Performance of the DEMO Algorithm on the Bi-objective BBOB Test Suite

Tea Tušar [1,2] Bogdan Filipič [2]

GECCO, July 20, 2016

[1]DOPHIN Group
Inria Lille – Nord Europe
Villeneuve d'Ascq, France

[2]Department of Intelligent Systems
Jožef Stefan Institute
Ljubljana, Slovenia

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The DEMO algorithm

The DEMO algorithm

Differential Evolution for Multiobjective Optimization (DEMO)

- Similar to NSGA-II
- Differential evolution (DE) used to search the decision space
- Immediate replacement of dominated parents

The DEMO algorithm

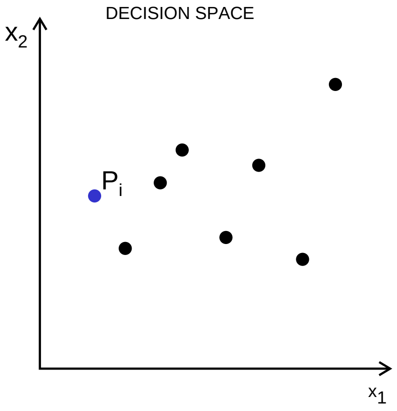
1. Evaluate the initial population $\mathcal{P}$ of *popSize* random individuals.
2. While stopping criterion not met, do:
    2.1 For each individual P_i ($i = 1, \ldots, popSize$) from $\mathcal{P}$ repeat:
    - Create candidate C from parent P_i using *DE/1/rand/bin*.
    - Evaluate the candidate.
    - If the candidate dominates the parent, the candidate replaces the parent. If the parent dominates the candidate, the candidate is discarded. Otherwise, the candidate is added to the population.

    2.2 If the population has more than *popSize* individuals, apply environmental selection to get the best *popSize* individuals.

    2.3 Randomly enumerate the individuals in $\mathcal{P}$.
3. Return nondominated individuals from $\mathcal{P}$.

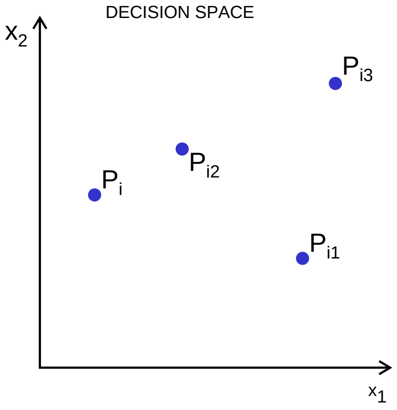
DE/1/rand/bin

Parameters *popSize*, *F* and *CR*



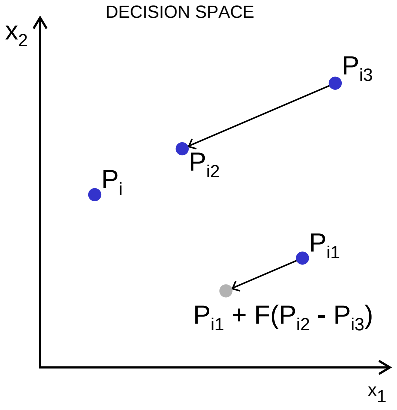
DE/1/rand/bin

Parameters *popSize*, *F* and *CR*



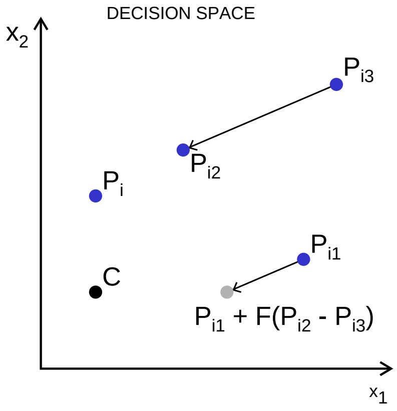
DE/1/rand/bin

Parameters *popSize*, *F* and *CR*



DE/1/rand/bin

Parameters *popSize*, *F* and *CR*



Environmental selection

Four variants

- NSGA-II → $\text{DEMO}^{\text{NS-II}}$
- SPEA2 → DEMO^{SP2}
- IBEA_{HD} → $\text{DEMO}^{\text{IB}_{\text{HD}}}$
- $\text{IBEA}_{\varepsilon+}$ → $\text{DEMO}^{\text{IB}_{\varepsilon+}}$

