

GP-Unet: Lesion Detection from Weak Labels with a 3D Regression Network

Florian Dubost,^{*††} Gerda Bortsova,^{*††} Hieab Adams,^{‡§} Arfan Ikram,^{‡§¶}
 Wiro Niessen,^{*††**} Meike Vernooij,^{‡§} Marleen De Bruijne^{*††||}

^{*}Biomedical Imaging Group Rotterdam, Departments of Medical Informatics and Radiology, Erasmus MC, Rotterdam, The Netherlands,

[†]Department of Medical Informatics, Erasmus MC, Rotterdam, The Netherlands, [‡]Department of Radiology, Erasmus MC, Rotterdam, The Netherlands,

[§]Department of Epidemiology, Erasmus MC, Rotterdam, The Netherlands, [¶]Department of Neurology, Erasmus MC, Rotterdam, The Netherlands,

^{||}Department of Computer Science, University of Copenhagen, Copenhagen, Denmark,

^{**}Imaging Physics, Faculty of Applied Sciences, Delft University of Technology, The Netherlands

Introduction

- Lesion detection problem in 3D MRI brain scans
- For training, **only a global label per image**
- This label is the count of a given lesion in a region of interest
- **No information about the location** or shape of the lesions is given to the network during training
- The network **outputs a 3D heatmap of the size of the input**. The heatmap highlights the presence of lesions.

