
Algorithm 1 Iterative Reweighted Algorithm (IRWA) Pseudo-code

Require: Hessian matrix $H \in \mathbb{R}^{n \times n}$

Gradient vector $g \in \mathbb{R}^n$

Constraint matrix $AE \in \mathbb{R}^{m_1 \times n}$ and vector $bE \in \mathbb{R}^{m_1}$

Constraint matrix $AI \in \mathbb{R}^{m_2 \times n}$ and vector $bI \in \mathbb{R}^{m_2}$

Initial ϵ vector $\epsilon_{\text{init}} \in \mathbb{R}^{m_1+m_2}$

Initial solution vector $x_{\text{init}} \in \mathbb{R}^n$

Parameters $\eta = 0.95$, $\gamma = \frac{1}{6}$, $M = 10\,000$

Tolerances $\sigma = 10^{-4}$, $\sigma' = 10^{-8}$

Maximum iterations $\text{max_iter} = 1000$

Ensure: Final solution vector $x \in \mathbb{R}^n$

1: Initialize $x \leftarrow x_{\text{init}}$

2: Initialize $\epsilon \leftarrow \epsilon_{\text{init}}$

3: Construct the combined constraint matrix $A \leftarrow \begin{bmatrix} AE \\ AI \end{bmatrix}$

4: Construct the combined vector $b \leftarrow \begin{bmatrix} bE \\ bI \end{bmatrix}$

5: **for** Iterations = 1 to max_iter **do**

6: Compute weights:

7: $w_1 \leftarrow ((AE \cdot x + bE)^2 + \epsilon_1^2)^{-1/2}$

8: $w_2 \leftarrow (\max(AI \cdot x + bI, 0)^2 + \epsilon_2^2)^{-1/2}$

9: Construct weight matrix $W \leftarrow \text{diag}(w_1 \parallel w_2)$

10: Construct vector $v \leftarrow \begin{cases} \begin{bmatrix} bE \\ \max(-AI \cdot x, bI) \end{bmatrix} & \text{if both } AE, AI \text{ exist} \\ bE & \text{if only } AE \text{ exists} \\ \max(-AI \cdot x, bI) & \text{if only } AI \text{ exists} \end{cases}$

11: Solve the reweighted subproblem:

12: Minimize $0.5 \cdot x^T (H + A^T W A) x + (g + v^T W A) x$ using conjugate gradient method, obtain x_{next}

13: Update ϵ :

14: Compute $q_k \leftarrow A \cdot (x_{\text{next}} - x)$

15: Compute $r_k \leftarrow (1 - v) \odot (A \cdot x + b)$

16: **if** $|q_k| \leq M \cdot (r_k^2 + \epsilon^2)^{0.5+\gamma}$ for all elements **then**

17: $\epsilon_{\text{next}} \leftarrow \begin{cases} \eta \cdot \epsilon_i & \text{for } i \in I1 \\ \begin{cases} \eta \cdot \epsilon_i & \text{if } A_i \cdot x_{\text{next}} + b_i \geq -\epsilon_i \\ \epsilon_i & \text{otherwise} \end{cases} & \text{for } i \in I2 \end{cases}$

18: **else**

19: $\epsilon_{\text{next}} \leftarrow \epsilon$

20: **end if**

21: Check convergence:

22: Compute $\Delta x \leftarrow \|x_{\text{next}} - x\|_2$

23: Compute $\Delta \epsilon \leftarrow \|\epsilon_{\text{next}} - \epsilon\|_2$

24: **if** $\Delta x \leq \sigma$ and $\Delta \epsilon \leq \sigma'$ **then**

25: **Terminate** the loop

26: **end if**

27: Update $x \leftarrow x_{\text{next}}$

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28: Update $\epsilon \leftarrow \epsilon_{\text{next}}$

29: **end for**

30: **return** x
