



Evaluating the Fidelity of Explanations for Convolutional Neural Networks in Alzheimer's Disease Detection

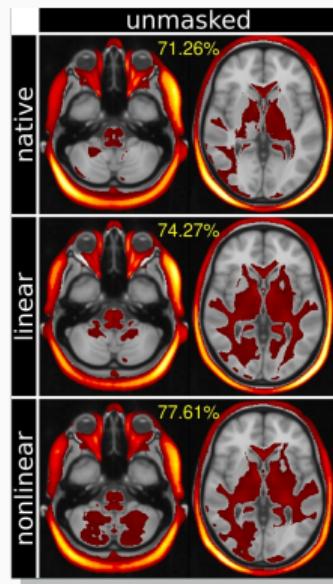
Bjarne C. Hiller

2025-03-09

University of Rostock

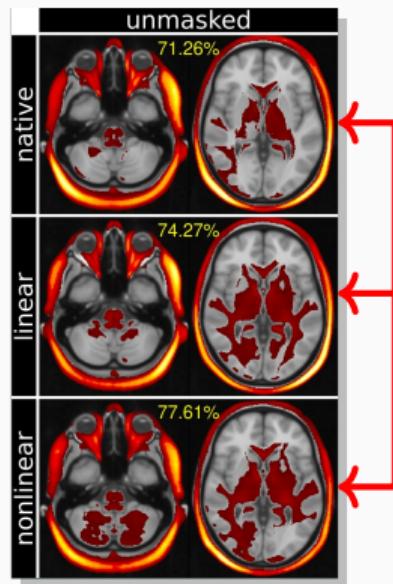
Motivation: Can you trust Neural Networks for Medical Image Processing?

Motivation: Can you trust Neural Networks for Medical Image Processing?



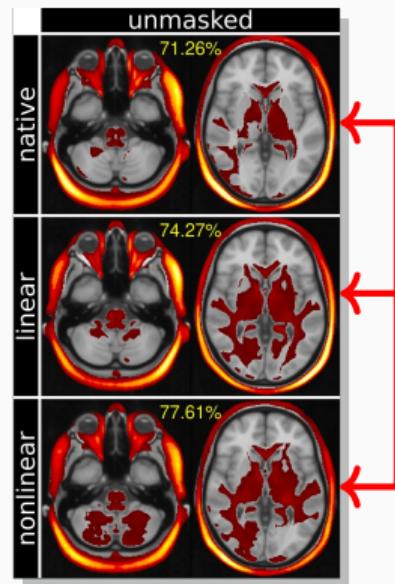
(a) From: Tinauer et al. [2]

Motivation: Can you trust Neural Networks for Medical Image Processing?

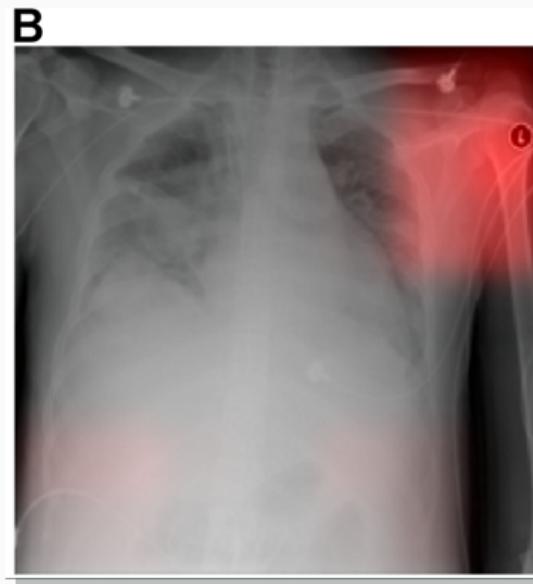


(a) From: Tinauer et al. [2]

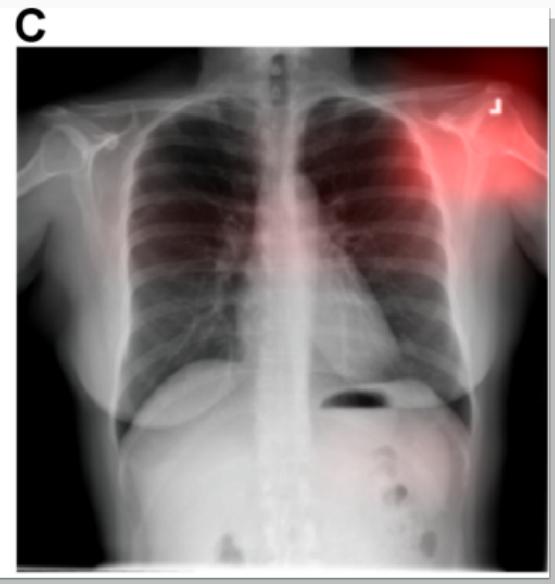
Motivation: Can you trust Neural Networks for Medical Image Processing?



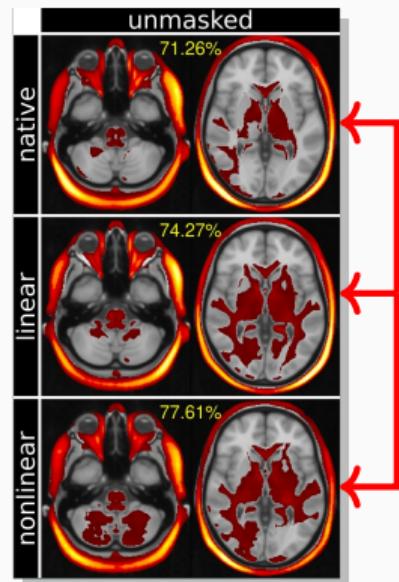
(a) From: Tinauer et al. [2]



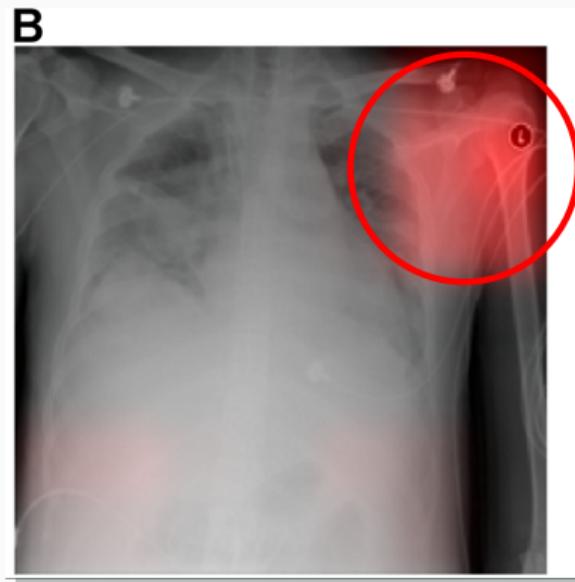
(b) From: Zech et al. [3]



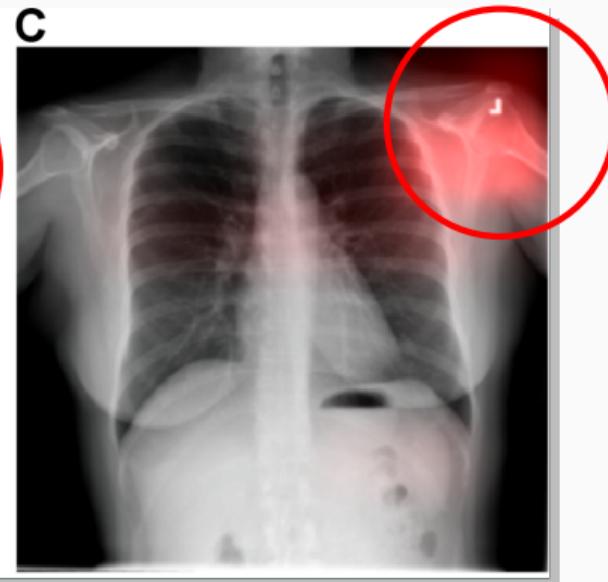
Motivation: Can you trust Neural Networks for Medical Image Processing?



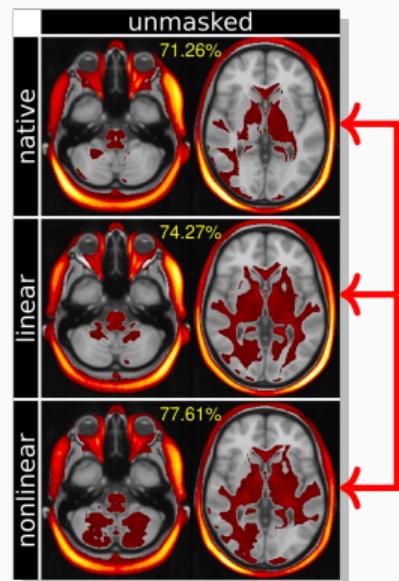
(a) From: Tinauer et al. [2]



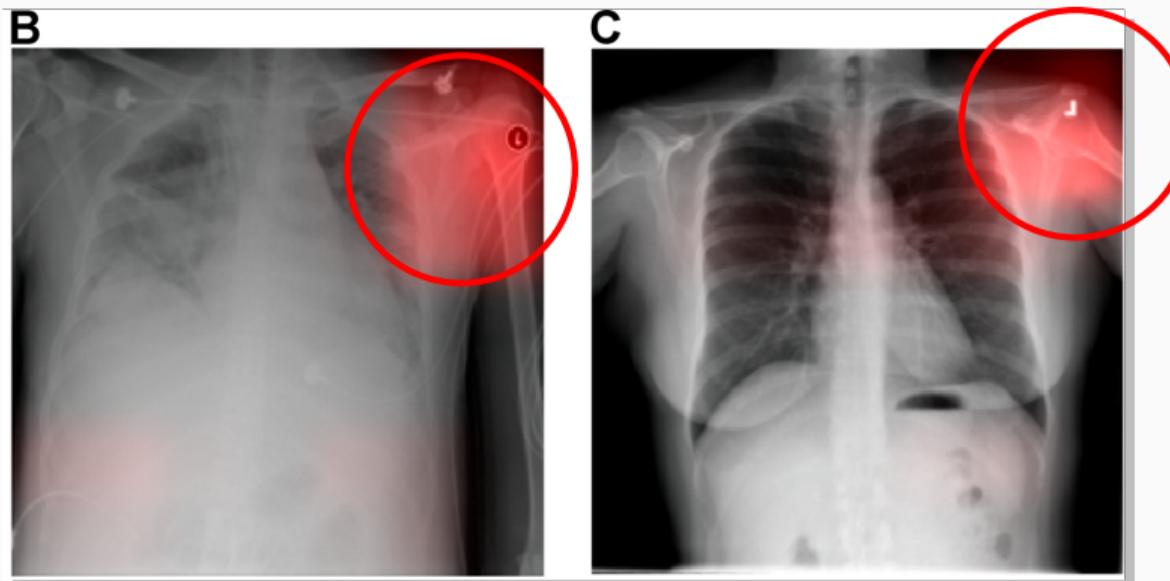
(b) From: Zech et al. [3]



Motivation: Can you trust Neural Networks for Medical Image Processing?



