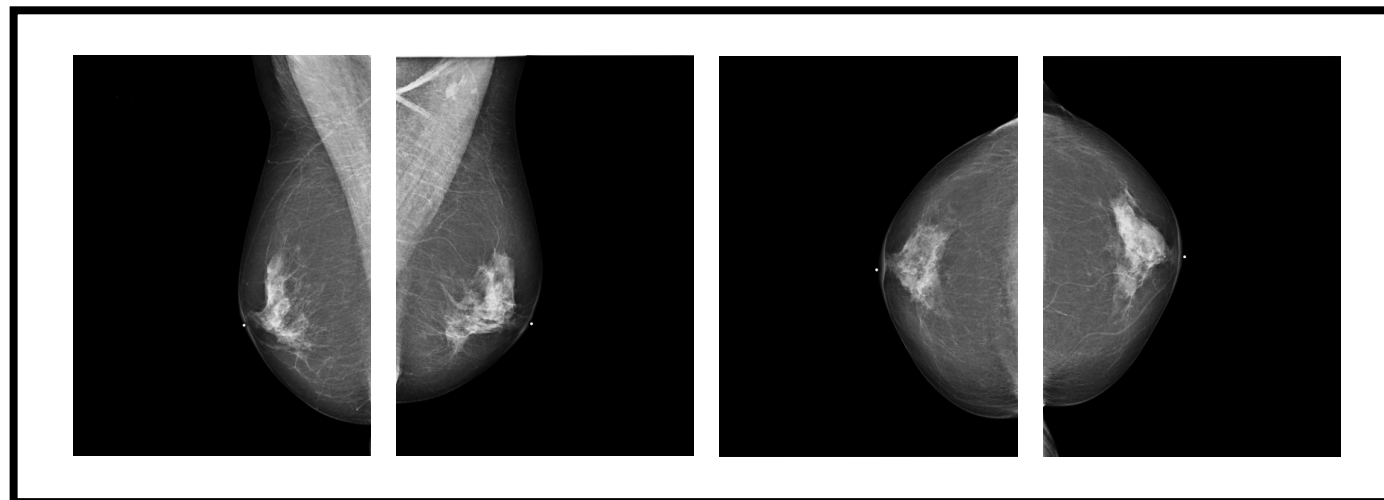
Nan Wu,

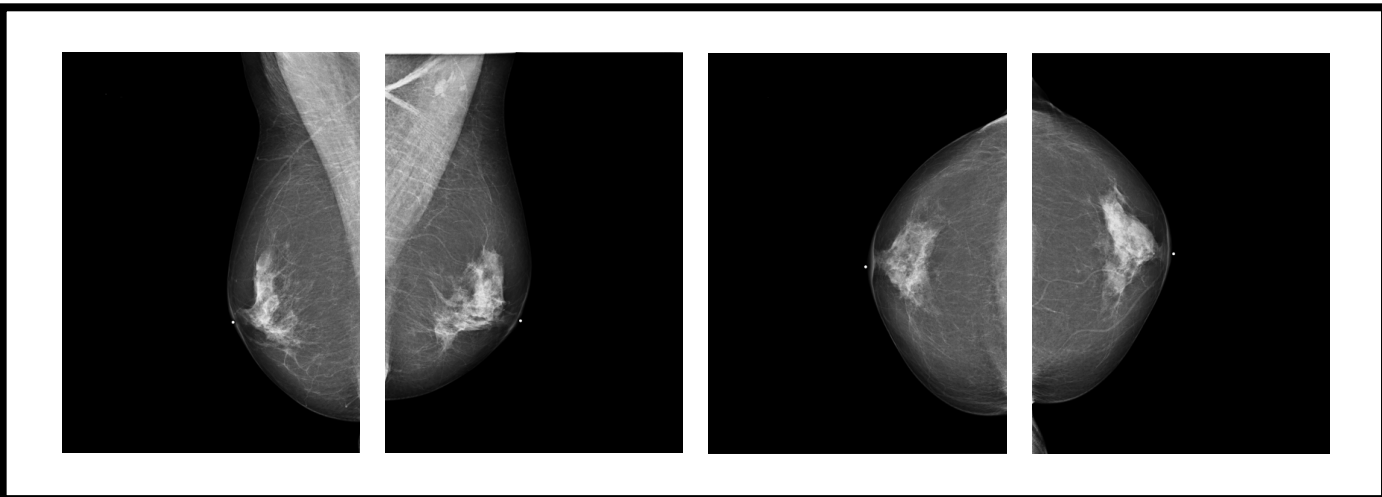# Breast cancer screening with multiple views

