An automatic protocol to detect the fed and fasted brain using multivariate analysis of diffusion weighted data sets

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Introduction

The automatic classification of medical images into different pathological categories is currently an active area of research. In the context of functional neuroimaging, a variety of techniques allow for the automatic analysis of the acquired images, the most popular being Statistical Parametric Mapping (SPM) [1]. It is aimed at the generation of parametric maps which are able to reveal specific cerebral activation events as obtained by functional imaging methods. However, SPM requires extensive pre-processing of images in order to perform the statistical analysis, in many cases involving the intervention of an expert. Moreover, it does not directly solve the problem of classifying images into pathological categories, but it just identifies local areas probably related to the case of interest or pathology. In this work, we propose a new technique that is able to resolve, directly, the classification of images into two different classes without the need of a pre-processing stage, and illustrate the performance of the method with the classification of diffusion weighted MR images from the brain of fed and fasted mice. Using a collection of diffusion weighted images (DWI), it became possible to ascribe the images to a fed or fasted animal in 100% of the cases.

Materials and Methods

We used a set of mouse brain diffusion weighted images (11 b values) obtained by MR. A total of 8 mice were investigated. For each mouse, axial images containing the hypothalamus were obtained in the two conditions of interest: fed and fasted. In both conditions, DWI were acquired with the diffusion gradient oriented in three orthogonal directions (left-right L-R, anterior-posterior A-P and head-foot H-F). DWI were acquired using a spin-echo Stejskal-Tanner sequence [2], with an in plane resolution of 128 x 128 pixels, every pixel being described by a 33 component vector representing intensity values along each of the three orthogonal directions. Fisher's discriminant analysis [3] was then applied to the data set in order to find the linear projection that best discriminates the pixels as belonging to a fed or fasted animal. The discriminant function so obtained may be used later to classify additional data into one of the two classes.

Results and Discussion

Fisher's projection can be interpreted as an "appetite index", a numerical value that allows classification between two possible classes (fed and fasted). Histograms of the appetite index were drawn for each animal and parameter maps of pixels with the extreme appetite index values (5% of the points at each end of the histogram of each mouse) were represented superimposed to anatomical images (Fig 1, right). The histogram of appetite index values from an animal may be used to decide if the animal is fed or fasted, since the histogram from fed and fasted animals are different. We used a leave-one-out strategy [3] to estimate the accuracy of the predictions in mice not used for constructing the classifier. Using this method, we were able to classify correctly the images of all mice between the fed or fasted classes, resulting in 100% correct classifications.

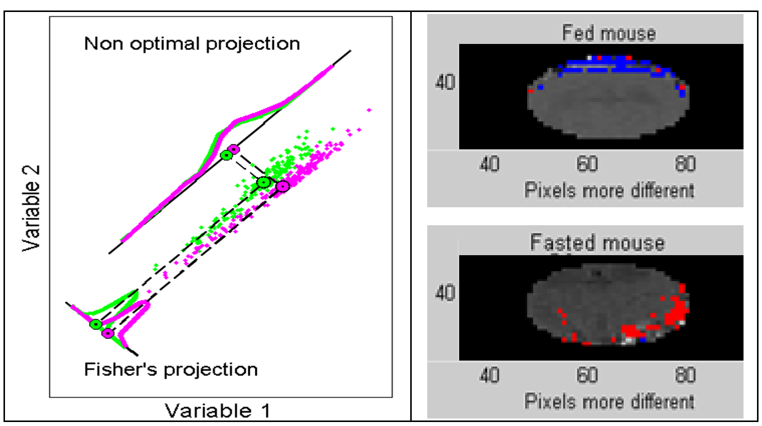

Figure 1. Left: Representative example of Fisher's analysis when only two variables (1 and 2) are considered for each pixel. The mass center of each class (fed-green dots/fasted-purple dots) and their corresponding projections are represented by circles. Note that the Fischer projection ("appetite index") provides the optimal separation between the fed and fasted classes, while a non optimal projection is unable to separate them appropriately. Right: representative "appetite index" images from the brain of fed (blue pixels) or fasted (red pixels) mice.

Conclusion

We present a model to automatically classify DWI of mouse brain between fed and fasted states, with 100% success without any pre-processing of the images. The absence of pre-processing steps avoids the possibility to introduce information previously not present in the original image and favors an automatic unbiased interpretation. The approach outlined here may be useful in the investigation of the cerebral causes of obesity and its treatments and could extend to an automated diagnostic imaging system for eating disorders, provided an adequate training database is obtained.

Reference

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