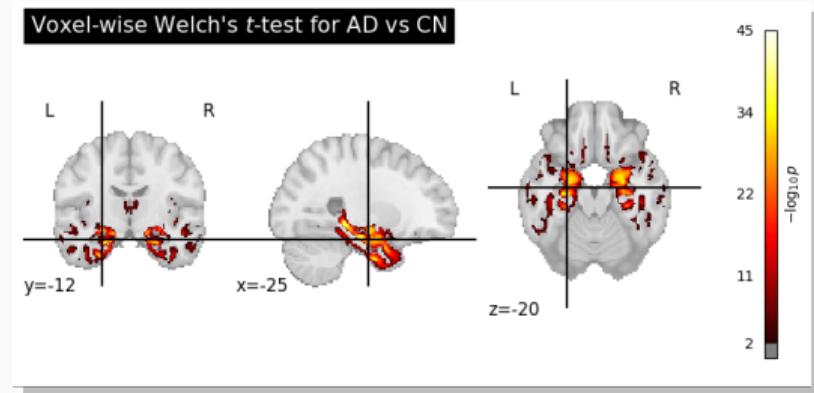
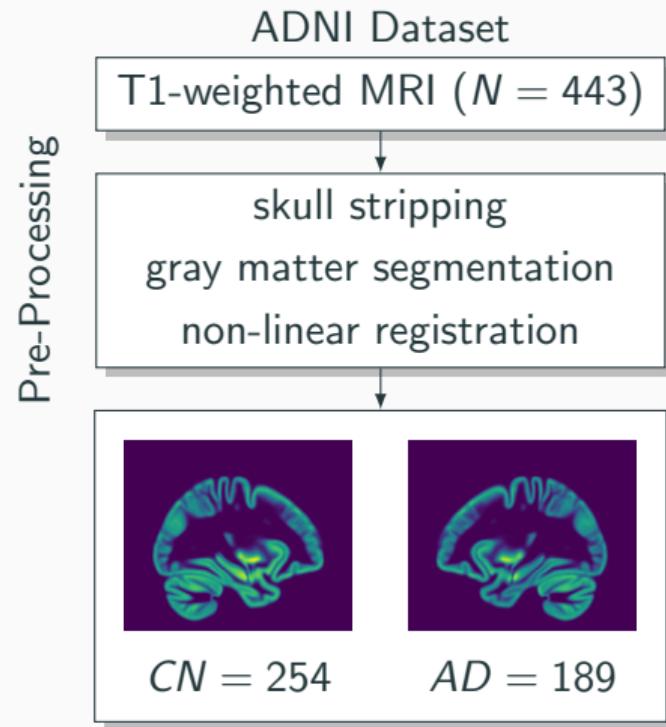
(a) From: Tinauer et al. [2]



(b) From: Zech et al. [3]

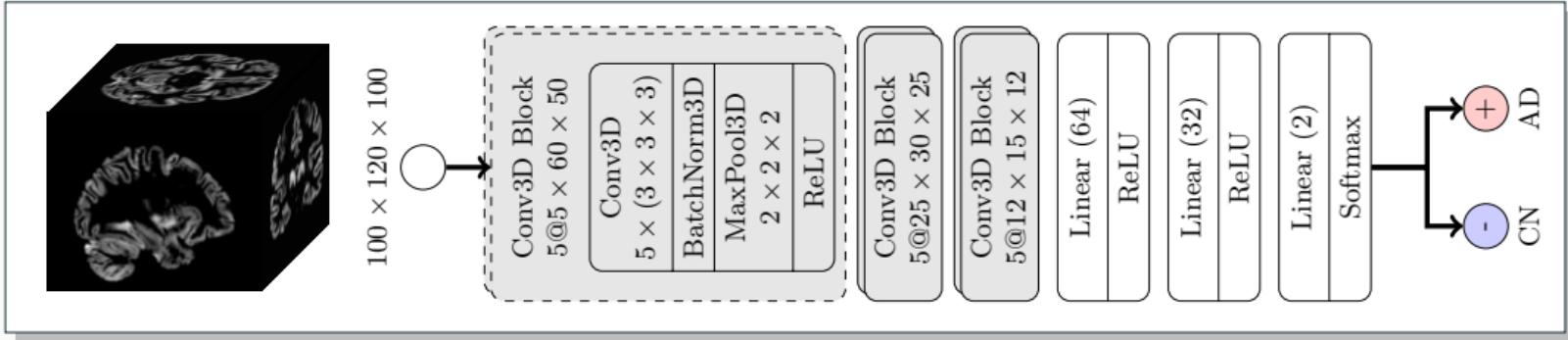
Attribution maps can reveal **shortcut learning**: Neural Networks can use features outside of the brain parenchyma (a) or X-ray side marker tokens (b) for classification.

Data and Preprocessing

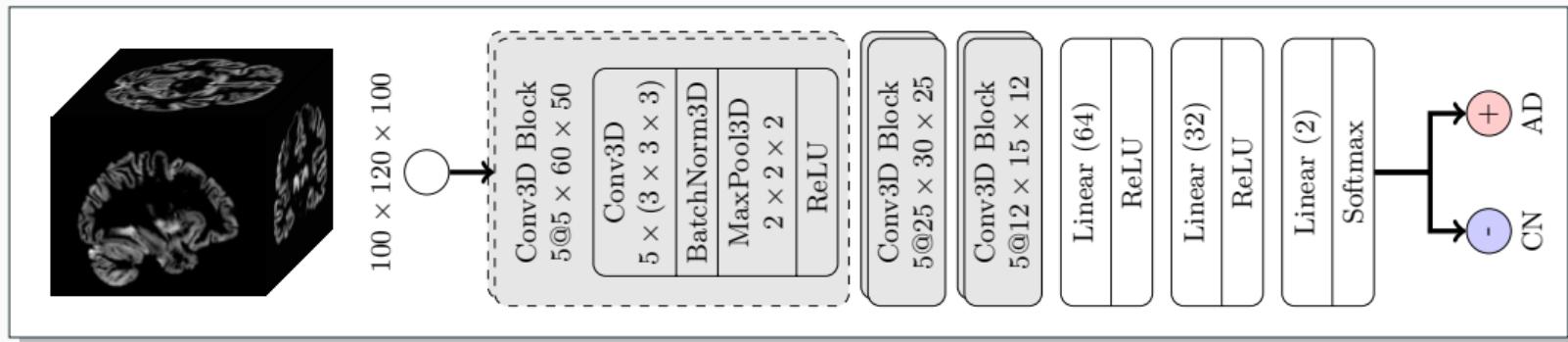


Voxel-wise Welch's t -test ($\alpha = 0.01$)

A CNN Model for AD vs CN Classification



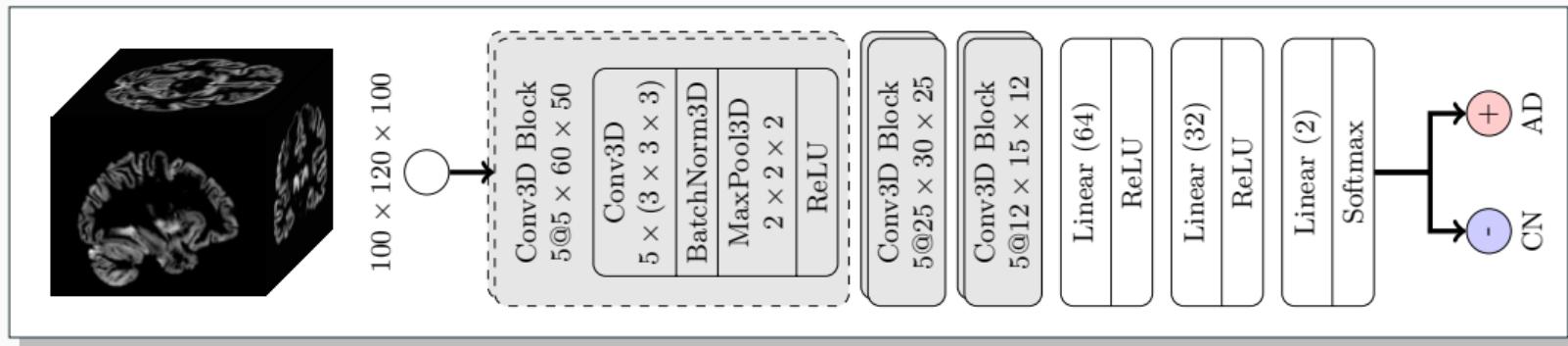
A CNN Model for AD vs CN Classification



AUC ROC	Accuracy
0.95 ± 0.02	87.64%

5-fold Cross Validation Results

A CNN Model for AD vs CN Classification



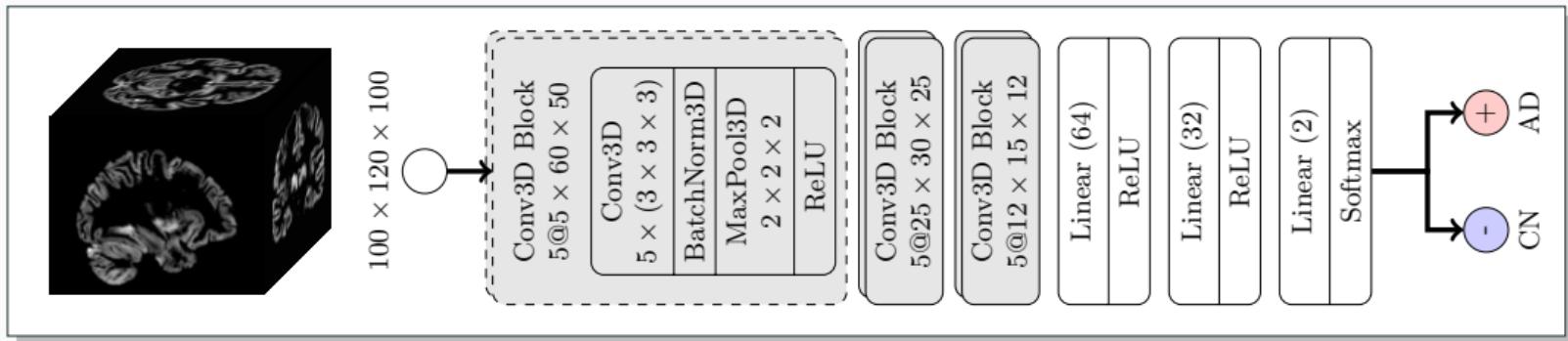
AUC ROC	Accuracy
0.95 ± 0.02	87.64%

5-fold Cross Validation Results

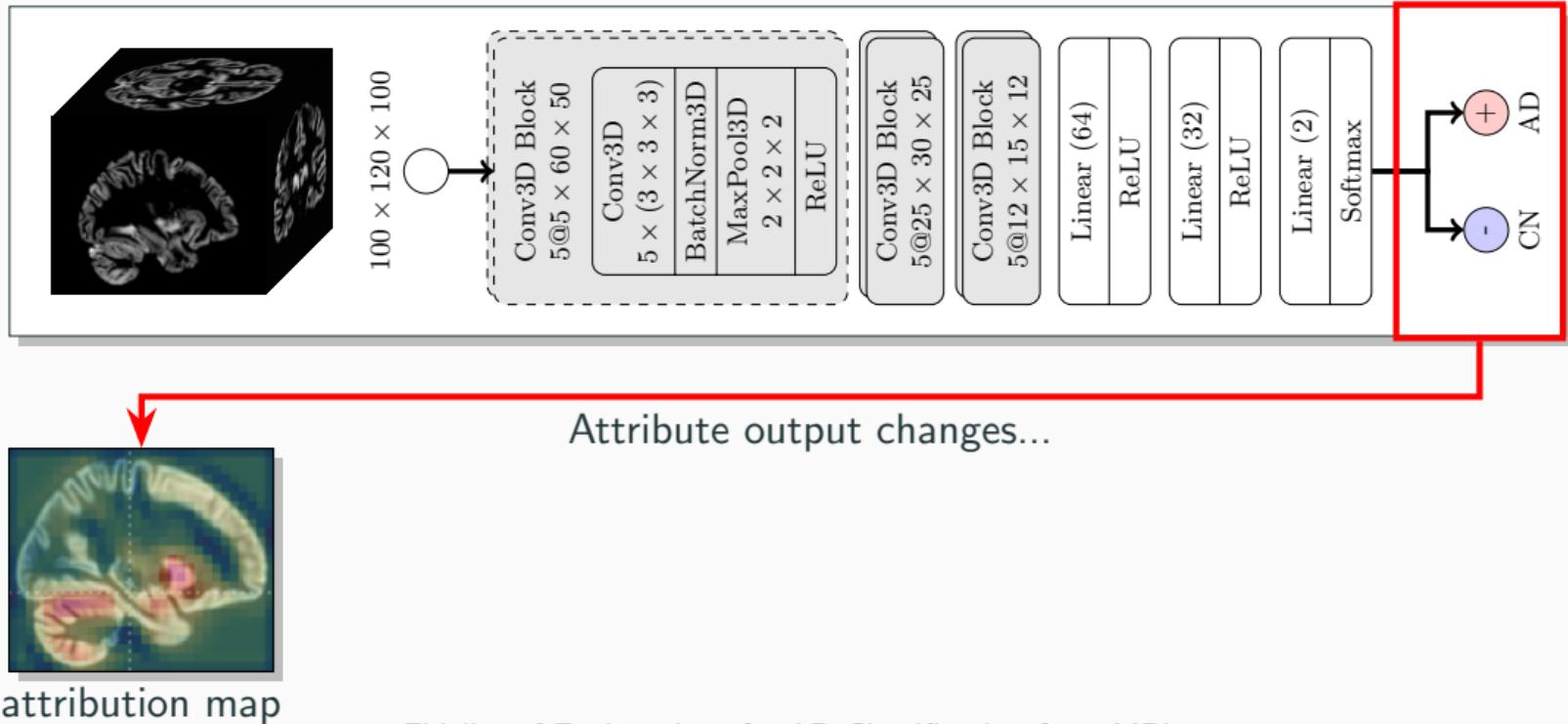
Acceptable Performance...

