Small White Matter Lesion Detection

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2020.01.10

Overview

Contents

Introduction

Object of Research

- Small white matter lesions(diameter is smaller or equal to 3mm), which are important markers for cerebral small vessel disease of elderly people.

Introduction

Related Work

- Researches focus on the segmentation of WML, and are tuned and validated with volume or Dice measurements, which aim at large lesions, and are not suitable for the detection for small lesions.
  - Non-classification approach
    - Ong et al. use a histogram based method that adaptively detects intensity outliers.
    - Wu et al. utilize a fuzzy connected algorithm to iteratively grow the seed points obtained from FLAIR image intensity histogram
  - Voxel classification
    - Use KNN classifier on spatial and intensity features
    - Combine intensity, Gabor and spatial information using SVM and KNN classifiers
    - make use of KNN with intensities, MNI normalized spatial information and tissue type priors
  - SVM and random forest classifiers on intensity and texture features in order to segment WMLs for the patients diagnosed with Alzheimer's diseases

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Materials

Data

- MRI images of 503 patients diagnosed with SVD (small vessel disease) who showed mild cognitive impairment evidences.
- 3D T1 magentization-prepared rapid gradient-echo sequence (TR/TE/TI 2250/3.68/850 ms; flip angle 15 ▫ ; voxel size 1.0×1.0×1.0 mm)
- FLAIR pulse sequences (TR/TE/TI 9000/84/2200 ms; voxel size 1.0×1.2×5.0 mm, interslice gap 1 mm)
- transversal T2* weighted gradient echo sequence (TR/TE 800/26 ms; voxel size 1.3×1.0×6.0 mm, interslice gap 1 mm)
- 50 out of these 503 cases were manually annotated by experts.

Contents

Methods

Preprocess

- To setup a voxel classification framework, T1, T2 and FLAIR three modalities are aligned. (mutual information measure with trilinear interpolation resampling in FSL-FLIRT)
- Bias field correction: brain extraction to remove the skull, eyes and all other non-brain tissue.(FSL-BET, FSL-FAST)
- Use a Gaussian mixture modeling (GMM) method on T1 and FLAIR intensities to extract gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF).
- Projecte each Gaussian on the FLAIR axis resulting in a 1D Gaussians for the FLAIR image

Methods

Features

Group	Feature
Intensities	FLAIR intensity
	T1 intensity
	T2* intensity
Tissue Probabilities	WM probability
	GM probability
	CSF probability
Location information	X, Y and Z in MNI space
	2D Euclidean distance from left and right ventricle
	2D Euclidean distance from brain cortex
	2D Euclidean distance from mid-sagittal brain surface
	WMLs prior probability
Second order derivatives	Multi-scale Laplacian of Gaussian (t=1,2,4 mm)
	Multi-scale determinant of Hessian (t=1,2,4 mm)
	Vesselness (σ=1 mm)
	Gauge derivative in the direction of the normal vector
Annular filter	Multi-scale gray-scale annular filter (t=1,2,4)

Methods

Sampling and Training

- A random subset of 100 images is selected for training
- A random forest with 20 sub-trees was selected as the base classifier
- three iterations of Adaboost were run over the random forest

Methods

Validation

- FROC (free-response receiver operating characteristic) analysis. (each local maxima that is found outside of the manual WML annotations is considered as a false positive, and every annotation segment hit by at least one local maxima, a true positive)

