A Comprehensive Framework for the Detection of Individual Brain Perfusion Abnormalities Using Arterial Spin Labeling

Camille Maumet[1,2,3], Pierre Maurel[1,2,3], Jean-Christophe Ferré[1,2,3,4], Christian Barillot[1,2,3]

1. INRIA, VisAGeS Project-Team, F-35042 Rennes, France
2. INSERM, U746, F-35042 Rennes, France
3. University of Rennes I, CNRS, UMR 6074, IRISA, F-35042 Rennes, France
4. CHU Rennes, Department of Neuroradiology, F-35033 Rennes, France

Purpose

Context: Arterial Spin Labeling (ASL) enables measuring cerebral blood flow (CBF) in MRI without injection of a contrast agent.

Problem: In ASL, perfusion abnormality studies usually rely on manual regions of interest delineations, a time-consuming task prone to inter-expert variability.

Our approach: We propose an automatic framework to identify hypoperfused and hyperperfused regions in individual patients by comparison to a model of normal perfusion. This model takes into account the first level variance in order to model the subject-specific spatial noise distribution.

Method

ASL Template, a model of normal perfusion:

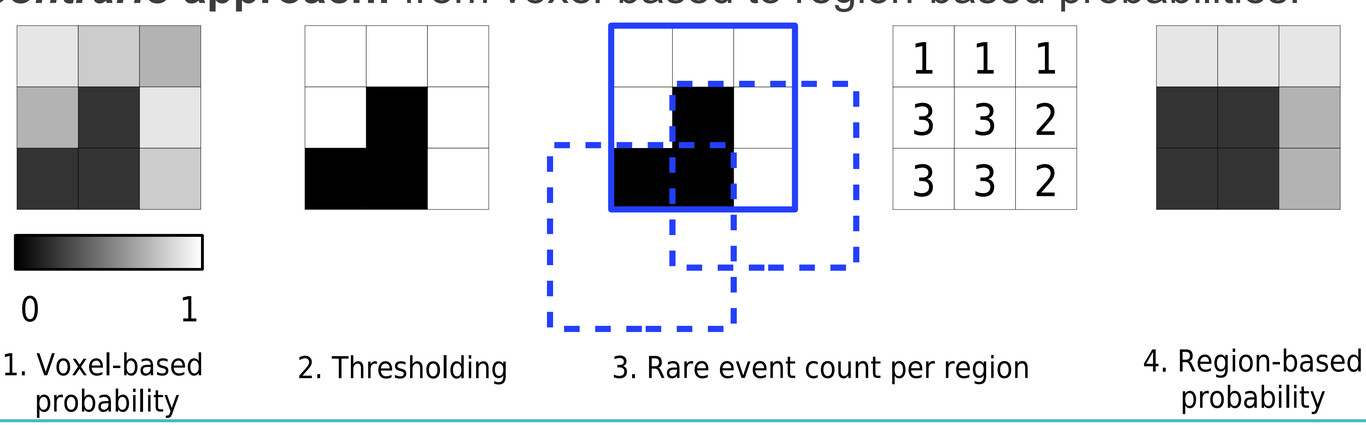
$$Perf \sim N(\mu_{pop}, \sigma^2_{pop} + \sigma^2_{sub,tpl})$$

inter-subject variance — intra-subject variance

Comparison of a new subject:

$$\hat{\beta} = perf_{N+1} - \hat{\mu}_{pop}, \quad \mathrm{Var}(\hat{\beta}) = \frac{\sigma^2_{pop} + \sigma^2_{sub,tpl}}{N} + \sigma^2_{pop} + \sigma^2_{sub,N+1}$$

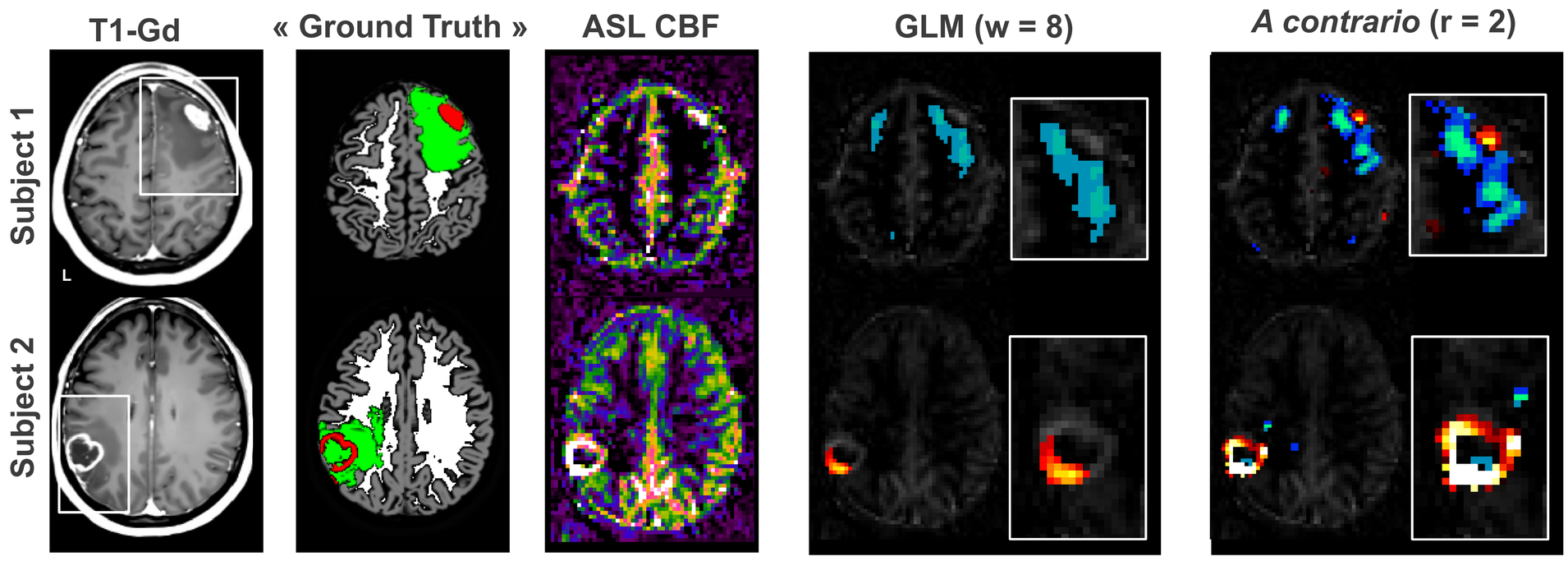
***A contrario* approach:** from voxel-based to region-based probabilities:



Results

Data: 12 patients diagnosed with brain tumors and 35 healthy subjects were involved in this study.

Detection of patient-specific perfusion abnormalities:



Quantitative comparison:

	GLM					*a contrario*	
	$w=2$	$w=4$	$w=6$	$w=8$	$w=10$	$r=1$	$r=2$
$pseudo-sensitivity$	0.29	0.31	0.32	**0.33**	0.34	0.37	**0.53**
$pseudo-specificity$	0.98	0.97	0.96	**0.95**	0.94	0.96	**0.89**

Conclusion

We have presented a comprehensive framework for the detection of brain perfusion abnormalities in individual patients by comparison to a template of healthy subjects. We applied this model to 12 patients suffering from brain tumors and compared our *a contrario* approach to the classical GLM with FDR correction. This analysis pointed out the benefits of the *a contrario* approach: a better conservation of the hypo- and hyper-perfusions boundaries and a greater sensitivity. This increase in sensitivity might be crucial in the study of pathologies presenting more subtle patterns of abnormal perfusion.