# Statistical Analysis of fMRI Data

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**Abstract**

There are some fascinating statistical problems with fMRI data both at the practical and theoretical level. The data itself is a time series at every one of up to 100,000 voxels in 3D space. An external stimulus, such as a cognitive task, is given to he subject during the course of the experiment, so design is an important issue. Since the experiment is repeated over subjects, random effects must be considered. To keep down computation time, only simple models and methods are feasible. The final result is a 3D image of effects, standard errors, and $T$ statistics for a contrast in the stimulus. However the most challenging theoretical problem is how to interpret images of test statistics. Here concepts from differential topology, integral geometry and random fields are important. The Euler characteristic of the (random) excursion set of the $T$ statistic image, first introduced by Robert Adler, plays a vital role in determining which regions of the brain are 'activated' by the stimulus. Recent results of David Siegmund, Jiayang Sun, Satoshi Kuriki, Akemichi Takemura and Jonathan Taylor link this to the volume of tubes and Steiner's formula. Thus brain mapping data is a fascinating blend of mathematics and statistics, with applications beyond neuroscience to other areas such as astrophysics.