I[123]FP-CIT SPECT brain imaging for Parkinson's diagnosis using contour lines

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Introduction

Parkinson's disease (PD) is a degenerative disorder affecting the motor system. PD causes death of brain cells in some regions of the brain, resulting in a loss of dopamine in some areas. As [123I]FP-CIT SPECT (DaTSCAN) radiotracer binds in dopamine transporters in the striatal area, low intensity levels in the striatum are related with PD [1,2].

Objective: In this work, we have focused on the shape of the striatum as a feature to perform classification of a database including Healthy Normal Controls (NC) and PD patients.

Limitation: The specific region in these images is usually very small (the striatal area) compared to the whole brain volume. Moreover, in this study, the database has very low resolution (a pixel dimension of 3,29 mm which yields to a voxel volume of 3,29^3 mm^3). For this reason, a voxel-based morphometry strategy could possibly fail to delineate the shape of the striatum. It is difficult to perform a study of the shape of a very small area (the striatum) using the information provided by a image with this voxel volume.

Idea: In order to surmount this problem, we propose a method to extract features from [123I]FP-CIT SPECT images based in the use of contour lines: a 2D curve joining points in the image with equal intensity values. Thus, the shape of the functional brain regions are not limited to a voxel. A contour line can define a region including a fraction of a voxel.

Materials & Methods

A total of 147 images were obtained after a period of 3-4 h following the intravenous injection of 185 MBq (5 mCi) of I[123]-FP-CIT, after the thyroid was blocked with Lugol's solution. The dimension of the resulting images was 128×128×60. Images were labelled by a committee of trained experts from the Hospital Virgen de las Nieves in Granada (Spain). Resulting in 88 NC and 59 PD.

1. Image Preprocessing

The intensity of the images has been normalized by the ratio of the intensity value in each voxel to the average of the intensity in the non-specific region (occipital region). Thus, calculating the specific binding ratio.

2. Contour lines

Firstly, from each of the 147 3D images in the database, we project the maximum in each transaxial slide to a 2D brain image. Secondly, we also project the maximum in the coronal slide. Thus, the database under study will consists in 2×147 2D images.

Fig. 1 depicts the contour lines and intensity values of the [NC | PD] mean Axial Image and mean Coronal Image. There, it can be easily noticed that the specific region is only the striatal area. This figure also shows the main differences between the average NC and PD images: The intensity values is lower in the striatum and the shape of the striatal area is rounder and smaller for PD images.

Using the information provided by the projections, we estimate the intensity value that delineate the left and right striatum area. These values will be our intensity reference for a given image. Once this value has been calculated, we choose 4 different equally spaced increasing intensity values up to the maximum intensity value in the left and right striatum area. Thus, finally we obtain 4 contour lines in the striatum.

3. Feature extraction

We perform the feature extraction using the information provided by the 4 contour lines calculated in the striatum for each hemisphere in the brain and the two 2D images considered: the transaxial and coronal projections. The list of features calculated includes: the area of each contour line, the perimeter, the roundness measured as the area divided by the square of the perimeter, the intensity level of each contour line, the position of the center of each contour line and the distance between contours in the left and right hemisphere. In addition we also measure the differences in area, roundness, perimeter and intensity between a contour line and the adjacent to this one. Lastly, the minimum, maximum and mean level of each feature extracted for each hemisphere is also calculated.

4. SVM Classification

We perform the classification task using Support Vector Machines (SVM) with linear kernel. In addition, the performance of the classification is calculated using a leave-one-out cross validation strategy.

Results & Discussion

Fig. 2 shows the correct rate, sensitivity and specificity when we combine different number of ranked features for the projected transaxial image. We can easily noticed that the performance of the classification method is improved concomitantly with the number of features until we select 24 features where we obtain a maximum correct rate value of 92.5%.

A similar result is obtained when we test the proposed methodology using the projected coronal image. In that case, the performance of the classification method is improved concomitantly with the number of features until we use the 23 most significative features where we obtain a maximum correct rate value of 91.16%.

