Benchmarking of the Indicator-based Evolutionary Algorithm

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Outline

- Motivation
- IBEA setting
- Implementation & Tests
- Results
- Discussion

Motivation

Explore seminal approaches for evolutionary algorithms

Benchmark and compare algorithms using the COCO platform.
Measure performance in terms of:

- Average Runtime
- Convergence speed
- ECDF

Setting

Multi-objective optimization

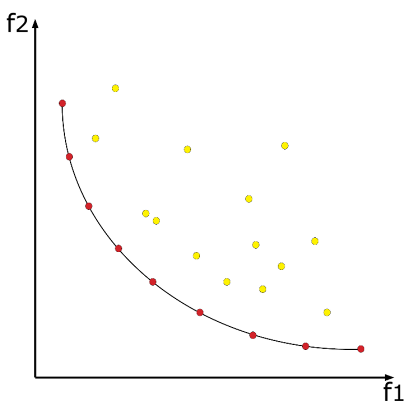
Given unknown $f : \mathbb{R}^n \to \mathbb{R}^k$, find

$x^* = \min(f_1(x), f_2(x), ..., f_k(x))$
s.t $x \in X$

Pareto optimal approximation set

Indicator function:
Subjective (*a priori*) preference information.

Non-dominated set of solution vectors.



IBEA Design

- MOEA Design: historically based on false assumptions The user has implicit contradictory preferences: maximize diversity,convergence $\rightarrow$ not even compliant with the Pareto dominance relation
- Choice of INDICATOR: implements user's preferences $\rightarrow$ actually compliant with the Pareto dominance relation
- Fitness assignment phase: uses indicator that specifies the user's preference through fitness function

Examples of Indicators:

- $I_{\epsilon+}$: implemented, low computation time, conservativity
- I_{HD}: implement by another group, it has more of an average population behavior

Implementation

Input: population size, max generations, budget, fitness scaling factor
Output: approximation of the Pareto-Set
Steps:

1. Initialization
2. Fitness Assignment
3. Environmental Selection
4. Termination Criteria
5. Mating Selection
6. Variation (recombination & mutation)

Recombination

Different recombination operators.

- One point crossover
- Intermediate weighting
- SBX

Simulated Binary Crossover

Goal: control the domain in which offspring is generated.

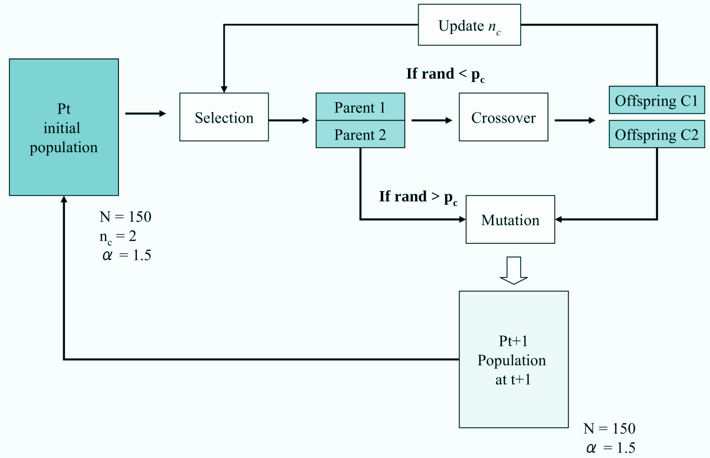
'Spread' distribution approximated by "proxy" distributions

Contracting $c(\beta) = 0.5(n_c + 1)\beta^{n_c}, \beta \leq 1$

Expanding $e(\beta) = 0.5(n_c + 1)\frac{1}{\beta^{n_c+2}}, \beta > 1$

Distribution index: $n_c \in \mathbb{N} \implies$ find optimal value?

Simulated Binary Crossover [1]



[1] Kalyanmoy Deb, S Karthik, Tatsuya Okabe, GECCO 2007

Variation operator

Adaptating the step-size: essential to find targets **fast**.

Results

Success (comparatively to other approaches)

- Separable
- moderate
- weakly-structured

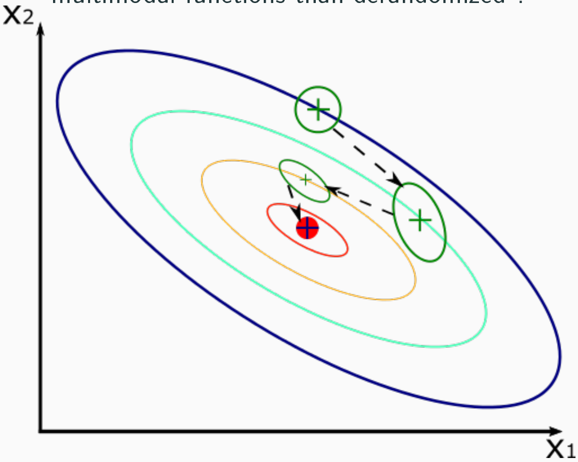
Fails in:

- multi-modality
- ill-conditioning

Dimensionality of search space.

Discussion - variance step-size

Why does isotropic gaussian works better for some ill-conditioned and multimodal functions than derandomized ?



Discussion - indicator function

Tradeoffs to consider

- problem-specific preference information vs. generality of the indicator
- precision vs. computational complexity

Thank you for your attention!

Questions & Answers

References I

- Eckart Zitzler and Simon Künzli, “Indicator-Based Selection in Multiobjective Search”. In Parallel Problem Solving from Nature (PPSN 2004), pp. 832-842, 2004.
- Deb, Kalyanmoy, and Ram B. Agrawal. "Simulated binary crossover for continuous search space." Complex Systems 9.3 (1994): 1-15.