...but can we **trust** the model?

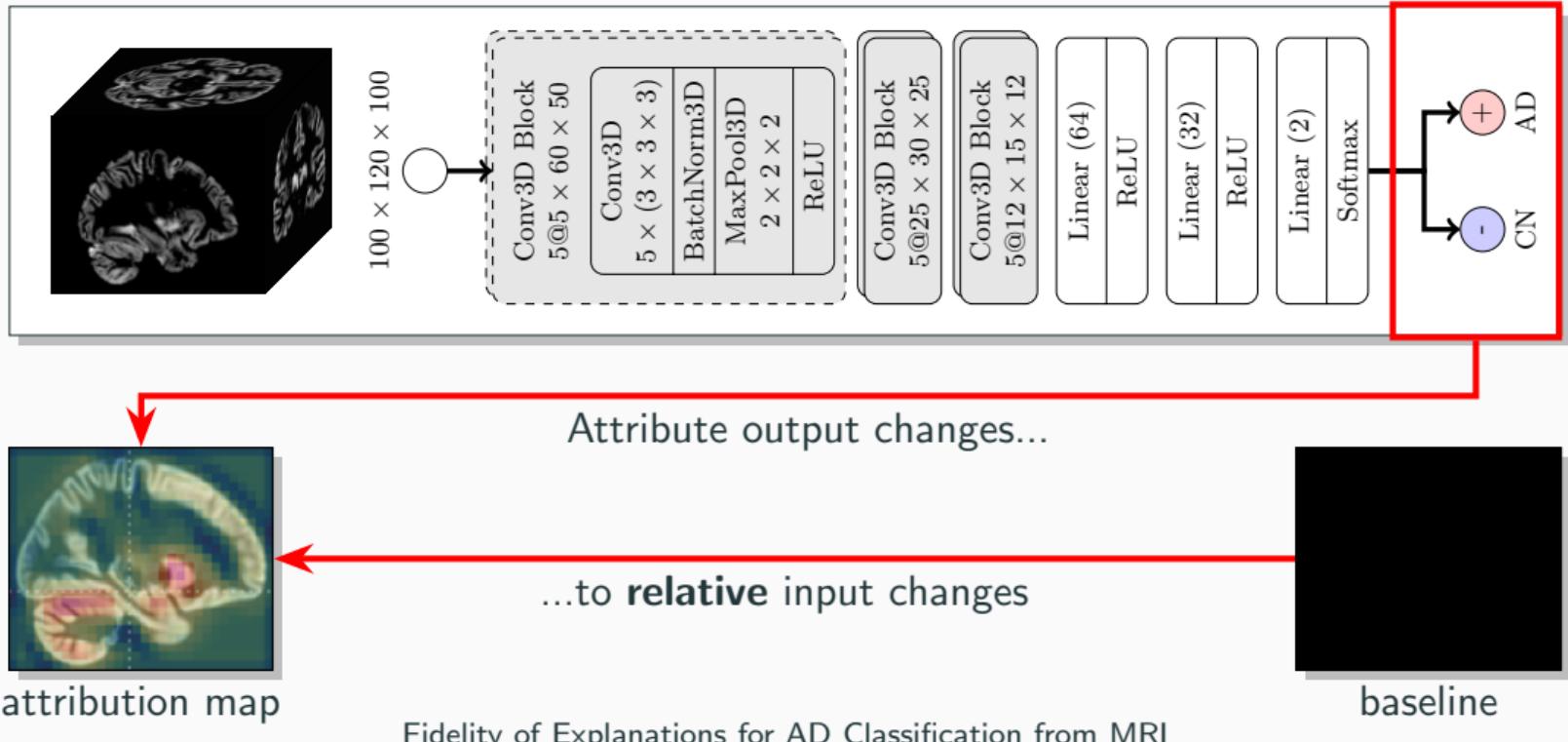
Attribution Maps: What did the network look at?

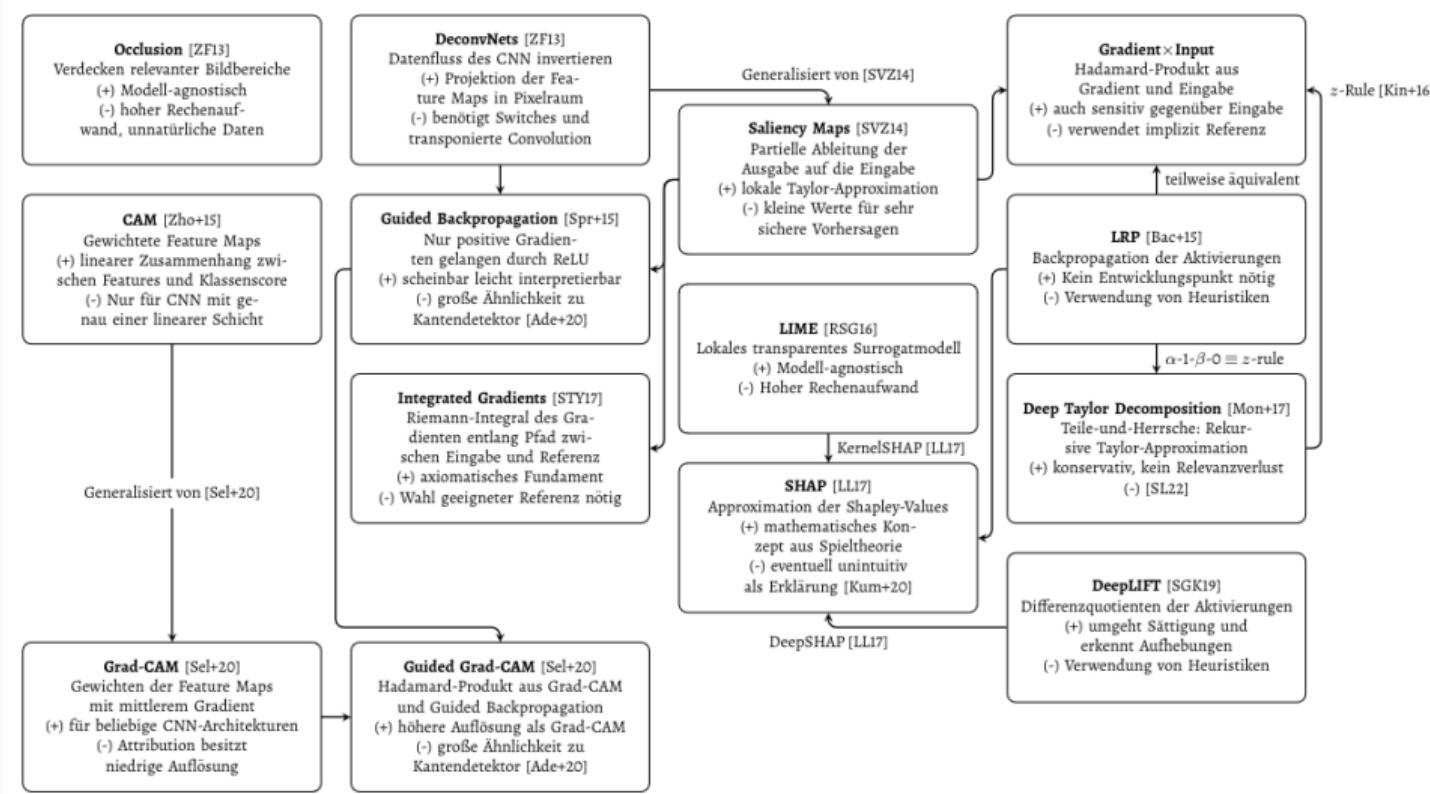


Attribution Maps: What did the network look at?

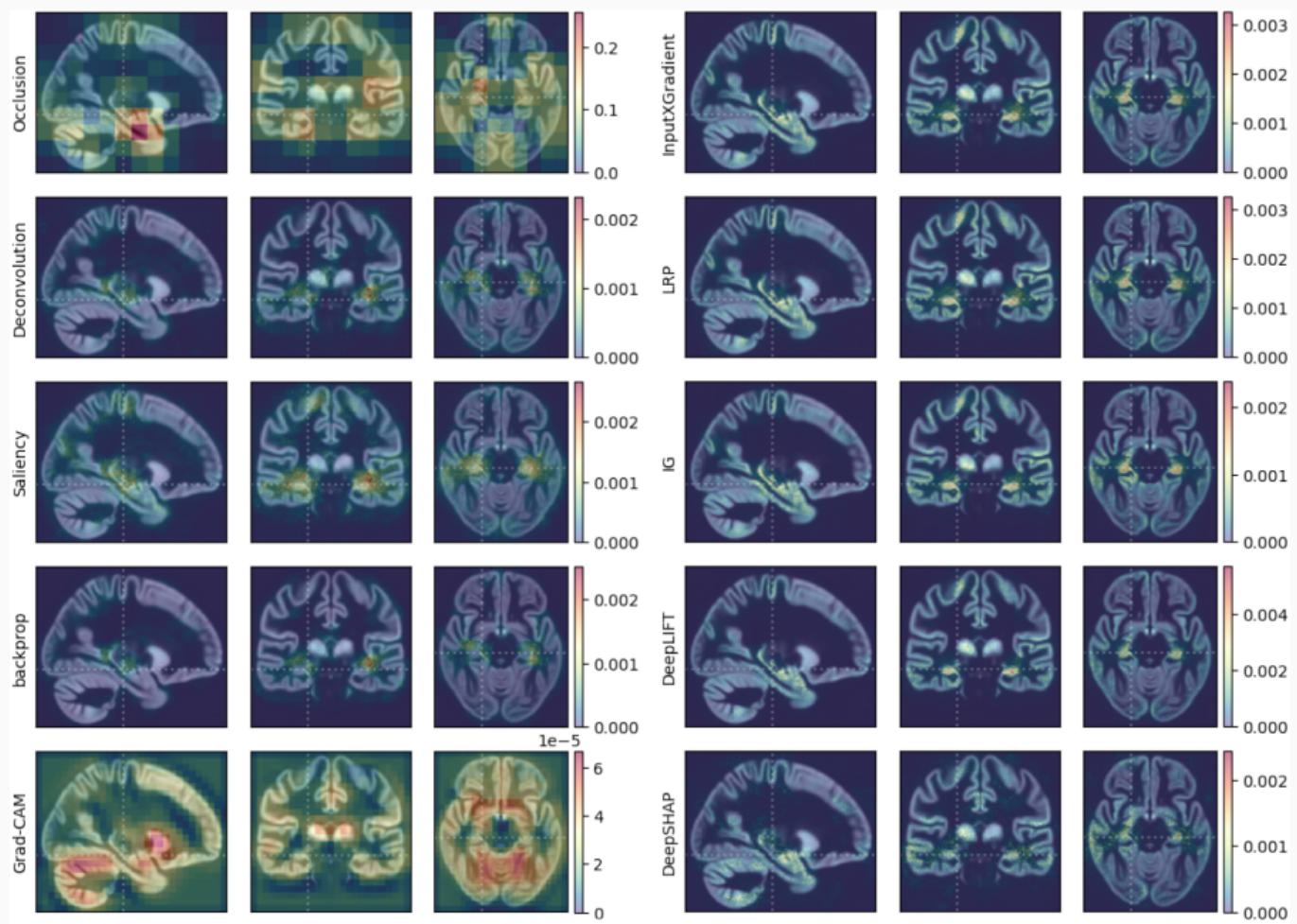


Attribution Maps: What did the network look at?