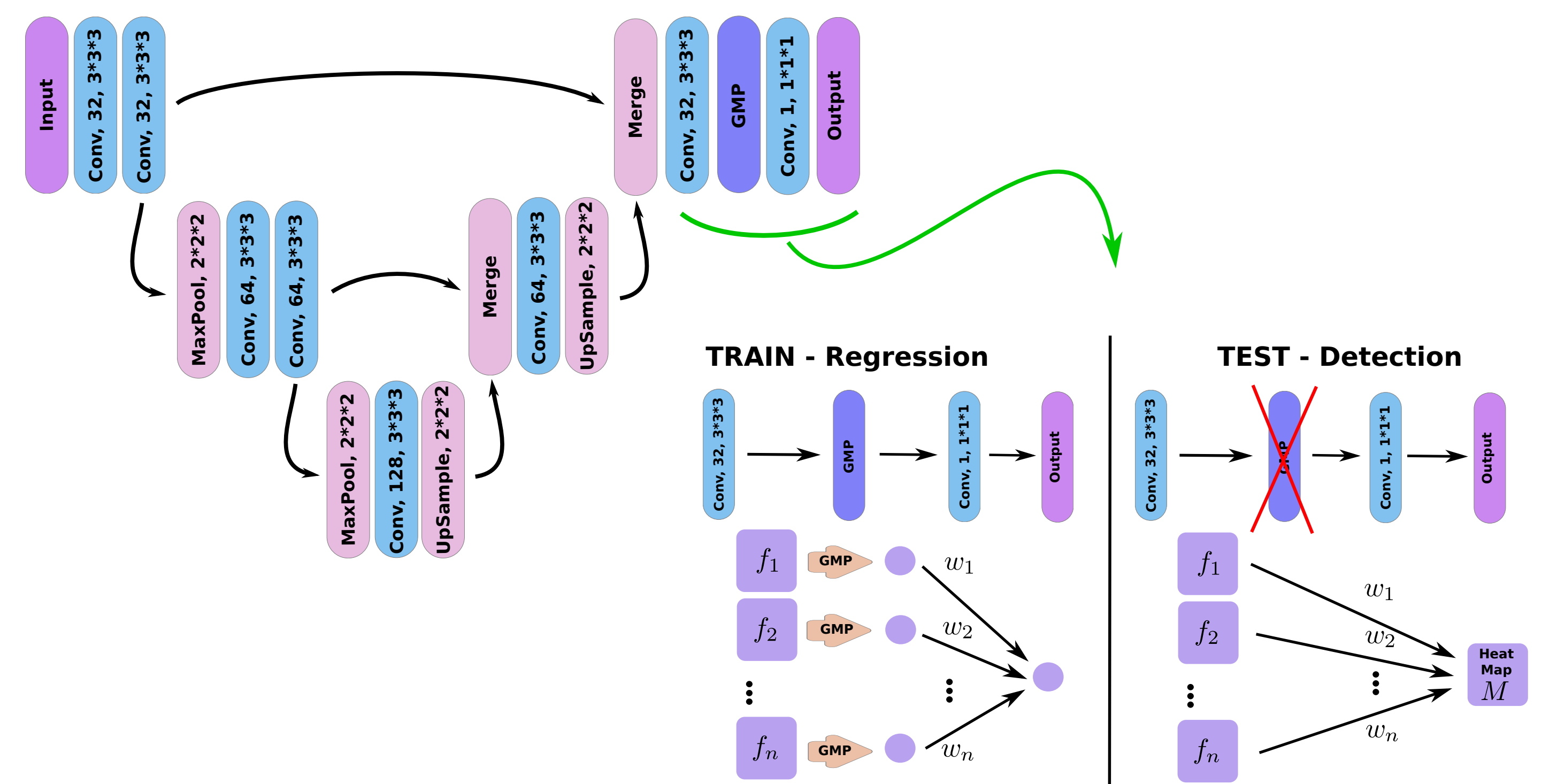


Figure 1: **Network architecture.**

Dataset

- Method tested on the detection of Enlarged Perivascular Spaces (EPVS): space between a vein or an artery and pia matter
- Dataset: Rotterdam Scan Study, GE 1.5T scanner
- We focus on EPVS in the basal ganglia (168*128*64 pixels)
- 1642 PD-w MRI scans visually-scored with EPVS by a specialist (EPVS count)
- Random subset of 30 scans => EPVS annotated by a dot
- Remaining data split into 1289 scans for training and 323 for validation

