



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

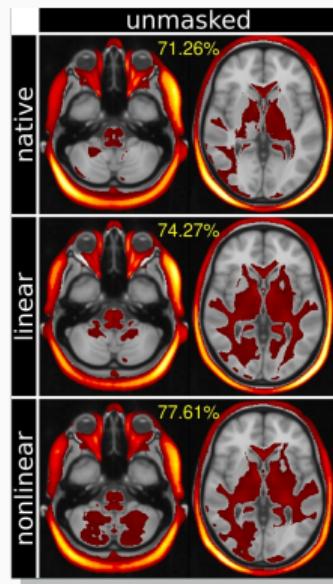
Bjarne C. Hiller

2025-03-09

University of Rostock

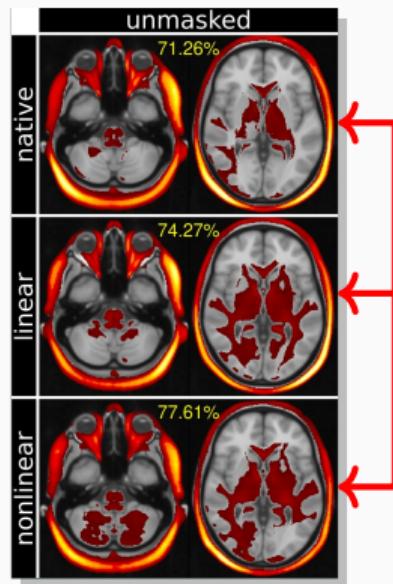
Motivation: Can you trust Neural Networks for Medical Image Processing?

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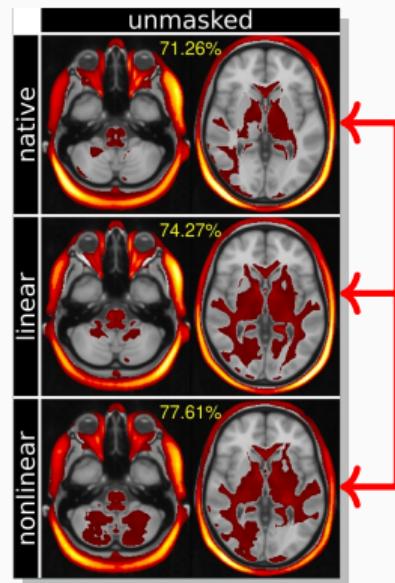
(a) From: Tinauer et al. [2]

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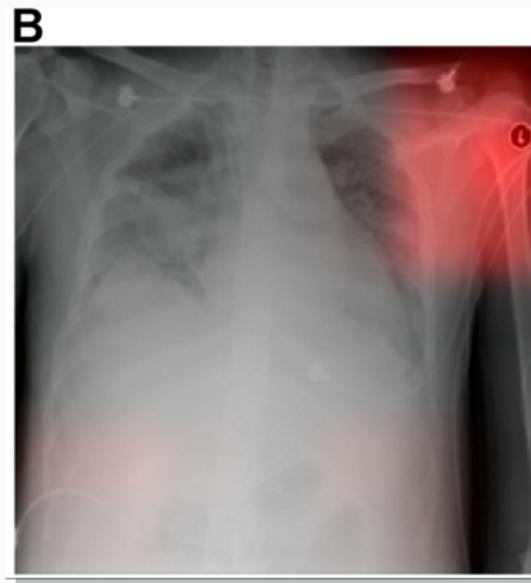


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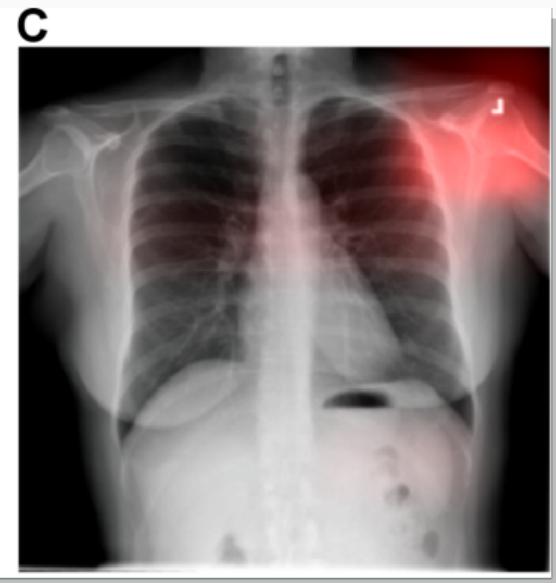
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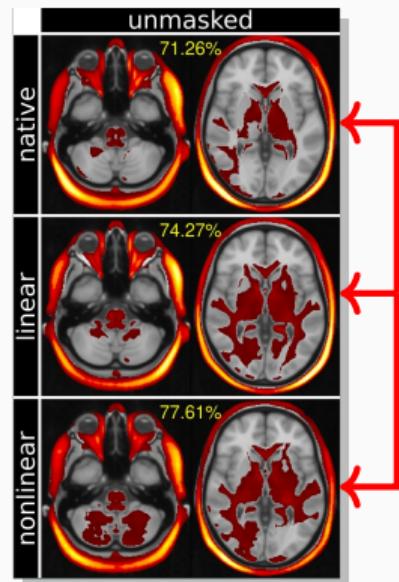
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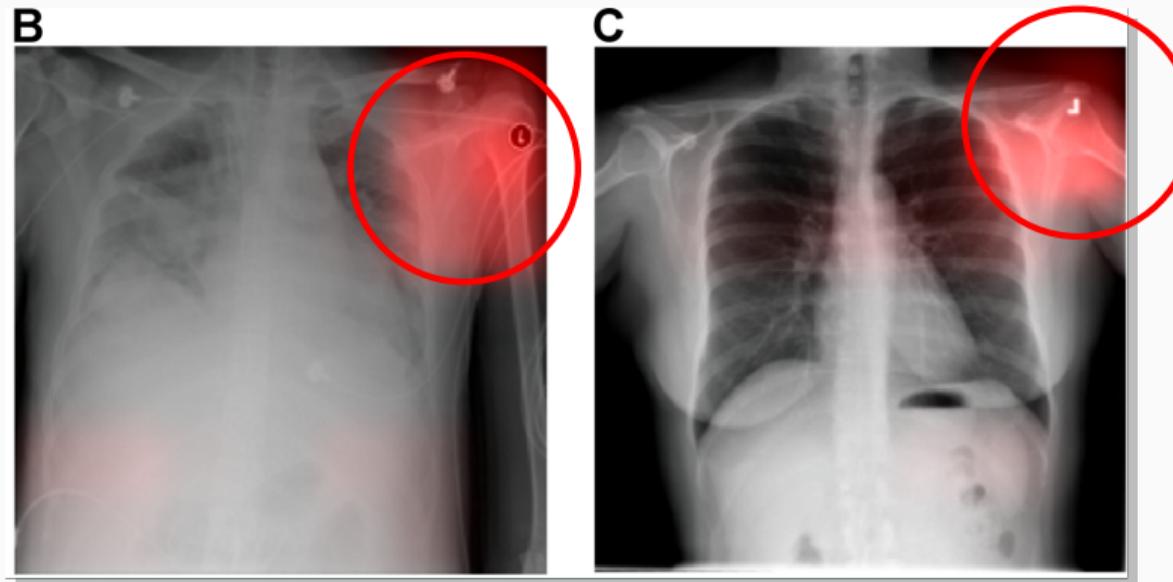
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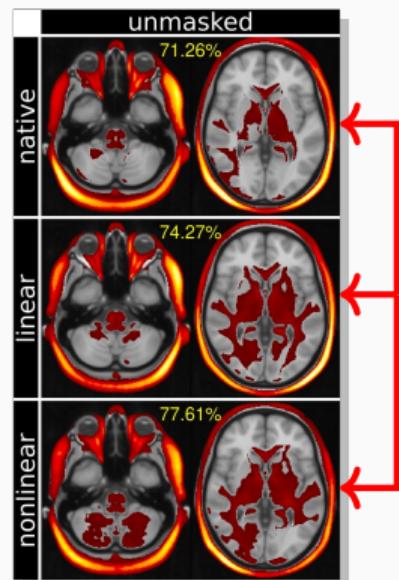


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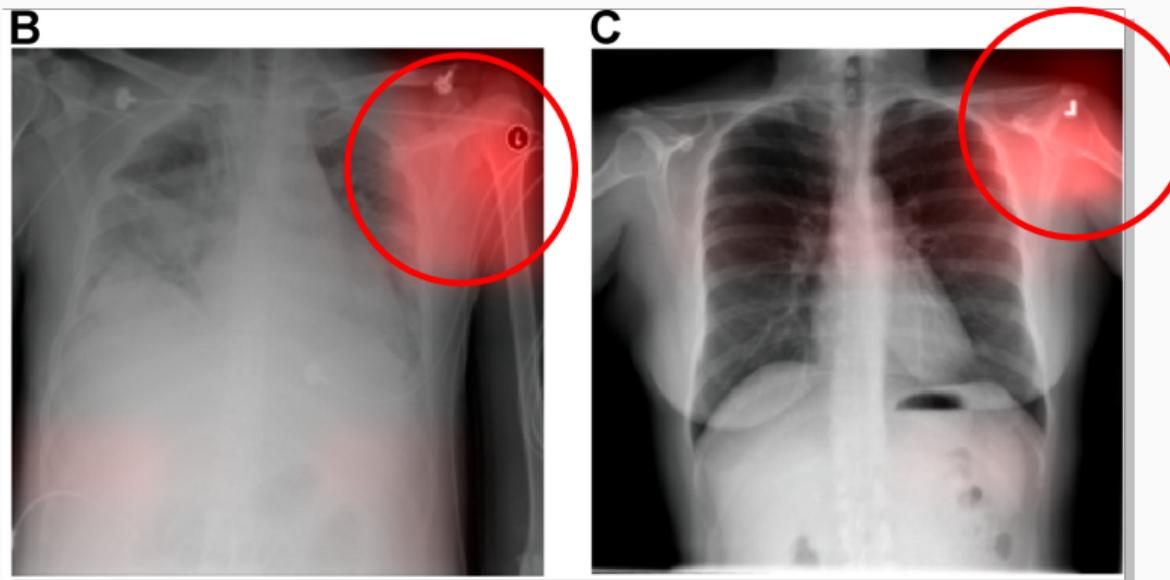