screening mammography

Breast cancer screening with multiple views

screening mammography

Breast cancer screening with multiple views

screening mammography

Medio Lateral Oblique (MLO)
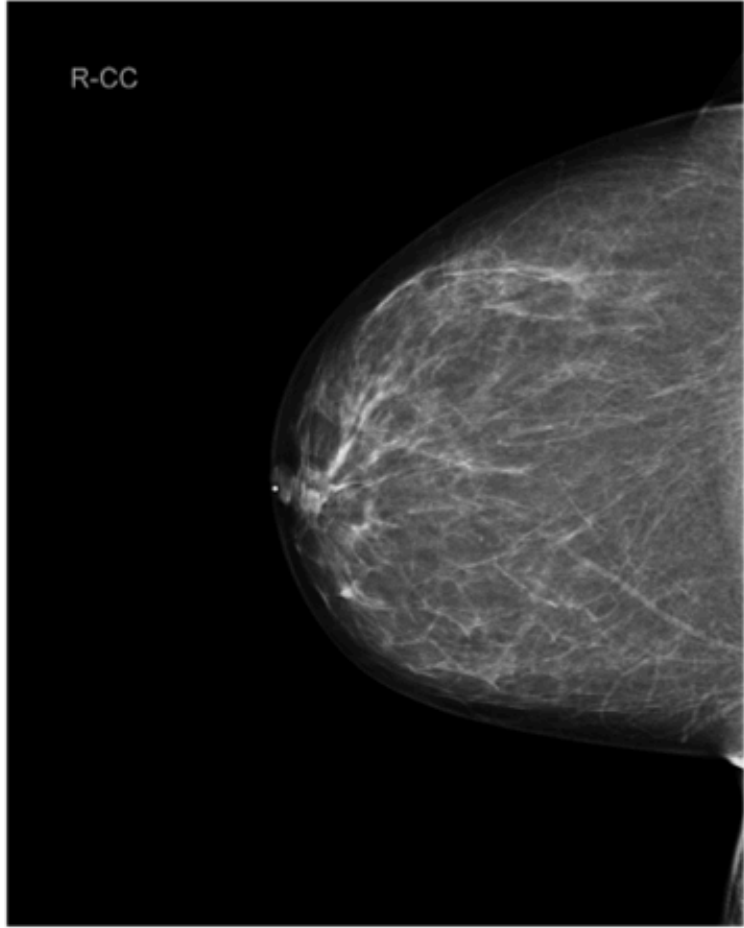
Cranio Caudal (CC)

Research question

Research question

Radiologists

Using both views is essential to make an accurate diagnosis in breast cancer screening.

Research question

Radiologists

Using both views is essential to make an accurate diagnosis in breast cancer screening.

Multiview deep neural networks

Classifier

Fusion operation

DNN   DNN

CC   MLO
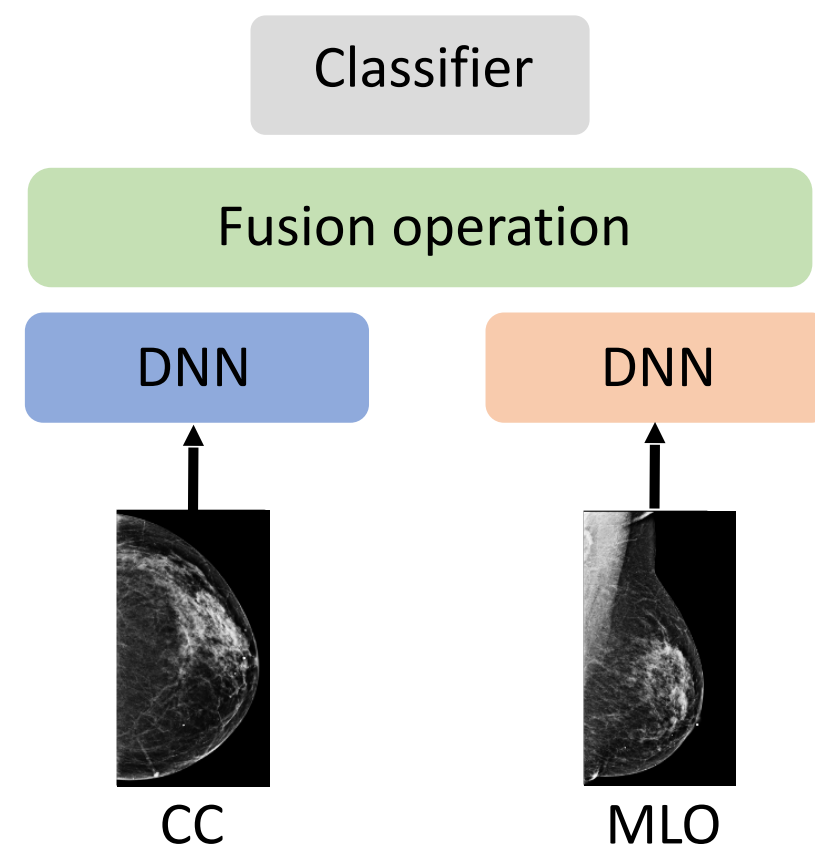
Does it utilize information in both views?

Evidence of difficulties in multiview learning

Evidence of difficulties in multiview learning

[1] Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.

