AN ENHANCED DISTRIBUTED DIFFERENTIAL EVOLUTION ALGORITHM FOR PORTFOLIO OPTIMIZATION PROBLEMS

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https://www.sciencedirect.com/science/article/pii/S0952197623001884

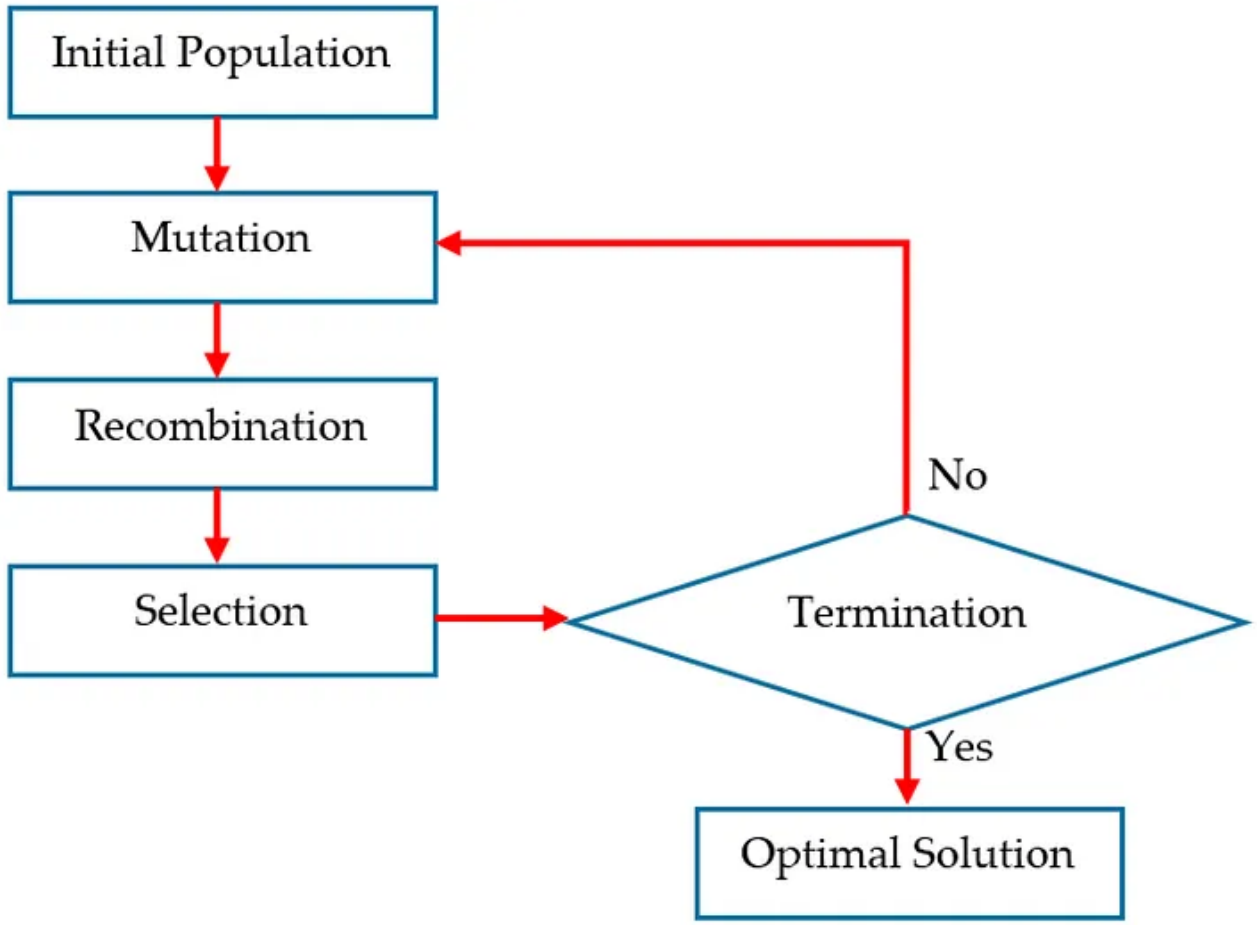
OVERVIEW

- development of a co-evolutionary multi-swarm adaptive differential evolution algorithm (ECMADE)

- The study includes experiments on test functions and portfolio optimization problems to demonstrate the effectiveness of ECMADE compared to classical DE algorithms.

