Tampere University

ICPR 2020

AARHUS UNIVERSITY

Data Normalization for Bilinear Structures in High-Frequency Financial Time-series

temporal mode

Input series

$\mathbf{X}^{(i)}$

spatial mode

$\mathbf{x}_1^{(i)}(1)$

$\mathbf{x}_1^{(i)}(d)$

$\mathbf{x}_1^{(i)}(D)$

$$\bar{\mathbf{x}}_1^{(i)} = \mathrm{mean}\big(\mathbf{x}_1^{(i)}(d)\big), \forall d = 1, \ldots, D$$

$$\sigma_1^{(i)} = \mathrm{std}\big(\mathbf{x}_1^{(i)}(d)\big), \forall d = 1, \ldots, D$$

$$\mathbf{Z}_1^{(i)} = \big(\mathbf{X}^{(i)} - \mathbf{1}_D(\bar{\mathbf{x}}_1^{(i)})^{\mathrm{T}}\big)\big(\mathbf{1}_D(\sigma_2^{(i)})^{\mathrm{T}}\big)$$

$$\tilde{\mathbf{X}}_1^{(i)} = \big(\mathbf{1}_D\gamma_1^{\mathrm{T}}\big) \odot \mathbf{Z}_1^{(i)} + \mathbf{1}_D\beta_1^{\mathrm{T}}$$

spatial mode normalization

$\mathbf{x}_2^{(i)}(1)$ $\mathbf{x}_2^{(i)}(t)$ $\mathbf{x}_2^{(i)}(T)$

$$\bar{\mathbf{x}}_2^{(i)} = \mathrm{mean}\big(\mathbf{x}_2^{(i)}(t)\big), \forall t = 1, \ldots, T$$

$$\sigma_2^{(i)} = \mathrm{std}\big(\mathbf{x}_2^{(i)}(t)\big), \forall t = 1, \ldots, T$$

$$\mathbf{Z}_2^{(i)} = \big(\mathbf{X}^{(i)} - \bar{\mathbf{x}}_2^{(i)}\mathbf{1}_T^{\mathrm{T}}\big)\big(\sigma_2^{(i)}\mathbf{1}_T^{\mathrm{T}}\big)$$

$$\tilde{\mathbf{X}}_2^{(i)} = \big(\gamma_2\mathbf{1}_T^{\mathrm{T}}\big) \odot \mathbf{Z}_2^{(i)} + \beta_2\mathbf{1}_T^{\mathrm{T}}$$

temporal mode normalization

$$\tilde{\mathbf{X}}^{(i)} = \lambda_1\tilde{\mathbf{X}}_1^{(i)} + \lambda_2\tilde{\mathbf{X}}_2^{(i)}$$

normalized series

Learnable Parameters via SGD: $\gamma_1, \beta_1, \gamma_2, \beta_2, \lambda_1, \lambda_2$