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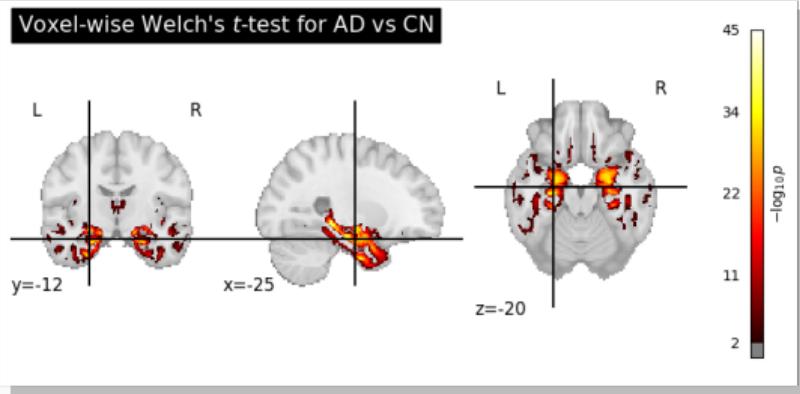
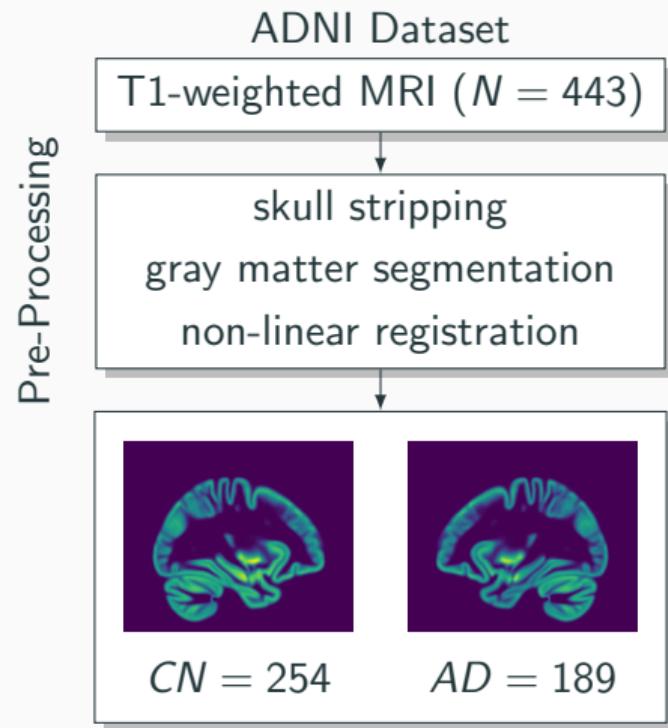
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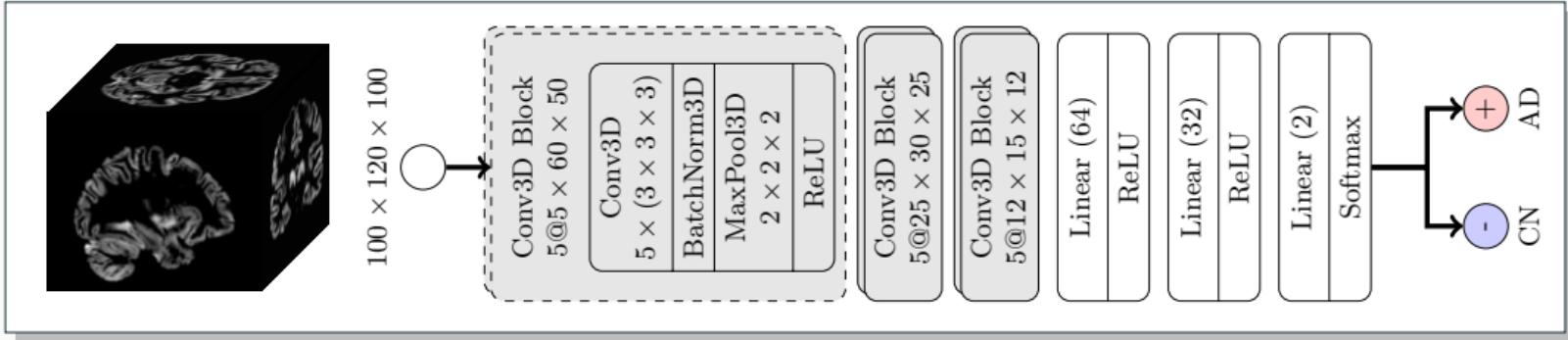
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Attribution maps can reveal **shortcut learning**: Neural Networks can use features outside of the brain parenchyma (a) or X-ray side marker tokens (b) for classification.

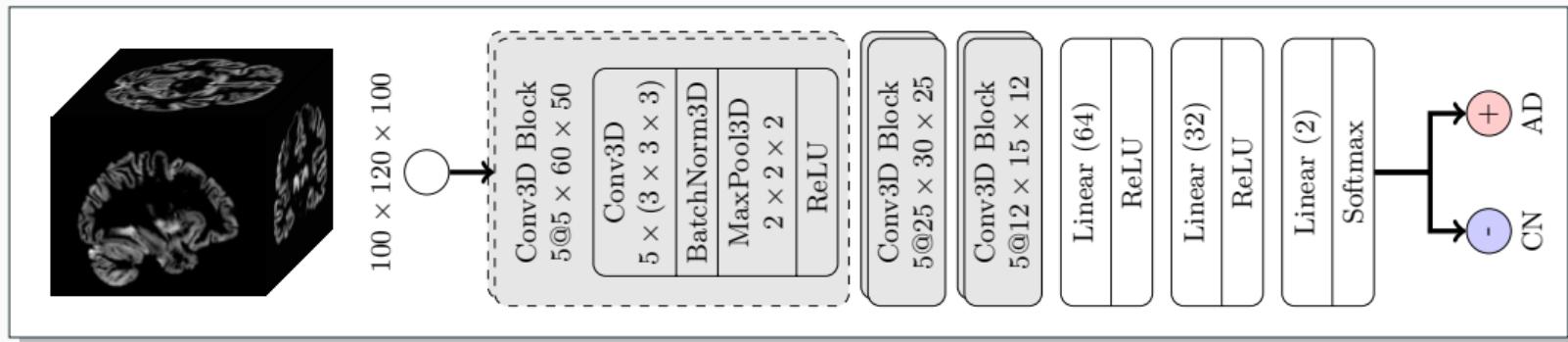
Data and Preprocessing



A CNN Model for AD vs CN Classification



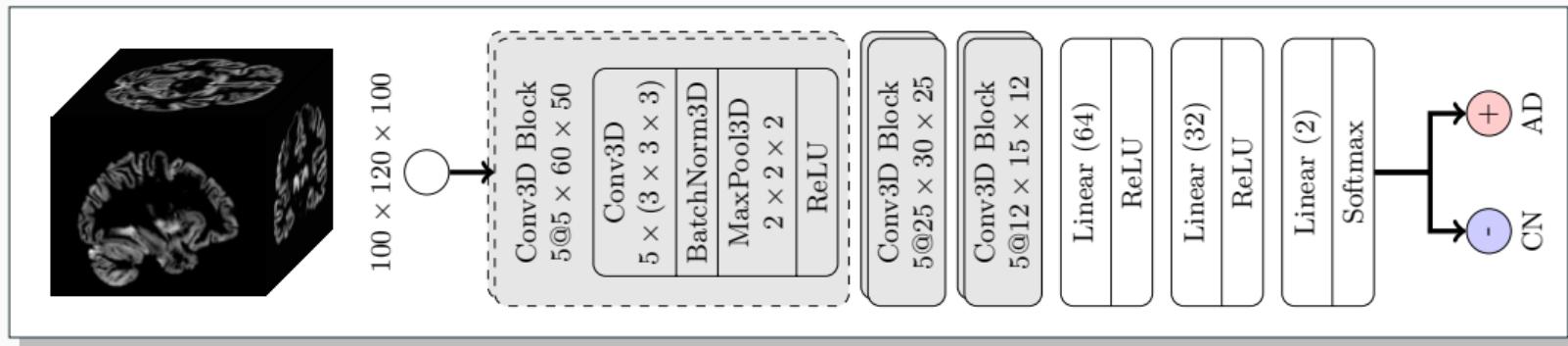
A CNN Model for AD vs CN Classification



AUC ROC	Accuracy
0.95 ± 0.02	87.64%

5-fold Cross Validation Results

A CNN Model for AD vs CN Classification



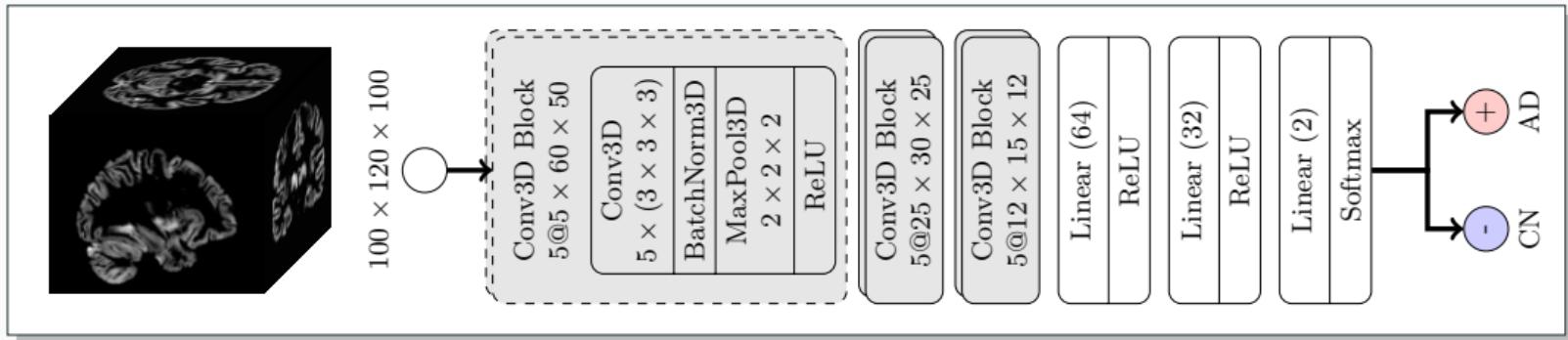
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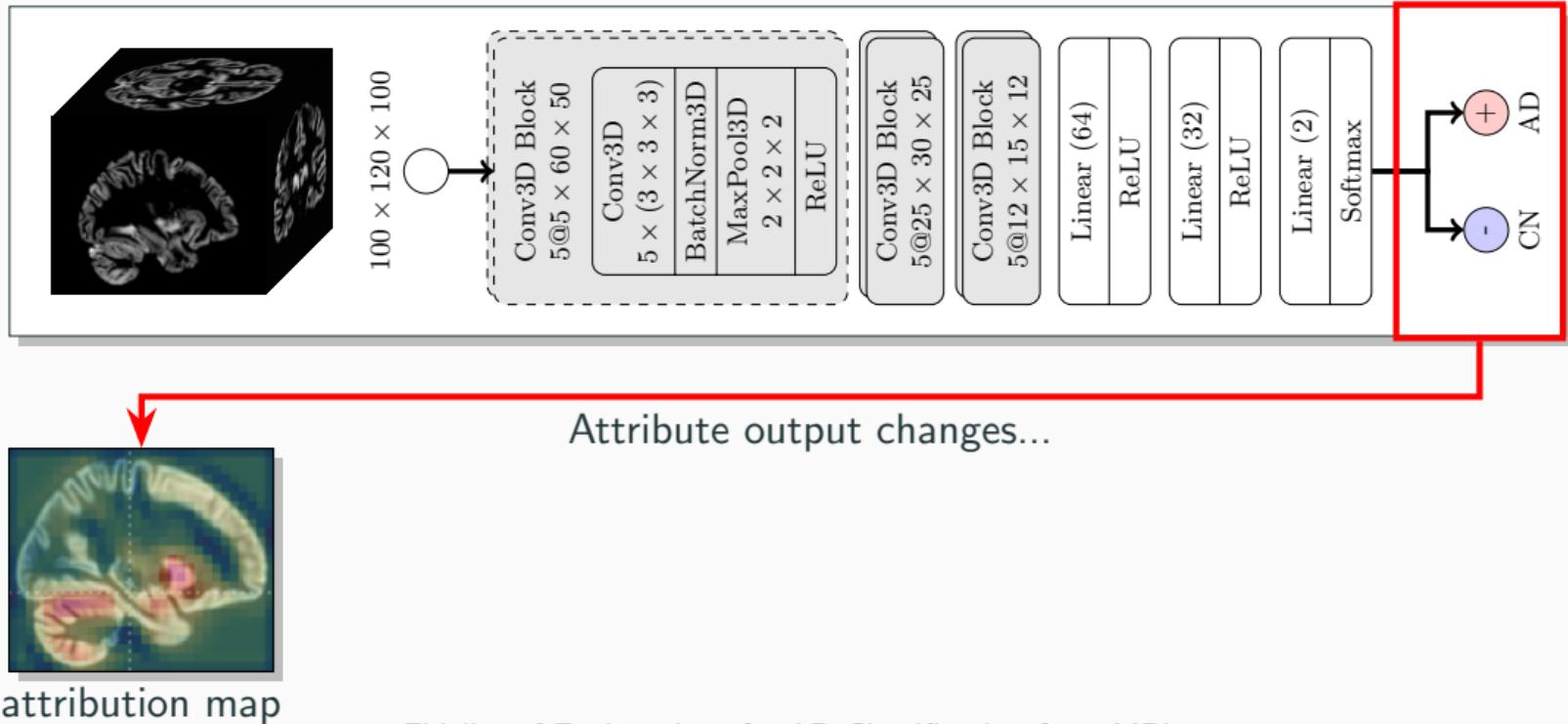
Acceptable Performance...