- The results show that ECMADE outperforms other algorithms in terms of accuracy, efficiency, and robustness, making it a promising solution for complex optimization problems.

DIFFERENTIAL EVOLUTION



DIFFERENTIAL EVOLUTION

1. Initialization Population: The DE algorithm randomly generates a population of D-dimensional vectors in the search space. Each individual in the population represents a candidate solution for the optimization problem.

2. Mutation Operation: In the mutation step, the DE algorithm generates a mutant individual by adding a weighted vector difference between two randomly selected individuals to a third individual. The mutation operation is crucial in introducing diversity to the population.

3. Crossover Operation: The DE algorithm typically uses a binomial crossover operator to combine the target individual with the mutant individual. This step helps in exploring the search space efficiently.

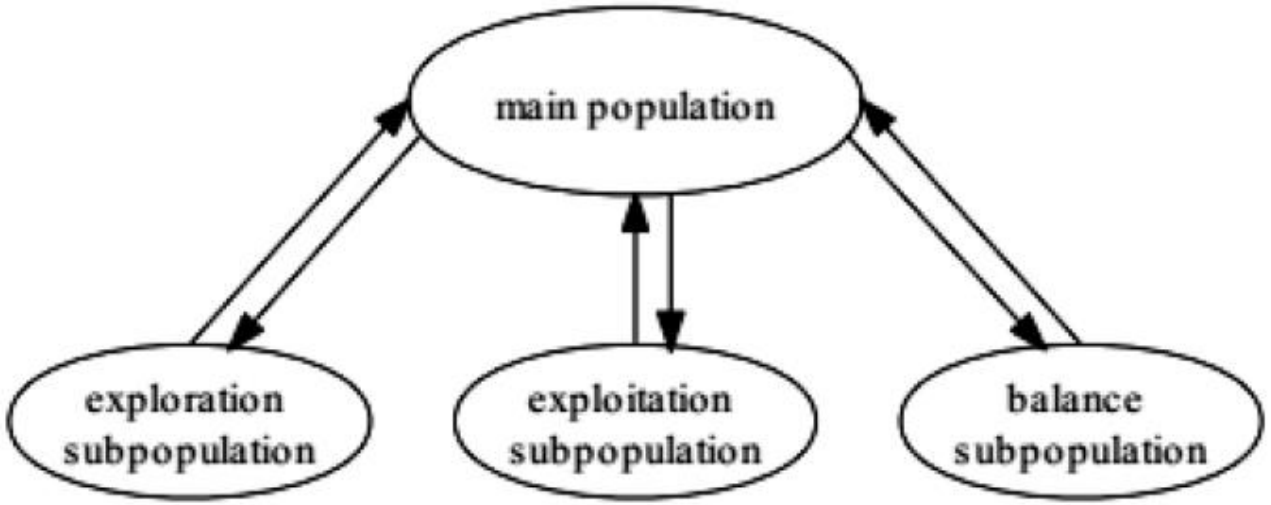
4. Selection Operation: In the selection step, the fitness of the target individual and the trial individual (resulting from crossover) is compared. The individual with better fitness is selected to proceed to the next iteration, while the less fit individual is discarded.

ADVANTAGES AND DISADVANTAGES OF DE

- **+** Higher Robustness: making it suitable for various problem domains.
- **+ Fewer Control Parameters**: fewer control parameters, simplifying the tuning process.
- **+ No Need for Problem-Specific Information**: making it versatile and easy to apply to different optimization tasks.

