Parkinsons Disease Detection by using Isosurfaces with Convolutional Neural Networks

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Introduction

- Parkinson's Disease (PD) is the second most common neurodegenerative disorder in the occidental world, but its early diagnosis remains a challenge.
- Numerous works have explored the capacity of Imaging methods for detecting and predicting (PD), mainly:
  - DaTSCAN-PET (Ioflupane I^{123}) Detection of the loss of dopaminergic neurons in the striatum.
  - Magnetic Resonance Imaging - To Study neuroanatomical changes in the brain related to the neurodegeneration process.
- In this work we proposed a method to model regions of interest in DaTSCAN images, instead of using raw volxel intensities, based on the computation of isosurfaces:
  - Isosurface extraction from DaTSCAN images
  - Feature selection (isosurface selection)
  - Classification of images based on their isosurface model using Deep Learning.

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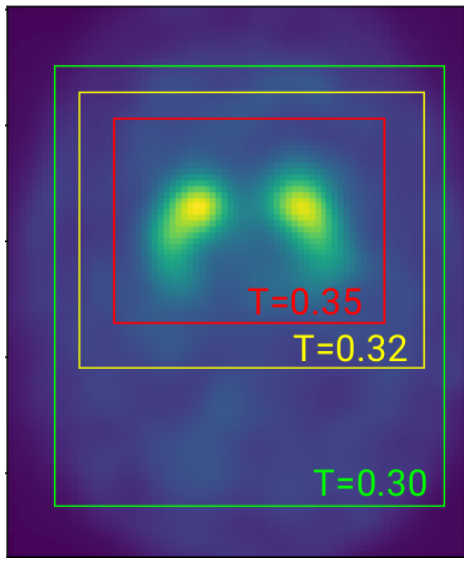
Methods

- Images used in this work have been obtained from the Parkinson's Progression Markers Initiative (PPMI) - https://www.ppmi-info.org/
- DaTSCAN images from 111 Controls and 158 PD patients
- Image size: 79, 95, 69

Methods
Region of Interest

- Extraction of the dopaminergic region by thresholding (Region of Interest)



Region of interest selected depending on the Threshold intensity value.

- 48x48x48 regions are extracted

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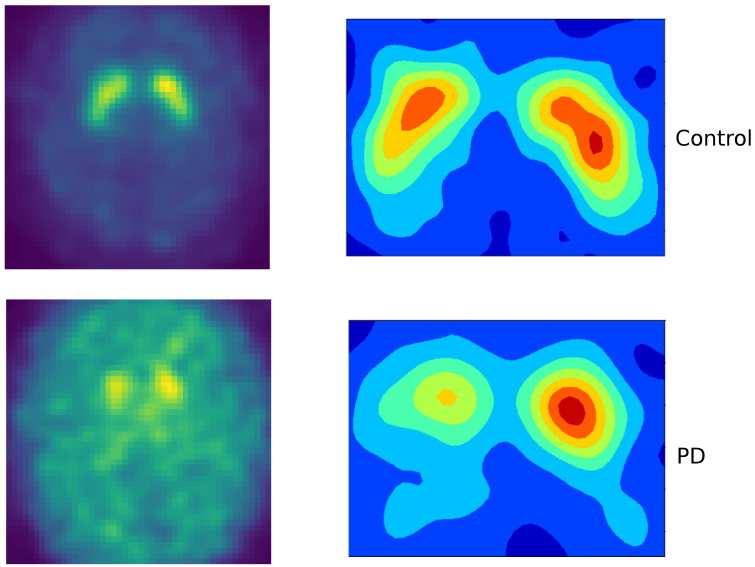
Why Isosurfaces?

- An Isosurface is the three-dimensional analog of an isoline. They represent points of a constant value for a measure (voxels with the same intensity, in our case).
- Information contained in medical imaging is mostly related to the relationship among voxels
- The use of complex features taking into account the voxel neighbourhood usually outperforms tecniques based on raw voxels (VAF)