Evidence of difficulties in multiview learning

Joint network

left breast
malignant /
not malignant

left breast
benign /
not benign

right breast
malignant /
not malignant
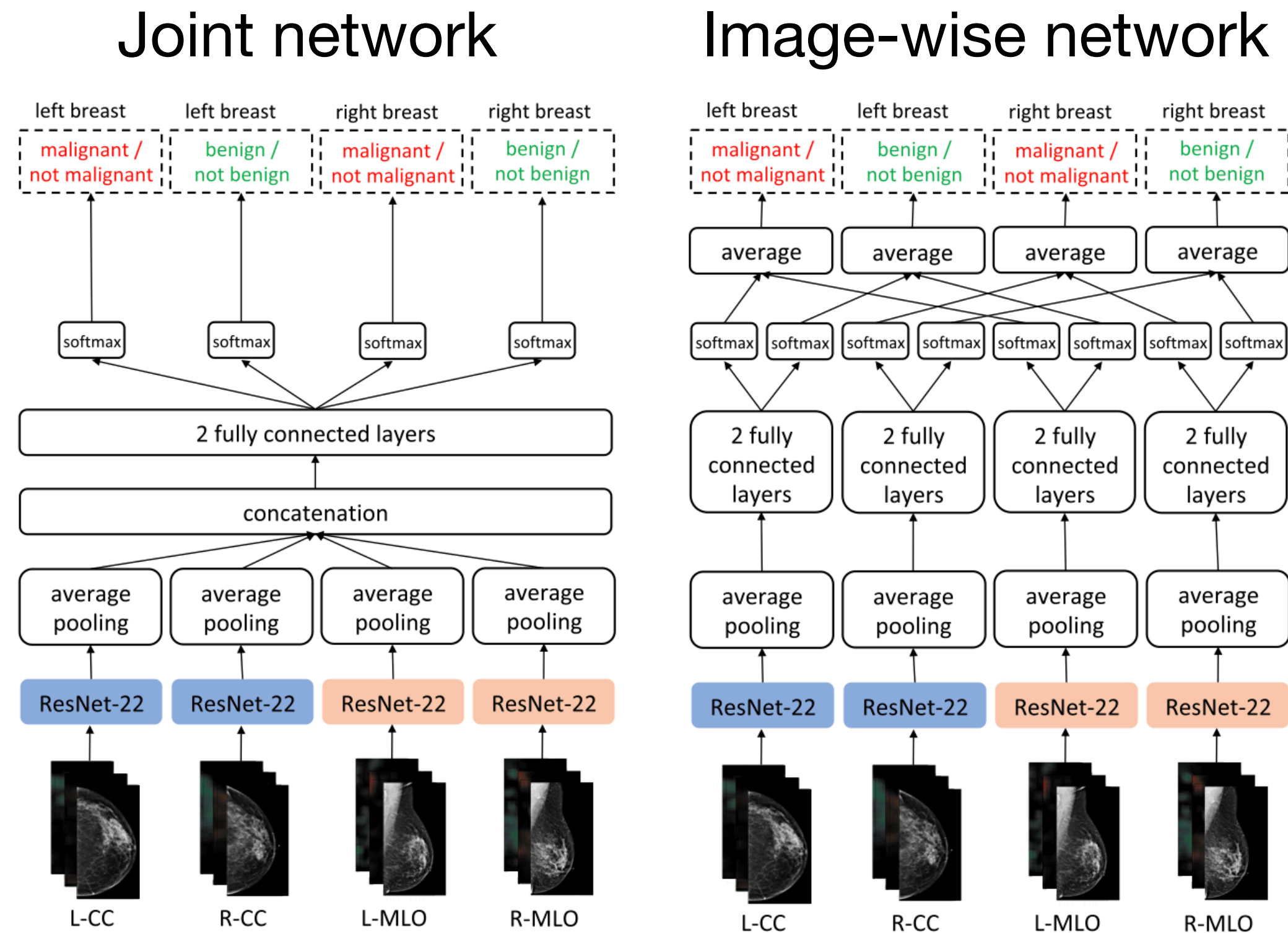
right breast
benign /
not benign

softmax | softmax | softmax | softmax

2 fully connected layers

concatenation

average pooling | average pooling | average pooling | average pooling

ResNet-22 | ResNet-22 | ResNet-22 | ResNet-22

L-CC | R-CC | L-MLO | R-MLO

Image-wise network

left breast
malignant /
not malignant

left breast
benign /
not benign

right breast
malignant /
not malignant

right breast
benign /
not benign

average | average | average | average

softmax softmax | softmax softmax | softmax softmax | softmax softmax

2 fully connected layers | 2 fully connected layers | 2 fully connected layers | 2 fully connected layers

average pooling | average pooling | average pooling | average pooling

ResNet-22 | ResNet-22 | ResNet-22 | ResNet-22
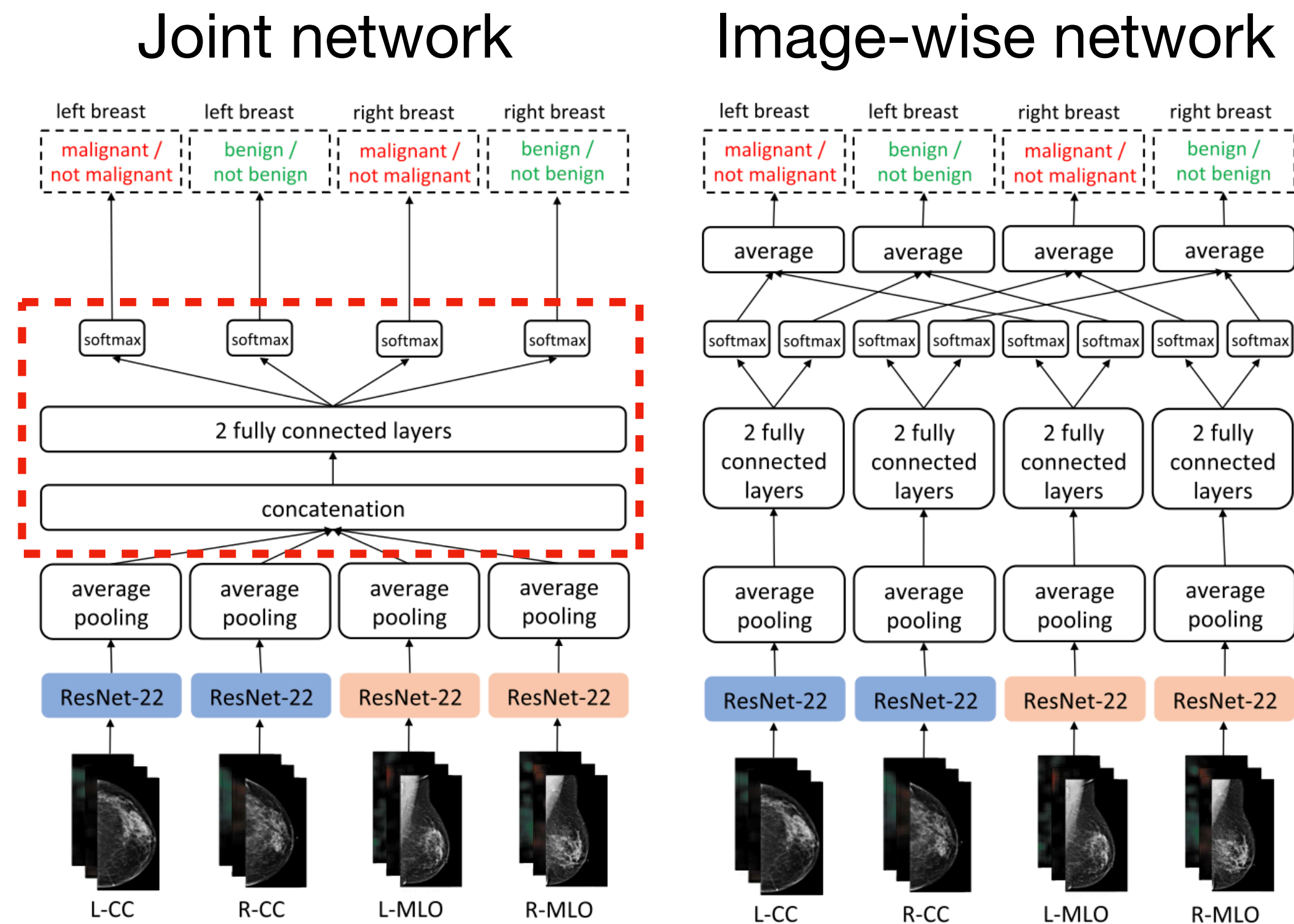
L-CC | R-CC | L-MLO | R-MLO