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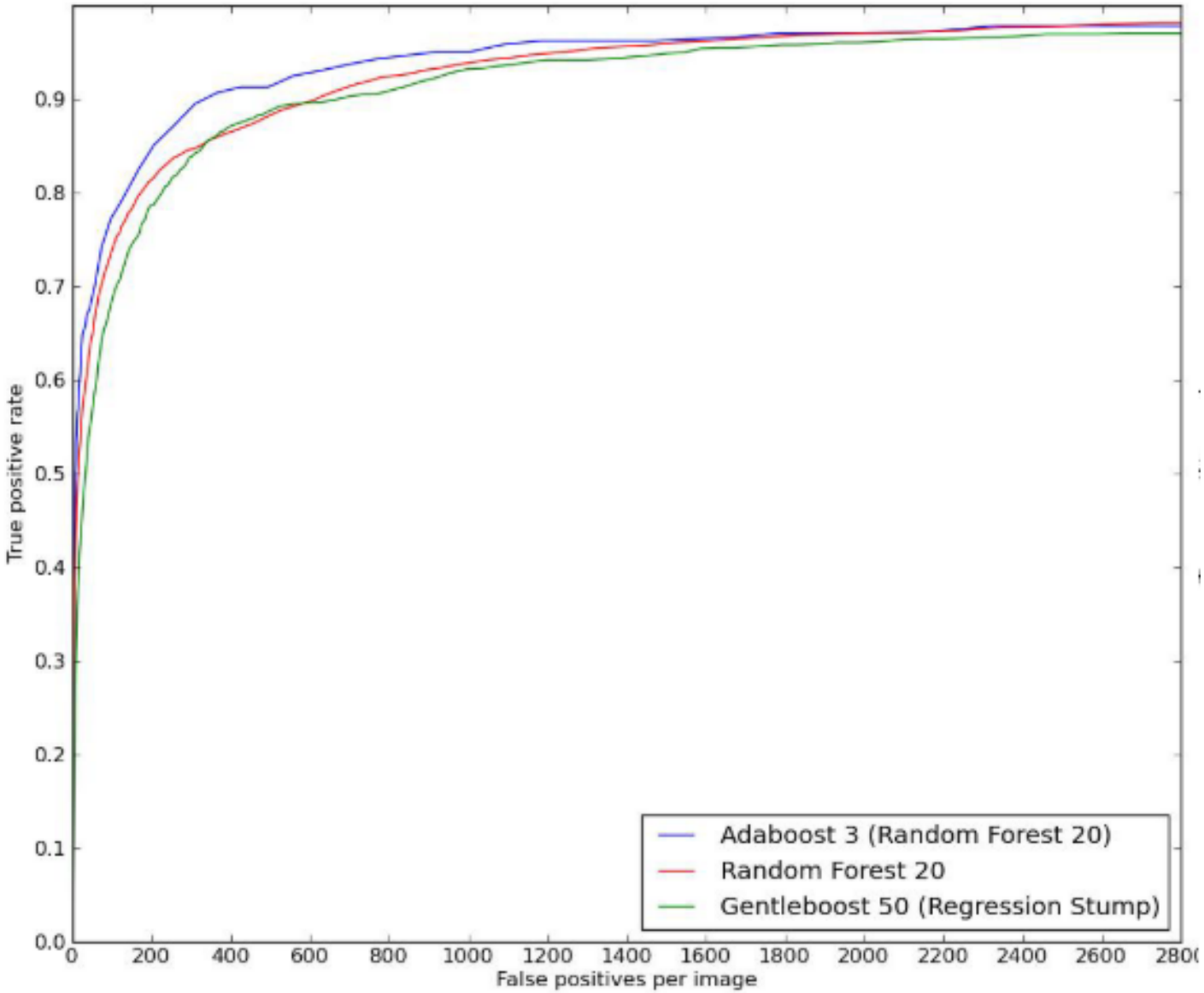
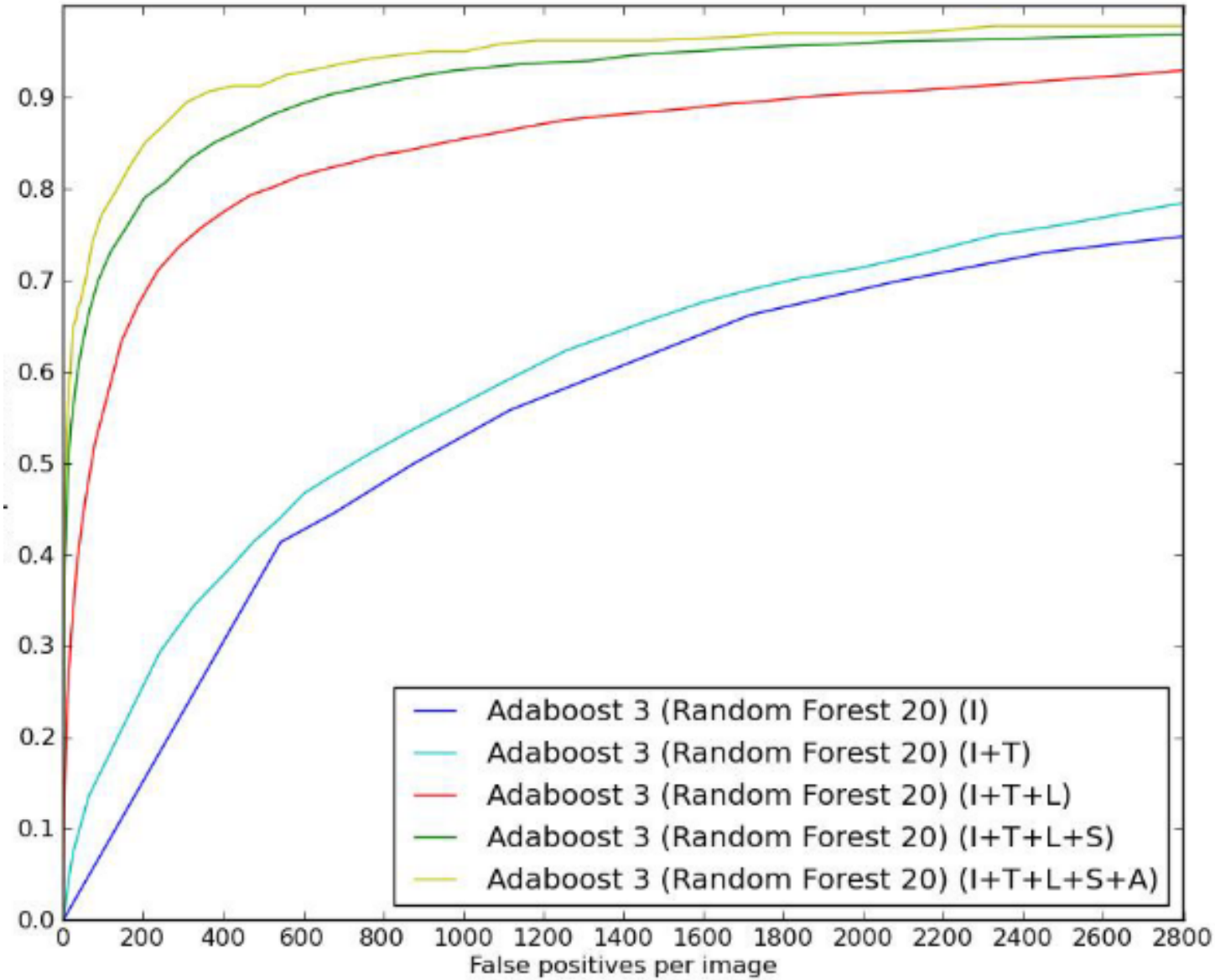
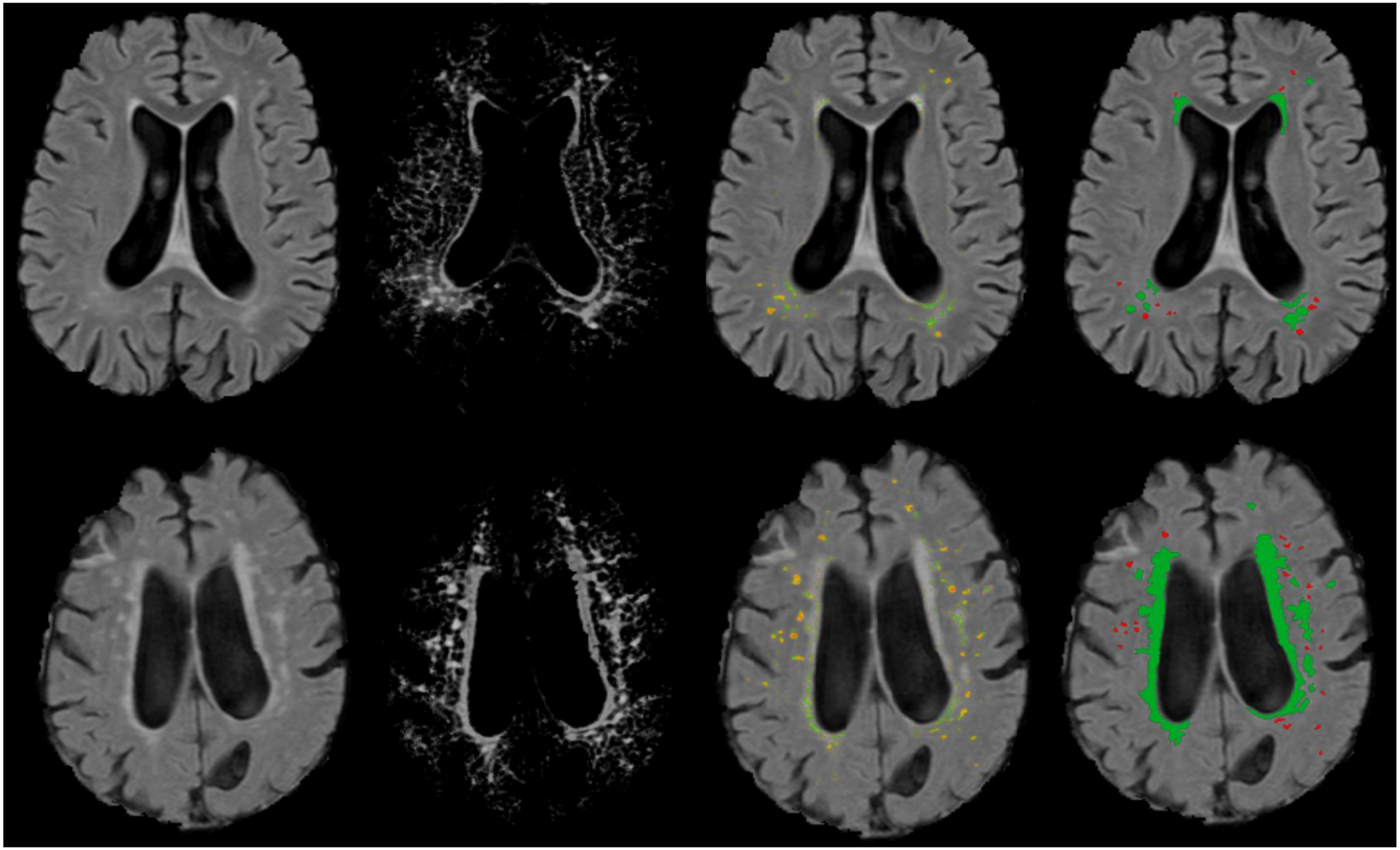
FROC Curves


True positive rate
False positives per image
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Adaboost 3 (Random Forest 20)
Random Forest 20
Gentleboost 50 (Regression Stump)

Sets of features



CAD system



(a) (b) (c) (d)