Hybrid metaheuristics for constrained portfolio selection problem

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Overview

In this project we used a metaheuristic algorithm that is the particle swarm optimization as a master solver to generate possible solutions from the search space which were further transferred to a quadratic problem solver to find an optimal solution for portfolio optimization. Further, we added constraints which are analogous to decisions faced in the real world.

Problem Definition

The formulation of the basic (unconstrained) problem is thus the following:

$$\min F(X) = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} x_i x_j,$$

s.t.

$$\sum_{i=1}^{n} r_i x_i \geq R, \qquad (1)$$

$$\sum_{i=1}^{n} x_i = 1, \qquad (2)$$

$$x_i \geq 0 \quad (i = 1, \ldots, n). \qquad (3)$$

$$x_i \leq z_i \quad (i = 1, \ldots, n). \qquad (4)$$

$$k_{\min} \leq \sum_{i=1}^{n} z_i \leq k_{\max}. \qquad (5)$$

$$z_i \geq p_i \quad (i = 1, \ldots, n). \qquad (6)$$

Technique

- The particle swarm optimization(PSO) is a computational method that iteratively keeps looking for a better solution.
- The particles are spread throughout the search space and are moved in relation to the current Momentum, GlobalBest, and PersonalBest positions such that they near-about search the entire space for best solutions.
- The PSO finds the positions(combination of assets) which is then sent to a quadratic problem solver which uses the fmincon function to find the weights and risks associated with the selected assets.

Results

Solving for the following constraints:

1. Minimum number of assets: 5
2. Maximum number of assets: 15
3. Number of preassigned assets: 2 (Asset no. 8 and 18)
4. Expected return: 0.02%

The following graphs were obtained which show the iteratively decreasing risk (left figure) and the weights for the final solution (right figure).