Special Topics on Intelligent Control： Program Report I

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Algorithm：

GA：

- Concept：

  According to the biological concept -- Survival of the fittest, the initial population evolves based on artificial calculation processes, such as reproducing, mating and mutating, and finally the approximate Optimal solution is obtained.

- Procedure：
  - ✧ Step1：Initialize the chromosomes' genes
  - ✧ Step2：Define fitness_function, crossover_ probability, mutation_probability
  - ✧ Step3：Calculate fitness values
  - ✧ Step4：Reproduction：Produce population of the next generation according to fitness values
  - ✧ Step5：Crossover：Elitism Selection：parent keep stay in next generation, offspring are generated by parent
  - ✧ Step6：Mutation：randomly choose the segment, change number randomly
  - ✧ Step7： Loop to Step3

PSO：

- Concept：PSO simulates the predatory behavior of flock of birds. Each particle(bird) refers to two values to determine its movement. The first value is the best solution of the particle's past iterations and the second value is the best solution of the group's past iterations.
- Procedure：
  - ✧ Step1：Initialize the positions and velocities of particles with random values.
  - ✧ Step2：Calculate the fitness function of each particle.
  - ✧ Step3：Compare the new value from fitness function with the individual best value. If the new value is smaller than the individual best value, update the previous value to the new value.
  - ✧ Step4：Compare the new value from fitness function with the group best value. If the new value is smaller than the group best value, update the previous value to the new value.
  - ✧ Step5：Change the velocity by the following formula：

    $$v_{id}^{k+1} = \omega v_{id}^{k} + c_1\, rand(\,)\,(p_{id} - x_{id}^{k}) + c_2\, rand(\,)\,(p_{gd} - x_{id}^{k})$$

    where w：weight

c1：weight of particle’s experience

c2：weight of group’s experience

pid：particle’s best position of its past iterations

pgd：group’s best position of past iterations

- ✧ Step6：Update the position by the following formula：

$$x_{id}^{k+1} = x_{id}^{k} + v_{id}^{k+1}$$

- ✧ Step7：Loop to Step2 until the iteration number is met.

ABC：

- Concept：

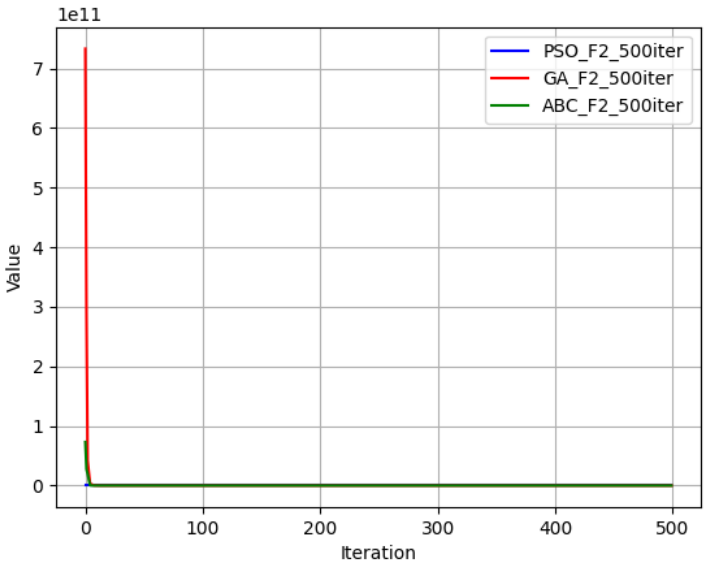
  In ABC, the population of the model is composed of three groups： Employees, Onlookers, and Scouts. Every employee will be assigned to a food source. Employed bees update the food source in every iteration. Onlookers will take a use of the experience from Employee bees, and will attempt to improve the Employees work. After the depletion of a food nectar source, an employee bee turns into a scout and looks for other valuable food resources.

- Procedure：
  - ✧ Step1：Initialize the food sources and the population of bees.
  - ✧ Step2：New candidate solutions are produced for each employed bee. If the fitness mutant bee solution is better than that of the original bee, the new vector is assigned to the bee.
  - ✧ Step3：Define as many onlooker bees as there are employed bees. Onlooker bees will attempt to improve the solution path of the employed bee.
  - ✧ Step4：Check whether Trail_time of the food source is over the limit. If yes, an employee bee turns into a scout and looks for other valuable food resources.