[1] Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.

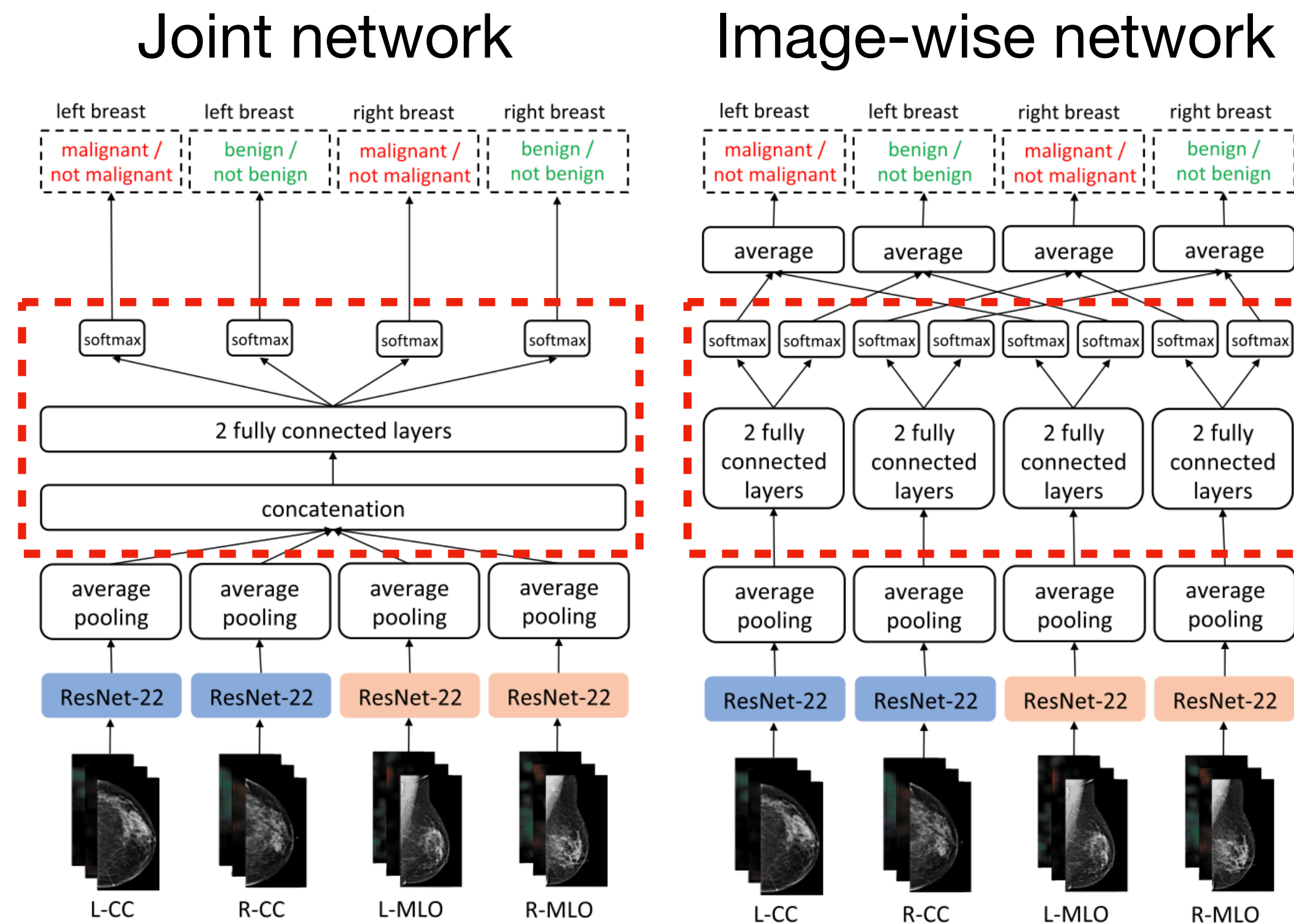# Evidence of difficulties in multiview learning

