

# Introduction to Evolutionary Multi-objective Optimisation - part 2

Dr. Bing Xue  
Dr. Yi Mei

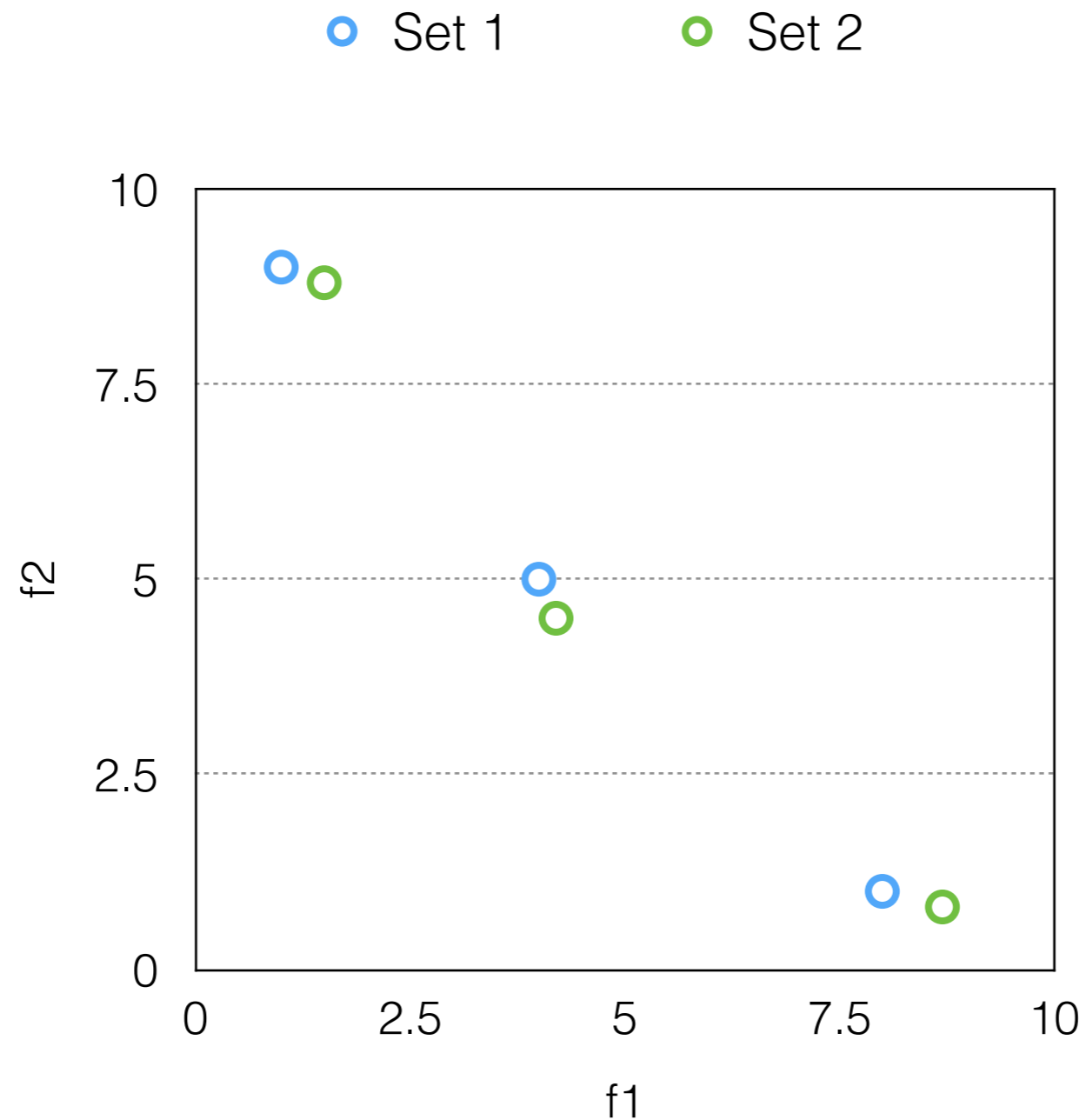
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- How to evaluate different trade-off solution sets?



