# Automatic brain tumor grading from MRI data using convolutional neural networks and quality assessment

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# Introduction and Motivation

- Gliomas.
  - Low grade gliomas (LGGs) vs. high grade gliomas (HGGs).
    - Possible different treatment strategies.
  - Grading through biopsy and histological studies.

- Limited previous work on grading from imaging data.
- CNNs: automatic grading directly from MRI.
- Interpretability: visual explanations to assess predictions.



# CNNs for glioma grading

- Grading strategies.
  - Based on the whole brain.
  - Based on a tumor ROI.





# CNNs for glioma grading



# Interpretability for prediction assessment

- Interpretability through visual explanations.
- Assess the grade prediction.
- Diagnose processing issues and hint on improving strategies.
- Guided Backpropagation (GBP).
- Gradient-weighted Class Activation (GradCAM).
  - Class discriminative.
  - Low resolution explanation maps.

$$\alpha_l^c = \frac{1}{N} \sum_i \sum_j \sum_k \frac{\partial y^c}{\partial F_{i,j,k}^l}; \qquad E^c = \max\left(\sum_l \alpha_l^c F^l, 0\right)$$

### Results

- BRATS 2017
  - 210 HGGs.
  - 75 LGGs.
  - Structural MRI: T1, post-contrast T1, T2, FLAIR.
- Training -60%, Validation -20%, and Test -20%.
- Metrics
  - Accuracy (acc).
  - Recall.
  - Precision.
  - F1-score.
  - Area under the receiver operating characteristic curve (ROC-AUC).

#### Results

Region	Standardization	Grade	F1-score	Precision	Recall	Acc	<b>ROC-AUC</b>
Whole brain	Whole image	LGG HGG	$0.8000 \\ 0.929$	$0.8000 \\ 0.929$	0.8000 0.929	0.8950	0.8857
	Brain mask	LGG HGG	0.8000 0.9286	0.8000 0.9286	0.8000 0.9286	0.8950	0.8913
Tumor ROI	Whole image	LGG HGG	0.7879 0.9136	0.7222 0.9487	0.8667 0.881	0.8770	0.8841
	Brain mask	LGG HGG	0.8667 0.9524	0.8667 0.9524	0.8667 0.9524	0.9298	0.9841



Example of the effect of intensity standardization on the GBP maps. Warmer colors represent stronger responses. From left to right: T1c, T2, GBP map on image standardized over the whole image, and GBP map on image standardized in the brain region only.

#### Results



Interpretability maps for grade predictions from a) whole brain, and b) tumor ROI. Warmer colors represent larger responses. In a) the arrows indicate the tumor lesions; on top is a correctly classified as HGG, while example in the bottom is a HGG misclassified as LGG. In b), the top example is a correctly classified HGG, while in the bottom a LGG is misclassified as HGG.

## Conclusion

- Fast and non-invasive tumor grade anticipation.
- Possible from the whole brain and a tumor ROI.
  - Although the latter achieves better results.
- Interpretability plays a role in two stages.
  - Assessment of the prediction.
  - During development.

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