EE6024 Engineering Machine Learning Solutions

EEG Time Domain Features

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Epoch

- An Epoch of EEG consists of N values.
- Depending on the programming language used the index for the Epoch can vary.
- For example it can be from 1 to N ie. $x(1)$ to $x(N)$
- in Python the index of a list starts at 0.
- Therefore the Epoch index is from 0 to $N-1$, ie. $x(0)$ to $x(N-1)$

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Time Domain Features I

- Line Length

$$L = \sum_{i=0}^{N-2} |x(i+1) - x(i)|$$

- Root Mean Squared Amplitude

$$A = \sqrt{\frac{1}{N} \sum_{i=0}^{N-1} x^2(k)}$$

- Non Linear Energy

$$NLE = \frac{1}{N-2} \sum_{k=1}^{N-1} \left(x^2(k) - x(k-1) \times x(k+1) \right)$$

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Hjorth Parameters

- 1st Hjorth Parameter is Activity.
- Need to calculate the mean μ of the Epoch

$$\mu = \frac{1}{N}\sum_{k=0}^{N-1} x(k)$$

- Activity is given by the Variance (σ_x^2) of the Epoch

$$activity = \sigma_x^2 = \frac{1}{N}\sum_{k=0}^{N-1} (x(k) - \mu)^2$$

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2nd Hjorth Parameter: Mobility

- First derivative of the Epoch using a first difference differentiator:

$$\frac{d(x(n))}{n} = x_{\triangle}(n) = x(n+1) - x(n)$$

- Mean of first derivative

$$\mu_{\triangle} = \frac{1}{N-1} \sum_{k=0}^{N-2} x_{\triangle}(k)$$

- Variance of first derivative

$$\sigma_{\triangle}^2 = \frac{1}{N-1} \sum_{k=0}^{N-2} (x_{\triangle}(k) - \mu_{\triangle})^2$$

- Mobility

$$mobility = \sqrt{\frac{\sigma_{\triangle}^2}{activity}} = \sqrt{\frac{\sigma_{\triangle}^2}{\sigma_x^2}}$$

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3rd Hjorth Parameter: Complexity

- Second derivative of the Epoch using a first difference differentiator:

$$\frac{d^2(x(n))}{n^2} = x_{\triangle^2}(n) = x_{\triangle}(n+1) - x_{\triangle}(n)$$

- Mean of second derivative

$$\mu_{\triangle^2} = \frac{1}{N-2}\sum_{k=0}^{N-3} x_{\triangle^2}(k)$$

- Variance of second derivative

$$\sigma^2_{\triangle^2} = \frac{1}{N-2}\sum_{k=0}^{N-3} \left(x_{\triangle^2}(k) - \mu_{\triangle^2}\right)^2$$

- Complexity

$$complexity = \frac{\sqrt{\frac{\sigma^2_{\triangle^2}}{\sigma^2_{\triangle}}}}{\sqrt{\frac{\sigma^2_{\triangle}}{activity}}} = \frac{\sqrt{\frac{\sigma^2_{\triangle^2}}{\sigma^2_{\triangle}}}}{\sqrt{\frac{\sigma^2_{\triangle}}{\sigma^2_{x}}}} = \frac{\sqrt{\sigma^2_{\triangle^2}}}{\sqrt{\sigma^2_{x}}}$$

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