# Performance Indicators

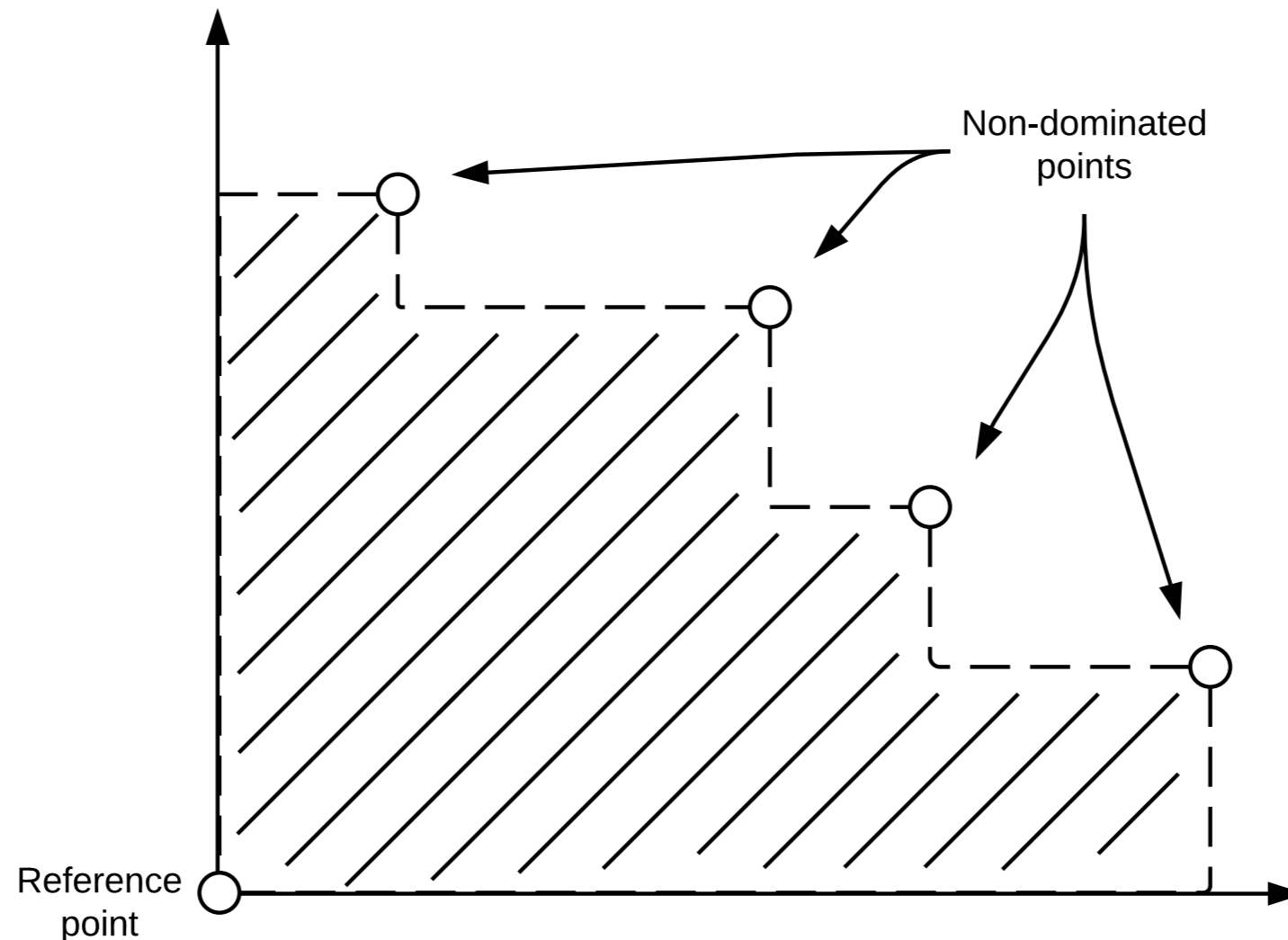
- How to evaluate different trade-off solution sets?
  - **Convergence** (closeness to the Pareto front)
  - **Diversity** (Uniformity of distribution)
  - **Spread** (Coverage)
- No single indicator can perfectly reflect all these features

# Performance Indicators

- Unary Indicators (*Absolute*)
- Binary Indicators (*Relative*)

# Unary Indicators

- **Hypervolume:** the area dominated by the solution set. The **larger** the better.



# Unary Indicators

- Advantages of hypervolume:
  - Consistent to Pareto dominance - the Pareto front always has the largest hypervolume;
  - No need to know the true Pareto front
  - Reflects convergence, diversity and spread simultaneously
  - The most commonly used indicator