Methods
Isosurfaces

- Isosurface extraction

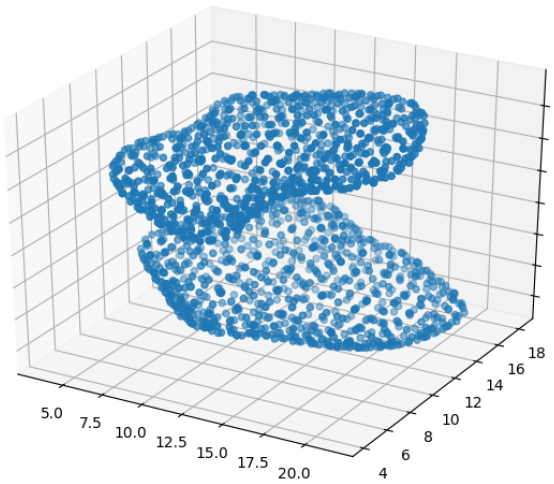


Example of isoline calculation from the DaTSCAN images at a relevant slice

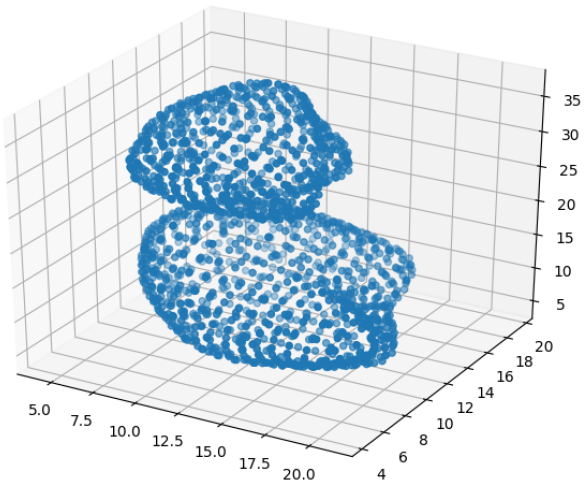
Methods

Isosurfaces - 3D model

- 3D model (Isosurfaces)



Control

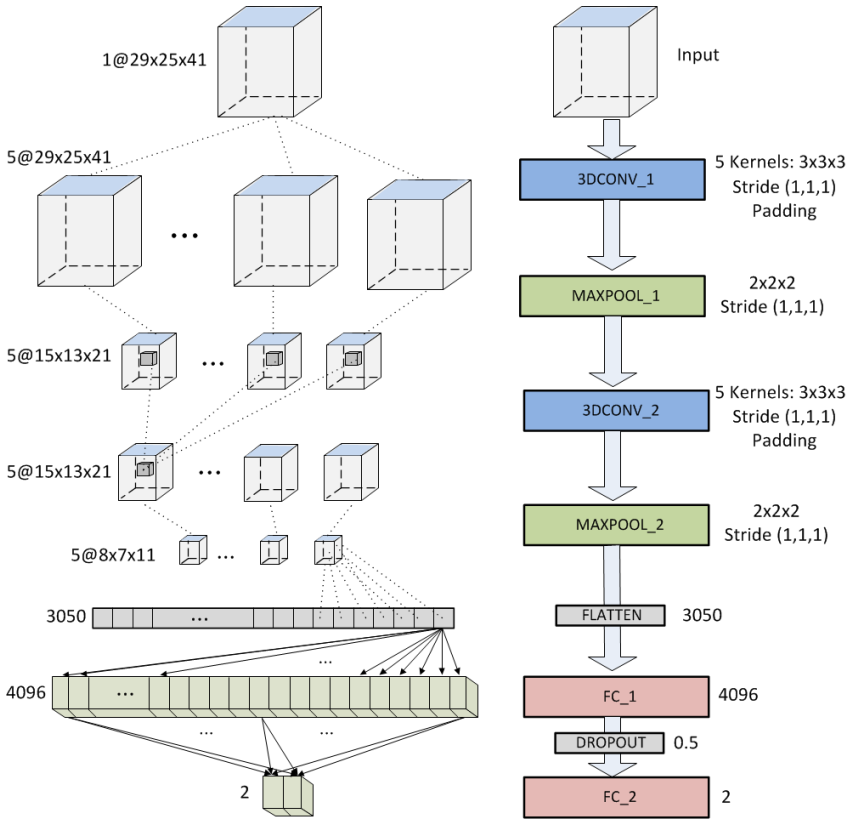


PD

Methods

Classification using Convolutional Neural Network

- Classification is carried out using a LeNet type CNN with 3D convolutions and two output neurons



Results

- The performance of the overall method has been assessed using stratified cross-validation (k-fold, k=10)
- Experimental results using a single isosurface (single channel LeNet) and multiple isosurfaces obtained for different thresholds simultaneously (multi-channel CNN).

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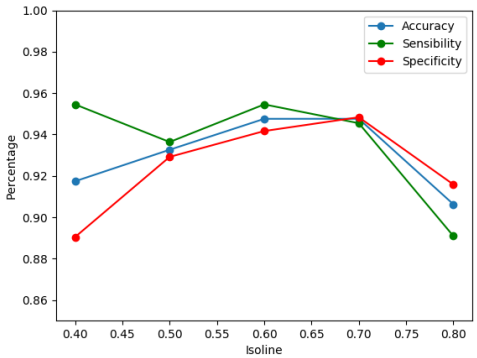
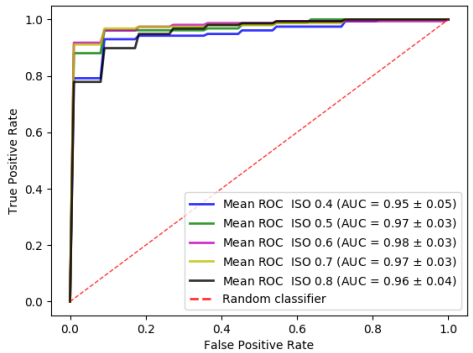
Results
Single-channel CNN

- Experimental results using a single isosurface (single channel LeNet). Figures show the results obtained for different thresholds.