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

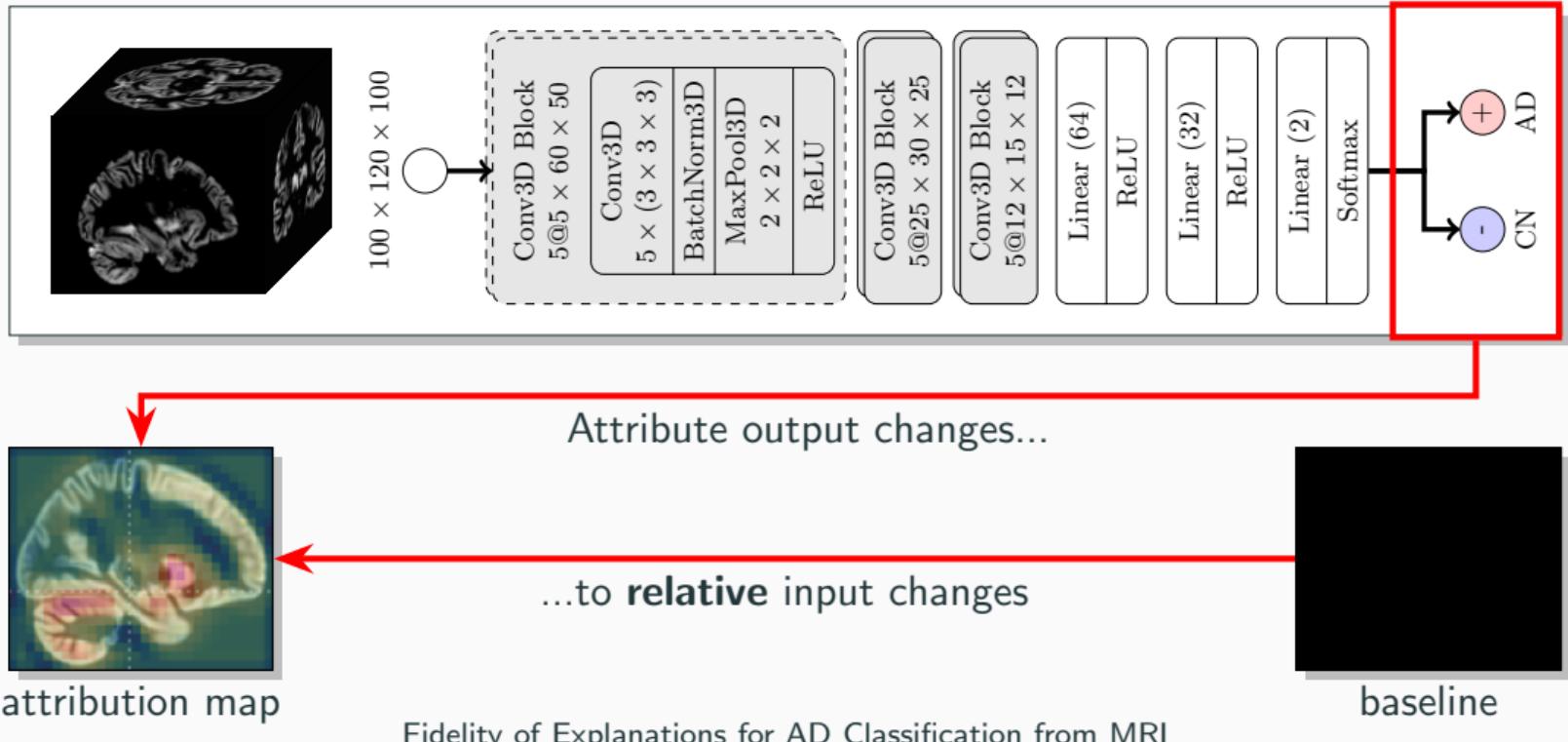
Attribution Maps: What did the network look at?

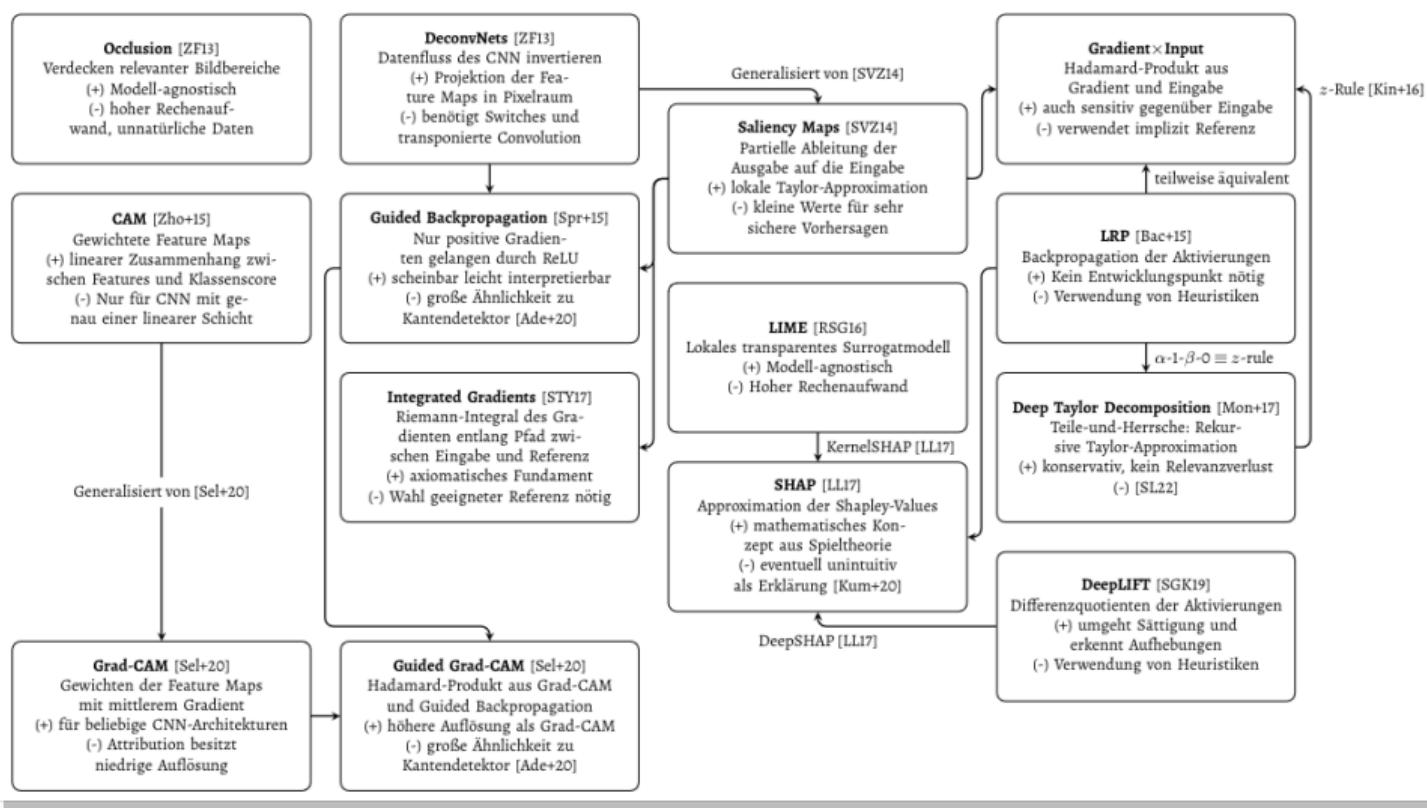


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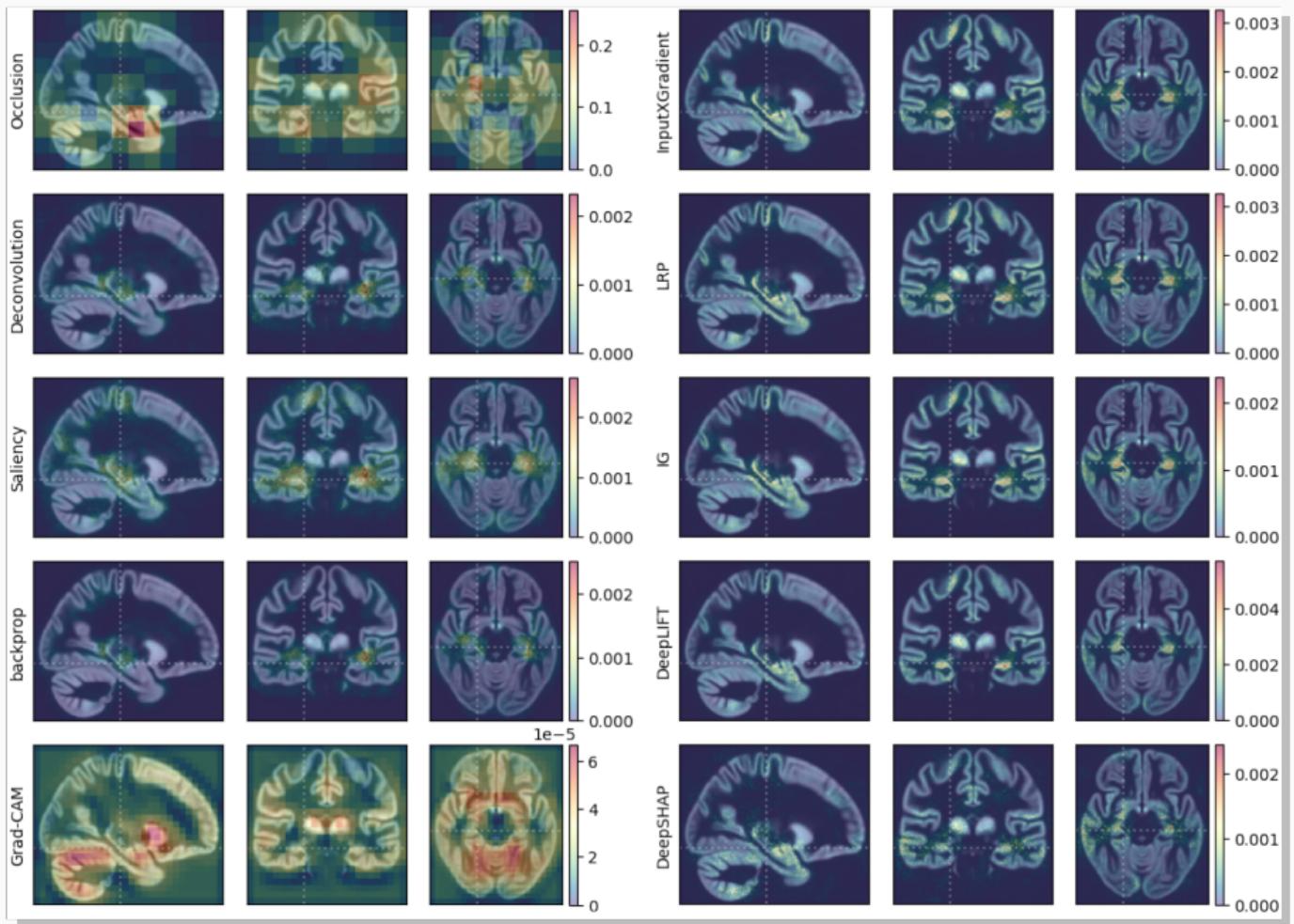


Attribution Maps: What did the network look at?