- **- Sensitivity to Control Parameters**
- **- Premature Loss of Diversity**: The population in DE can lose diversity prematurely, leading to convergence to local optima or invalid population updates in high-dimensional problems.
- **- Risk of Local Optima**: DE may fall into local optima due to its population diversity challenges, affecting the algorithm's ability to find the global optimum in some cases.

CO-EVOLUTIONAY MULTI-SWARM ADAPTIVE DIFFERENTIAL EVOLUTION ALGORITHM



ECMADE

The ECMADE algorithm divides the population into three independent subpopulations:

- **Exploration Subpopulation**: Explores a larger search space to find potential solutions.
- **Development Subpopulation**: Focuses on precise convergence towards solutions.
- **Auxiliary Subpopulation**: Balances convergence and diversity, aiding in early exploration and later convergence.

ECMADE

In ECMADE the mutation process involves using three different mutation strategies:

- **Exploration Subpopulation**: Utilizes mutation strategy for stronger disturbance and better global search ability.
- **Development Subpopulation**: Employs a decisive mutation strategy to close in on the optimal solution faster.
- **Auxiliary Subpopulation** : Assists Development Subpopulation by enriching population diversity, improving convergence speed, and preventing local optima.

ECMADE

- **Cross operation**: the three sub populations indepedently generate trial individual as in DE

- **Selection operation**: the three subpopulations indepedently select individuals to enter the next evolution as in DE

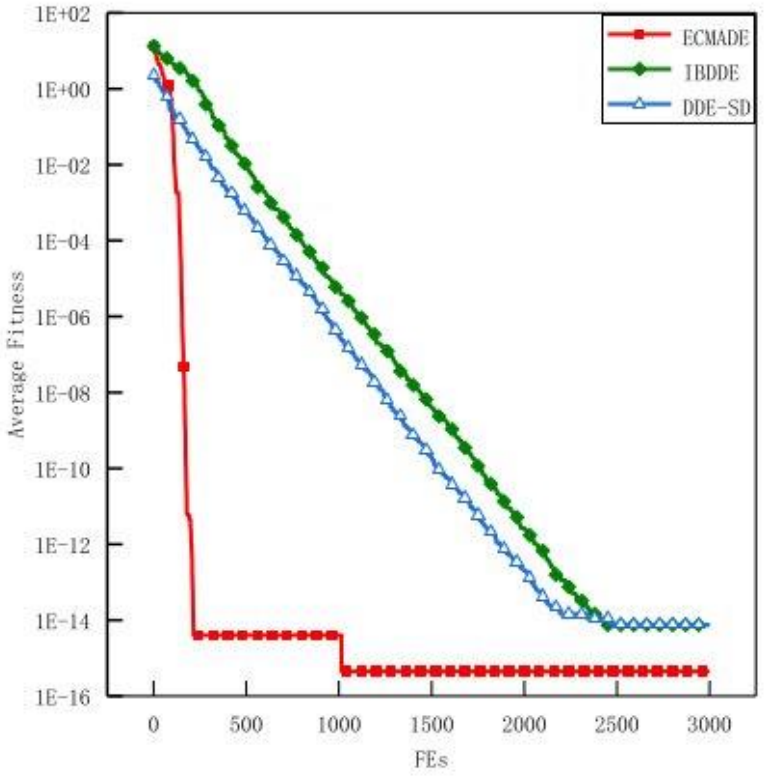
- **Adaptive information exchange:** When the stagnation threshold is exceeded, indicating thorough exploration, an information exchange mechanism is triggered. Subpopulations are merged, divided randomly, and the top 5% fittest individuals are copied to each subpopulation to enhance diversity and facilitate escaping local optima.