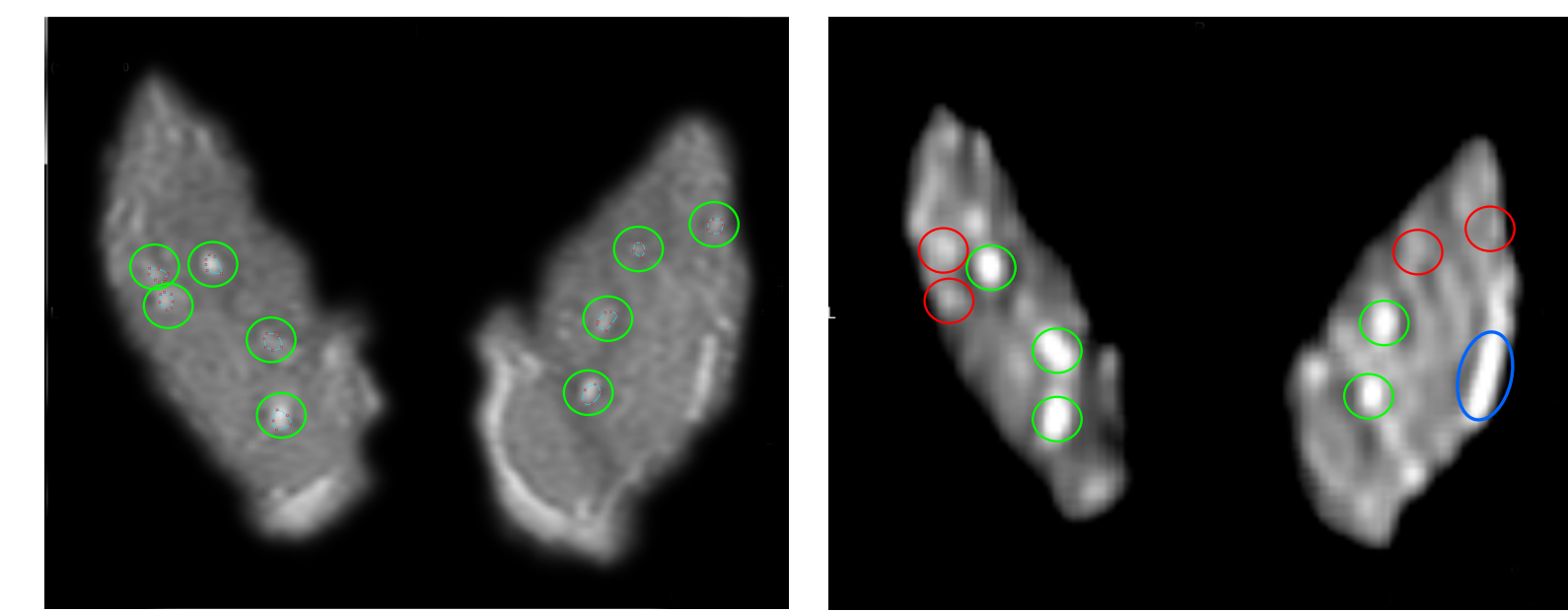


Figure 2: **Examples of lesion detection.** Left: Ground truth on the intensities - lesions circled in green. Right: Heatmap generated by the neural network. True positives in green, false positives in blue and false negatives in red.

Method	TPR	FPav	FDR
Intensities (a)	40.6	2.3	59.8
Saliency (b)	39.8	2.7	54.2
Saliency FCN (c)	18.7	3.3	70.2
Regression (d)	19.6	3.2	70.5
Regression FCN (e)	54.8	1.9	37.7
Intensities + Reg FCN (f)	62.0	1.5	31.4

Figure 3: **Comparison with baselines.** TPR: True positive rate or Sensitivity, FPav: False positive per image in average, FDR: false discovery rate.

Method and Results

1. Computation of a smooth ROI
2. 3D regression neural network: Global Pooling (GP) + Unet. Optimized with MSE and Adadelta, mini-batches of one image
3. To compute heatmaps: remove the GP layer

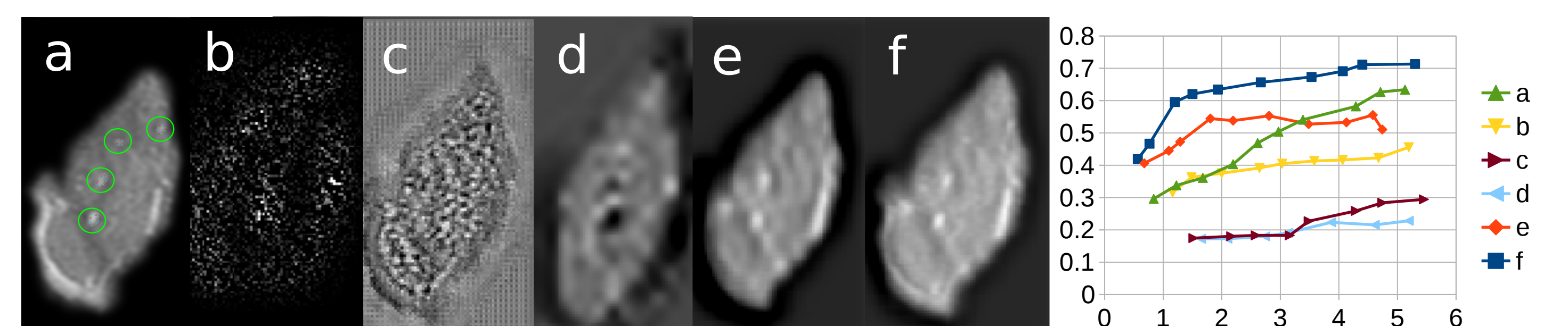


Figure 4: **Heatmaps of the different methods.** EPVS circled in green on the original image (a). Right: Free-ROC curves, FPav on the x-axis and sensitivity on the y-axis.