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

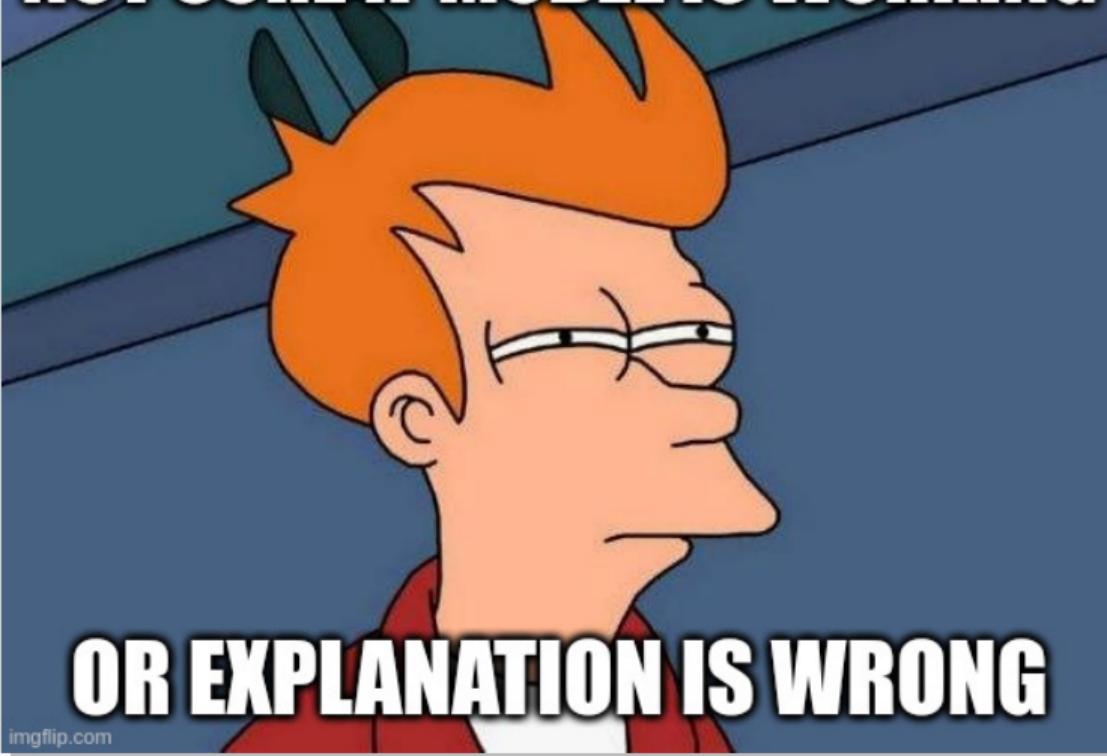
Top 10 AAL ROIs by total relevance for class AD

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

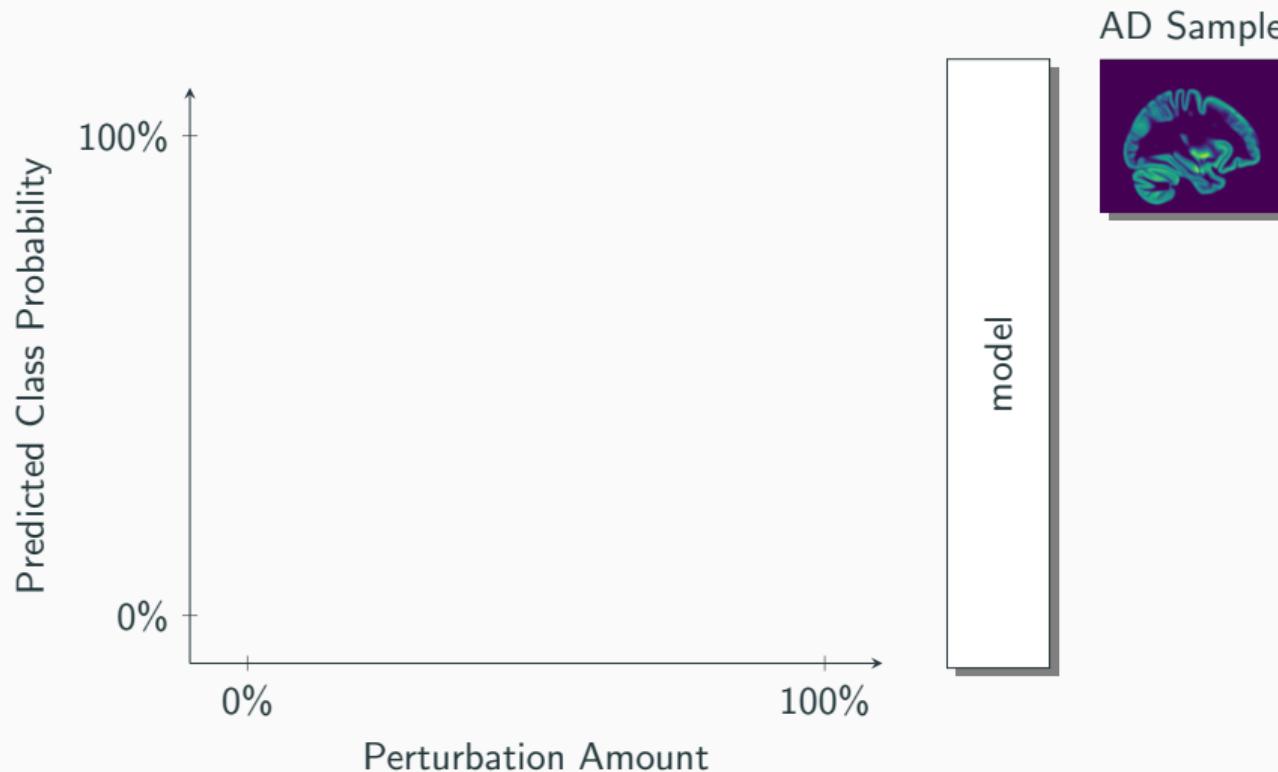
NOT SURE IF MODEL IS WORKING



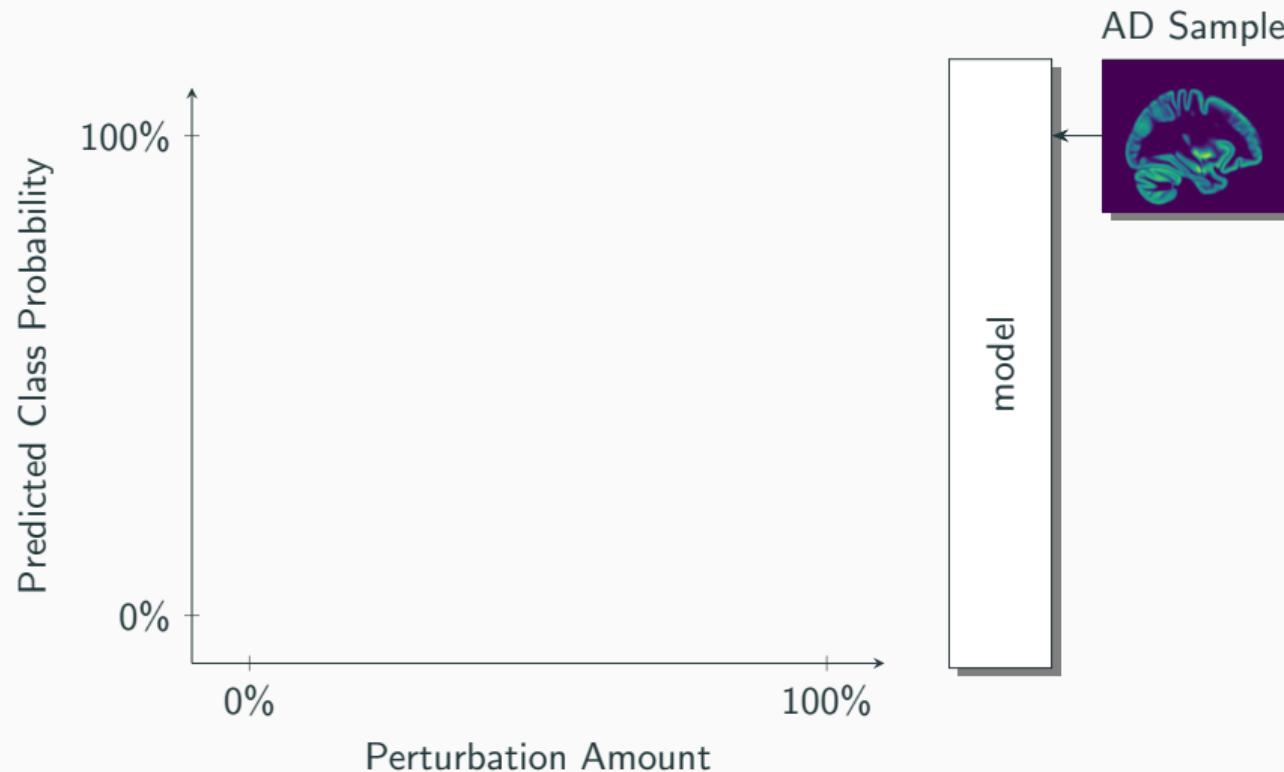
imgflip.com

But can the **explanation** be trusted?

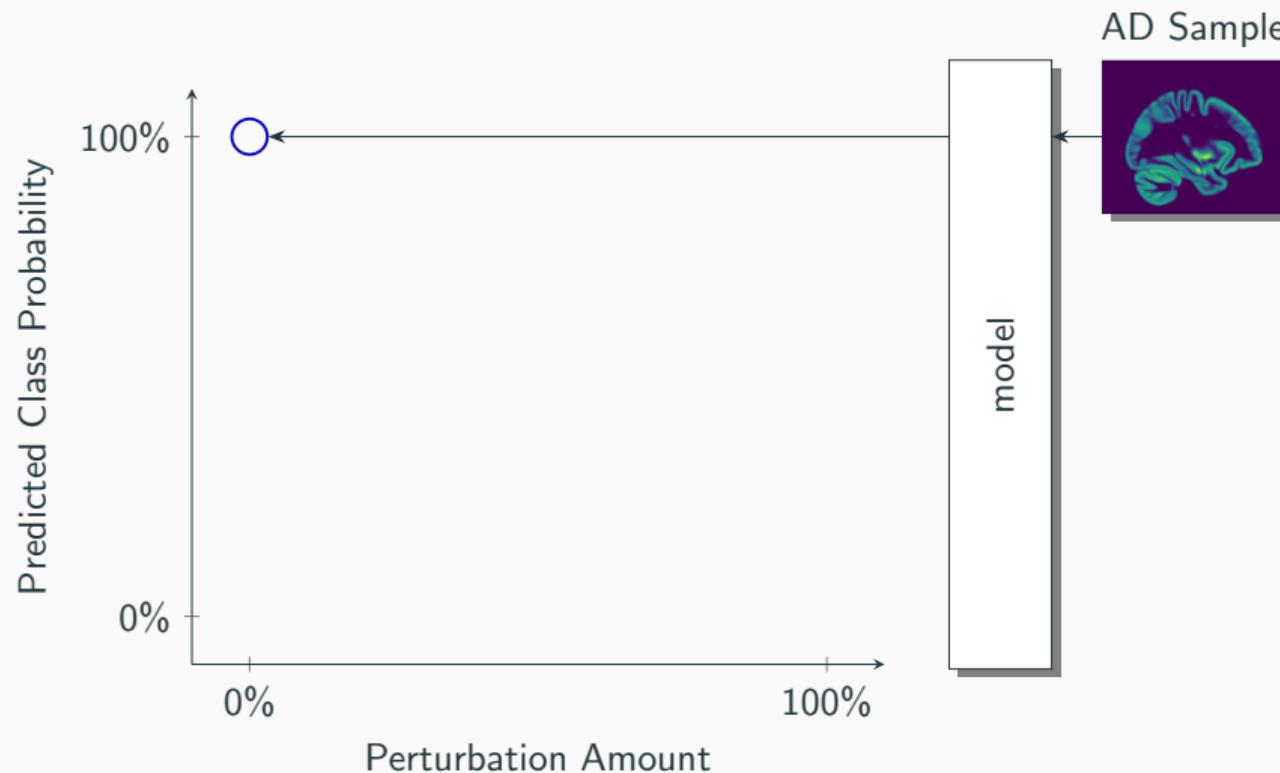
Perturbation Tests: Insertion and Deletion [1]