RESULTS ON TEST FUNCTIONS

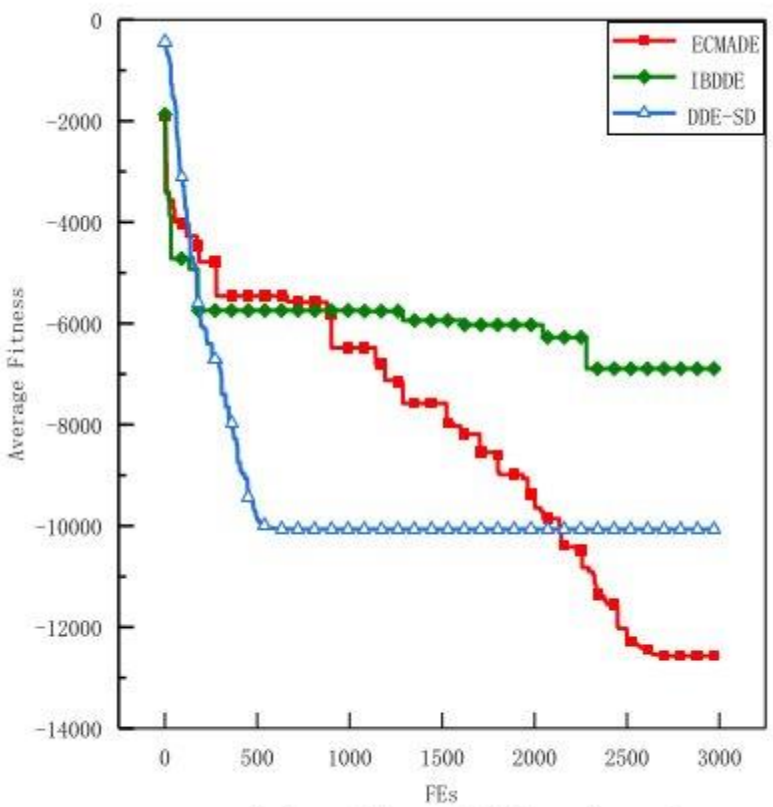
- ECMADE outperforms other algorithms in terms of convergence accuracy and optimization performance on both multimodal and unimodal test functions.

- It demonstrates strong robustness, stable performance, and high convergence accuracy