Popular feature attribution methods for Deep Neural Networks and their Relationships



Total Relevance per ROI

	Occlusion	IG	DeepLIFT	DeepSHAP
1.	Precuneus_L	Temporal_Mid_L	Temporal_Mid_L	Calcarine_L
2.	Precuneus_R	Temporal_Mid_R	Temporal_Mid_R	Precentral_R
3.	Postcentral_L	Temporal_Inf_L	Temporal_Inf_L	Calcarine_R
4.	Supp_Motor_Area_L	Precentral_R	Precuneus_R	Cerebellum_6_R
5.	Supp_Motor_Area_R	Postcentral_L	Precuneus_L	Precentral_L
6.	Postcentral_R	Frontal_Mid_L	Temporal_Inf_R	Lingual_L
7.	Precentral_L	Postcentral_R	Parietal_Inf_L	Postcentral_R
8.	Cingulum_Mid_R	Hippocampus_L	Frontal_Mid_L	Postcentral_L
9.	Frontal_Sup_Medial_L	Temporal_Inf_R	Hippocampus_L	Lingual_R
10.	Cingulum_Mid_L	Parietal_Inf_L	Supp_Motor_Area_R	Cuneus_L

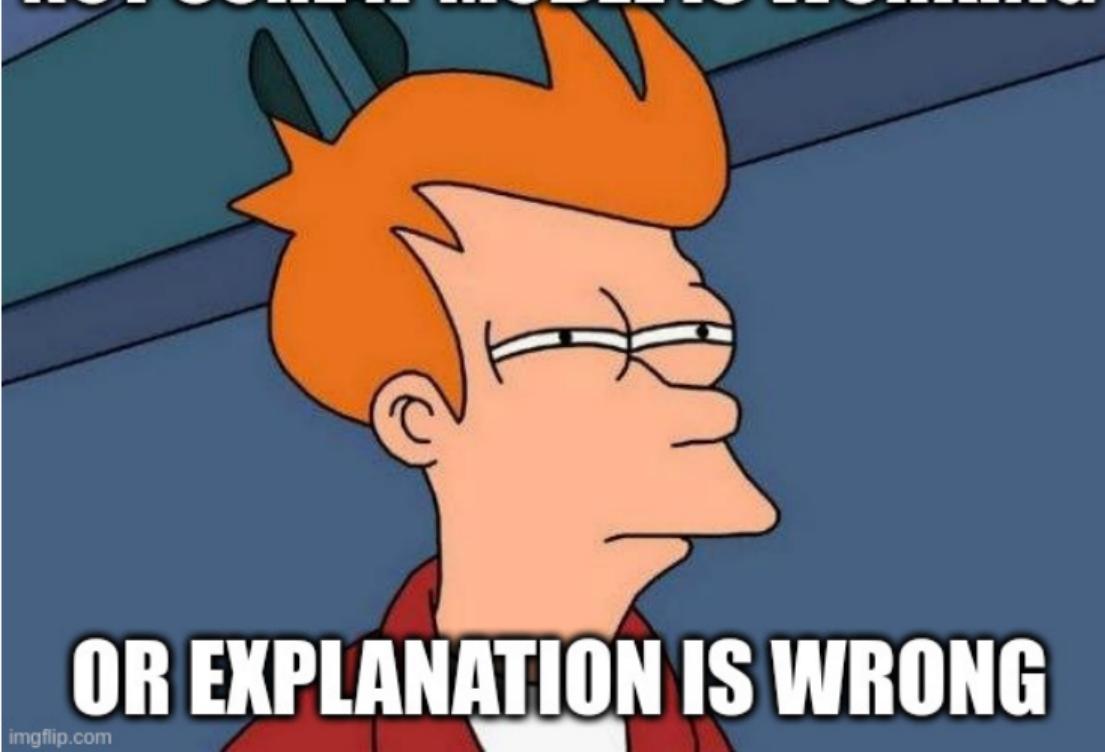
Top 10 AAL ROIs by total relevance for class AD

Mean Relevance per ROI

	Occlusion	IG	DeepLIFT	DeepSHAP
1.	Supp_Motor_Area_L	Hippocampus_L	Hippocampus_L	Calcarine_L
2.	Supp_Motor_Area_R	Hippocampus_R	Hippocampus_R	Calcarine_R
3.	Rolandic_Oper_L	ParaHippocampal_R	Parietal_Inf_R	Vermis_10
4.	Cingulum_Mid_L	Heschl_L	Amygdala_L	Vermis_7
5.	Cingulum_Mid_R	Parietal_Inf_L	ParaHippocampal_R	Vermis_6
6.	Paracentral_Lobule_R	Thalamus_R	Parietal_Inf_L	Vermis_9
7.	Precuneus_L	Rolandic_Oper_L	Calcarine_R	Vermis_8
8.	Precuneus_R	Temporal_Inf_L	Supp_Motor_Area_R	Cuneus_R
9.	Heschl_L	Temporal_Mid_L	Temporal_Inf_L	Cerebellum_6_R
10.	Frontal_Med_Orb_R	Supp_Motor_Area_R	SupraMarginal_L	Precentral_R

Top 10 AAL ROIs by mean relevance per voxel for class AD

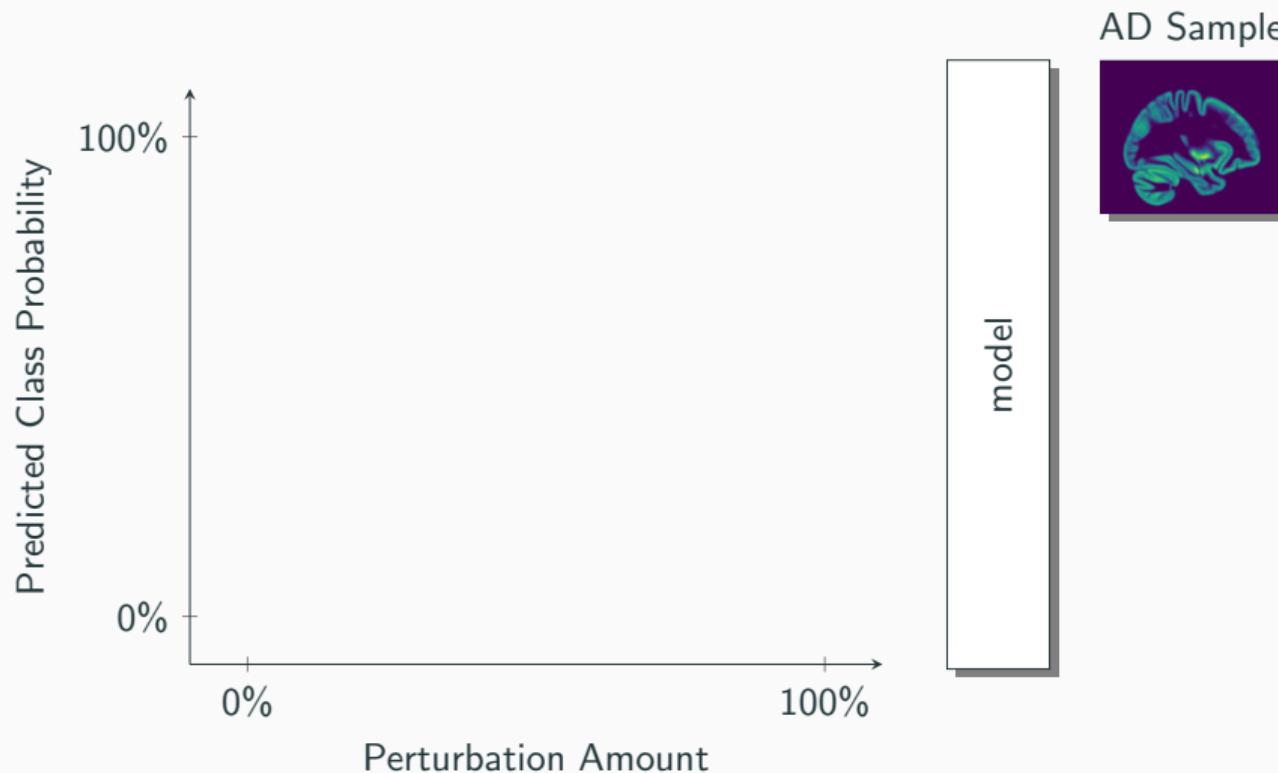
NOT SURE IF MODEL IS WORKING



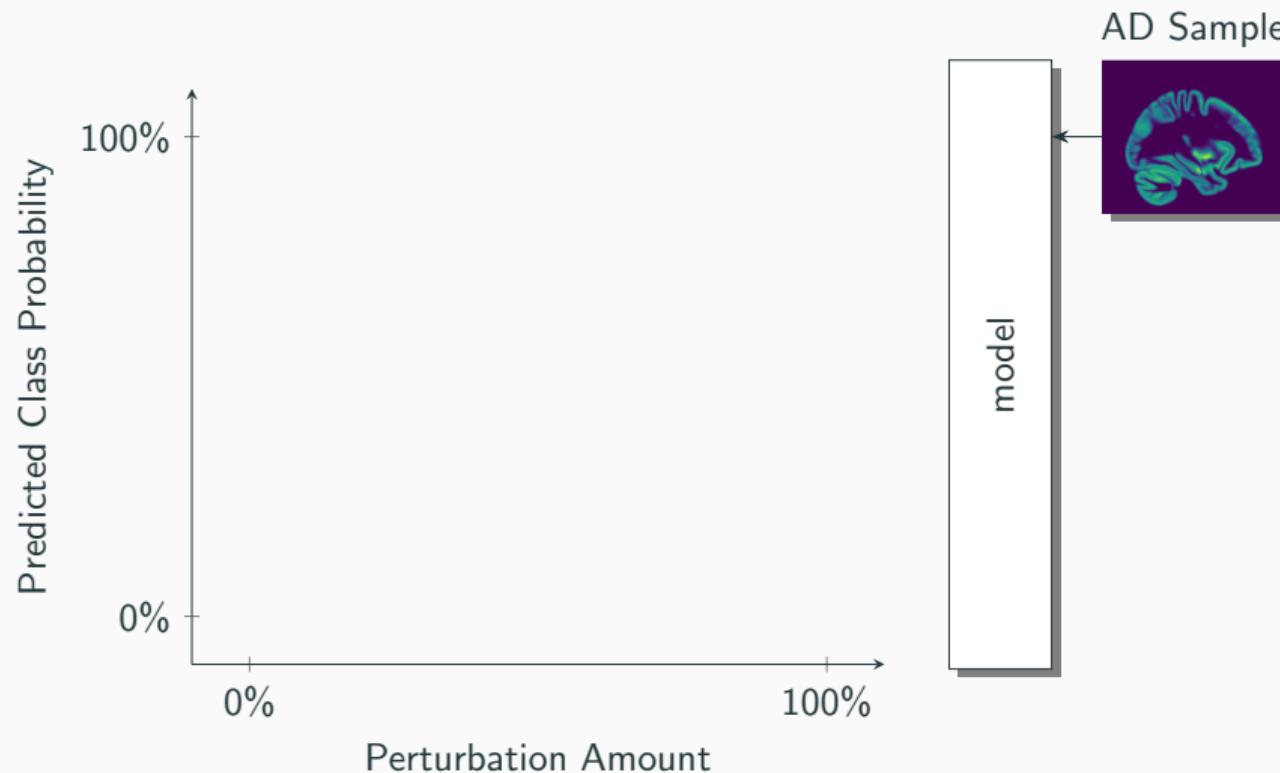
imgflip.com

But can the **explanation** be trusted?