Joint network   Image-wise network

[1] *Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.*
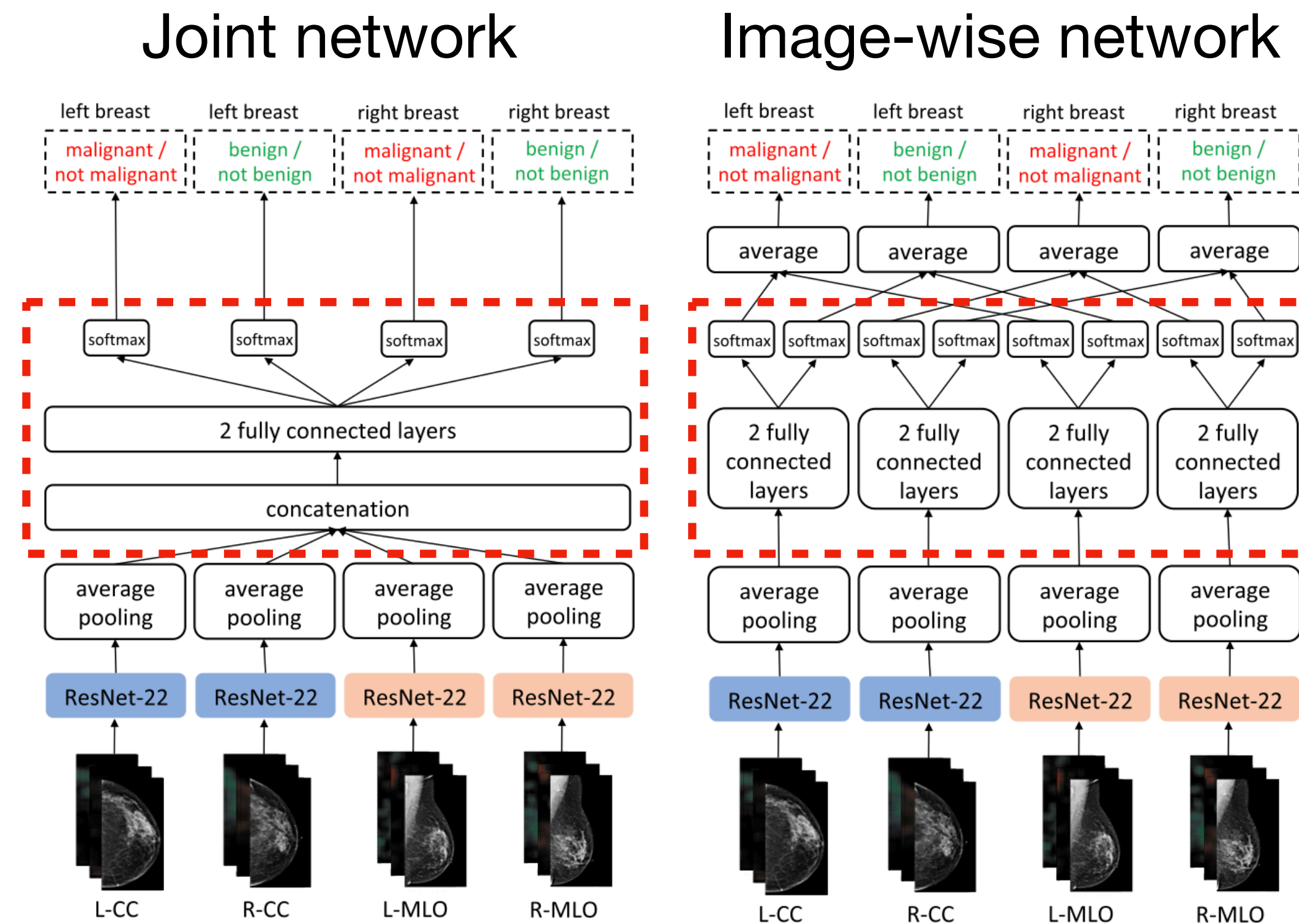
Evidence of difficulties in multiview learning

Joint network

left breast
malignant / not malignant

left breast
benign / not benign

right breast
malignant / not malignant

right breast
benign / not benign

softmax · softmax · softmax · softmax

2 fully connected layers

concatenation

average pooling · average pooling · average pooling · average pooling

ResNet-22 · ResNet-22 · ResNet-22 · ResNet-22

L-CC · R-CC · L-MLO · R-MLO

Image-wise network

left breast
malignant / not malignant

left breast
benign / not benign

right breast
malignant / not malignant

right breast
benign / not benign

average · average · average · average

softmax softmax · softmax softmax · softmax softmax · softmax softmax

2 fully connected layers · 2 fully connected layers · 2 fully connected layers · 2 fully connected layers