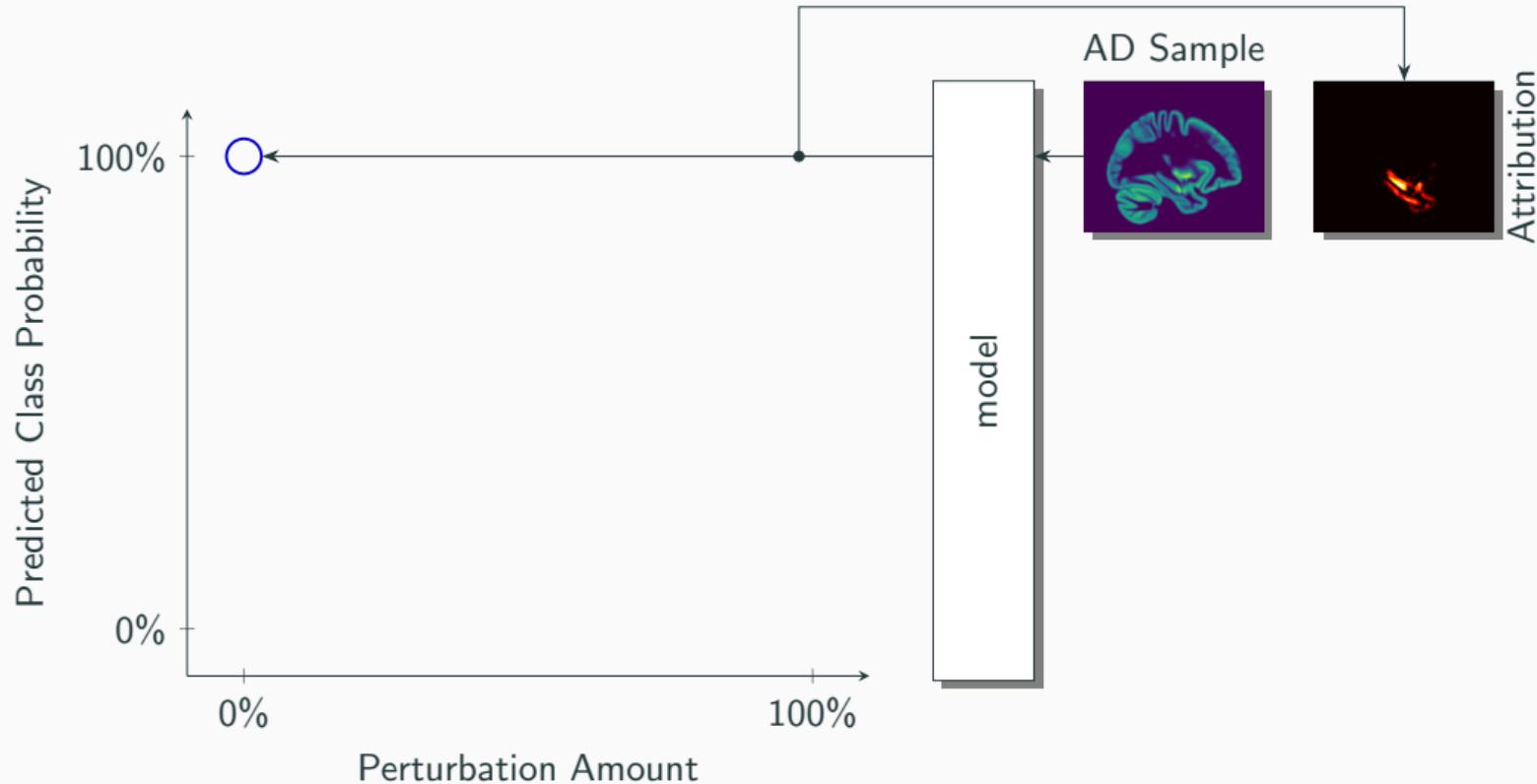
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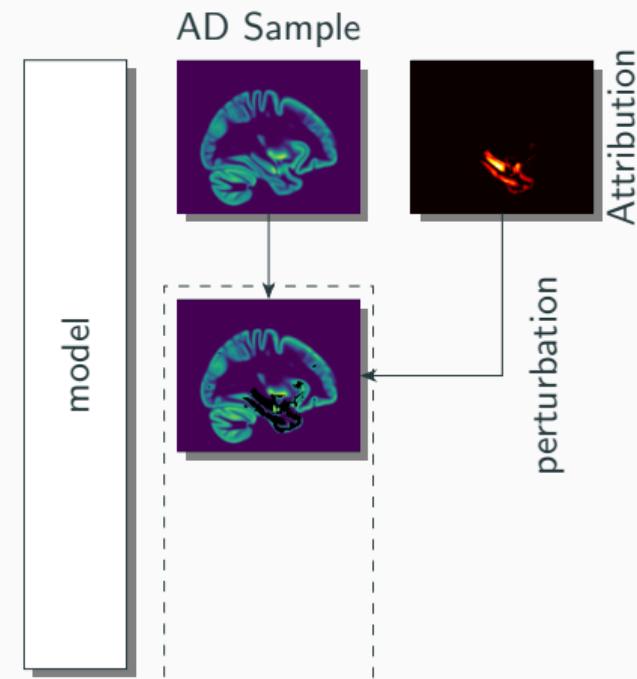
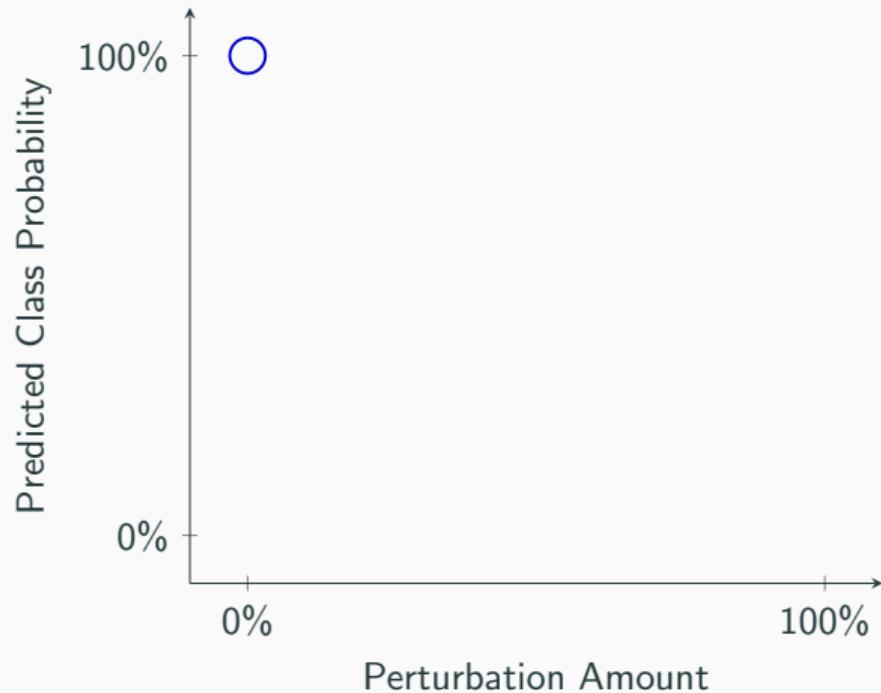
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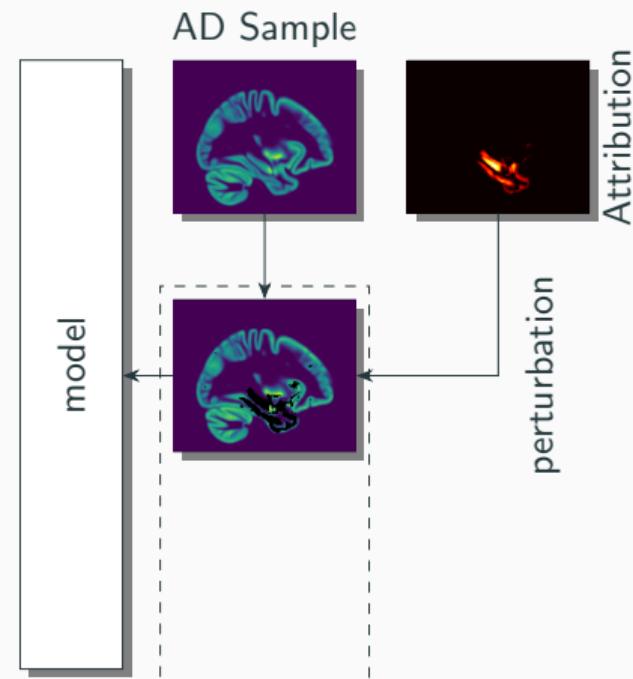
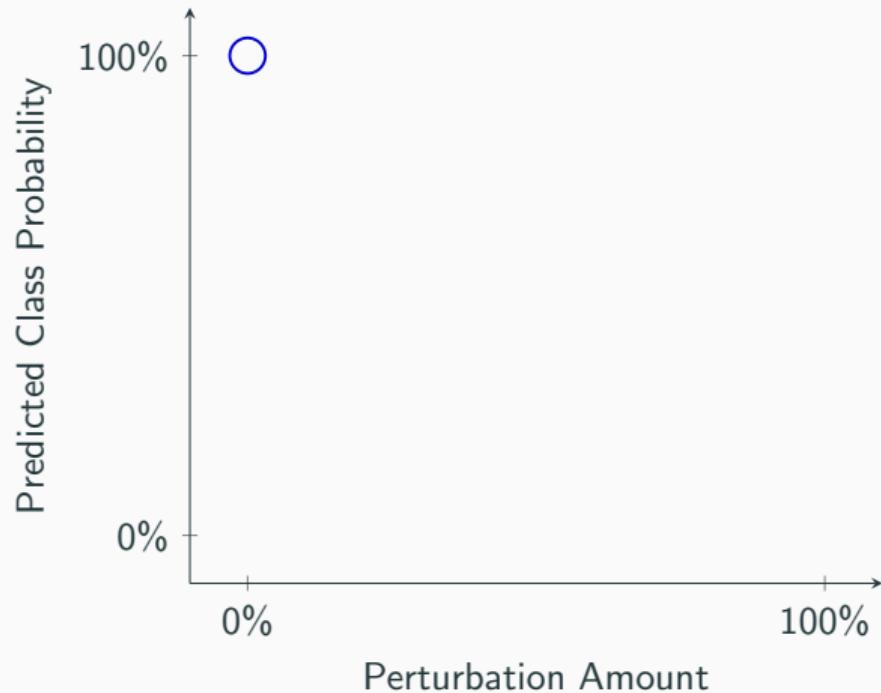
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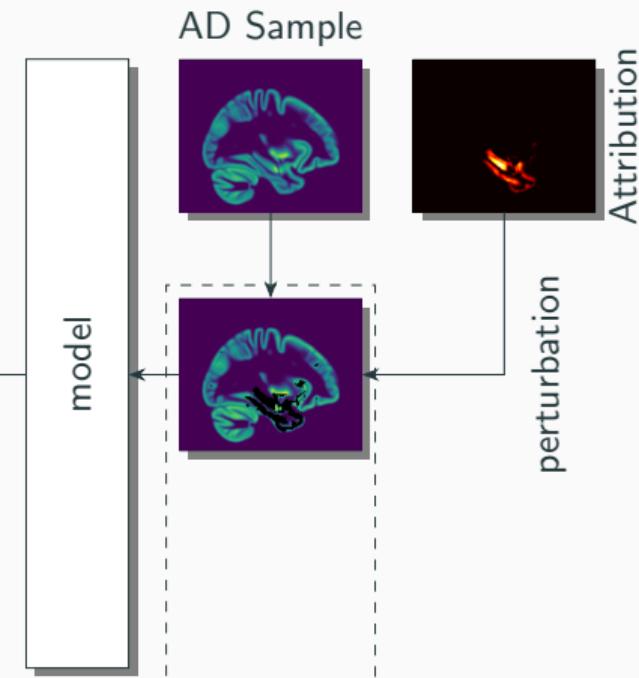
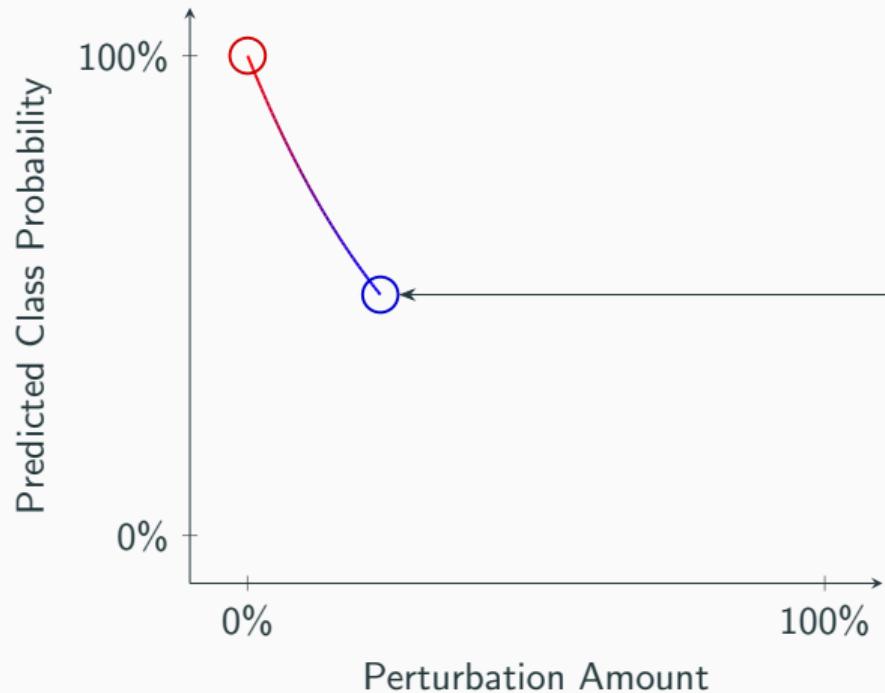
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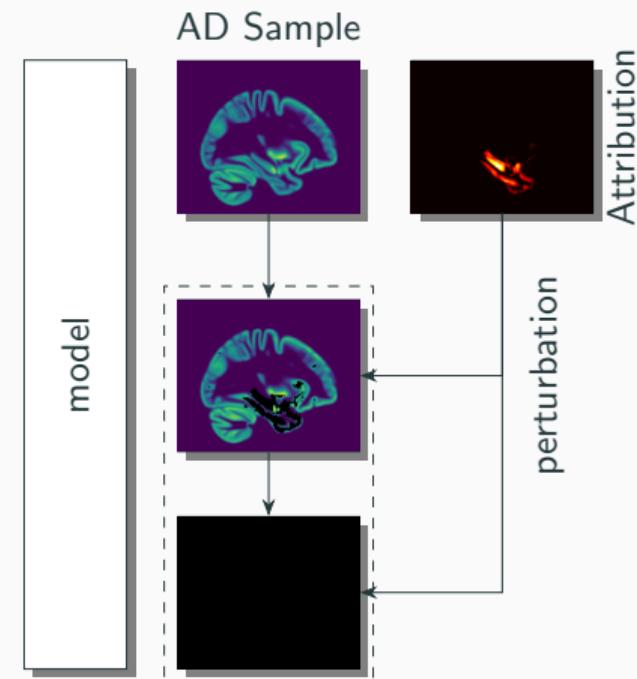
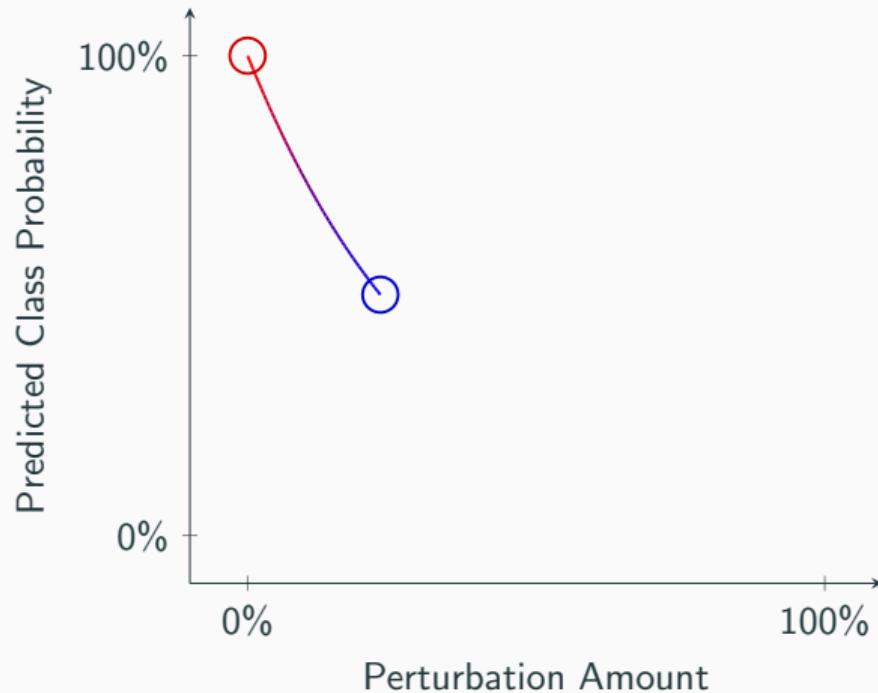
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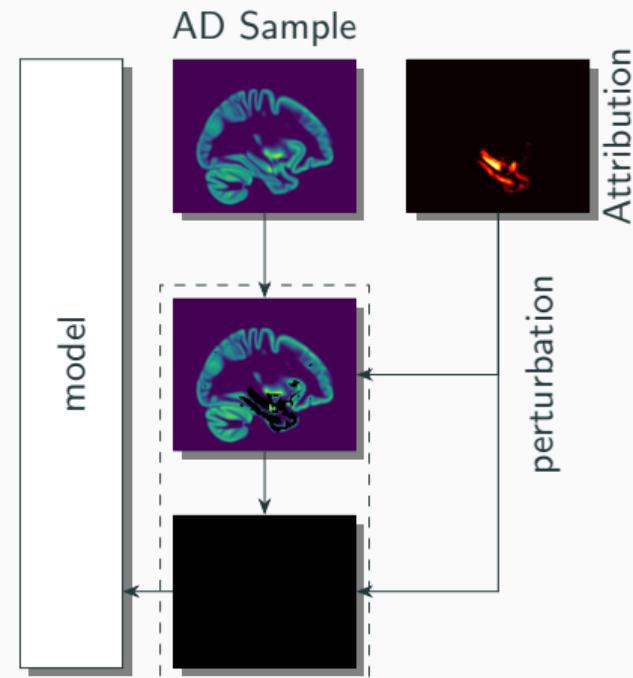
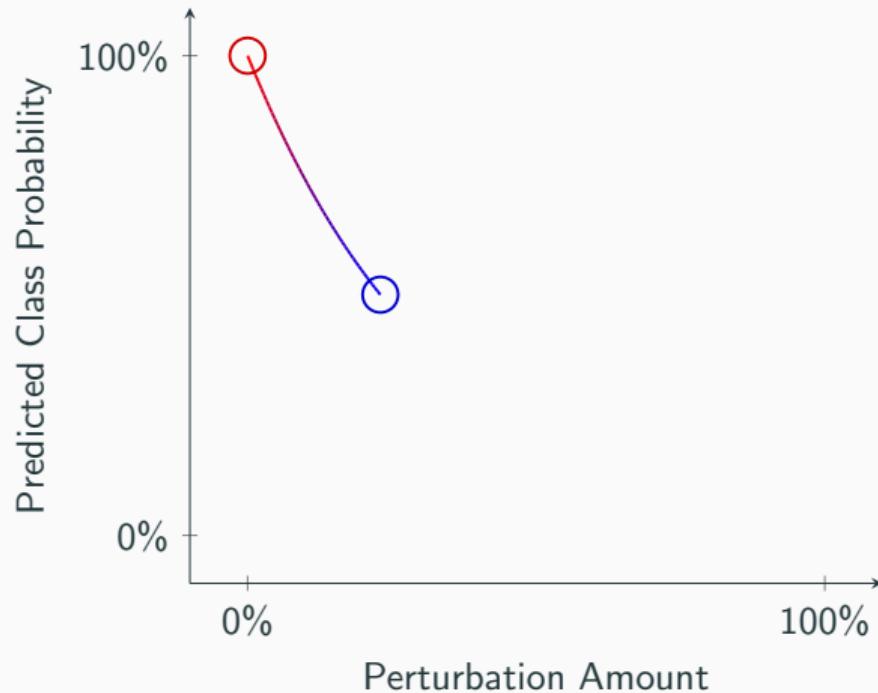
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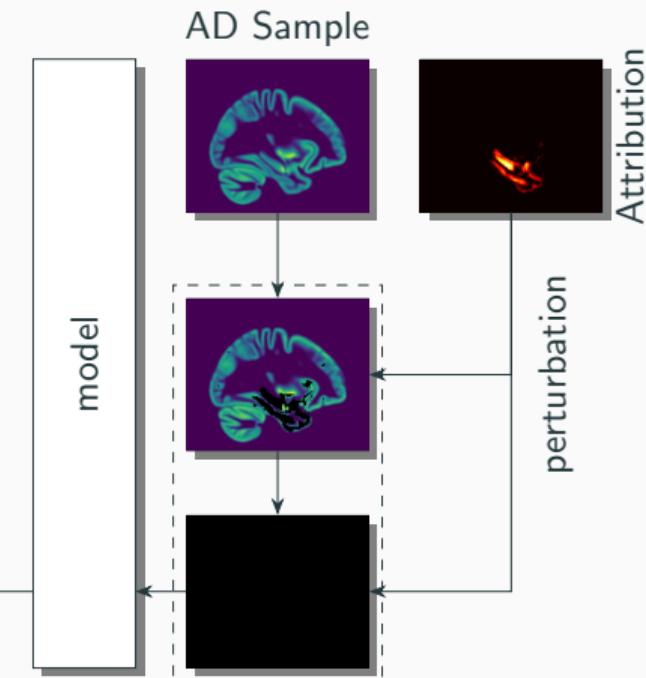
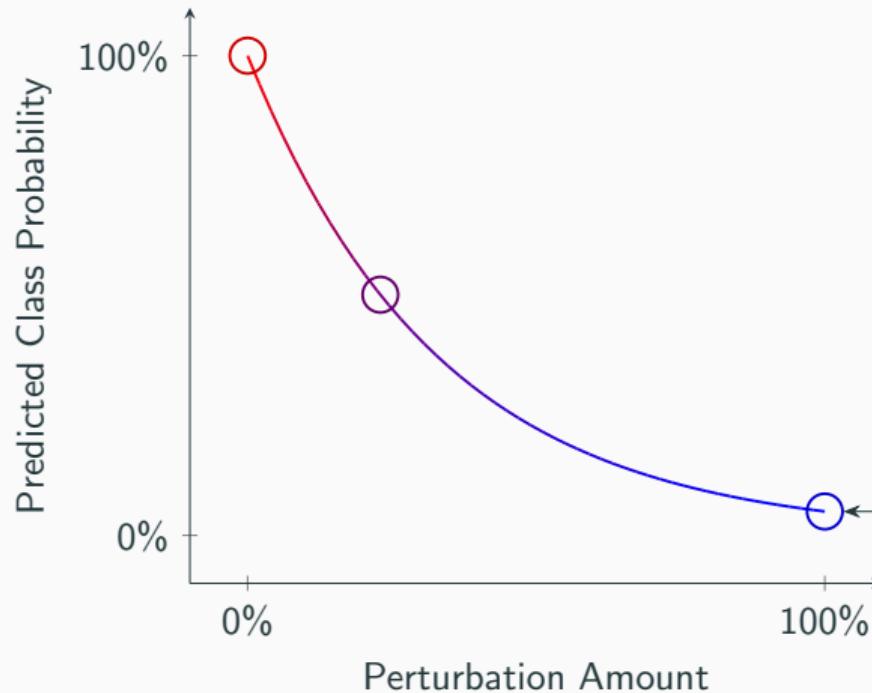
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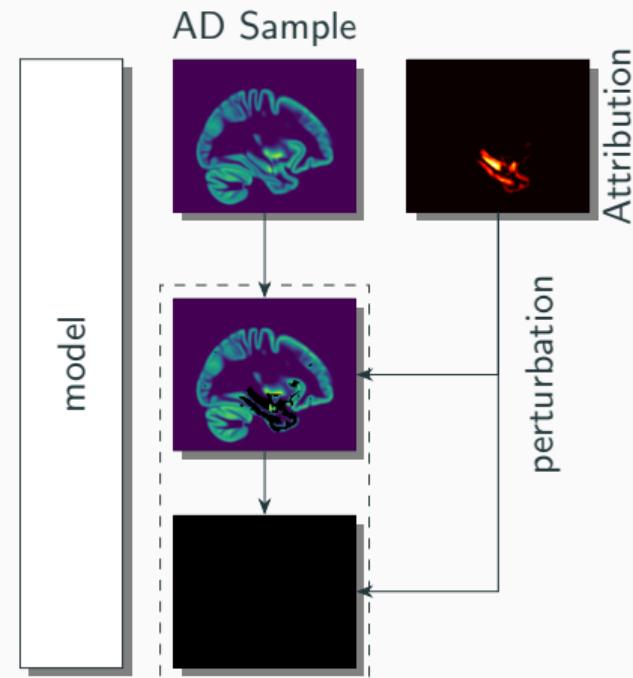
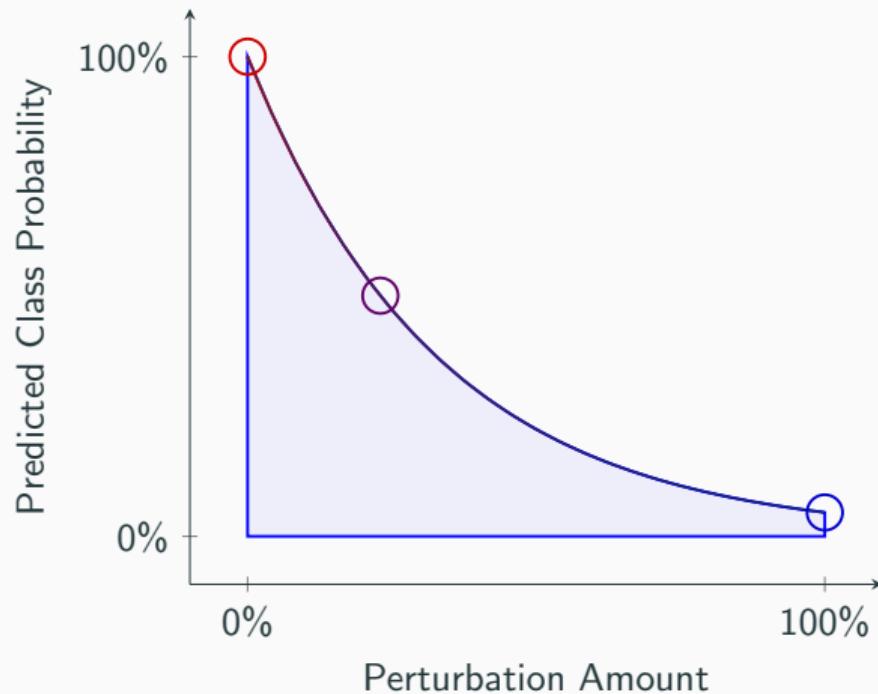
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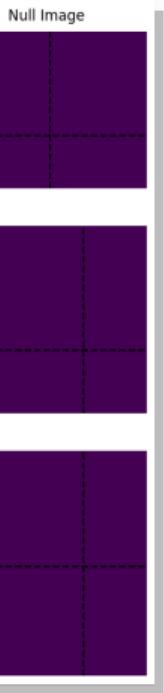
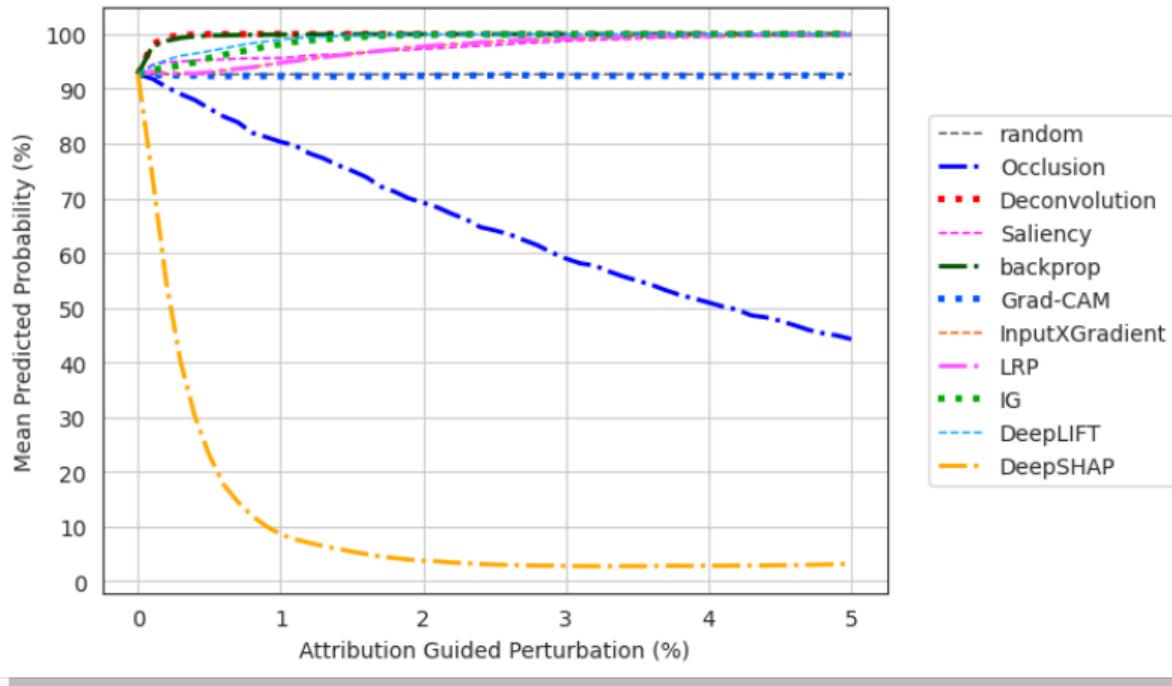