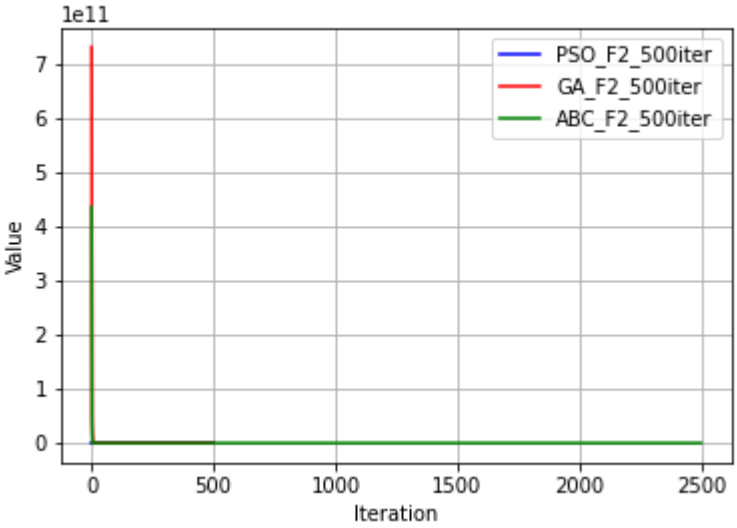
1. Plot the progress of the average best-so-far solution vs. iteration over 50 runs with 500 and 2500 iterations for these functions and make some comments or interpretations.
   - ❖ Comments：

     Basically, the convergence speed of PSO is fastest because there is the minimal program in PSO’s for loop. And the speed of GA is slower than the speed of ABC because GA code is much more complicated. However, sometimes the convergence of PSO will go wrong to local minimum like Figure F14_500 and F14_2500 below but GA won’t. Therefore, use the PSO algorithm if you want to find the global minimum with the fastest speed. Besides the PSO, the ABC algorithm is also a fast algorithm. And if you want to find the precise value of the global minimum, try the GA algorithm.

