Klinik und Poliklinik für Neuroradiologische Diagnostik und Intervention

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Improved localized prediction of tissue outcome in acute ischemic stroke patients

Purpose: An adequate estimation of the disease progress and ongoing infarct remains of particular interest for therapy decision in patients with acute ischemic stroke. The acquisition of diffusion- and perfusion-weighted MRI sequences during the diagnosis allows predicting the final tissue outcome and supporting treatment decisions. However, integrating additional spatial information e.g. atlas regions often requires non-linear prediction models that usually lack proper interpretability. This study introduces an approach to split the modelling into one global and one individual voxel-level model resulting in a hybrid prediction method with directly interpretable spatially varying coefficients.

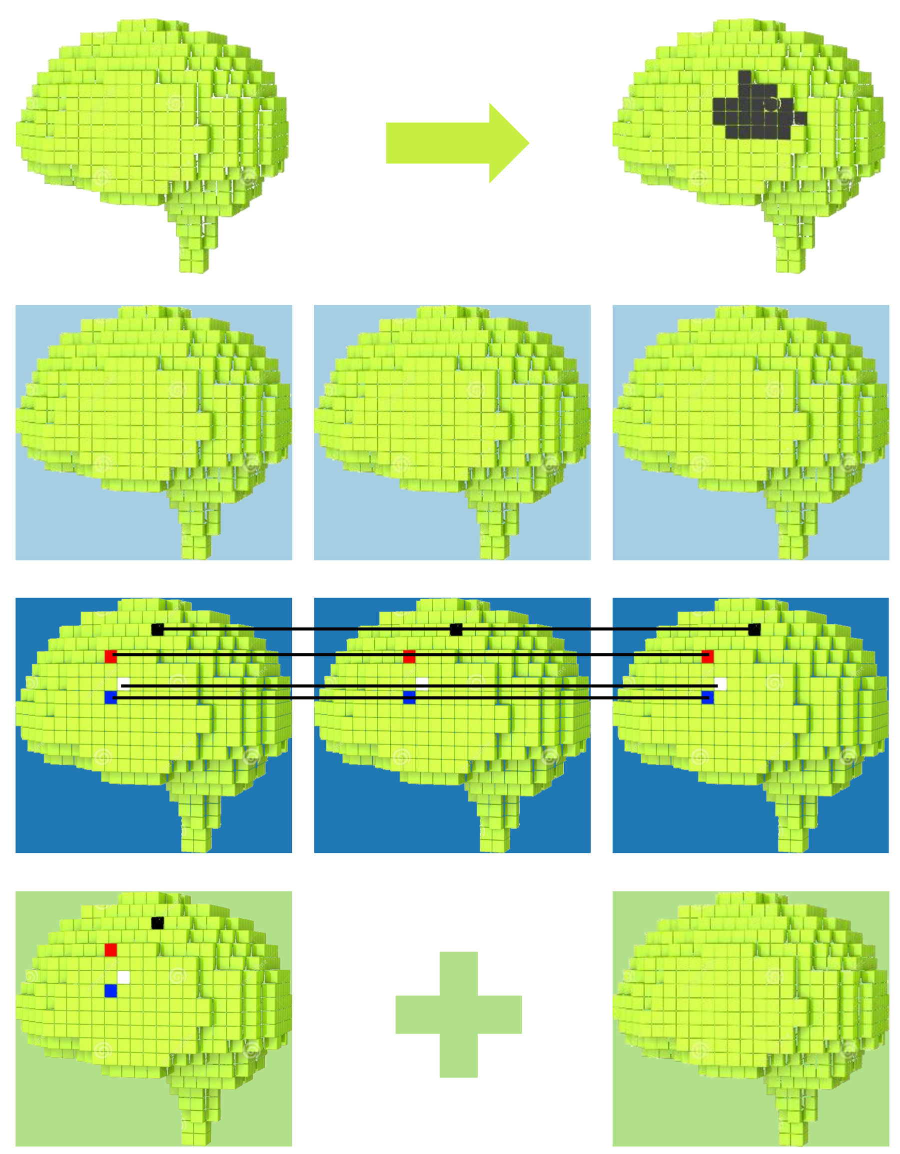


Figure illustrating the purpose of voxel-wise outcome prediction and related modelling strategies.