# Unary Indicators

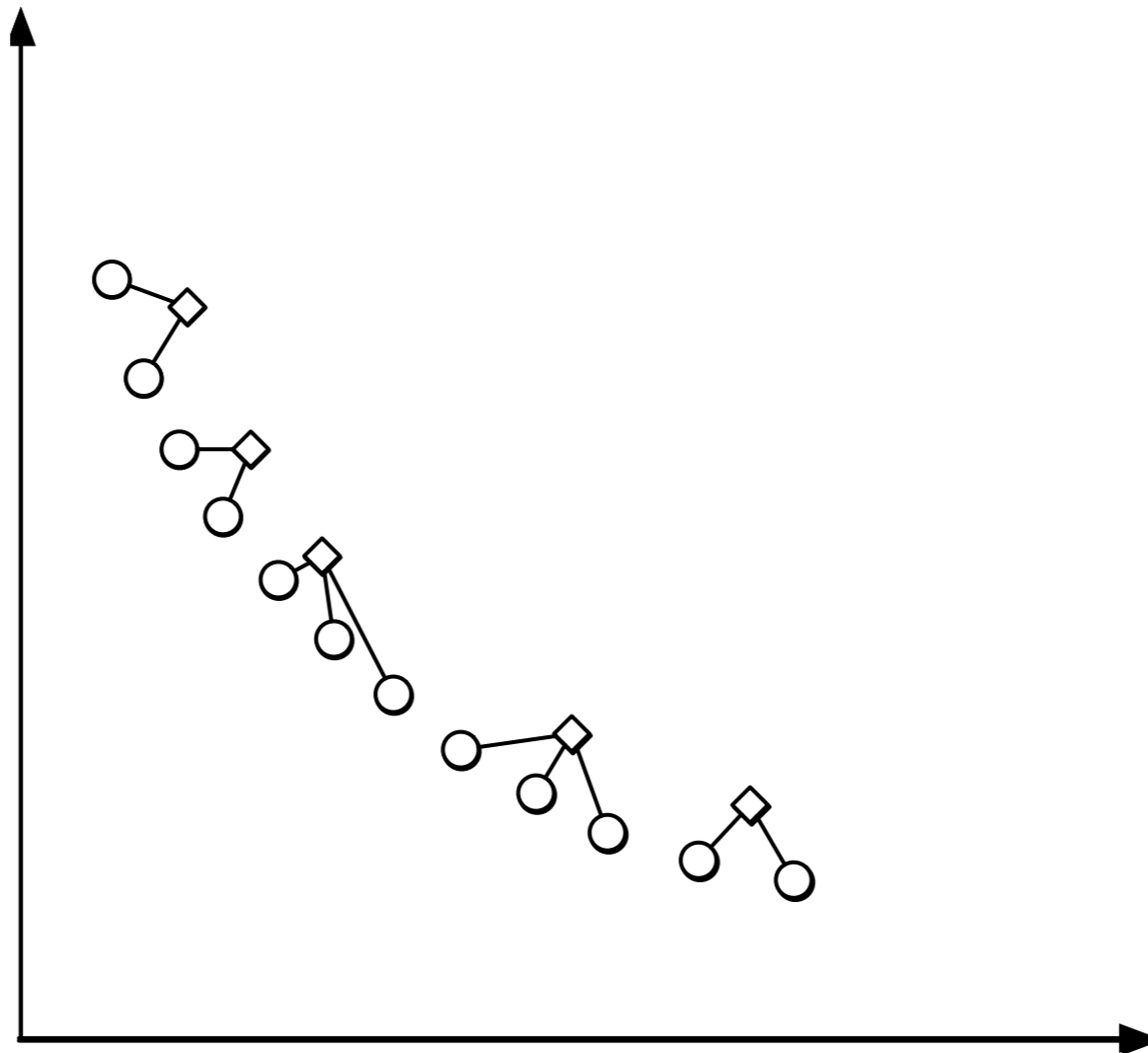
- Disadvantage of hypervolume:
  - Computationally **expensive**, and **poor scalability** (impractical to use as fitness function and many-objective optimisation)



# Unary Indicators

- **Inverted Generational Distance (IGD)**
  - Step 1: select a set of uniformly distributed reference points on the Pareto front
  - Step 2: for each reference point, find out the closest point in the solution set, and calculate the distance between them
  - Step 3: Average such distance for all the reference points

# Unary Indicators



# Unary Indicators

- $IGD = 0$  means all the reference points are covered by the solution set (perfect match)
- Needs to know the true Pareto front or at least a very good approximated reference set

# Unary Indicators

- Spacing: Measuring uniformity
  - For each solution  $x$ , find the closest solution in the solution set, and calculate the distance  $d(x)$
  - Calculate the standard deviation of all the  $d(x)$ 's

# Unary Indicators

- Remember to **normalise** beforehand!
- Be careful when using IGD when the true Pareto front is unknown

# Reference

- Zitzler, Eckart, Lothar Thiele, Marco Laumanns, Carlos M. Fonseca, and Viviane Grunert Da Fonseca. "Performance assessment of multiobjective optimizers: an analysis and review." *IEEE Transactions on Evolutionary Computation*, vol. 7, no. 2 (2003): 117-132.
- Sarker, Ruhul, and Carlos A. Coello Coello. "Assessment methodologies for multiobjective evolutionary algorithms." *Evolutionary Optimization*. Springer US, 2002. 177-195.