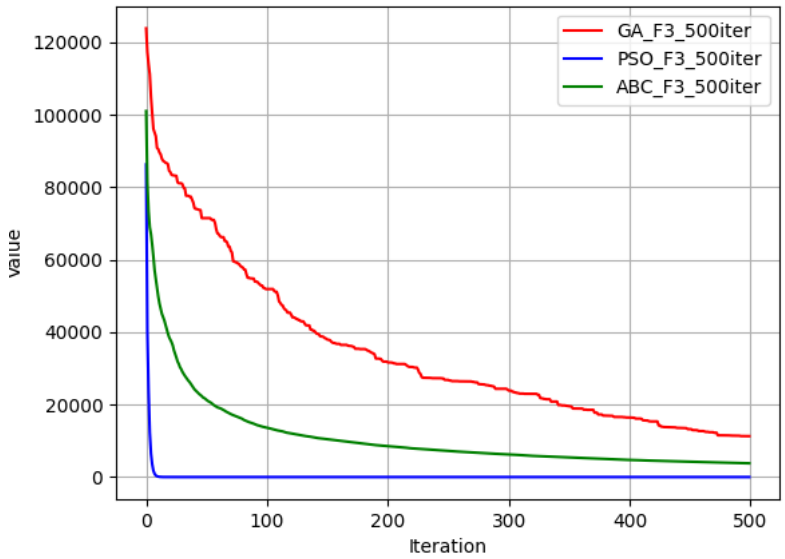
F2_500



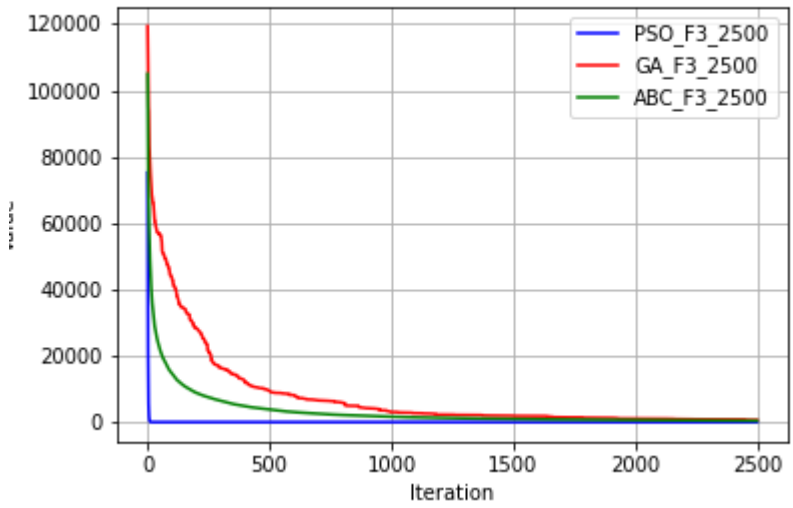
F2_2500



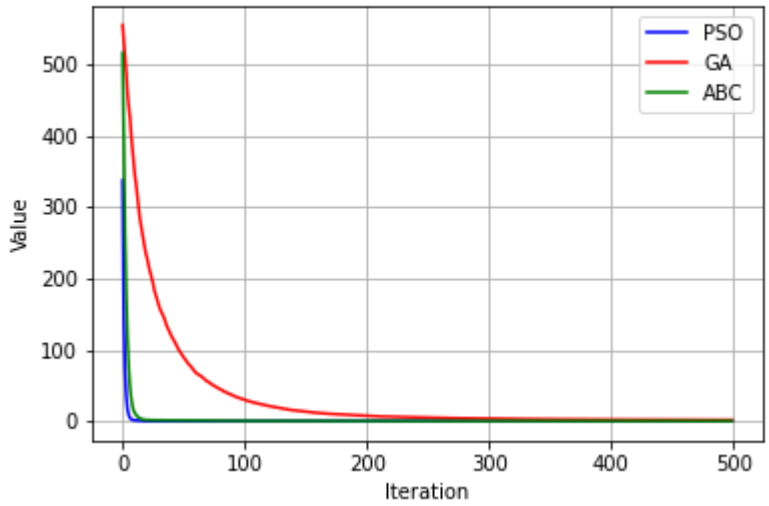
F3_500



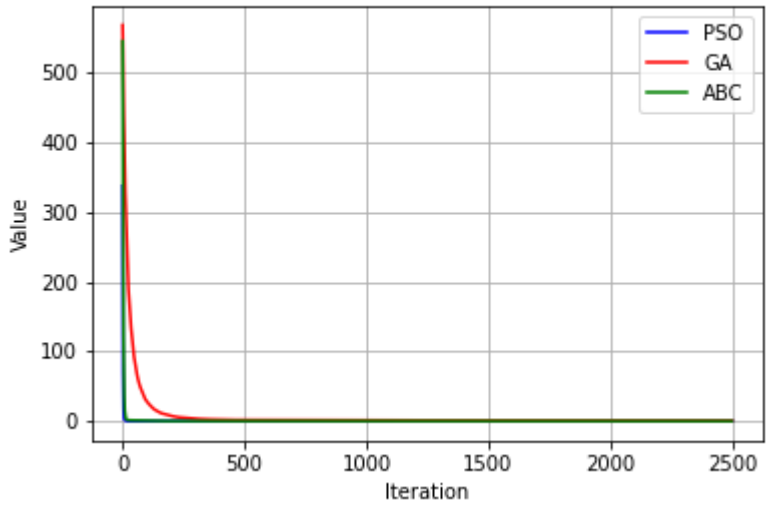
F3_2500



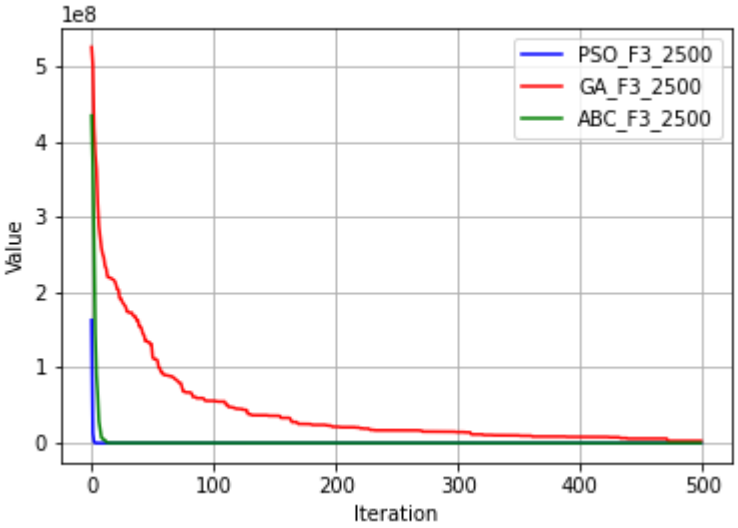
F11_500



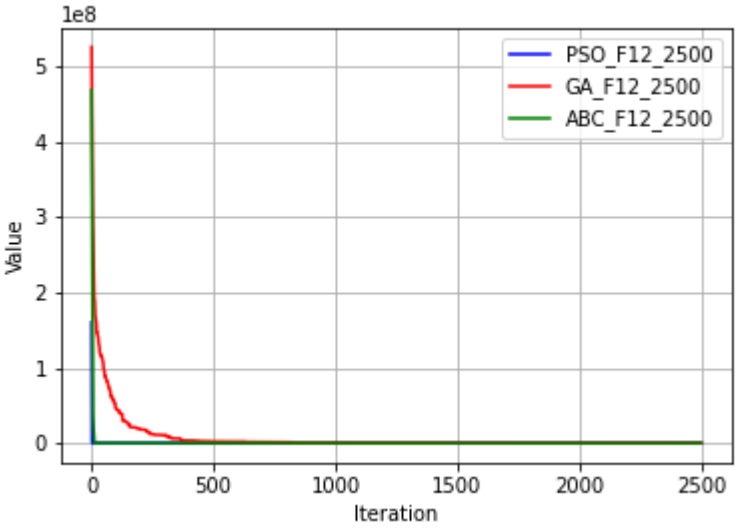
F11_2500



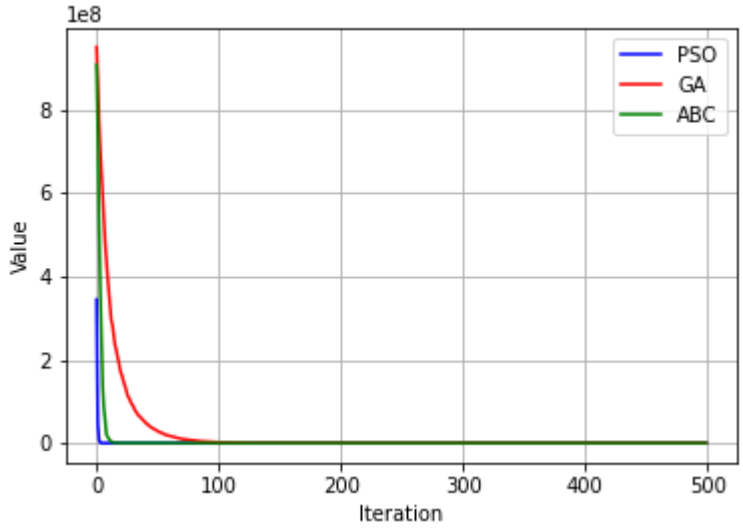
F12_500



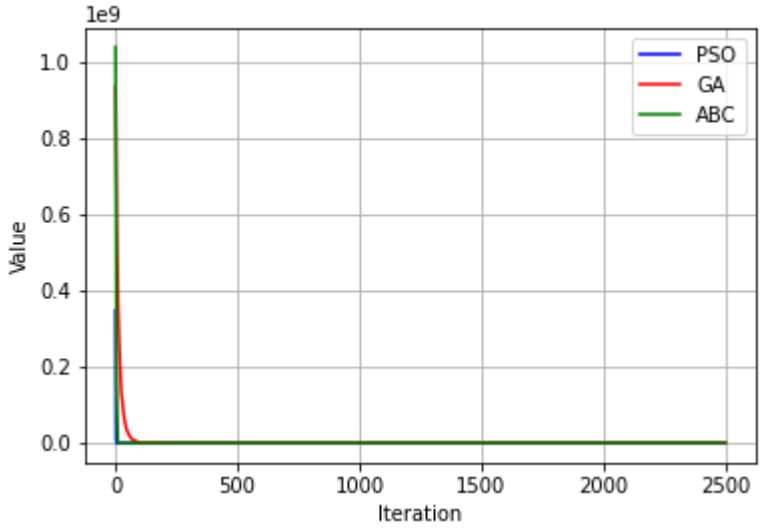
F12_2500



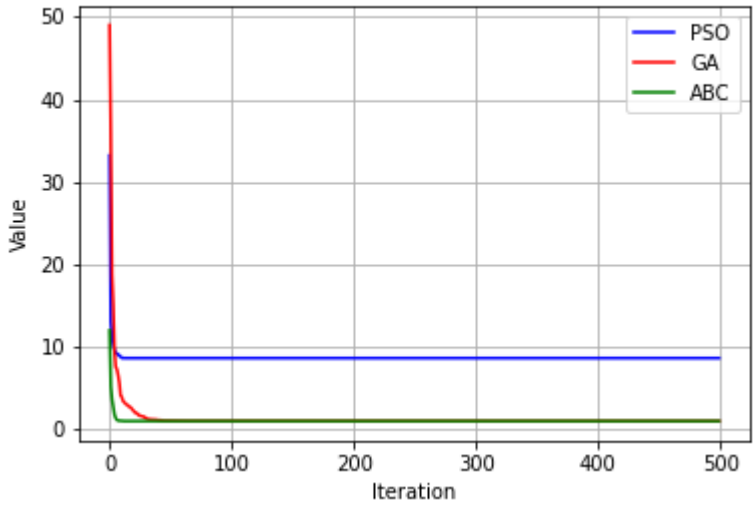
F13_500



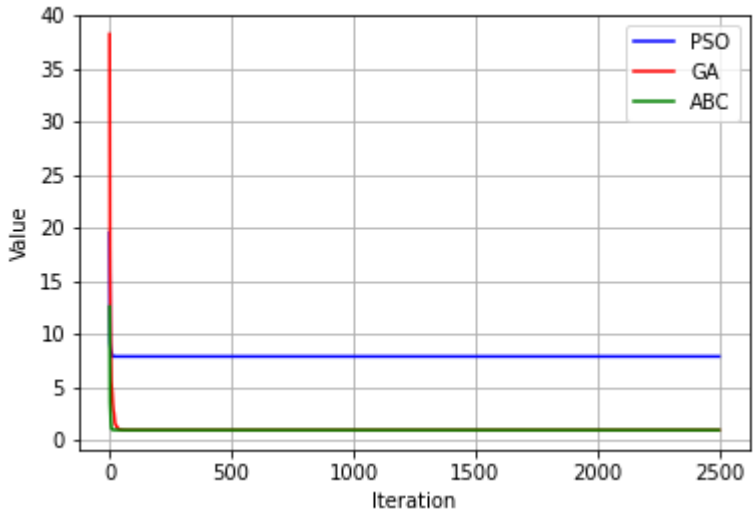
F13_2500