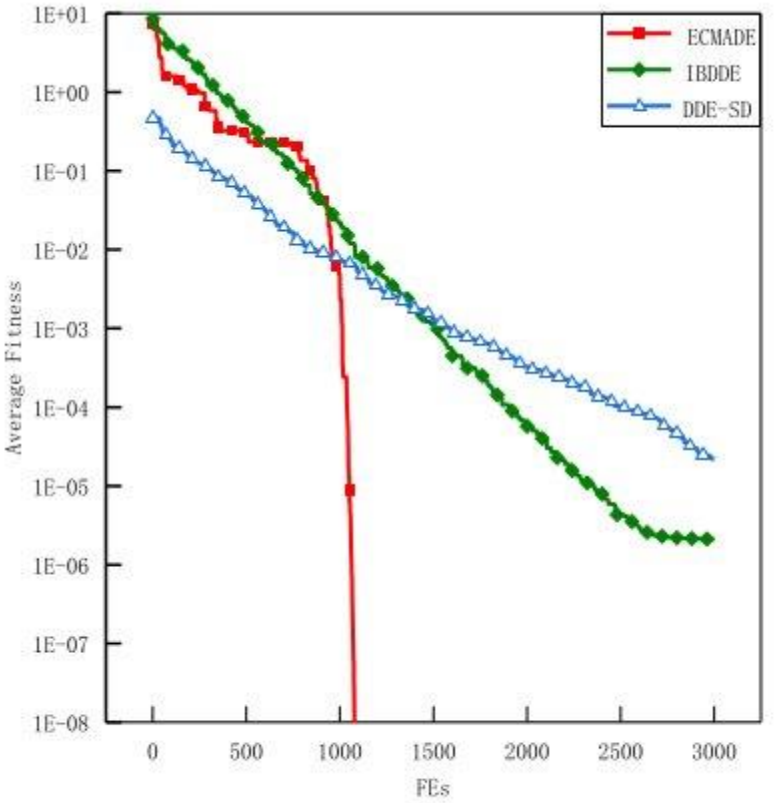
RESULTS ON TEST FUNCTIONS



(a) multimodal function f_1



(c) multimodal function f_6



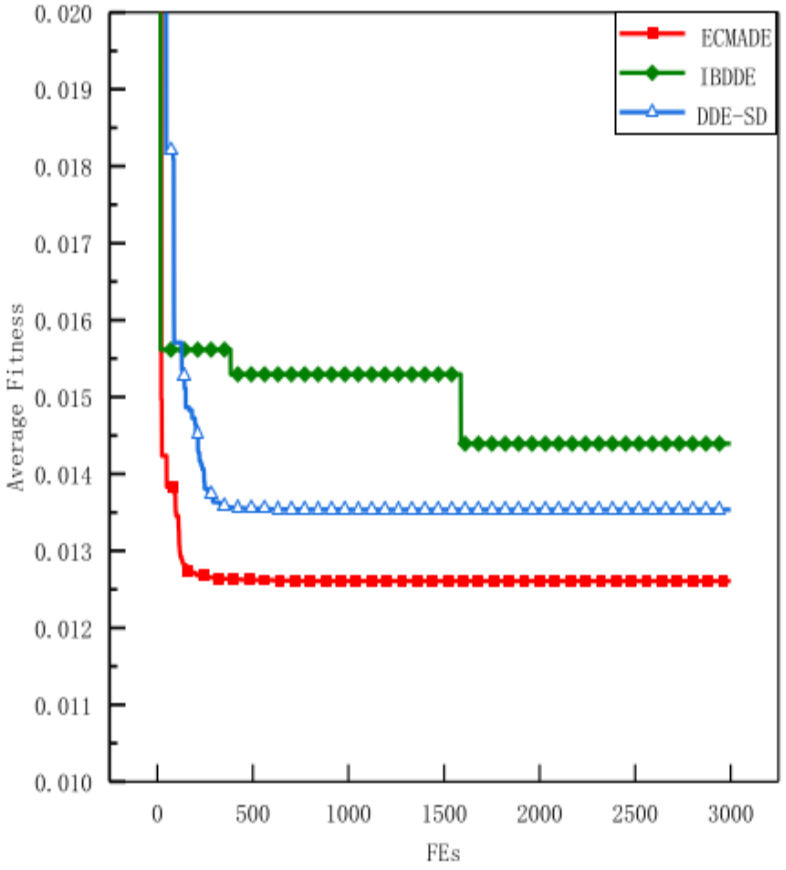
(f) unimodal function f_{13}

PORTFOLIO OPTIMIZATION

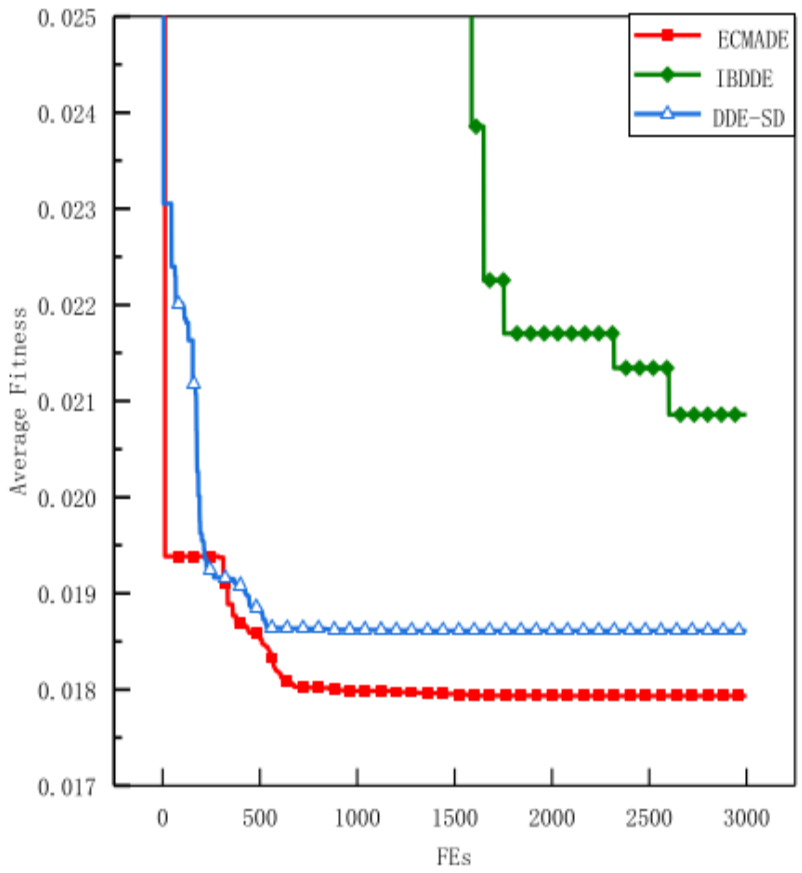
- ECMADE is applied to optimize the Mean-CVaR model in portfolio theory.
- The Mean-CVaR (Conditional Value at Risk) model is a portfolio optimization model that measures the average loss of a portfolio under conditions where losses exceed the Value at Risk (VaR)