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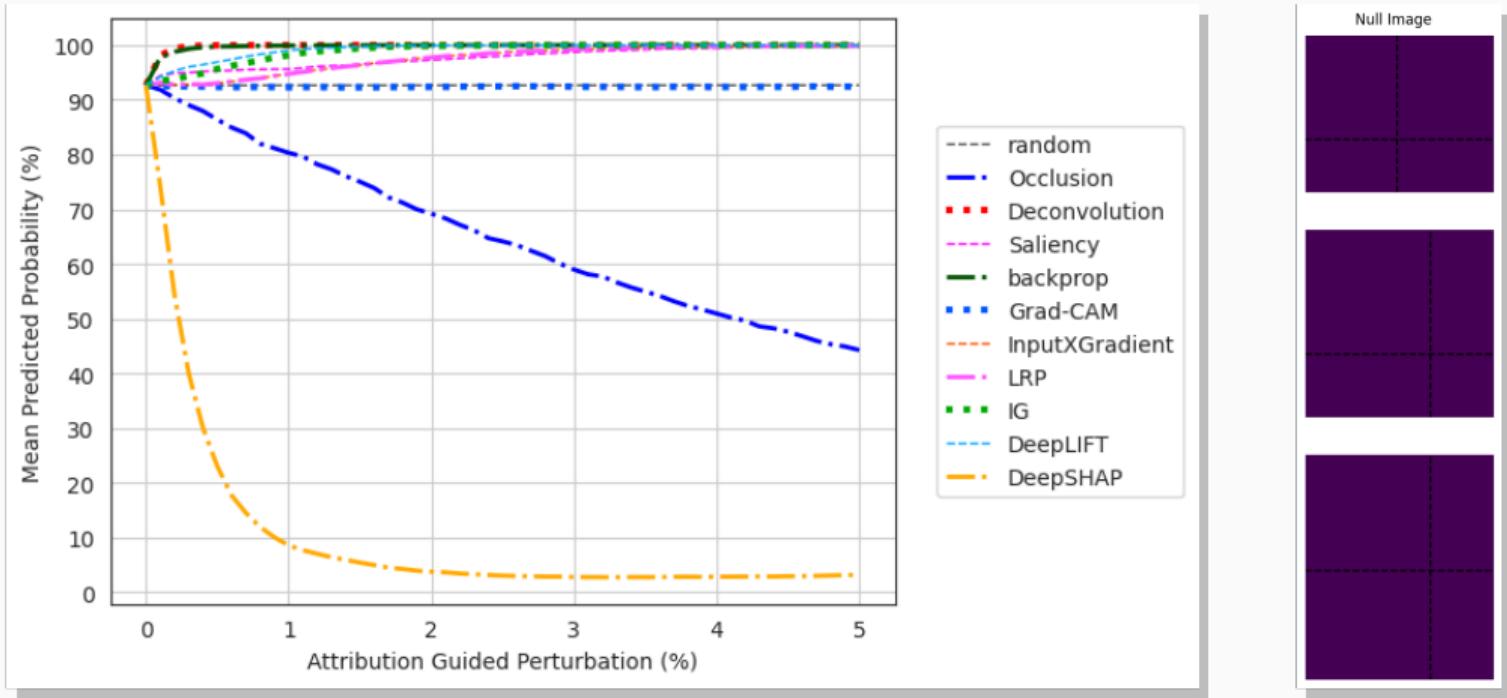