(a)

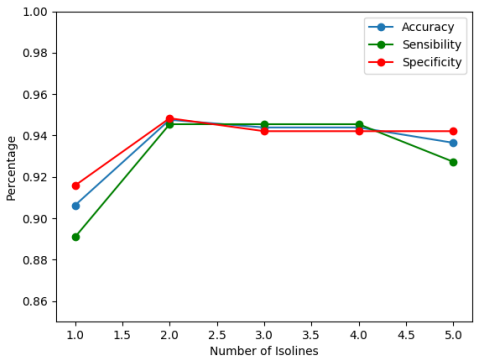


(b)

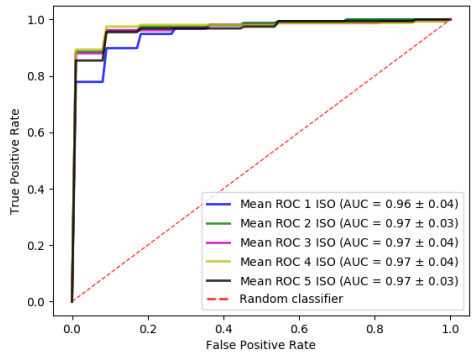
Performance for a single isosurface (a) and ROC curves (b)

Results
Multiple-channels CNN

- Experimental results using several isosurfaces (multi-channel LeNet)



(c)

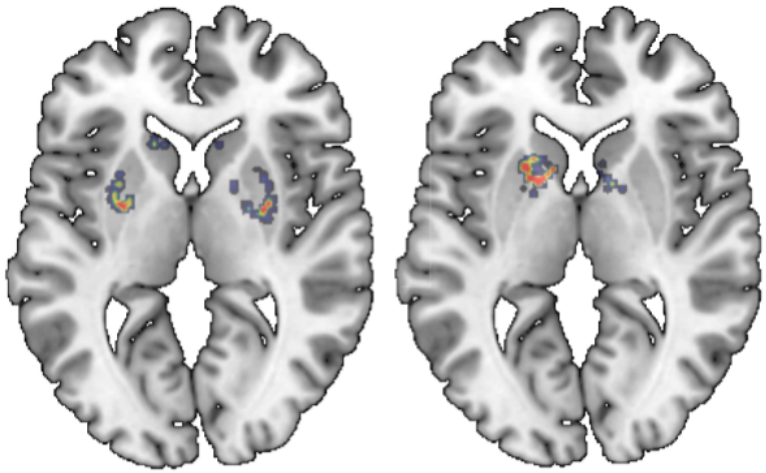


(d)

Performance for multiple isosurfaces (a) and ROC curves (b)

Results

- Class activation map (CAM) - Overlayed in an MRI template



** Class activation map is computed from the last convoutional layer instead of using gradients with respect to the output (saliency map)

Results

- Performance comparison

Method	Accuracy	Sensitivity	Specificity	AUC
EMD Rojas et al. (2013b)	0.95	0.95	0.94	0.94
Significance M. Martínez-Murcia et al. (2014a)	0.92	0.95	0.89	0.90
Brahim et. alBrahim et al. (2015)	0.92	0.94	0.91	-
VAF	0.8±0.05	0.72±0.17	0.85± 0.14	0.87
PCA	0.87±0.04	0.96±0.03	0.86±0.04	0.9
EfPCA Ortiz et al. (2018)	0.93±0.05	0.97±0.08	0.88±0.05	0.94
LeNet-based	**0.95± 0.03**	**0.94 ± 0.04**	**0.95±0.04**	**0.97**
AlexNet-based	**0.95± 0.03**	**0.95± 0.05**	**0.95± 0.04**	**0.97**

Conclusions

- We propose the use of isosurfaces instead of raw voxels to model the striatum using DaTSCAN imaging
- Isosurfaces computed are classified using a 3D convolutional neural network
- Two different approaches have been considered:
  - Classification using a single isosurface, using a single-channel CNN
  - Classification using a several isosurfaces, using a multi-channel CNN
- We explored the effect of the threshold used to compute the isosurfaces, which determines the volume enclosed.
- The results obtained demonstrated that isosurfaces provide discriminative enough information, providing AUC values up to 0.97.

Thank you for your attention!
Questions?