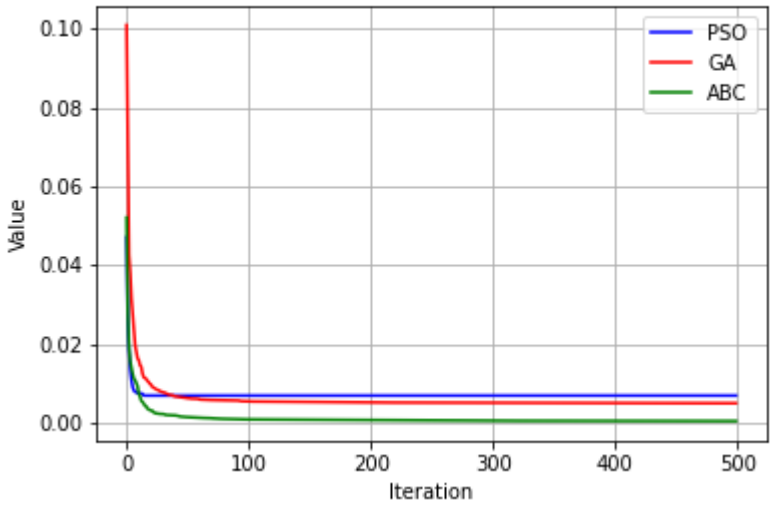
F14_500



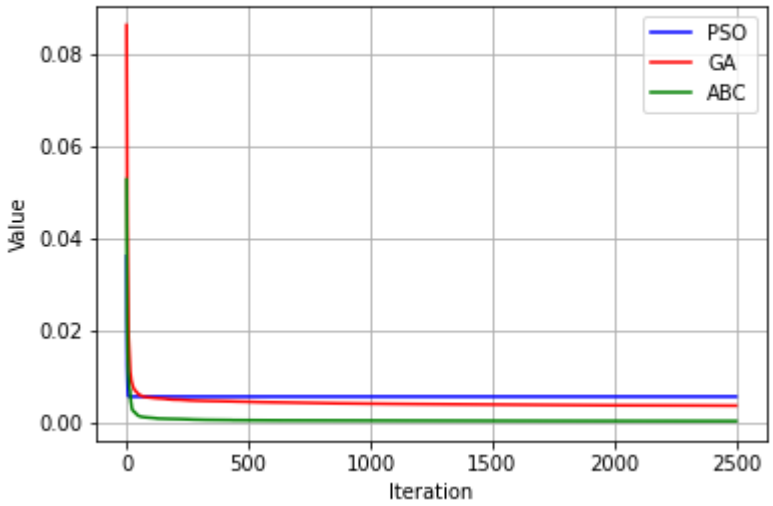
F14_2500



F15_500



F15_2500



2. List a table of the averaged results over 50 runs with 500 and 2500 iterations for solutions of average best-so-far, average mean fitness, and the median best-so-far solution in the last iteration.

✧ 500 iterations：

Benchmark function		GA	PSO	ABC
F2	Average best-so-far	0.7035	9.296737572288834e-88	0.000402
	Average mean fitness	248449193117.9255	1.6574341479407291e-87	3.5703
