GLOBAL ENERGY EFFICIENCY MAXIMIZATION
IN NON-ORTHOGONAL INTERFERENCE NETWORKS

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Summary

• Resource allocation (RA) over rate region: Non-convex (NC) due to powers
• Computational complexity grows exponentially in the number of variables
• SoA (e.g., canonical monotonic optimization (MOO)) treat all variables as NC
• Energy efficient RA: Fractional objective → SoA combines Dinkelbach’s Algorithm with MO
• Novel resource allocation framework:
  • Fractional objectives
  • Differentiable between convex and non-convex variables
  • Numerically stable and guaranteed convergence
  • Feasible solution even if terminated prematurely

Motivation

• Global Energy Efficiency:
  Key performance indicator in 5G+ networks
• Non-orthogonal interference networks: Beyond treating interference as noise
• Problem (R) Non-convex in \( p \), linear in \( R \)
• SoA solution:
  • Decompose: inner linear & outer monotonic program
• Fractional Objective: Dinkelbach’s Algorithm
  → 3 layer algorithm
• Goals: Keep polynomial complexity in \( R \), fast solution, easily applicable framework

Robust Global Optimization [1]

- \( g_i, i = 1, \ldots, m \): Non-convex functions
- SoA: Branch & Bound or Outer Approximation
- Convergence in finite iterations not guaranteed
- Usual approach: Solve relaxed problem

Problem Statement & Solution

Problem (R)

\[
\begin{align*}
\max \quad & f(x) \\
\text{s.t.} \quad & g_i(x) \leq 0, \quad i = 1, \ldots, m \nend{align*}
\]

- Non-convex variables \( x \), convex variables \( \xi \)
- Dual Problem has robust feasible set → no isolated feasible point! (cf. Lemma 1)

Technical Requirements:

- \( \Xi \) closed convex
- \( f(x, \xi) \): common maximizer over every box \( M \subseteq R^q \)

Separable functions \( f(x, \xi) = f_i(x) + \xi_i \) and for all \( \gamma \geq 0 \) if \( f(x, \xi) + \gamma \)

\[
\begin{align*}
&\gamma f_i(x) - \gamma f_i(x) \\
\text{s.t.} \quad & f_i(x) - \gamma f_i(x) \leq 0 \nend{align*}
\]

Core Problem: Compute lower bound for (Q) over box \( M \)

Algorithm (Solution of Problem (R))

Step 0: Initialize \( \mu, \eta > 0 \) and \( M_0 = [p, q]^T, p_i = [\mu, \eta], \forall i = 1, \ldots, m \), and \( \gamma = 1 \)

Step 1: For each box \( M \subseteq \mathbb{R}^q \)

- Set \( \|M\| \) as the solution of (B) or \( \|M\| = \infty \) if (B) is infeasible.
- Add \( M \) to \( \mathcal{M} \) if \( \|M\| < \epsilon \)

Step 2: Terminate if \( \mathcal{M} = \emptyset \) or if no feasible solution. Else \( \alpha \) is an essential \( (\epsilon, \eta) \)-optimal solution.

Step 3: Let \( M^\star = \arg\min\{\|M\| : M \in \mathcal{M}\} \) and solve the feasibility problem for \( \Xi \subseteq \mathbb{R}^q \)

- For all \( \xi \in \Xi \)

- If feasible go to Step 4; otherwise go to Step 5.

Step 4: \( x_M^{(\star)} \) is a nonisolated feasible solution satisfying \( f(x_M^{(\star)}) \leq \gamma \) for some \( \Xi \) Solve.

Step 5: Stop and output \( x_M^{(\star)} \) via \( x_M^{(\star)} \), where \( x_M^{(\star)} \) s.t. \( x_M^{(\star)} \in \Xi \) and \( \xi = x_M^{(\star)} \).

Remove Box \( M^\star \) from \( \mathcal{M} \). Let \( \mathcal{M} = \mathcal{M} \setminus \{M^\star\} \). Increment \( \gamma \) and go to Step 1.

Application to Problem (RA)

Identify \( f(p) \) as \( f(x) \), \( x = p \), \( X = \mathbb{R}^m \), \( Y = \mathbb{R}^n \),

\[
\begin{align*}
\text{Problem (R)}: \quad & \max \quad f(p) \\
\text{s.t.} \quad & x_p \leq 0 \nend{align*}
\]

- For a box \( M = [\alpha, \beta]^T \): \( \alpha = \arg\max x_p^T \)

- Problem (B) is a LP:

Numerical Evaluation

- Example: Gaussian MIMO with AF relaying and multiple unicast transmissions.
- Treating interference as noise vs. purely joint decoding vs. simultaneous non-unique decoding
- Algorithm vs. Dinkelbach (auxiliary problem solved with our algorithm)

References

