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Biogeography-Based Optimization Combined with Evolutionary Strategy and Immigration Refusal

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Outline

1. BBO introduction
2. Modification of BBO based on evolutionary strategy (ES) and immigration refusal (RE)
3. Simulation results
4. Statistic analysis based on F-tests and T-tests
5. Conclusion and future work

Biogeography Based Optimization

- Heuristic algorithms are used to solve complex optimization problems which are hard to solve using traditional methods.
- Biogeography-based optimization (BBO) was invented by Dr. Simon in 2008.

Modified BBO based on ES and RE

- In order to improve the performance of BBO, modification of BBO is necessary.
- Two techniques are used:
  - One is borrowed from evolutionary strategy (ES)
  - The other is created by myself - immigration refusal (RE).

Evolution Strategy

- Evolutionary strategy was created by students at the Technical University of Berlin.
- It is one of the classic optimization techniques among heuristic methods.

- The procedure of ES:
  1. Define α parents, β children.
  2. Initialize the population.
  3. Use α parents to form β children.
  4. Perform mutation on all the children.
  6. Out of the α+ β individuals, select α individuals as the new population.
  7. If the termination criterion is not met, go to step 3; otherwise, terminate.

Immigration refusal theory

- If an island receives immigration from an island which has a bad performance:
  - The probability of degrading the performance is larger than the probability of improving the performance.
- Therefore, immigration from a bad performance island should be denied.
- This is called immigration refusal.

- In immigration refusal, the immigrating island only accepts immigration from a better island, and this island should also satisfy some thresholds which can be defined by the user.
- For example, the threshold can be accepting immigration only from top 10 islands.

Simulation

- Simulation details
  - Number of Monte Carlo simulations: 100
  - Number of islands (individuals): 100
  - Number of SIVs (Dimensions) per island: 20
  - Generations per Monte Carlo simulation: 100
  - Mutation probability: 0.005
  - Elitism parameter: 1

- BBO algorithms:
  - Original BBO
  - BBO with features borrowed from ES (BBO/ES)
  - BBO with immigration refusal (BBO/RE)
  - BBO with features borrowed from ES and immigration refusal (BBO/ES/RE)

Best performance of different BBOs in 20 dimensional benchmarks after 100 Monte Carlo simulations

	BBO	BBO/ES	BBO/RE	BBO/ES/RE
Ackley	3.56	**1.34**	3.03	1.42
Fletcher	9570.10	4503.96	6216.63	**2248.52**
Griewank	1.40	**1.04**	1.42	1.07
Penalty #1	1.05	0.04	1.10	**0.03**
Penalty #2	4.07	**0.46**	4.56	0.51
Quartic	3.68E-04	**4.81E-06**	2.22E-04	6.33E-06
Rastrigin	1.93	**0.00**	4.04	**0.00**
Rosenbrock	17.83	**12.80**	21.41	13.44
Schwefel 1.2	51.41	**9.52**	28.69	12.10
Schwefel 2.21	680.93	**654.65**	866.16	889.69
Schwefel 2.22	0.80	**0.10**	0.70	**0.10**
Schwefel 2.26	10.70	**8.40**	10.50	9.30
Sphere	0.16	**0.00**	0.12	0.01
Step	62.00	**7.00**	39.00	**7.00**

F-test and T-test

- How can we determine if the differences between groups are statistically significant?
- Two statistical methods are used to analyze the differences between different BBO algorithms:
  - F-tests
  - T-tests

F-test values and thresholds

Benchmarks	F-test value	Threshhold		
		$P = 0.001$	$P = 0.01$	$P = 0.05$
Ackley	6.23	5.51	3.82	2.62
Fletcher	0.29			
Griewank	3.74			
Penalty #1	3.65			
Penalty #2	0.16			
Quartic	1.64			
Rastrigin	5.40			
Rosenbrock	0.20			
Schwefel 1.2	2.90			
Schwefel 2.21	0.05			
Schwefel 2.22	3.14			
Schwefel 2.26	0.29			
Sphere	4.04			
Step	3.68			

T-test values and Probability

	BBO and BBO/ES		BBO and BBO/RE	
	Pro	T-test	Pro	T-test
Ackley	9.34E-04	3.15	0.25	0.66
Fletcher	0.30	0.52	0.39	0.27
Griewank	0.01	2.23	0.31	0.49
Penalty #1	0.01	2.25	0.20	0.85
Penalty #2	0.35	0.37	0.38	0.32
Quartic	0.07	1.50	0.32	0.46
Rastrigin	1.86E-03	2.94	0.37	0.32
Rosenbrock	0.27	0.63	0.41	0.22
Schwefel 1.2	0.01	2.37	0.34	0.42
Schwefel 2.21	0.47	0.07	0.36	0.36
Schwefel 2.22	8.44E-03	2.41	0.34	0.42
Schwefel 2.26	0.24	0.71	0.34	0.41
Sphere	3.46E-03	2.73	0.32	0.46
Step	7.37E-03	2.46	0.28	0.60

Conclusion

- The modification of BBO based on ES produce a significant improvement on the fitness performance.
- F-tests and T-tests provide statistical support.

Future Work

- Tuning parameters
- More benchmarks
- Applying to real-world problem

End

Thank you !

Questions ?

Reference

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