	Medium best-so-far	0.6841	2.183158343889797e-88	0.000408
F3	Average best-so-far	509.2115	2.269666786542153e-153	3535.3128
	Average mean fitness	993484.9452	2.777375456061767e-152	46821.2027
	Medium best-so-far	90.1840	6.565253296183251e-155	3549.1276
F11	Average best-so-far	0.9926	0.0	0.0217
	Average mean fitness	30.8418	0.0	5.9249
	Medium best-so-far	1.0171	0.0	0.0148

F12	Average best-so-far	2405392.7198	5.299549053681957	1.406877875916971e-06
	Average mean fitness	20501571.8329	6.896855173207498	74.2522
	Medium best-so-far	3.1107	5.502500579629917	5.920144224657144e-07
F13	Average best-so-far	1.2022	26.287014478239527	7.429457564892579e-06
	Average mean fitness	78218348.8668	28.574218465 02214	2458940.8224
	Medium best-so-far	0.6307	26.903494748254825	3.223368452836276e-06
F14	Average best-so-far	0.9980	7.802290478937198	0.9980
	Average mean fitness	43.4429	11.949673008330072	22.8218
	Medium best-so-far	0.9980	7.873994441 26841	0.9980
F15	Average best-so-far	0.0011	0.006717439159808837	0.0006
	Average mean fitness	10.8530	0.038397093235 29371	2.2992