The most relevant features are those related with the intensity values (mainly features ranked #1 to #10). Nevertheless, Fig. 2 show that the performance of the classification task is increased when we include also the features which are related with the shape of the contour lines (features ranked #11 to #30).

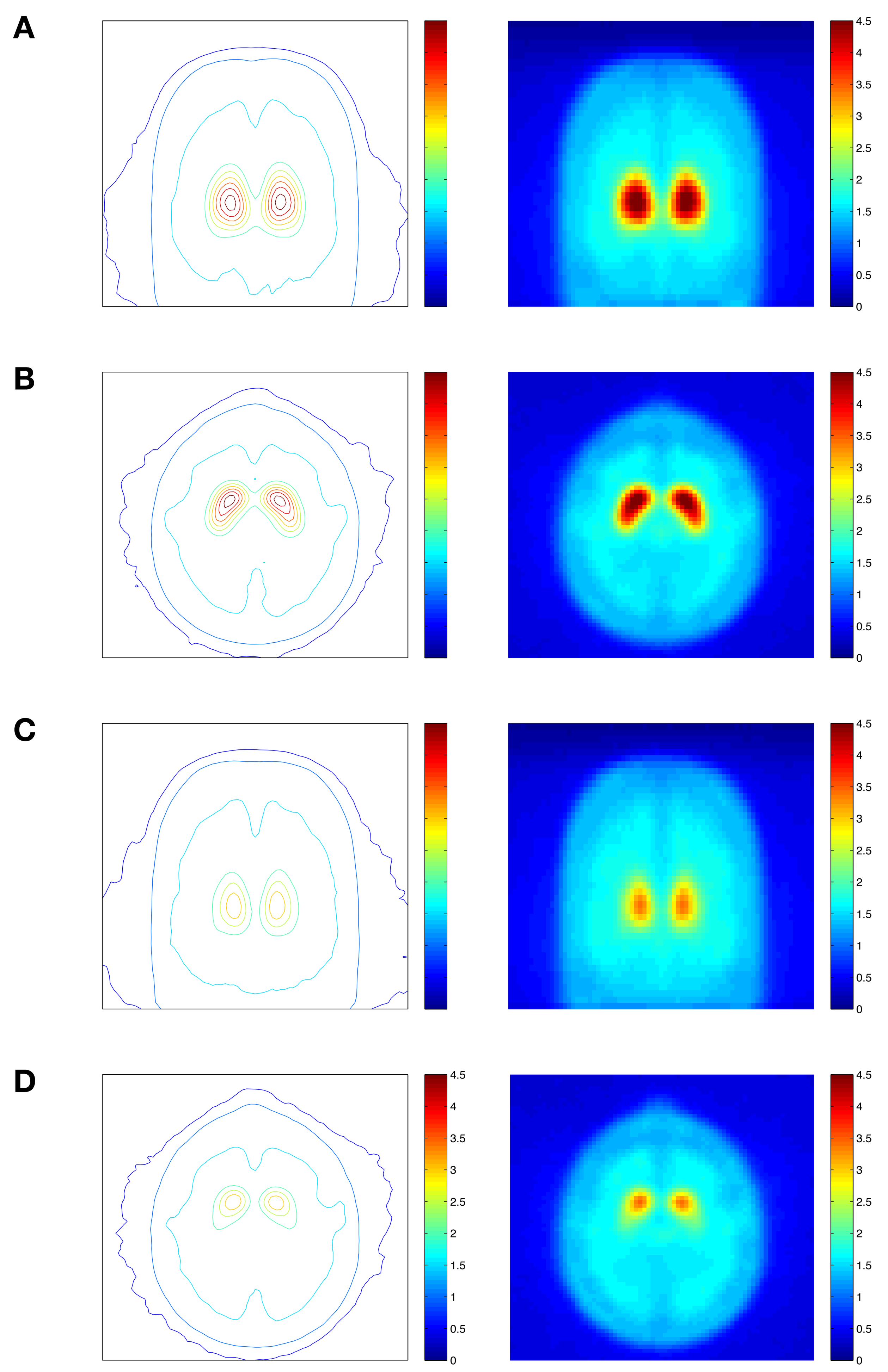

Figure 1 - Contour lines (left column) and intensity values (right column) of mean NC and PD subjects.
A: NC coronal view, B: NC axial view, C: PD coronal view, D: PD axial view.