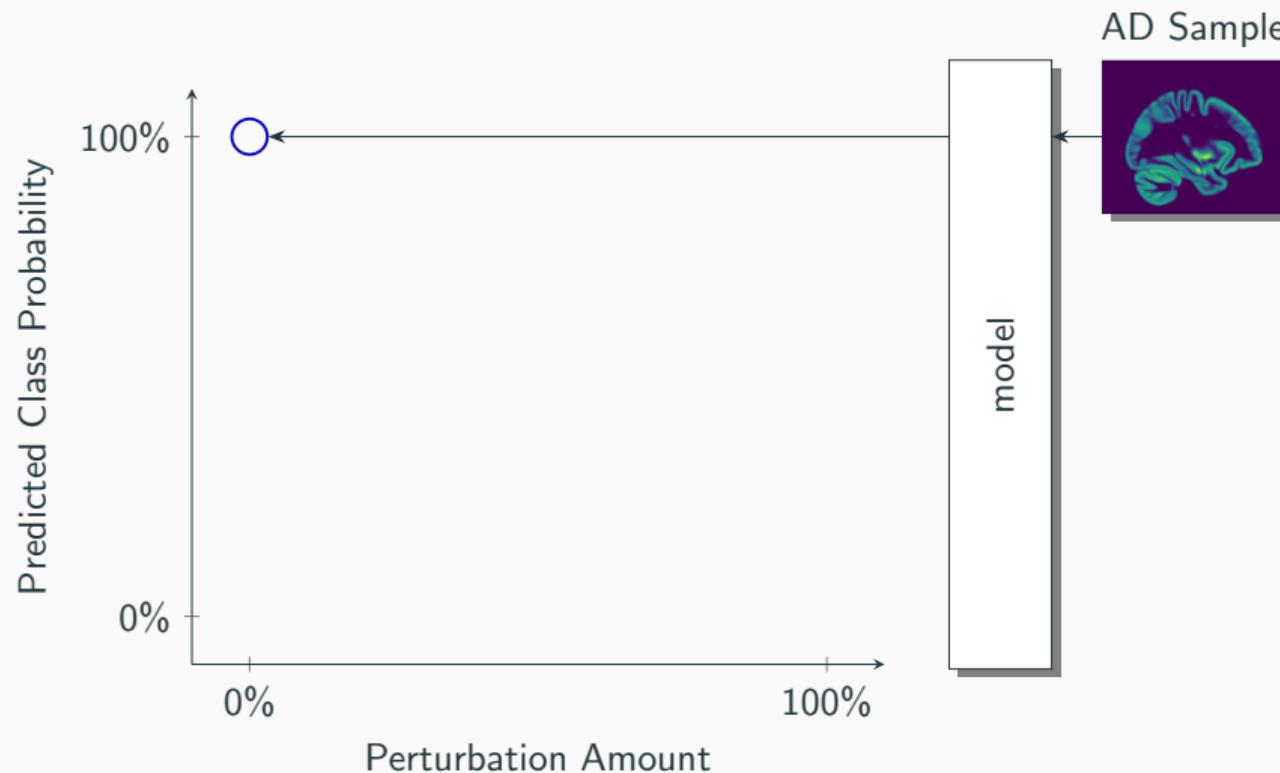
Perturbation Tests: Insertion and Deletion [1]



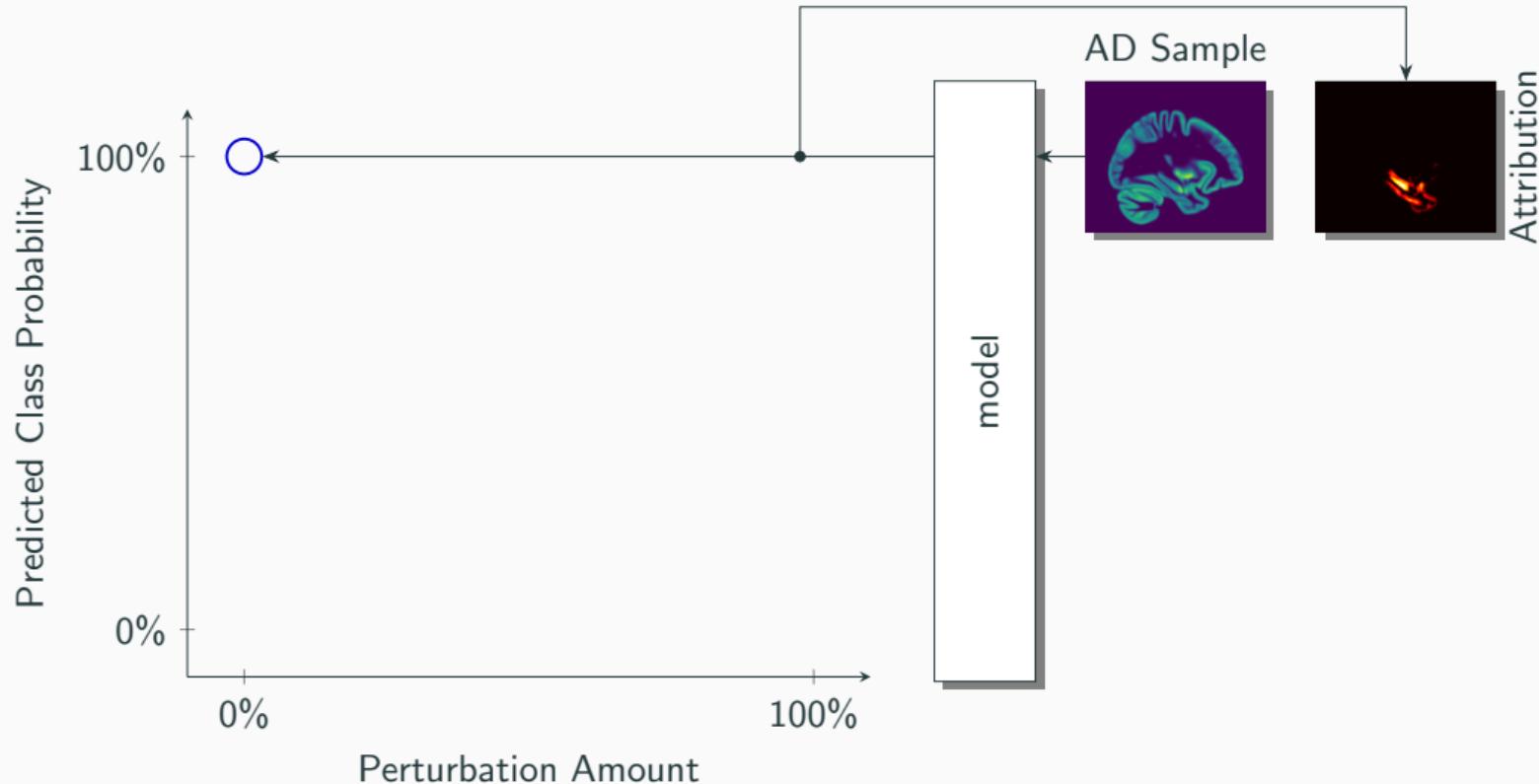
Perturbation Tests: Insertion and Deletion [1]



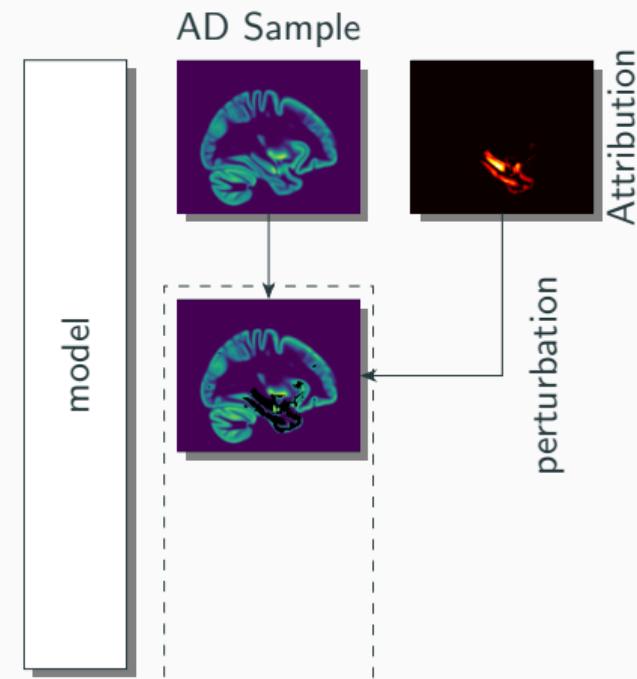
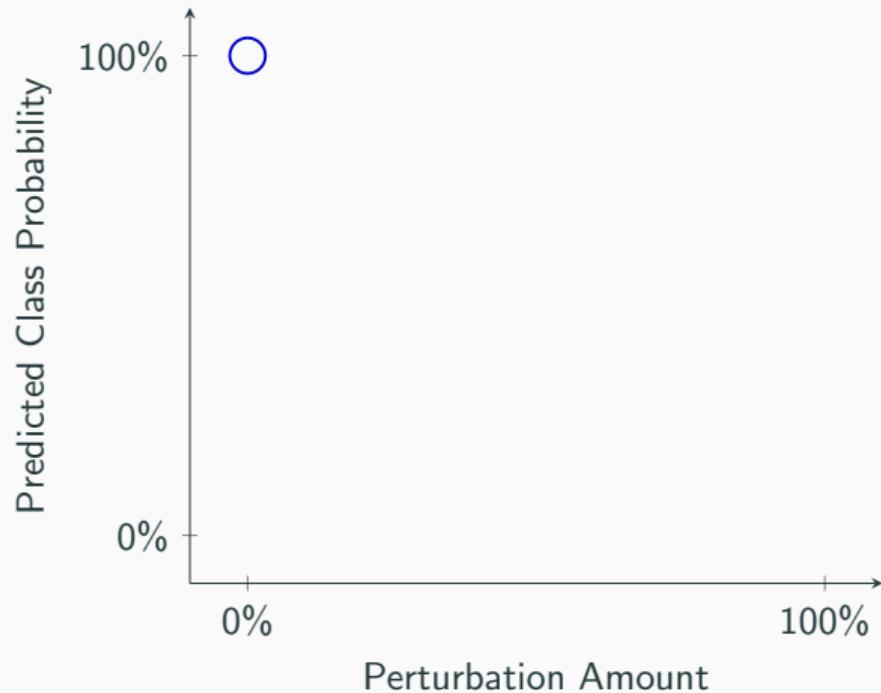
Perturbation Tests: Insertion and Deletion [1]



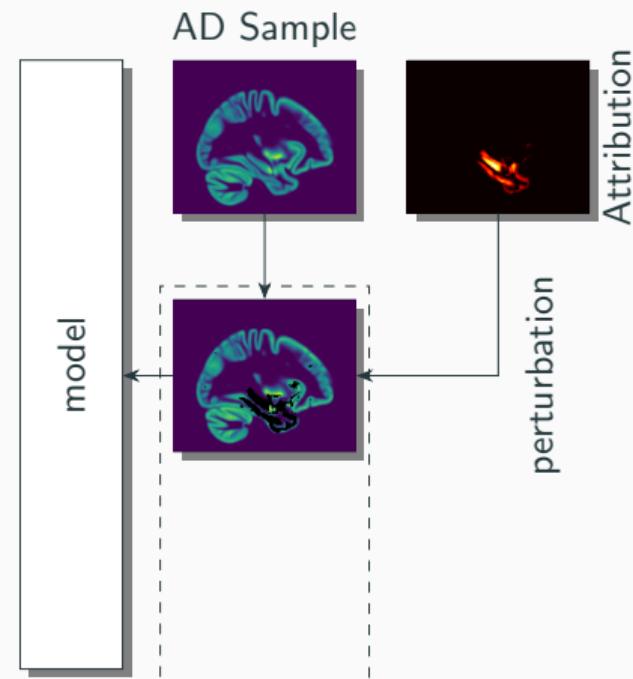
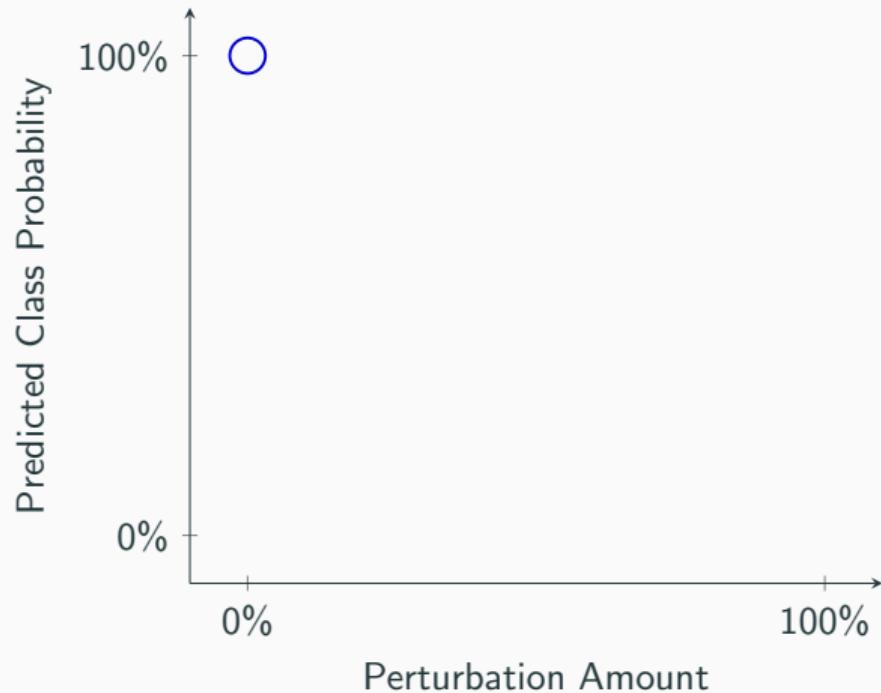
Perturbation Tests: Insertion and Deletion [1]