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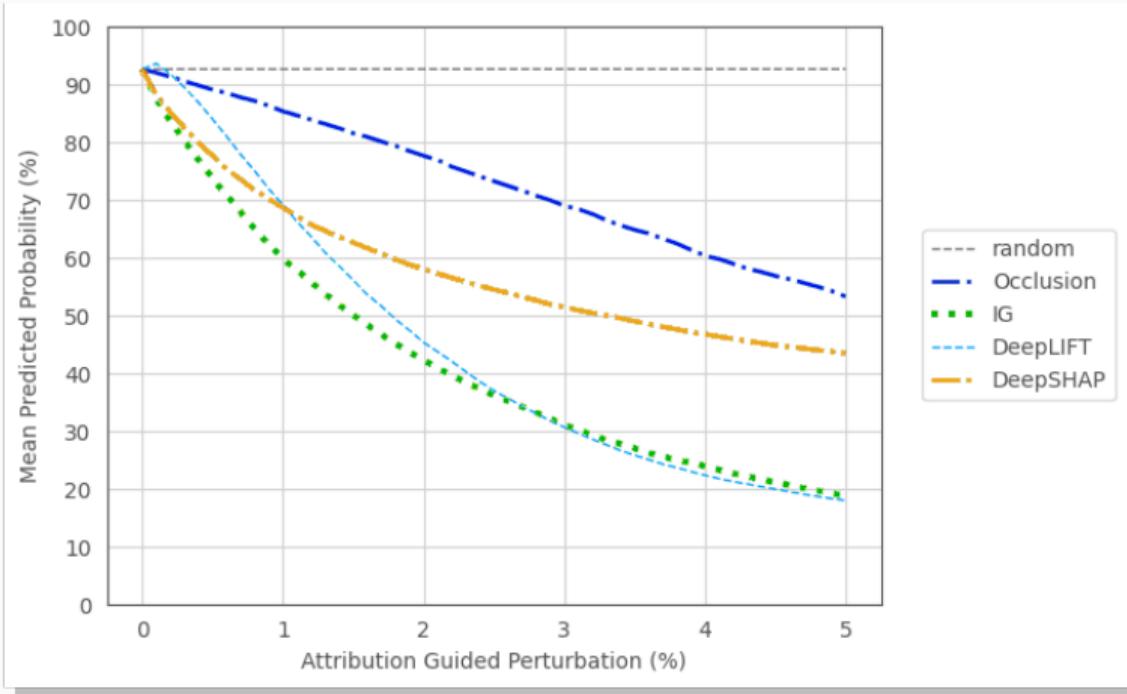
Mean Predicted AD Probability when replacing voxels by the null image baseline