Experiments

Experimental setup

Problem suite *bbob-biobj*

- 55 bi-objective functions
- 10 instances
- 5 out of 6 dimensions (2-D, 3-D, 5-D, 10-D, 20-D, 40-D)

DEMO

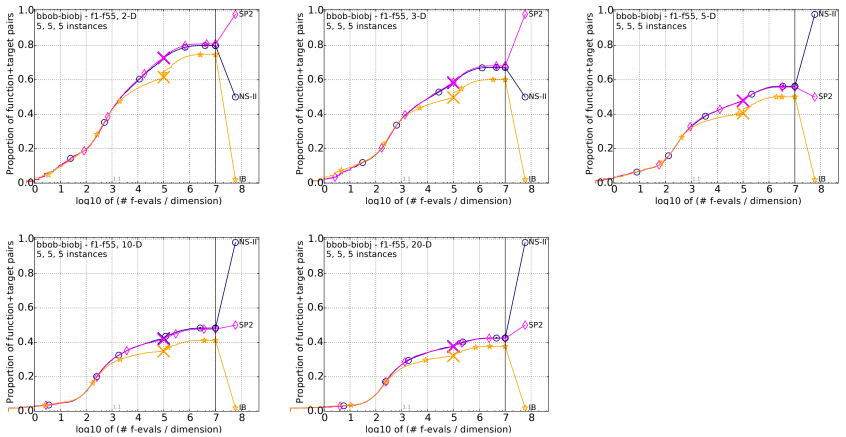
- First population sampled from $[-5, 5]^D$
- Exploration limited to $[-100, 100]^D$
- Environmental selection = NS-II
- $popSize = 100$
- Crossover probability $CR = 0.3$
- Scaling factor $F = 0.5$

Parameter tuning

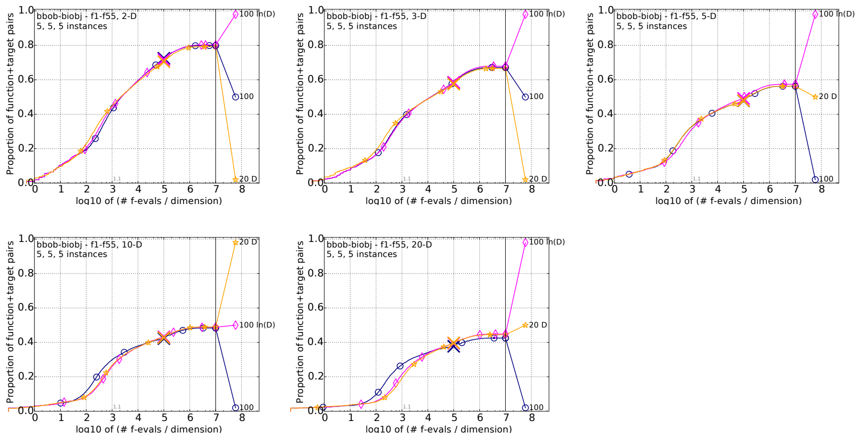
Environmental selection	Population size	Crossover probability *CR*	Scaling factor *F*
NS-II	100	0.3	0.5
SP2	100	0.3	0.5
IB_{HD}	100	0.3	0.5
NS-II	$\lfloor 100\ln(D)\rfloor$	0.3	0.5
NS-II	$20D$	0.3	0.5
NS-II	$\lfloor 100\ln(D)\rfloor$	0.1	0.5
NS-II	$\lfloor 100\ln(D)\rfloor$	0.5	0.5
NS-II	$\lfloor 100\ln(D)\rfloor$	0.7	0.5
NS-II	$\lfloor 100\ln(D)\rfloor$	0.9	0.5