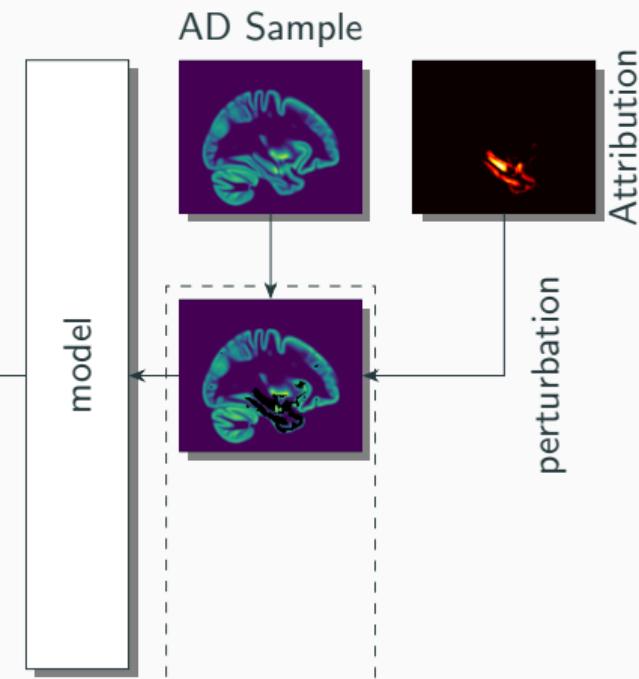
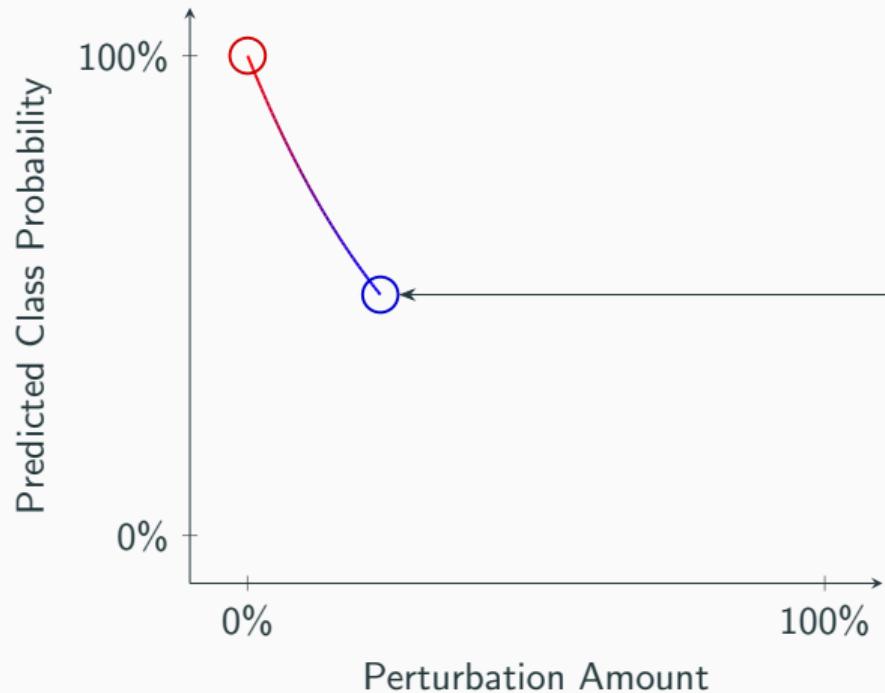
Perturbation Tests: Insertion and Deletion [1]



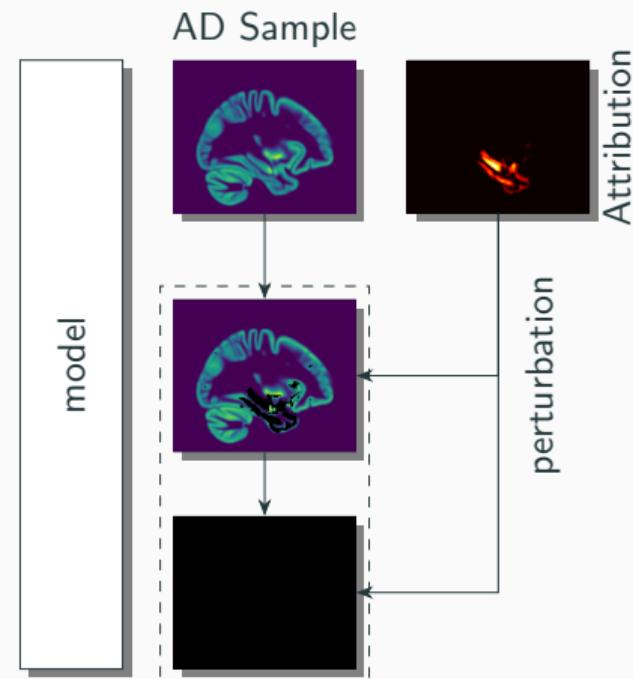
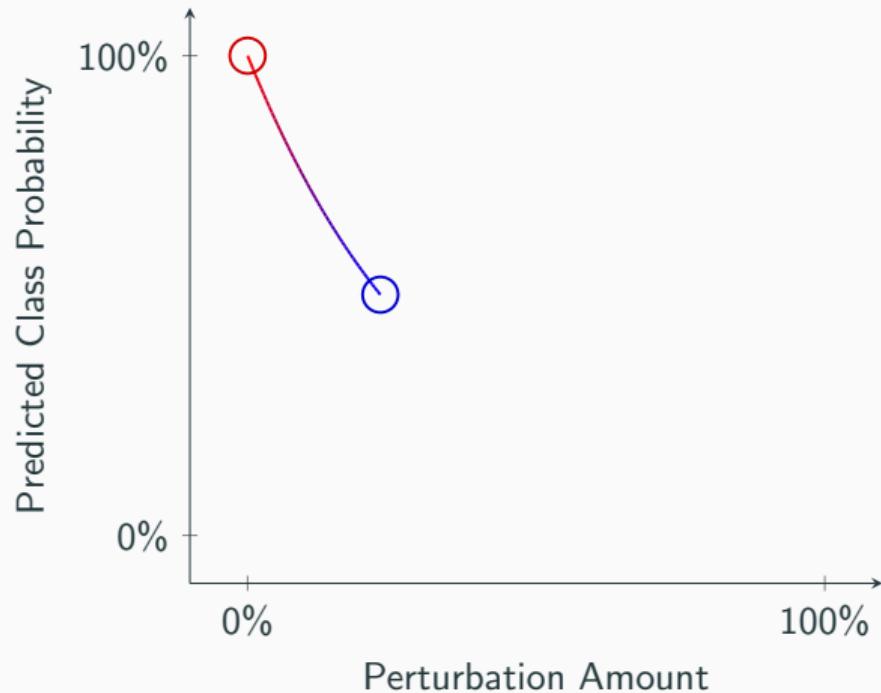
Perturbation Tests: Insertion and Deletion [1]



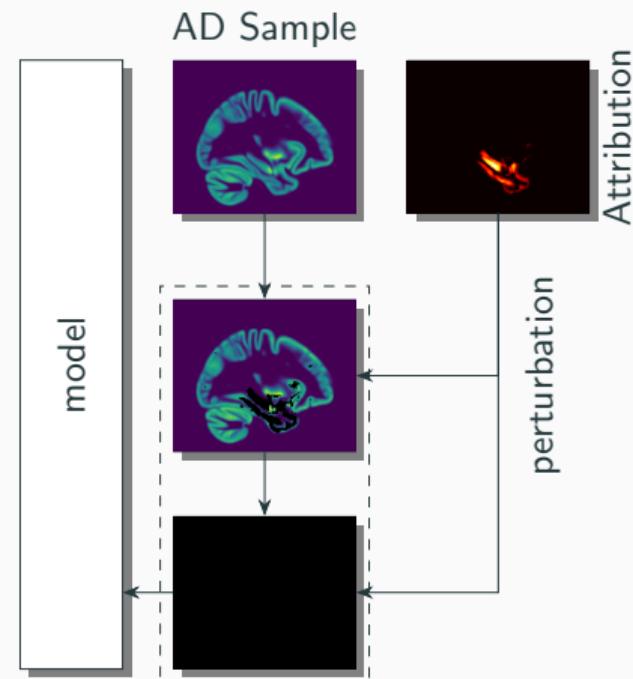
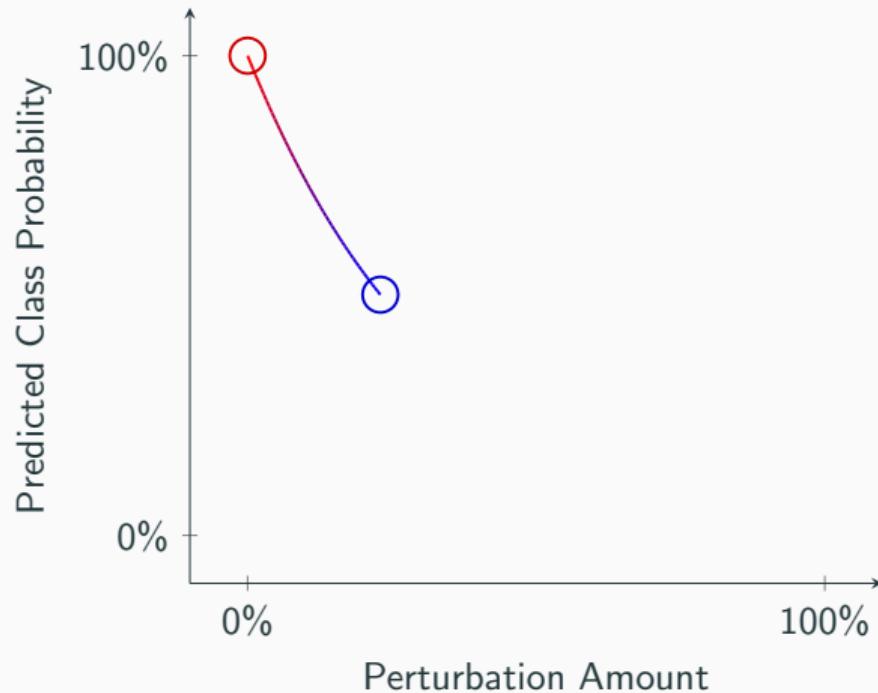
Perturbation Tests: Insertion and Deletion [1]



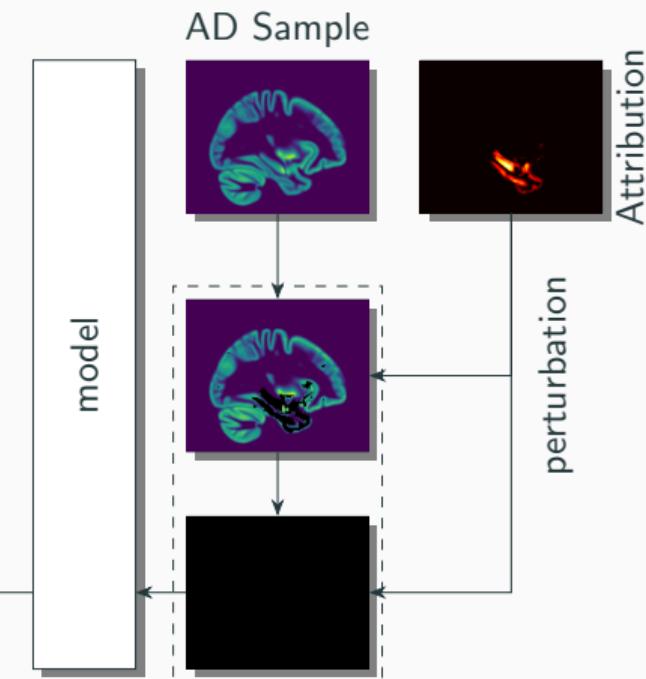
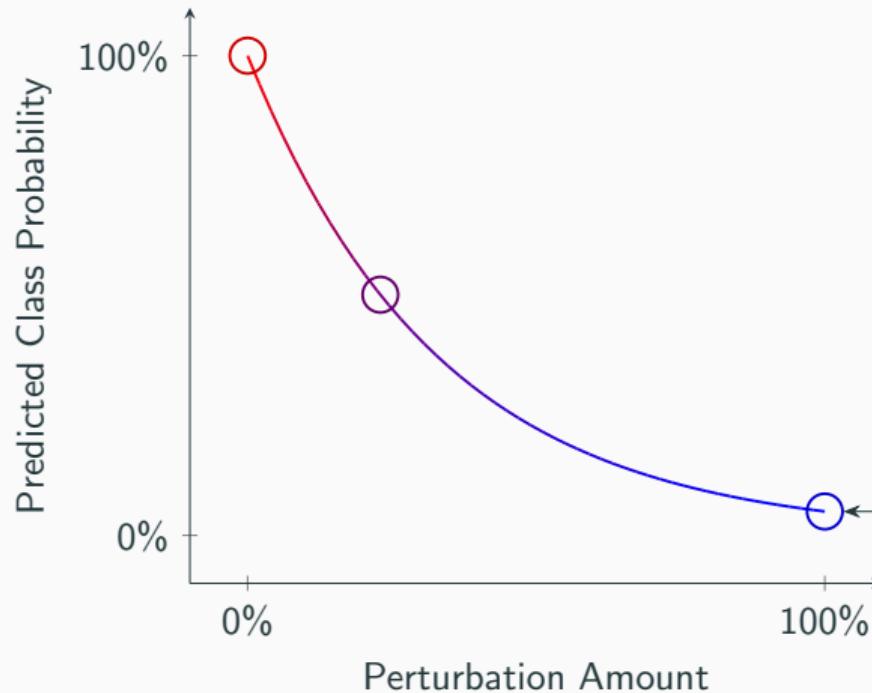
Perturbation Tests: Insertion and Deletion [1]