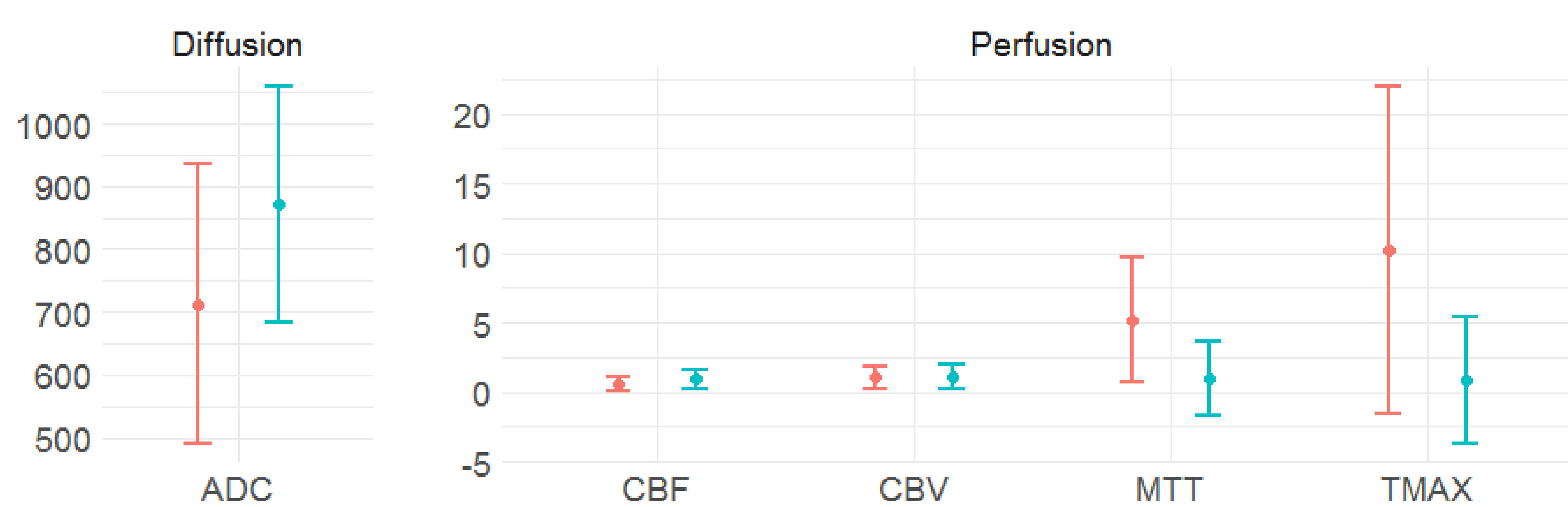
Top: Prediction of Infarcted outcome.

Top down: Different modelling strategies: Global, local and hybrid (mean of global and local model).