	Medium best-so-far	0.0007	0.001338581754799559	0.0006

✧ 2500 iterations：

Benchmark function		GA	PSO	ABC
F2	Average best-so-far	0.1369	4.4e-323	0.000449
	Average mean fitness	7.3575	4.4e-323	3.6473
	Medium best-so-far	0.1208	4.4e-323	0.000388
F3	Average best-so-far	5.8158	0.0	3827.0483
	Average mean fitness	898709.5669	0.0	46535.1548
	Medium best-so-far	3.2870	0.0	3565.9730
F11	Average best-so-far	0.3312	0.0	0.0247
	Average mean fitness	35.4592	0.0	5.6210

	Medium best-so-far	0.2080	0.0	0.01846
F12	Average best-so-far	0.2518	4.926973842432939	1.1191952262675013e-06
	Average mean fitness	12966344.4788	6.529220222426272	67.3356
	Medium best-so-far	0.0843	5.0323387751679425	4.727463653675855e-07
F13	Average best-so-far	0.0577	26.378513013591082	7.163382879196377e-06
	Average mean fitness	100901330.4828	28.54546078985214	2374602.0418
	Medium best-so-far	0.0339	26.824379719283797	3.4462198734917498e-06
F14	Average best-so-far	0.9980	7.599649877000182	0.9980
	Average mean fitness	47.4199	12.1026510129257	22.0764
	Medium best-so-far	0.9980	7.543884847077692	0.9980
F15	Average best-so-far	0.0006	0.008304691355737475	0.0006

	Average mean fitness	4.3795	0.0449180656 1470058	1.4220
	Medium best-so-far	0.0004	0.0014512622 6784881	0.0007

3. List a table of the averaged results (including mean and standard deviation) over 50 runs with 500 and 2500 iterations for the best solution in the last iteration.
   ✧ 500 iterations：

Benchmark function		GA	PSO	ABC
F2	Average best-so-far	0.7035	9.2967375722 88834e-88	0.000402
	Standard deviation	0.4037	1.8296670897 675924e-87	5.9491129120 13289e-05
F3	Average best-so-far	509.2115	2.2696667865 421153e-153	3535.3128
	Standard deviation	1547.9557	7.4219959149 62279e-153	1092.8894
F11	Average best-so-far	0.9926	0.0	0.0217
	Standard deviation	0.2190	0.0	0.0223

F12	Average best-so-far	2405392.7198	4.926973842432939	1.406877875916971e-06
	Standard deviation	10626237.5452	0.7646538312278036	2.330174838592577e-06
F13	Average best-so-far	1.2022	26.287014478239527	7.429457564892579e-06
	Standard deviation	1.3568	1.986348026415628	1.241595285809416 4e-05
F14	Average best-so-far	0.9980	7.802290478937198	0.9980
	Standard deviation	1.4137	3.890789037212133 6	1.451974782564474 8e-16
F15	Average best-so-far	0.0011	0.006717439159808837	0.0006
	Standard deviation	0.0008	0.010416936496740215	0.0001

✧ 2500 iterations：

Benchmark function		GA	PSO	ABC
F2	Average best-so-far	0.1369	4.4e-323	0.0004
	Standard deviation	0.0903	0.0	0.0002
F3	Average best-so-far	5.8158	0.0	3827.0483
	Standard deviation	7.4413	0.0	1267.0458
F11	Average best-so-far	0.3312	0.0	0.0248
	Standard deviation	0.3077	0.0	0.0278
F12	Average best-so-far	0.2518	5.080455957927692	1.1191952262675013e-06
	Standard deviation	0.3596	0.7920382078824725	2.143683897355206e-06
F13	Average best-so-far	0.0577	26.378513013591082	7.163382879196377e-06
	Standard	0.0562	2.0100318349	1.5625539091

	deviation		733564	712087e-05
F14	Average best-so-far	0.9980	7.599649877000182	0.9980
	Standard deviation	8.9407	3.745292651307458	1.199040866595169 1e-16
F15	Average best-so-far	0.0006	0.008304691355737475	0.0006
	Standard deviation	0.0003	0.012044812540372459	0.0001

4. Please also give all parameters settings in your simulations.
   - ✧ GA：

     crossover_ probability= 0.95
     mutation_probability = 0.1
     string length = "float64”
   - ✧ PSO：

     c1=2, c2=2
     w=0.5+random/2
   - ✧ ABC：Non