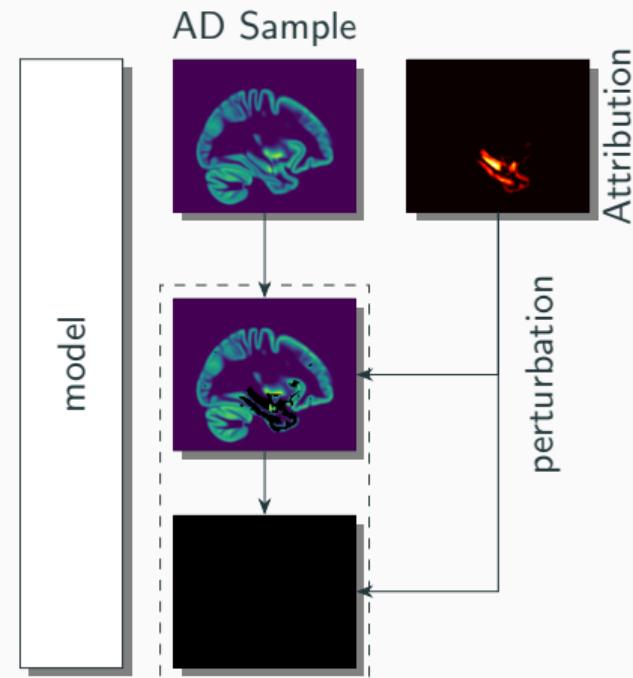
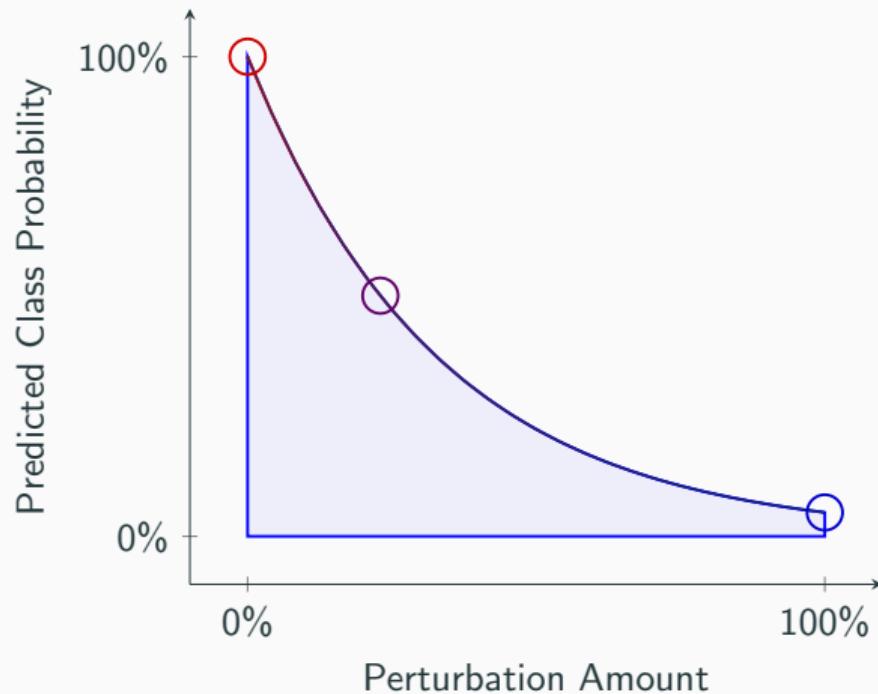
Perturbation Tests: Insertion and Deletion [1]

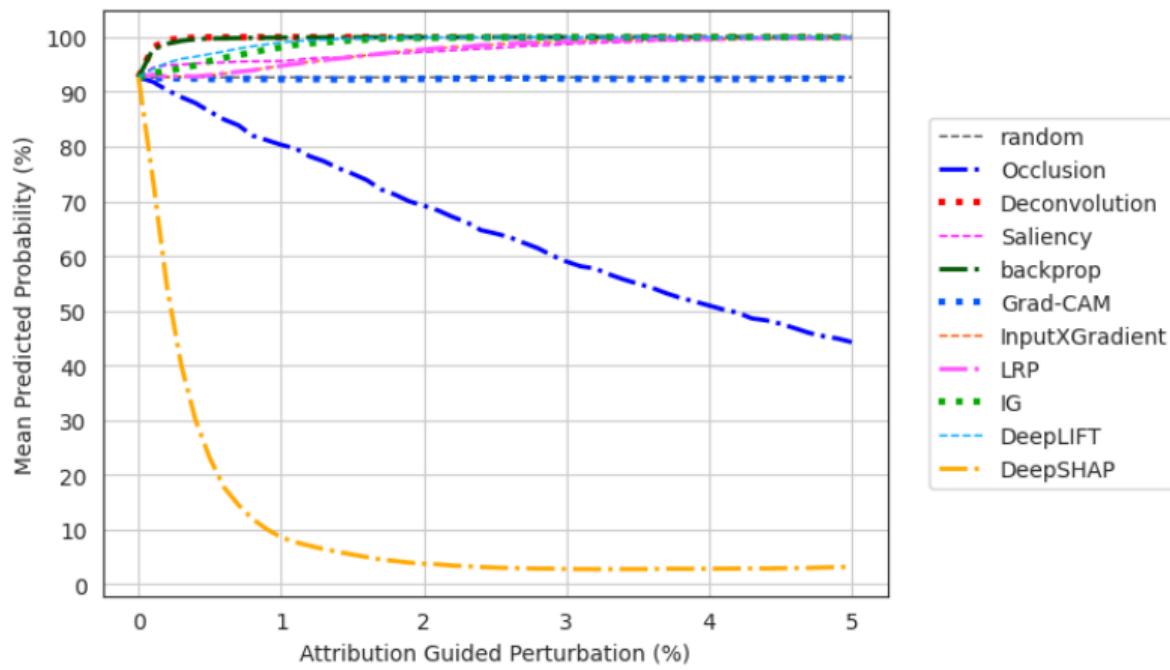


Perturbation Tests: Insertion and Deletion [1]

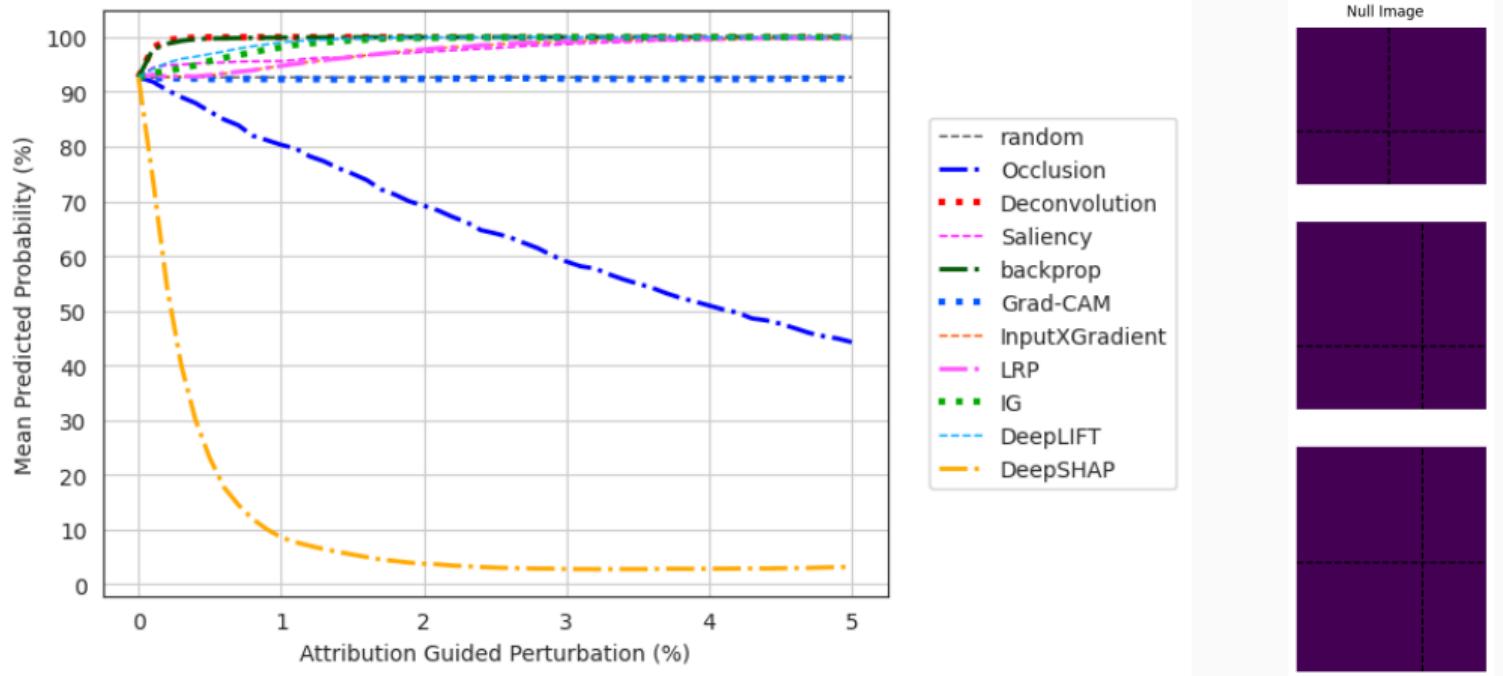


Perturbation Tests: Insertion and Deletion [1]





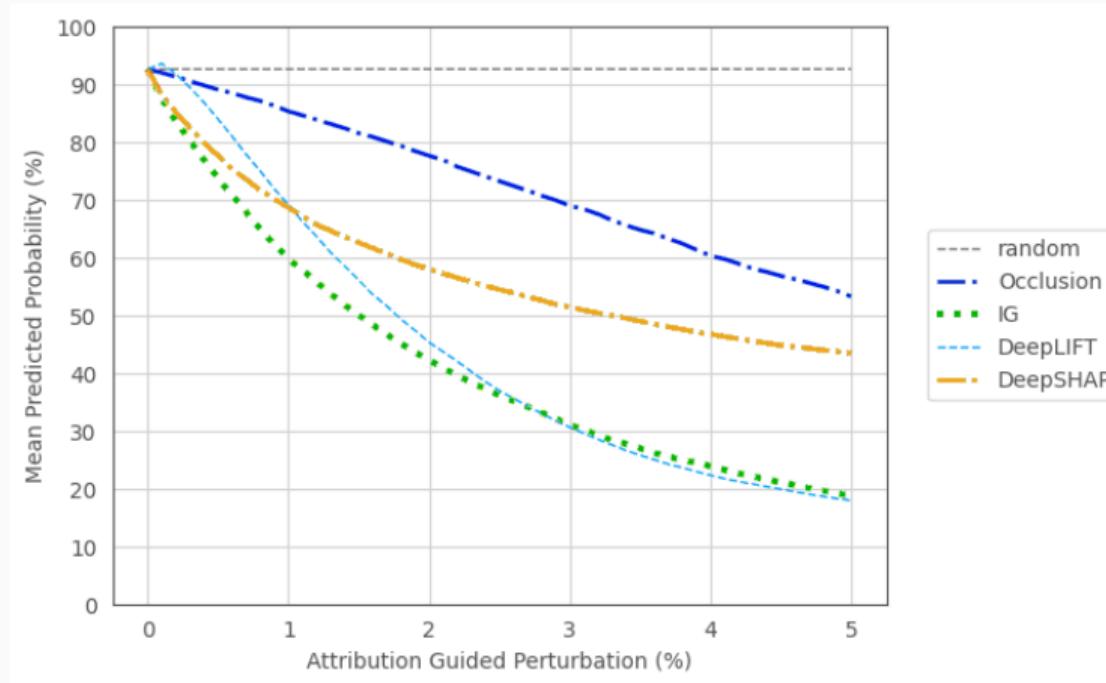
Mean Predicted AD Probability when replacing voxels by the null image baseline



Mean Predicted AD Probability when replacing voxels by the null image baseline

Hypothesis

The null image corresponds to "**maximum atrophy**".