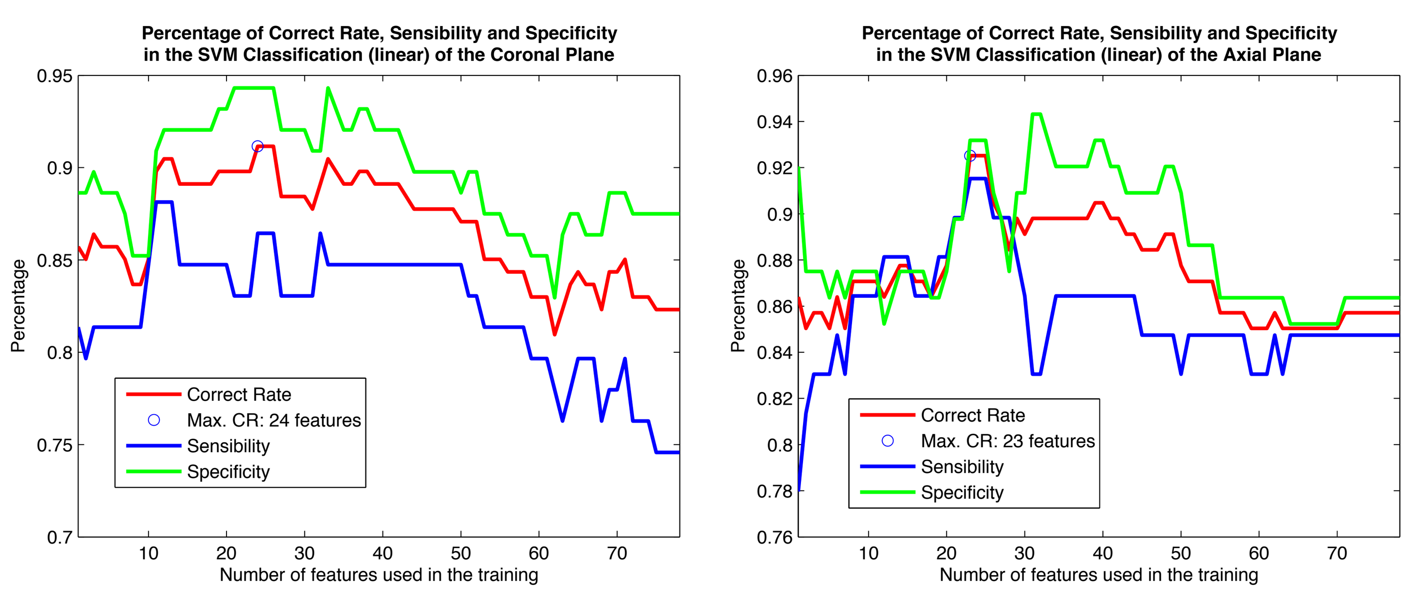

Figure 2 - Classification performance versus number of features.
Left: Coronal, Right: Axial

Conclusions

In this work, we propose a feature extraction method for the implementation of a Computer-Aided-Diagnosis (CAD) system to perform the classification of a database NC and PD patients. We extract features from [123I]FP-CIT SPECT images using contour lines. Thus, the shape of the functional brain regions are not limited to a voxel. The proposed methodology is tested in a set of 147 brain images. The performance results show that the inclusion of shape-based features improve the classification task compared with the case where only intensity-values features are used.

References

[1] R. A. Hauser and D. G. Grosset, "[123I]FP-CIT (DaTSCAN) SPECT brain imaging in patients with suspected parkinsonian syndromes," *Journal of Neuroimaging*, vol. 22, no. 3, pp. 225–230, 2011.

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