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

Hypothesis

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

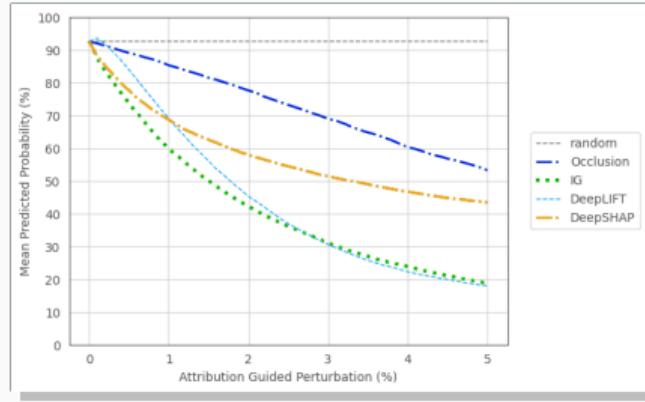
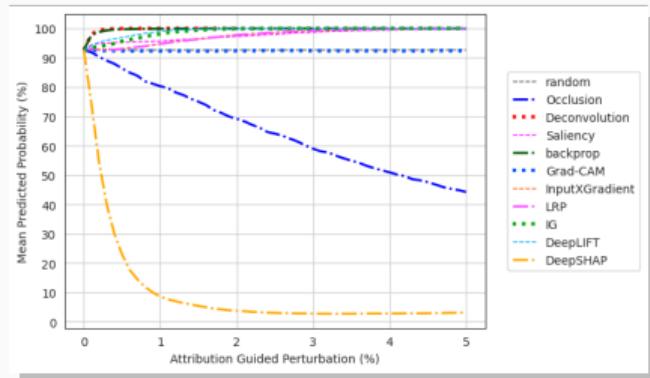


Using the **CN mean** as attribution baseline and perturbation target for AD samples

Question asked by a CN mean baseline

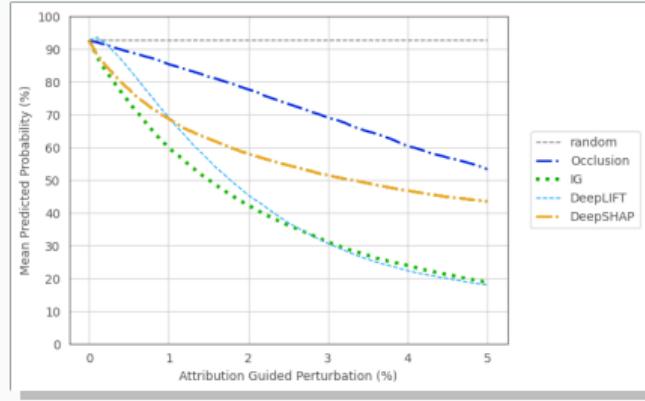
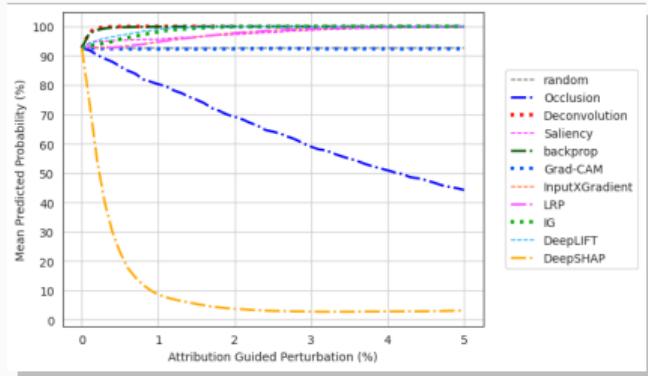
What caused this sample to be classified as AD - compared to a CN sample?

Conclusion



Take-Aways

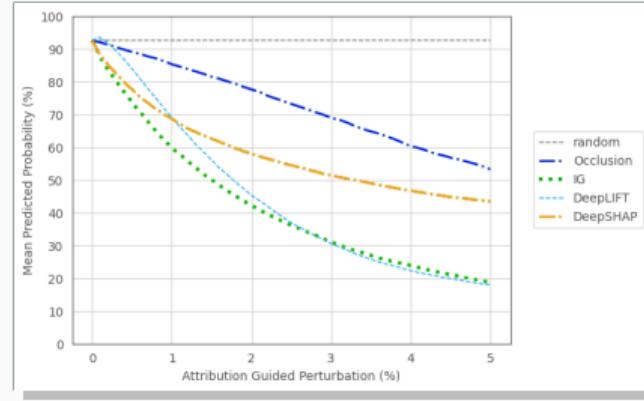
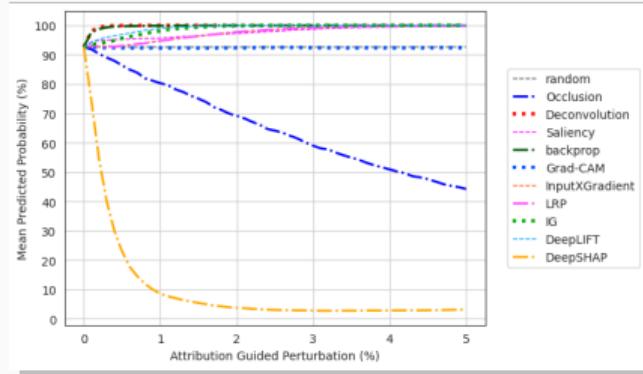
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Take-Aways

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

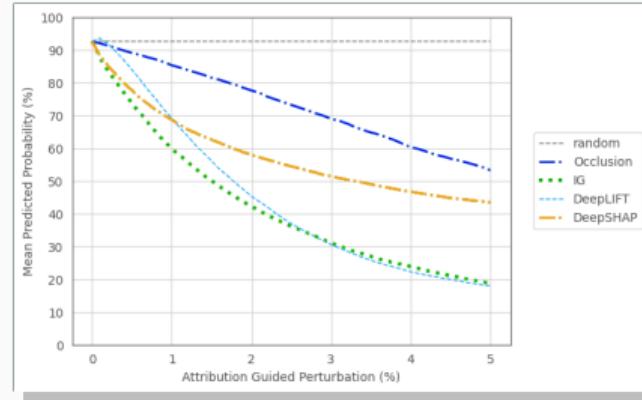
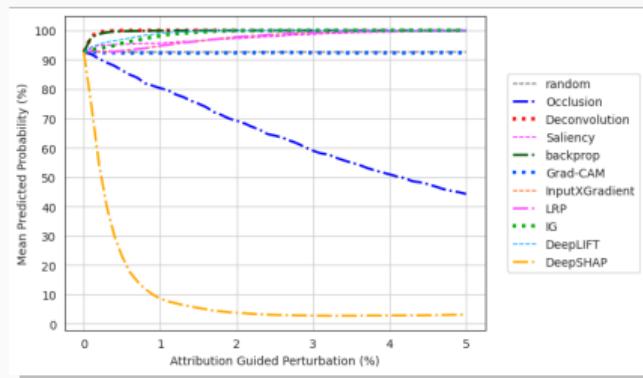
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Take-Aways

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

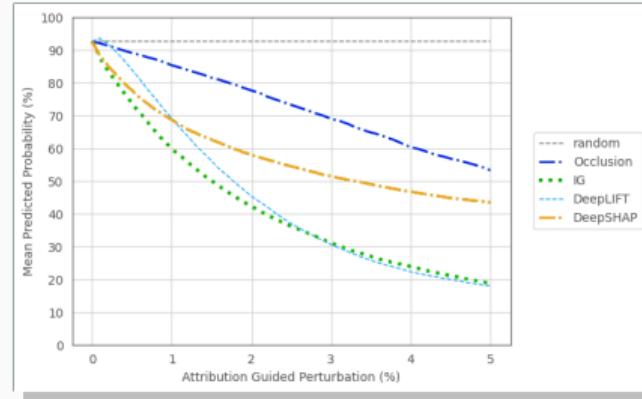
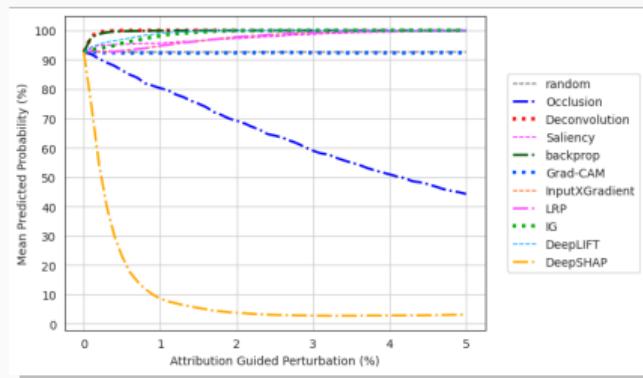
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Take-Aways

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



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