average pooling · average pooling · average pooling · average pooling

ResNet-22 · ResNet-22 · ResNet-22 · ResNet-22

L-CC · R-CC · L-MLO · R-MLO

[1] Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.
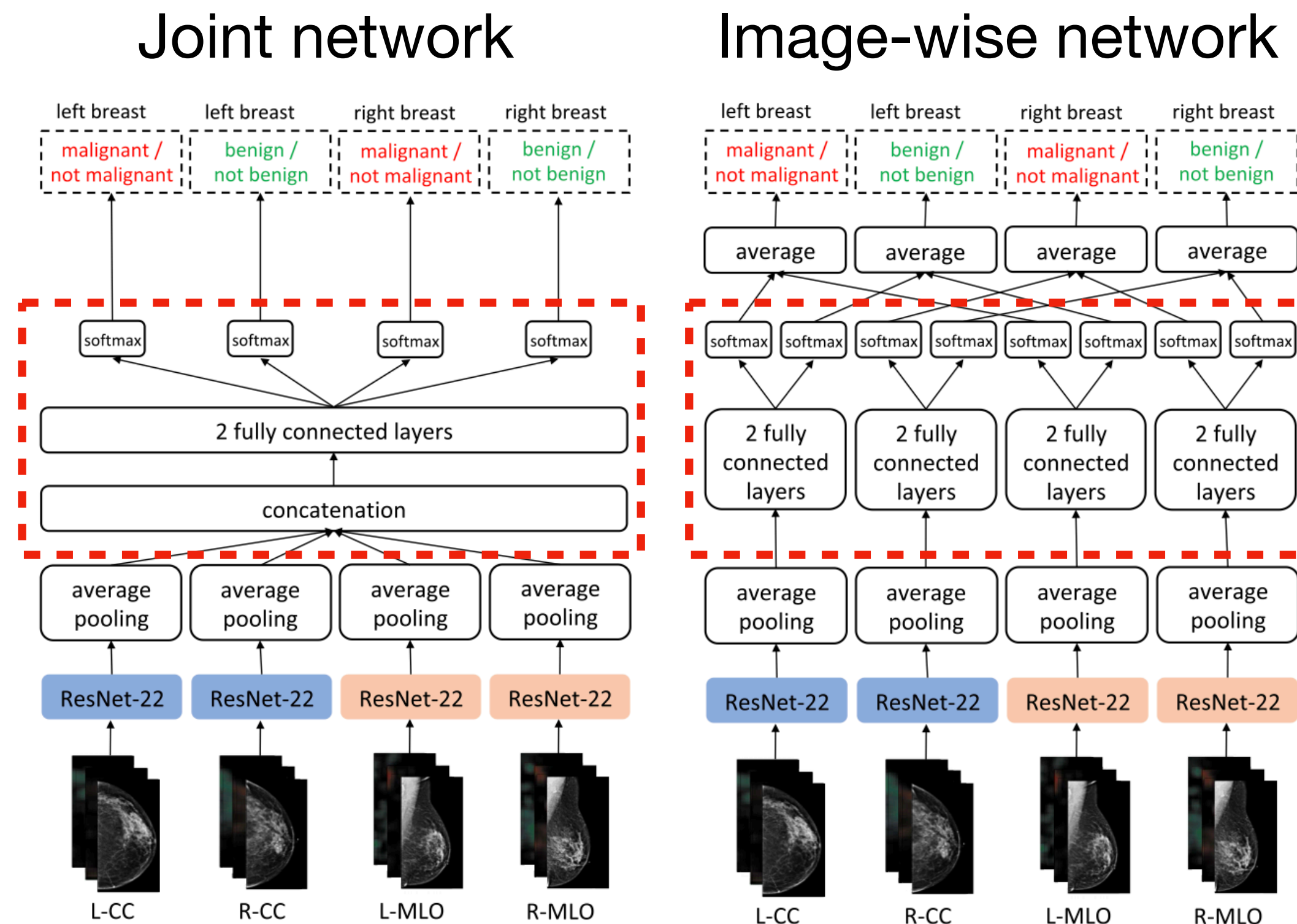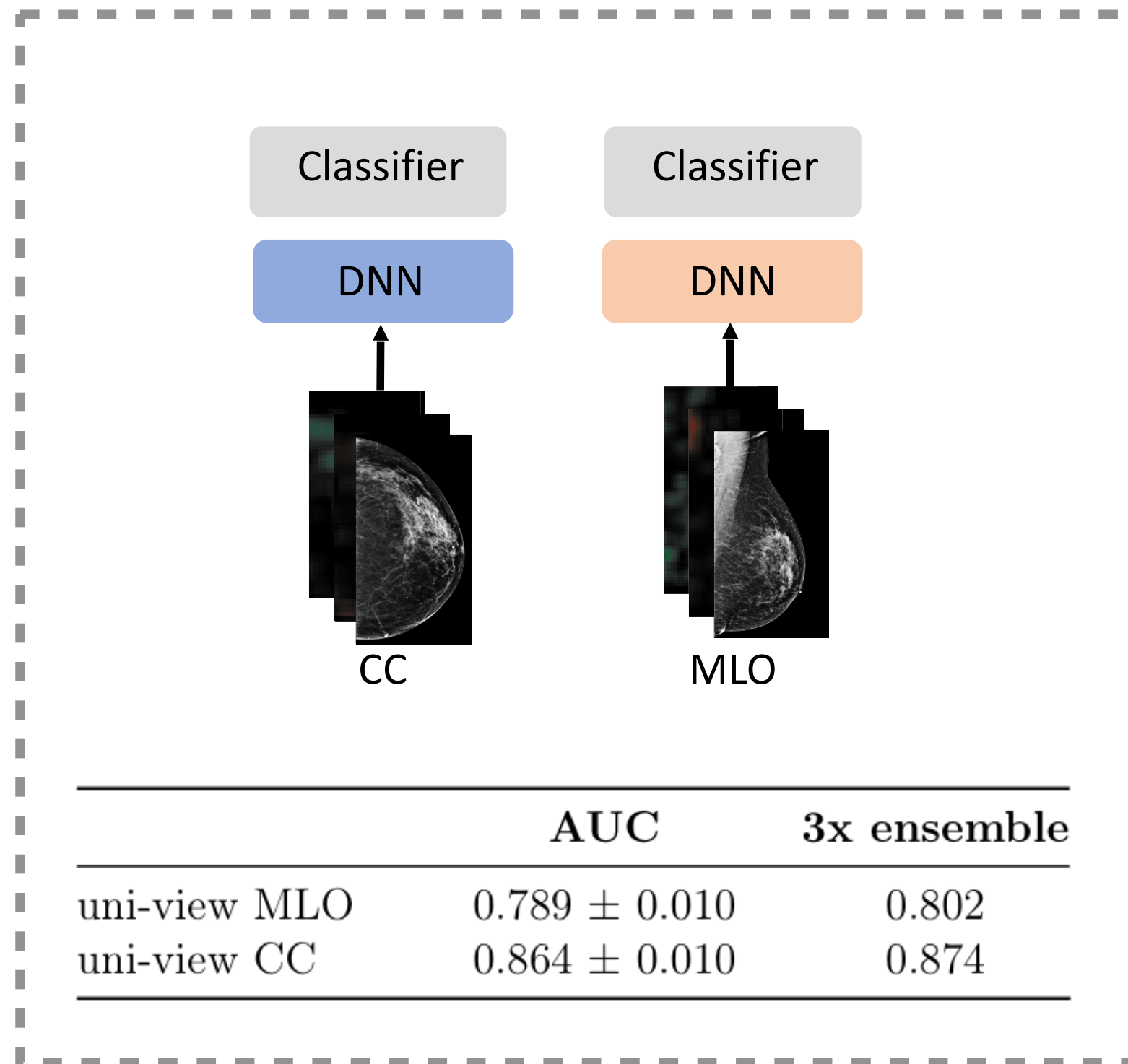
Evidence of difficulties in multiview learning

Joint network

Image-wise network

	AUC	
	joint	Image-wise
Image-only	0.822	**0.830**
Image-and-heatmaps	0.860	**0.875**

[1] Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.

