Output: Estimated signal tensor $\hat{\Theta} \in \mathbb{R}^{d_1 \times \cdots \times d_K}$. 1: for $\pi \in \mathcal{H} = \{-1, \dots, -\frac{1}{H}, 0, \frac{1}{H}, \dots, 1\}$ do Estimate sign tensor $\operatorname{sgn}(\mathcal{Z}_{\pi})$ by performing weighted classification using sub-algorithm. 3: end for 4: Return estimated tensor $\hat{\Theta} = \frac{1}{2H + 1} \sum_{\pi \in \mathcal{U}} \operatorname{sgn}(\mathcal{Z}_{\pi})$.

Sub-algorithm: Sign tensor estimation using weighted classification

Algorithm 1 Nonparametric tensor completion **Input:** Noisy and incomplete data tensor \mathcal{Y}_{Ω} , rank r.

end for

11: end while

10:

Input: Noisy and incomplete data tensor \mathcal{Y}_{Ω} , rank r, target level π .

tput: Sign tensor
$$\text{sgn}(\mathcal{Z}) \in \{-1, 1\}^{d_1 \times \cdots \times d_K}$$
 as the estimation of s

Output: Sign tensor $\operatorname{sgn}(\mathcal{Z}) \in \{-1,1\}^{d_1 \times \cdots \times d_K}$ as the estimation of $\operatorname{sgn}(\Theta - \pi)$.

Example 1. Sign tensor
$$\operatorname{sgn}(\mathcal{Z}) \in \{-1,1\}^{d+1}$$
 as the estimation of support $A_{k+1} = [a^{(k)}] \in \mathbb{R}^{d_k}$

Random initialization of tensor factors
$$\boldsymbol{A}_k = [\boldsymbol{a}_1^{(k)}, \dots, \boldsymbol{a}_r^{(k)}] \in \mathbb{R}^{d_k}$$

5: Random initialization of tensor factors
$$A_k = [a_1^{-1}, \dots, a_r^{-1}] \in \mathbb{R}^{n-k-1}$$
 for all $k \in [K]$.
6: Normalize columns of A_k to have unit-norm for $k \in [K-1]$, and absorb the scales into the columns of A_K .

5: Random initialization of tensor factors $\mathbf{A}_k = [\mathbf{a}_1^{(k)}, \dots, \mathbf{a}_r^{(k)}] \in \mathbb{R}^{d_k \times r}$ for all $k \in [K]$.

: Normalize columns of
$$A_k$$
 to have unit-norm for $k \in [K-1]$, and absorb the scales into the columns of A_K .
: while not convergence do

rmalize columns of
$$A_k$$
 to have unit-norm for $k \in [K-1]$, and absorb the scales into the columns of

7: **while** not convergence **do**

: **while** not convergence **do**
: **for**
$$k = 1, ..., K$$
 do

while not convergence do

for
$$k = 1$$
 K do

for
$$k = 1, ..., K$$
 do

Underto A_k , while holding others fixed: $A_k \leftarrow \arg\min_{x \in A_k} \sum_{x \in A_k} |\mathcal{V}(x)| = \pi |F(\mathcal{F}(x)) \operatorname{sgn}(\mathcal{V}(x))| = \pi |F(\mathcal{F}(x)) \operatorname{sgn}$

for
$$k = 1, \dots, K$$
 do

Update
$$A_k$$
 while holding others fixed: $A_k \leftarrow \arg\min_{A_k \in \mathbb{R}^{d_k \times r}} \sum_{\omega \in \Omega} |\mathcal{V}(\omega) - \pi| F(\mathcal{Z}(\omega) \operatorname{sgn}(\mathcal{V}(\omega) - \omega))$

Update
$$\mathbf{A}_k$$
 while holding others fixed: $\mathbf{A}_k \leftarrow \arg\min_{\mathbf{A}_k \in \mathbb{R}^{d_k \times r}} \sum_{\omega \in \Omega} |\mathcal{Y}(\omega) - \pi| F(\mathcal{Z}(\omega) \operatorname{sgn}(\mathcal{Y}(\omega) - \pi))$

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$$A_k$$
 while holding others fixed: $A_k \leftarrow \arg\min_{A_k \in \mathbb{R}^{d_k \times r}} \sum_{\omega \in \Omega} |\mathcal{Y}(\omega) - \pi| F(\mathcal{Z}(\omega) \operatorname{sgn}(\mathcal{Y}(\omega) - \pi)),$

9: Update
$$A_k$$
 while holding others fixed: $A_k \leftarrow \underset{(1)}{\operatorname{arg min}} A_k \in \mathbb{R}^{d_k \times r} \sum_{\omega \in \Omega} |\mathcal{Y}(\omega) - \pi| F(\mathcal{Z}(\omega) \operatorname{sgn}(\mathcal{Y}(\omega) - \pi))$

: Update
$$A_k$$
 while holding others fixed: $A_k \leftarrow \underset{(K)}{\operatorname{arg min}} A_{k \in \mathbb{R}^{d_k \times r}} \sum_{\omega \in \Omega} |\mathcal{Y}(\omega) - \pi| F(\mathcal{Z}(\omega) \operatorname{sgn}(\mathcal{Y}(\omega) - \pi))$

options
$$T(x)$$
 is the least specific and $T(x)$ and $T(x)$ and $T(x)$ and $T(x)$ and $T(x)$ and $T(x)$ are $T(x)$ are $T(x)$ are $T(x)$ and $T(x)$ are $T(x)$ are $T(x)$ and $T(x)$ are T

where
$$F(\cdot)$$
 is the large-margin loss and $\mathcal{Z} = \sum_{k \in \mathcal{X}} \mathbf{a}_{k}^{(1)} \otimes \cdots \otimes \mathbf{a}_{k}^{(K)}$

where
$$F(\cdot)$$
 is the large-margin loss and $\mathcal{Z} = \sum_{K \in \mathcal{X}} \mathbf{a}_{c}^{(K)} \otimes \cdots \otimes \mathbf{a}_{c}^{(K)}$

where $F(\cdot)$ is the large-margin loss, and $\mathcal{Z} = \sum_{s \in [r]} \mathbf{a}_s^{(1)} \otimes \cdots \otimes \mathbf{a}_s^{(K)}$.