Results

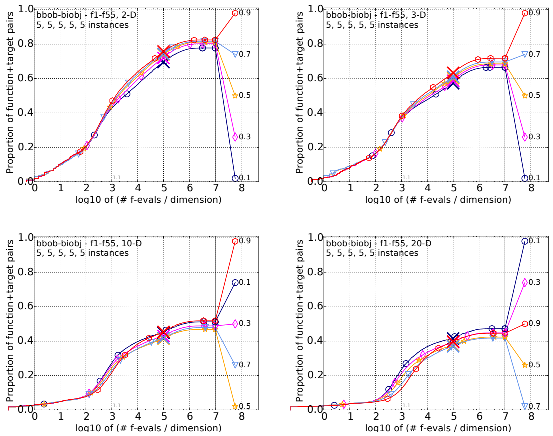
Results for environmental selection



Results for population size



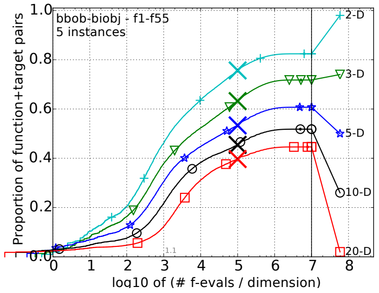
Results for crossover probability



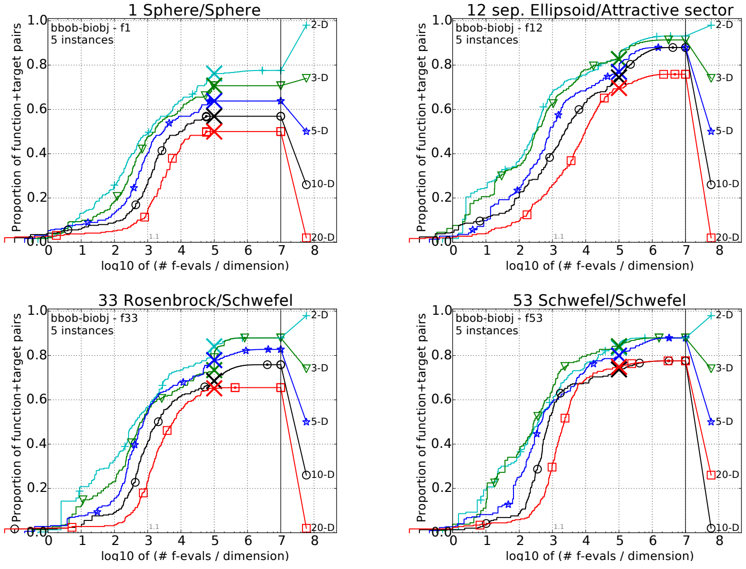
Summary

Chosen setting

- Environmental selection = NS-II
- $popSize = \lfloor 100 \ln(D) \rfloor$
- Crossover probability $CR = 0.9$
- Scaling factor $F = 0.5$



Summary



CPU timing experiment

- Windows 7 computer with Intel(R) Core(TM) i5-2410M CPU @ 2.60GHz with 1 processor and 4 cores
- 10*D* function evaluations on the entire *bbob-biobj* test suite took 9 seconds
- Time per function evaluation:

2-D	1.82×10^{-4} s
3-D	1.21×10^{-4} s
5-D	1.45×10^{-4} s
10-D	1.09×10^{-4} s
20-D	3.64×10^{-4} s

- DEMO implemented in C++

Conclusions

Conclusions

- Experimented with DEMO on the new *bbob-biobj* test suite
- Performed some parameter tuning
- Almost no difference between environmental selection NS-II and SP2
- Results might be different with an archive
- Should try increasing population size during evolution
- Surprisingly poor performance on the sphere problem, but good performance on some more difficult problems