Evidence of difficulties in multiview learning

	AUC	
	joint	Image-wise
Image-only	0.822	**0.830**
Image-and-heatmaps	0.860	**0.875**

[1] Nan Wu et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Transactions on Medical Imaging, 2019.

[2] Weiyao Wang, Du Tran, and Matt Feiszli. What makes training multi-modal networks hard? arXiv:1905.12681, 2019.

[3] Mohammad Hashir, Hadrien Bertrand, Joseph Paul Cohen. Quantifying the Value of Lateral Views in Deep Learning for Chest X-rays. MIDL 2020.

What makes using both views of the breast difficult?
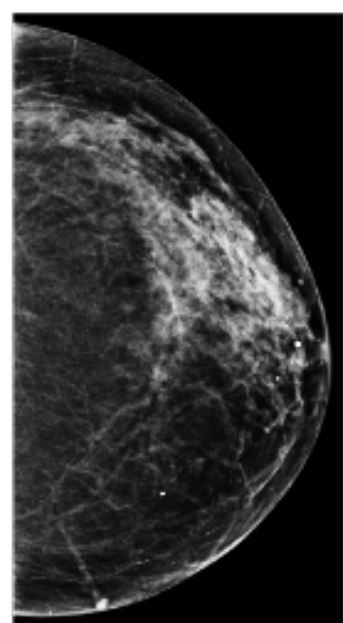
What makes using both views of the breast difficult?

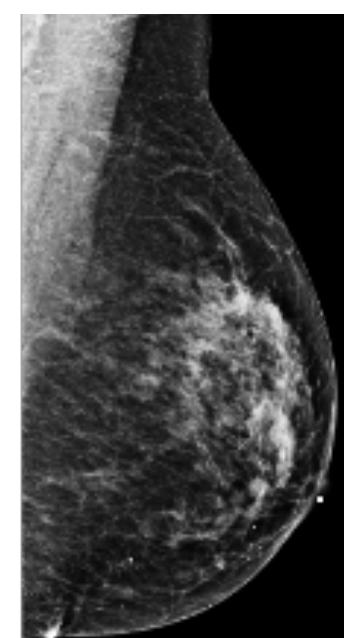|	AUC	3x ensemble
uni-view MLO	0.789 ± 0.010	0.802
uni-view CC	0.864 ± 0.010	0.874

What makes using both views of the breast difficult?

