EE6024 Engineering Machine Learning Solutions

EEG Frequency Domain Features

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Periodogram of an Epoch

- The EEG is split into 8s epochs with 50% overlap between epochs.
- Thus each epoch consists of $N = 256$ samples $x(0) \dots x(255)$
- Use DFT to calculate the periodogram.

$$p_i = \frac{1}{N} \left| \sum_{n=0}^{N-1} x(n) e^{\frac{-\jmath 2\pi n k}{N}} \right|^2 : i = 0, 1, 2, \cdots, N-1$$

Intensity Weighted Mean Frequency

- Intensity Weighted Mean Frequency f_m

$$f_m = \frac{\sum_{i=0}^{\frac{N}{2}-1} p_i i df}{\sum_{i=0}^{\frac{N}{2}-1} p_i}$$

- where i is the frequency bin number, with $i = 0 \ldots \frac{N}{2} - 1$, p_i the estimated power in that bin and df is

$$df = \frac{F_s}{N}$$

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Intensity Weighted Bandwidth

- Intensity Weighted Bandwidth bw

$$bw = \sqrt{\frac{\sum_{i=0}^{\frac{N}{2}-1} p_i (f_m - idf)^2}{\sum_{i=0}^{\frac{N}{2}-1} p_i}}$$

- where i is the frequency bin number, with $i = 0 \ldots \frac{N}{2} - 1$, p_i the estimated power in that bin and f_m is Intensity Weighted Mean Frequency for the same epoch.

Total Power

- The total power tp is given by

$$tp = \sum_{i=0}^{\frac{N}{2}-1} p_i$$

- where i is the frequency bin number, with $i = 0 \ldots \frac{N}{2} - 1$, p_i the estimated power in that bin.
- The bins represent frequency content from $0 - 16$Hz as $f_s = 32$
- However as the EEG has been bandpass filtered from $0.5 - 13$Hz you may wish to exclude those bins from the total power calculation.
- Exclude bins 0-4 and bin 104-127.
- Probably not relevant.

Peak Frequency

- Peak Frequency is defined as the frequency with the maximum power.

$$pf = \frac{F_s \times i}{N} \text{ where } \max(p_i)$$

- Simple Routine

```
k=0
max = p_0
For(i=1,i<128,i++)
        If p_i >max then
                k = i
                max = p_i
pf = (k) 32/256
```

Spectral Edge Frequency

- Spectral Edge Frequency (SEF) is defined as the frequency below which 90% of the total power tp in the signal exists.
- Simple Routine

```
sef90=0
i=0
While sef < 0.9 tp then
        sef = sef + p_i
        i++
sef90 = (i-1) 32/256
```

- Can repeat for SEF95 (95% total power) and SEF85 (80% total power)

Power in Specific Frequency Bands

- The total power in a particular frequency band can also be used as a feature.
- Divide the Spectrum from $0 - 13$Hz into bands of $2Hz$, ie. $0 - 2$Hz, $1 - 3$Hz, $2 - 4$Hz, ...
- 8 frequency bins give 1Hz so the features are

$$\text{band02} = \sum_{i=0}^{15} p_i, \text{band13} = \sum_{i=7}^{23} p_i, \ldots, \text{band1012} = \sum_{i=80}^{103} p_i$$

- Could also use Normalised frequency band power

$$\text{Nband02} = \frac{\text{band02}}{tp}$$