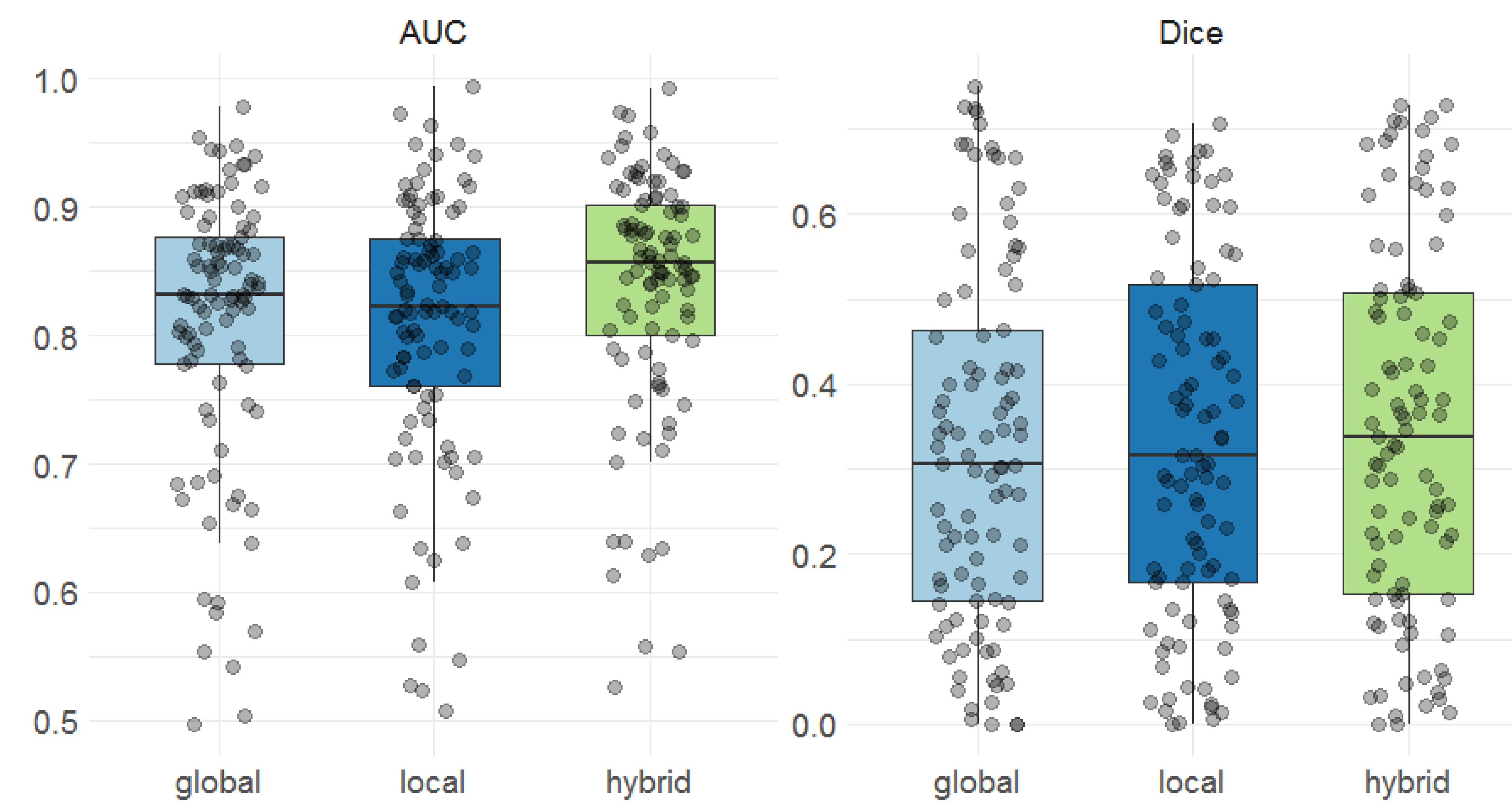
Modified from Voxel human brain

Materials and Methods: The modelling includes normalized ipsilateral voxel-wise diffusion (ADC) and perfusion features (CBF, CBV, MTT, TMAX) of 97 acute stroke patients, which were – together with the tissue outcome – registered on the symmetric MNI 152 brain atlas. Logistic regression of all predictors was fitted to the outcome on two levels i.e. on the total available ipsilateral voxel feature set and localized prediction model individually for each voxel position (without differentiating hemisphere). Thus, three models were available afterwards: global, local, and hybrid average of local and global. Model validation was conducted via ten fold cross-validation.

Errorbars representing mean and standard deviation of voxel with negative and positive outcome.



Results: A comparison of AUC and Dice coefficients on a pairwise patient basis revealed significant improvement for the the hybrid approach compared to the global model ($p < 0.001$).



Boxplots representing AUC and Dice coefficients of n = 97 out of sample predicted ipsilateral voxel sets, contained during a ten fold cross-validation. While there are no significant differences between the global and local model, the hybrid approach turns out to perform better on average than the global approach (+0.0266 in AUC, +0.0194 on Dice; respectively both $p < 0.001$).

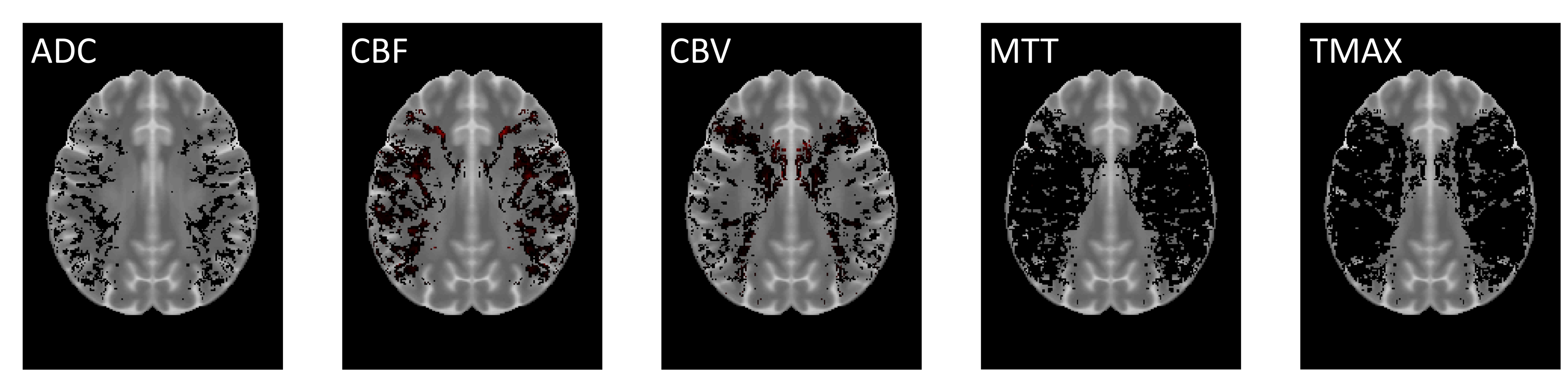


Figure illustrating coefficient maps of the local approach. Brain data was registered on the MNI 152 brain atlas, where one model per position was trained without differentiating hemisphere. Thus resulting coefficient maps are also symmetric. Individual models where trained on the closest voxels – within a search area — to each position, regarding both outcomes. It is possible to obtain also other statistics per voxel position including p-values, aggregated prediction statistics and measures of model fit.

Conclusion: Utilizing localized and global information in combination seems highly beneficial for the predictive performance and interpretability, both.