EEGLAB Bad Electrode Detection

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1 Joint Probability

1.1 Wrapper Function

1.2 Actual Function

1.3 Histogram Binning Function

Algorithm 1 jointprob: wrapper function to apply joint probability detection for EEGLAB function across the dataset.

Input: $INEEG \in \mathbb{R}^{C \times T \times N}$ input EEG data, C = number of channels, N = number of timepoints, T = number of trials. **NOTE:** the EEGLAB EEG object has other metadata objects attached to it

Input: $icacomp \in [1|0]$, which type of data to run on: 1 = electrode data, 0 = ICA component activations. 1 is default

Input: $elecrange \in \mathbb{R}^{j \leq C}$, which electrodes to inspect for rejections

Input: $locthresh \in \mathbb{R}$, threshold for single electrode inspection

Input: $globthresh \in \mathbb{R}$, threshold for all electrode detection

Input: *superpose* and *reject*, other extra variables in EEGLAB that aren't relevant to the algo

Output: $OUTEEG \in \mathbb{R}^{C \times N \times T}$ output EEG data, C = number of channels, N = number of timepoints, T = number of trials. The **metadata has been updated, not the actual data**.

procedure POP_JOINTPROB($INEEG$, $icacomp$, $elecrange$, $locthresh$, $globthresh$)
  if $icacomp == 0$ **then** ▷ If running on ICA components
    Prompt running ICA on $INEEG$ if not run yet
  if $icacomp == 1$ **then**
    $tmpdata = strip\_metadata(INEEG)$
    if $empty(INEEG.jpE)$ **then** ▷ If joint prob hasn't been done before
      This is for joint prob across each individual electrode
      $INEEG.jpE, rejE = jointprob(tmpdata, locthresh, EEG.stats.jpE, 1)$ ▷ Run it, get the prob distributions and the rejected electrodes
    This is for joint prob across all electrodes
    $tmpdata2 = permute(tmpdata, [312])$ ▷ switch the order of the dimensions to $T \times C \times N$
    $tmpdata2 = reshape(tmpdata2, size(tmpdata2, 1),$
      $size(tmpdata2, 2) * size(tmpdata2, 3))$ ▷ combine into 2D $T \times (C \times N)$
    $INEEG.jp, rej = jointprob(tmpdata, globthresh, EEG.stats.jp, 1)$ ▷ Run it, get the prob distributions and the rejected electrodes
  return (return nothing, EEG was directly modified)

Algorithm 2 jointprob: histogram binning implementation of joint probability function.

Input: $S \in \mathbb{R}^{C\times T\times N}$, $\mathbb{R}^{T\times N}$, $\mathbb{R}^{N}$, S = signal, C = number of channels, N = number of timepoints, T = number of trials.

Input: $threshold \in \mathbb{R}$, Absolute threshold. If normalization is used then the threshold is expressed in standard deviation of the mean. 0 means no threshold.

Input: $oldjp \in \mathbb{R}^{C\times T}$, pre-computed joint probability (only perform thresholding). Default is the empty array [].

Input: $normalize \in [0|1|2]$, 0 = do not not normalize entropy. 1 = normalize entropy. 2 is 20% trimming (10% low and 10% high) proba. before normalizing. Default is 0.

Input: $discret \in \mathbb{R}$, discretization variable for calculation of the discrete probability density. Default is 1000 points.

Output: $jp \in \mathbb{R}^{C\times T}$, normalized joint probability of the single trials

Output: $rej \in \mathbb{R}^{C\times T}$, Only 1's and 0's, all rejected electrodes per trial

1: **procedure** JOINTPROB(S, $threshold$, jp, $normalize$, $discret$)
2: $jp = \text{zeros}(C, T)$
3: **if** exists($oldjp$) **then**
4: $jp = oldjp$
5: **else**
6: **for** $c = 1 : C$ **do** ▷ Compute Density Function
7: $prob, dist = \text{realproba}(S(c,:), discret)$
8: **for** $t = 1 : T$ **do** ▷ Compute Density Function
9: $tmp = prob((t-1)\times n + 1, t \times n + 1)$
10: $jp(c, t) = -\sum(\log(tmp))$ ▷ log-likelihood
11: $tmpjp = jp$
12: **if** normalize == 2 **then**
13: $tmpjp = \text{sort}(jp)$
14: $tmpjp = tmpjp(\text{round}(\text{length}(tmpjp) \times 0.1)\text{:end-round}(\text{length}(tmpjp) \times 0.1))$
15: **if** ndims(S) = 2 **then**
16: $$jp = \frac{jp - \frac{1}{C\times T}\sum tmpjp}{\sigma(tmpjp)}$$
17: **if** ndims(S) = 3 **then**
18: $$\frac{jp - \frac{1}{C\times T}\sum tmpjp \times \text{ones}(1, \text{size}(jp, 2))}{\sigma(tmpjp, 0, 2) \times \text{ones}(1, \text{size}(jp, 2))}$$
19: **if** length(threshold) ¿ 1 **then**
20: $rej = (threshold(1) > jp)|(jp > threshold(2))$
21: **else**
22: $rej = \text{abs}(jp) > threshold$

Algorithm 3 realproba: compute the effective probability of the value in the sample.

Input: $D \in \mathbb{R}^{T \times N}$, D = data, N = number of timepoints, T = number of trials.
Input: $b \in \mathbb{R}$, number of bins divided in histogram
Output: $P \in \mathbb{R}^{C \times T}$, normalized joint probability of the single trials
Output: $P_{dist} \in \mathbb{R}^{C \times T}$, Only 1's and 0's, all rejected electrodes per trial

procedure REALPROBA(D, b)
    $M = T \times N$ ▷ size = trials x time
    zeros(1 dimension, b)
    $min = \min(D)$
    $max = \max(D)$
    $D = \text{floor}(\frac{D-min}{max-min} \times (b-1)) + 1$
    for $i = 1 : M$ **do**
        $P_{dist}(D(i)) = P_{dist}(D(i)) + 1$
    $P = \frac{P_{dist}(D)}{M}$
    $P_{dist} = \frac{P_{dist}(D)}{M}$