“Detecting brain damage using structure density, structure thickness, and vector deformations”

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Our motivation is to detect regions of brain damage in a sample of 19 non-missile brain trauma patients by comparing their brain shapes to a sample of 19 age and sex matched controls. We analyse three types of data for detecting structure change in general. Structure density is modeled as a smoothed binary image (1 inside, 0 outside the structure) and logistic regression is used to assess structure change related to a set of covariates (here trauma versus control). Cortical thickness is analysed using linear regression at each point on the cortical surface, a 2D manifold embedded in 3D. Deformation vectors required to warp the structure to an atlas standard also convey shape information. These are analysed using a trivariate linear model and changes in shape are detected using a Hotelling's T^2 statistic. Extending this further, we look at correlations between all pairs of voxels, which can be used to assess brain structual connectivity. Shape data is highly non-isotropic, that is, the effective smoothness is not constant across the image, so the usual random field theory does not apply. We propose a solution that warps the data to isotropy using local multidimensional scaling. We then show that the subsequent corrections to the random field theory can be done without actually doing the warping – a result guaranteed in part by the famous Nash Embedding Theorem.