- The algorithm uses the Fuzzy C-means clustering algorithm to select stocks and build a portfolio with transaction cost constraints
- The results show that ECMADE effectively solves the portfolio optimization problem.

PORTFOLIO OPTIMIZATION

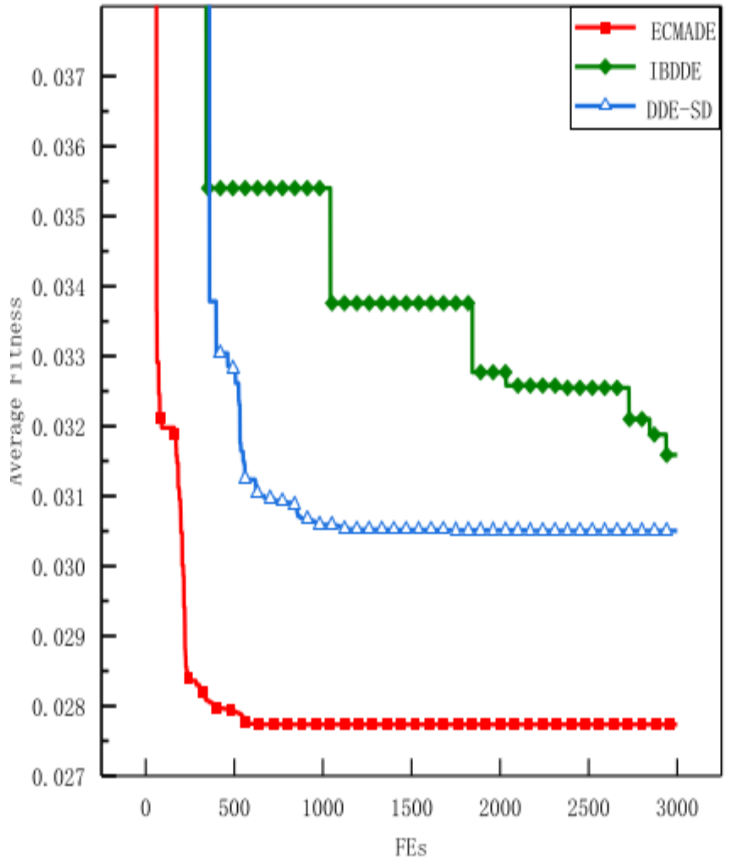
- **alpha (α)** represents the confidence level of investors, indicating their risk preference.



(a) average convergence curve when $\alpha = 75\%$



(b) average convergence curve when $\alpha = 90\%$



(c) average convergence curve when $\alpha = 99\%$

QUESTIONS ?