	AUC	3x ensemble
uni-view MLO	0.789 ± 0.010	0.802
uni-view CC	0.864 ± 0.010	0.874
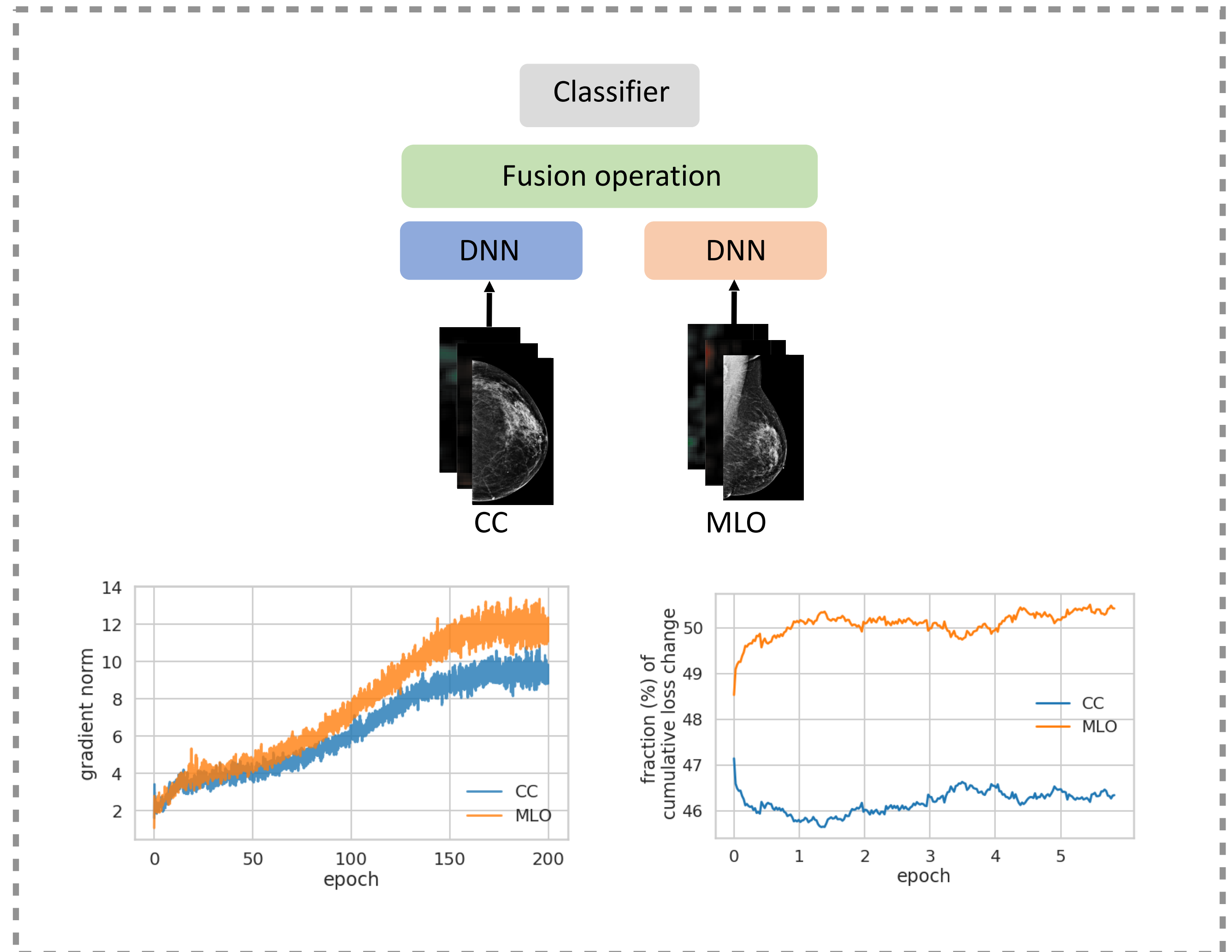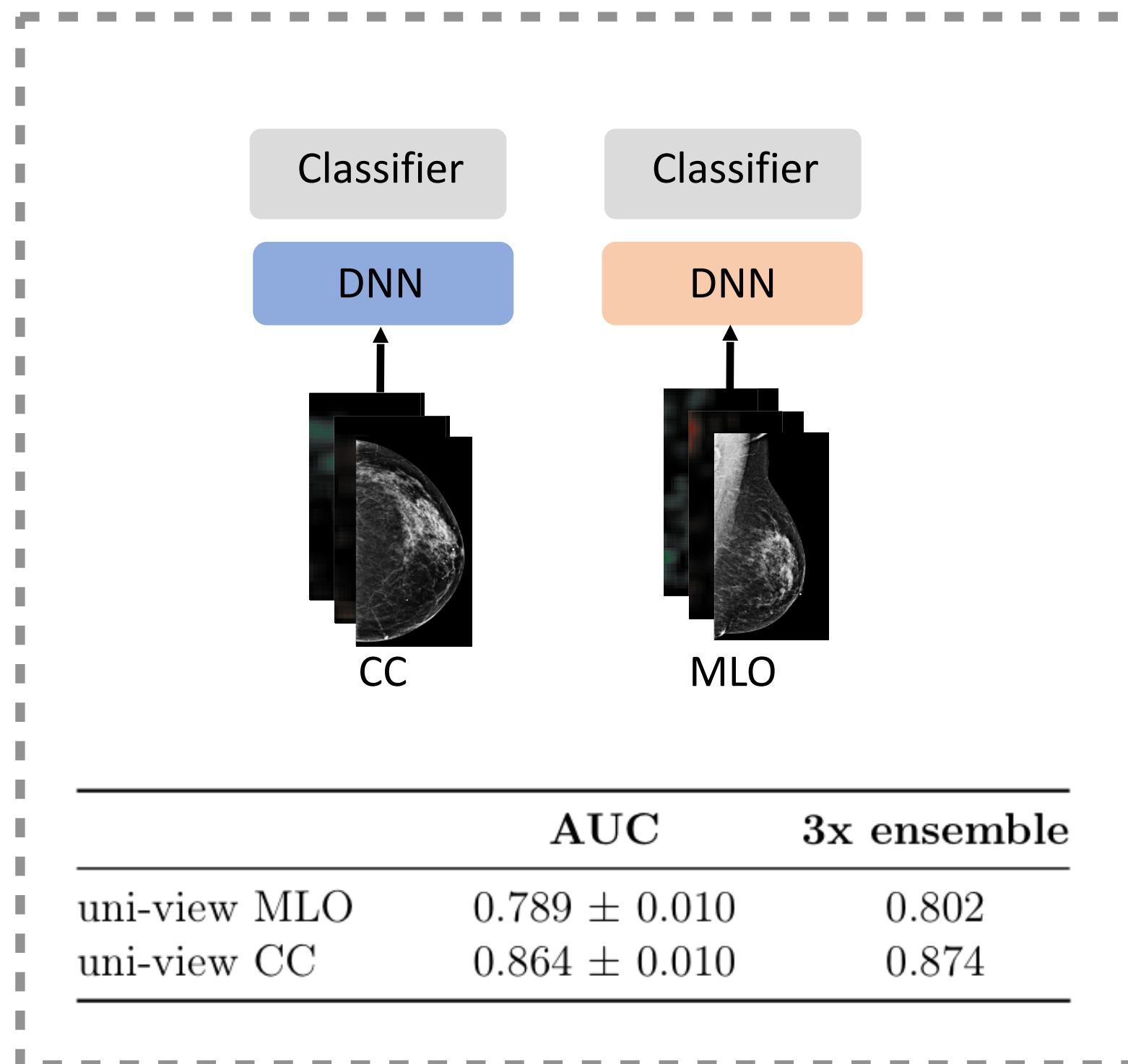
How to improve its ability in utilizing information in both views of the breast?

How to improve its ability in utilizing information in both views of the breast?

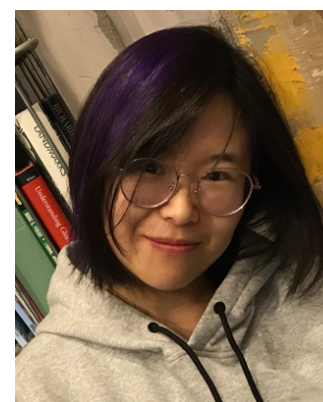Two methods that can help: *Modality Dropout and Sharing weights between part operating on each view.*

	AUC	3x ensemble
Joint ResNet	0.872 ± 0.005	0.887
+ Modality Dropout	0.876 ± 0.009	0.886
Shared ResNet	0.879 ± 0.003	0.890

Improving the Ability of Deep Neural Networks
to Use Information from Multiple Views in Breast Cancer Screening

Thank you!