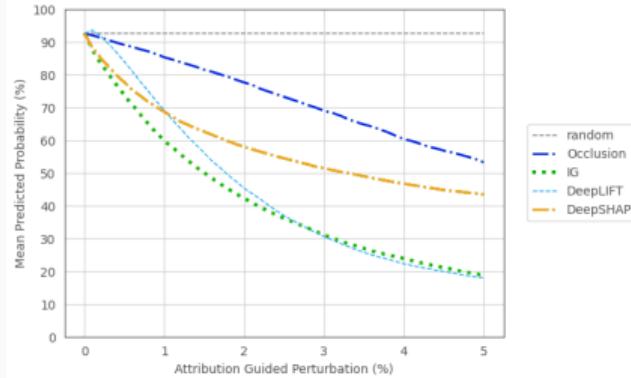
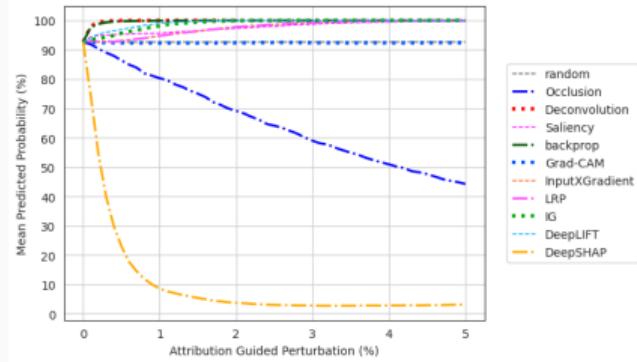


Using the **CN mean** as attribution baseline and perturbation target for AD samples

Question asked by a CN mean baseline

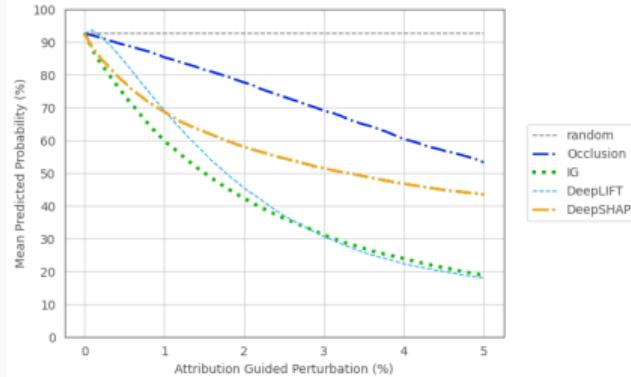
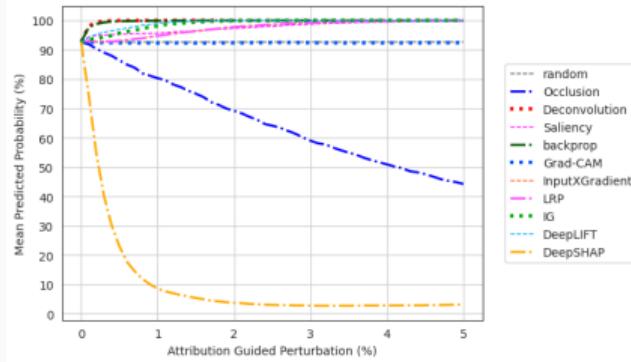
What caused this sample to be classified as AD - compared to a CN sample?

Conclusion



Take-Aways

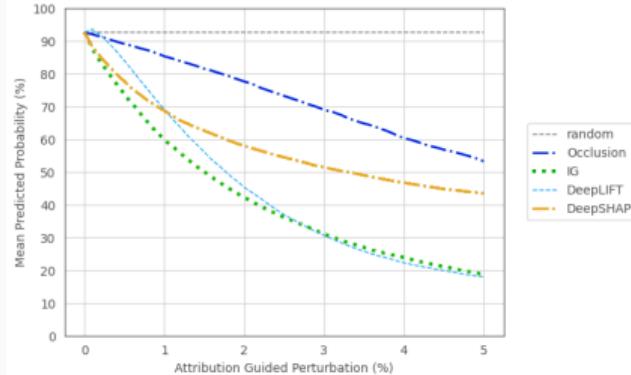
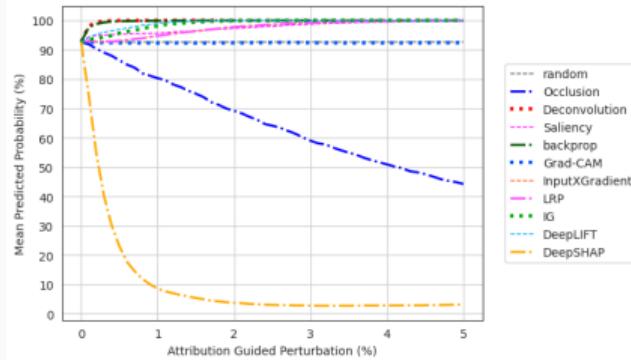
Conclusion



Take-Aways

1. Perturbation tests offer a **model-agnostic fidelity metric**.

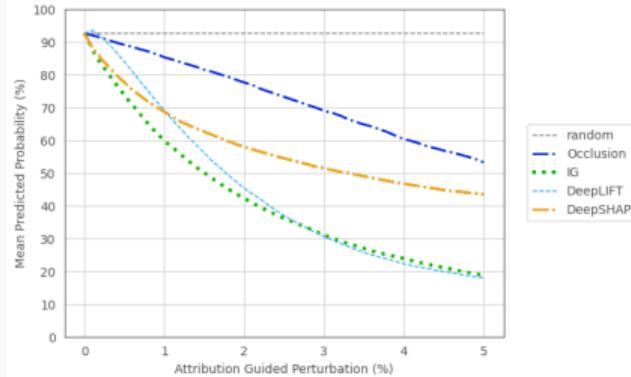
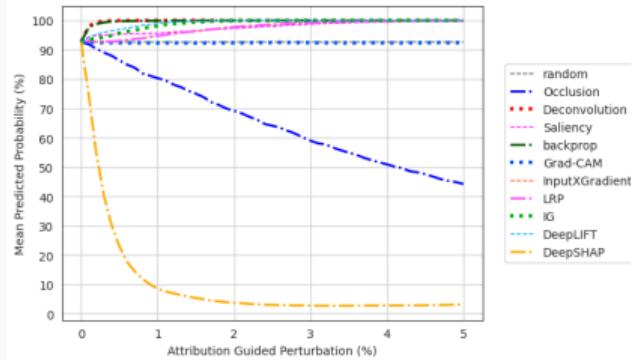
Conclusion



Take-Aways

1. Perturbation tests offer a **model-agnostic fidelity metric**.
2. The **attribution baseline** should be chosen carefully.

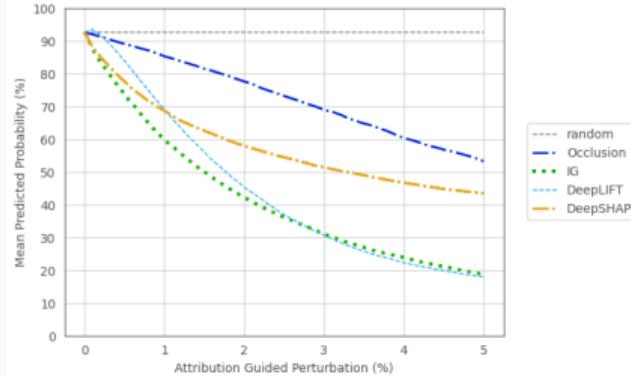
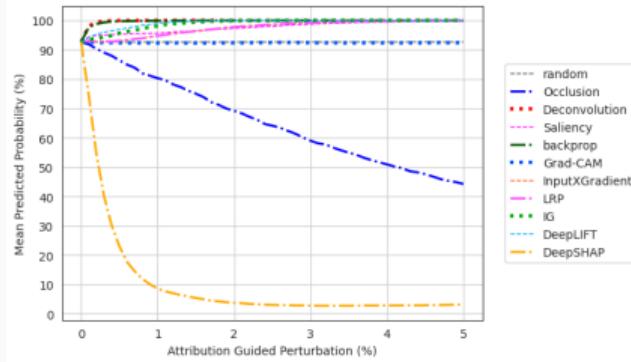
Conclusion



Take-Aways

1. Perturbation tests offer a **model-agnostic fidelity metric**.
2. The **attribution baseline** should be chosen carefully.
3. Attribution Maps **need interpretation** to actually explain anything.

Conclusion



Take-Aways

1. Perturbation tests offer a **model-agnostic fidelity metric**.
2. The **attribution baseline** should be chosen carefully.
3. Attribution Maps **need interpretation** to actually explain anything.

Meet the Team



University of Rostock



Thomas Kirste



Martin Becker



Sebastian Bader



Bjarne Hiller

DZNE



Martin Dyrba

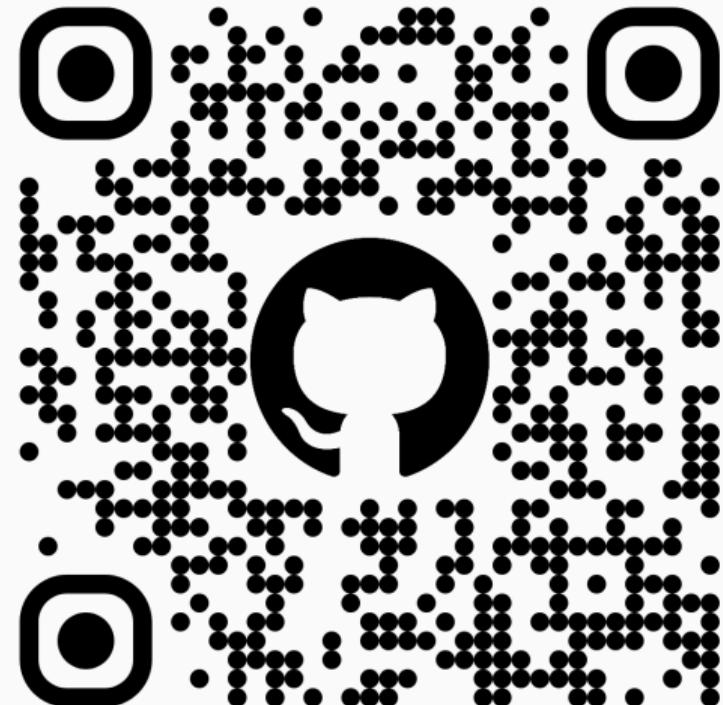


Devesh Singh



Thanks for your Attention!

See you on GitHub!
bckrlab/ad-fidelity



References i

- [1] Vitali Petsiuk, Abir Das, and Kate Saenko. **RISE: Randomized Input Sampling for Explanation of Black-box Models**. arXiv:1806.07421. Sept. 2018. DOI: 10.48550/arXiv.1806.07421. URL: <http://arxiv.org/abs/1806.07421> (visited on 10/22/2024).
- [2] Christian Tinauer et al. "Interpretable brain disease classification and relevance-guided deep learning". en. In: **Scientific Reports** 12.1 (Nov. 2022). Publisher: Nature Publishing Group, p. 20254. ISSN: 2045-2322. DOI: 10.1038/s41598-022-24541-7. URL: <https://www.nature.com/articles/s41598-022-24541-7> (visited on 10/12/2024).
- [3] John R. Zech et al. "Variable generalization performance of a deep learning model to detect pneumonia in chest radiographs: A cross-sectional study". en. In: **PLOS Medicine** 15.11 (June 2018). Publisher: Public Library of Science, e1002683. ISSN: 1549-1676. DOI: 10.1371/journal.pmed.1002683. URL: <https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1002683> (visited on 10/12/2024).