SMS-EMOAs:

1. Standard version: In each generation, the worst solution (with the least HV contribution) in the last front is removed from the population. In this case, only one solution is removed. So we only need to generate one offspring in each generation.
2. Variant I: In each generation, all the dominated solutions are removed from the population. That is, only the first front is kept as the next population. In this case, suppose N solutions are removed, we need to generate N offspring in the next generation. That is, the number of offspring is the number of removed solutions in the last generation.
3. Variant II: In each generation, if there are more than one front level, one random solution from the last front is removed. If there is only one front (i.e., all solutions are non-dominated), we use the standard SMS-EMOA (i.e., remove the least HV contributor).
4. Variant III: In each generation, if there are more than one front level, one random solution from all the dominated solutions (i.e., solutions not from the first front) is removed. If there is only one front (i.e., all solutions are non-dominated), we use the standard SMS-EMOA (i.e., remove the least HV contributor).

For Variant I and III, since we only need to know the first front (we do not need to know carefully the other fronts), the non-dominated sorting can be simplified (i.e., we only need to get the first front). This simplification can save some computation time.

Our experiments are to compare these algorithms. Two metrics are used: HV and runtime. For the experimental settings, refer to my paper: A new hypervolume-based evolutionary algorithm for many-objective optimization. In this paper, 5,10,15 objectives are considered. In our experiments, we consider 3,4,5 objectives. The maximum function evaluation can be decreased (e.g., 50% of the setting in this paper).

Save 20 results during the evolution for each run, and draw the figures of HV with respect to function evaluations, which is similar to the figures in my paper. That is, using these figures, we can examine the performance change of the algorithm as function evaluation increases.

Expected results:

1. Variant I will have a better convergence ability.
2. Variant II and III is faster than the standard SMS-EMOA.

Variant I 的运行时间会很慢，因为convergence更快了，相同的FEs下有更多的可能是在只有一个front的情况下，这个时候是run的standard SMS-EMOA，所以总的运行时间会很慢。

Variant II 和 III 更快可能是因为，以随机删来代替依据HVC来删。 在convergence上差不多，但是这个操作不用求HVC，所以快。