Outlier Detection in FMRI Time Series

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Goal: Find outliers (wild points) in FMRI time series data.

Synopsis: Compute range of "usual" values, then find values outside this range.

Step 1: Compute median $m(\mathbf{x})$ of each voxel time series $v(\mathbf{x},t)$.

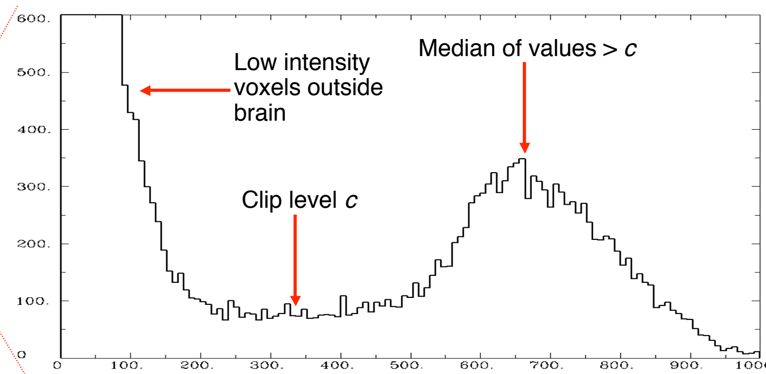
⇒ This provides the middle of the "usual" range for each voxel **x**.

We use the median and median-absolute-deviation (MAD) statistics instead of mean and standard-deviation to prevent contamination by a few outliers.

Step 2: Calculate clip level c such that

$c = 0.5 \cdot \text{median}\{m(\mathbf{x}) : m > c\}$.

⇒ From now on, ignore voxels with $m(\mathbf{x}) < c$ [as being too small and outside the brain].



Step 3: For each voxel time series, compute the median-absolute- deviation:

$\text{MAD}(\mathbf{x}) = \text{median}_t\{|v(\mathbf{x},t) - m(\mathbf{x})|\}$.

Step 4: The "usual" range in each voxel **x** is

$[m(\mathbf{x}) - a \cdot \text{MAD}(\mathbf{x}),\ m(\mathbf{x}) + a \cdot \text{MAD}(\mathbf{x})]$

where $a = Q^{-1}(0.01/N) \cdot \sqrt{(\pi/2)}$

Q()=reversed Gaussian cdf

N=length of time series

- If the noise is Gaussian, then $\text{MAD} = \sigma \cdot \sqrt{(2/\pi)}$.
- A standard $N(0,1)$ Gaussian will exceed $Q^{-1}(p)$ with probability p.
- The threshold $p = 0.01/N$ is chosen so that relatively few points will be counted as outliers if the noise is Gaussian.

Step 5: For each time t, the number of outlying voxels $n(t)$ is counted at all brain voxels **x** (defined as in Step 2).

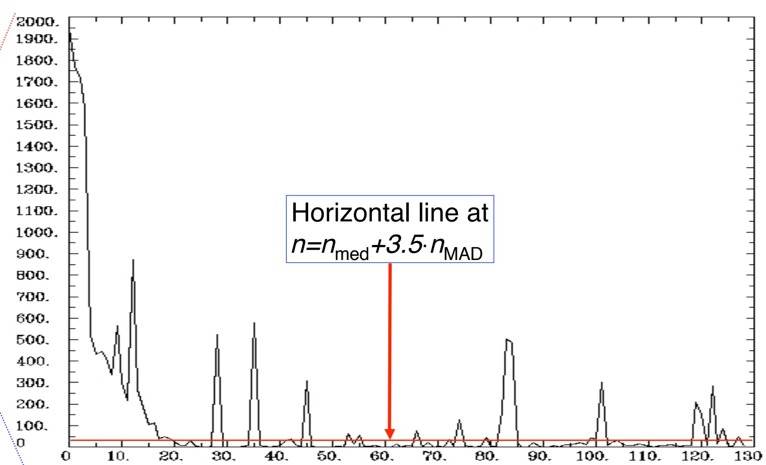
Step 6: The median n_{med} and MAD n_{MAD} of $n(t)$ are calculated.

⇒ Any t with $n(t) > n_{med} + 3.5 \cdot n_{MAD}$ is flagged as having an unusual number of outliers.

Example: Large counts at start are due to equilibration of M_z.

⇒ Spikes past $t = 20$ were due to intermittent problems with the RF system.

⇒ **This hardware problem was discovered due to the outlier detection process**.



Extension: Look for outliers in $\partial v(\mathbf{x},t)/\partial t$ as well.

Software: Now incorporated into ***AFNI*** package: http://afni.nimh.nih.gov/afni