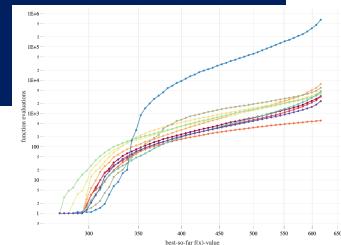
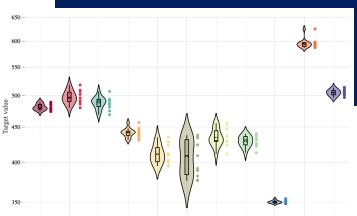


IOHprofiler

Standardized Benchmarking for Iterative Optimization Heuristics

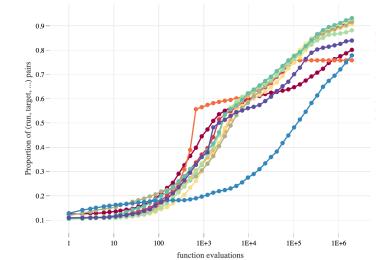


Carola Doerr¹, Hao Wang², Ofer M. Shir³, Thomas Bäck²

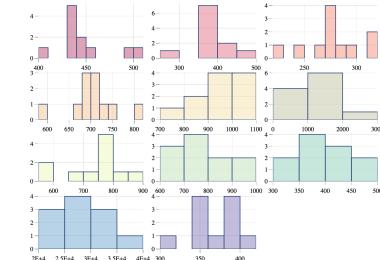
¹CNRS and Sorbonne University, Paris, France

²LIACS, Leiden University, The Netherlands

³Tel-Hai College and Migal Institute, Upper Galilee, Israel



Tutorial at CEC 2019, Wellington, NZ, June 2019



Overview of the tutorial

- ✓ **Introduction to *IOHprofiler* – 30 min**
- ✓ **Demo – 10 min**
- ✓ **Hands-on Session – 40 min**
- ✓ **Wrap-up, Q & A – 10 min**

IOHprofiler – Our Vision:

- ✓ a modern and effective tool for **benchmarking** and **analyzing iterative optimization heuristics** (IOHs)
- ✓ **standardized experimental environment**
- ✓ **interactive performance analyses and statistics**
- ✓ public, cloud-based **data repositories** for
 - **solvers**
 - **benchmark problems**
 - **performance data**



IOHprofiler Philosophy: Individual benchmarking made possible

User chooses

- ✓ **which benchmark problems and algorithms to use**
 - ✓ easy to add new benchmark functions and algorithms
- ✓ **which performance measures to use**
 - ✓ wide range of performance statistics:
 - ✓ fixed-target runtimes (+distributions)
 - ✓ fixed-budget results (+distributions)
 - ✓ probabilities of success, ECDF curves, etc.
 - ✓ statistical comparisons [work in progress]
- ✓ **how to aggregate results**
 - ✓ highly interactive evaluation tool

Availability of IOHprofiler

Documentation:

- ✓ IOHprofiler is online at GitHub: <https://github.com/IOHprofiler>
- ✓ Documentation available on arxiv: <https://arxiv.org/abs/1810.05281>
- ✓ Web-based evaluation tool: <http://iohprofiler.liacs.nl/>

Pre-installed problems and algorithms:

- ✓ Implementations and performance data available for
 - ✓ 11 algorithms (see appendix)
 - ✓ 23 *discrete* benchmark functions available (see appendix)
- more problems and algorithms are continuously added

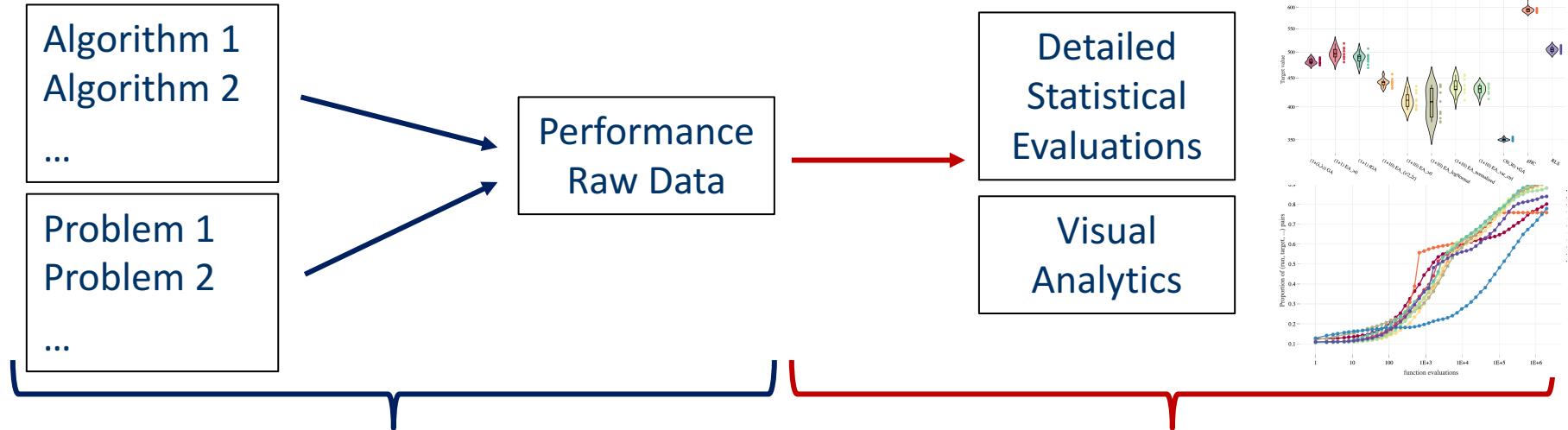
Your contributions are very welcome!

IOHAnalyzer

--

Performance evaluation
and visualization

IOHprofiler: A Ready-to-Use Benchmarking Suite with 2 Modules



IOHexperimenter (data generation)

Originally built on COCO/BBOB¹ modules now re-designed to enable interactive functionalities

Selected features:

- easy integration of new benchmark problems
- optional transformations to generate different problem instances
- parameter tracking: *algorithm profiling*
- user-specified granularity of data records

IOHanalyzer (data evaluation)

- Standalone tool, written in R
- Generates attractive plots in common formats for your next documentation
- Independent of IOHexperimenter: admits data from
 - IOHexperimenter
 - COCO/BBOB¹
 - Facebook's nevergrad² [in progress]
 - other sources (following some minimalistic format requirements)

IOHanalyzer – Vision

✓

The screenshot shows the IOHanalyzer web-interface. On the left is a dark sidebar with navigation links: Upload Data, Fixed-Target Results, Fixed-Budget Results, Algorithm Parameters, ReadMe, About, and Settings. The main area has two tabs: 'Performance Evaluation for Iterative Optimization Heuristics' (selected) and 'List of Processed Data'. The 'Upload Data' tab contains fields for dataset format (AUTOMATIC), maximization/minimization (AUTOMATIC), a note about alignment, efficient mode, and a file selection input ('Browse...'). The 'Load Data from Repository' tab contains dropdowns for selecting a dataset (2019gecco-ins1-11run), function (all), dimension (all), algorithm (all), and a 'load data' button.

Web-interface

generate the plots that you need for your next documentations!

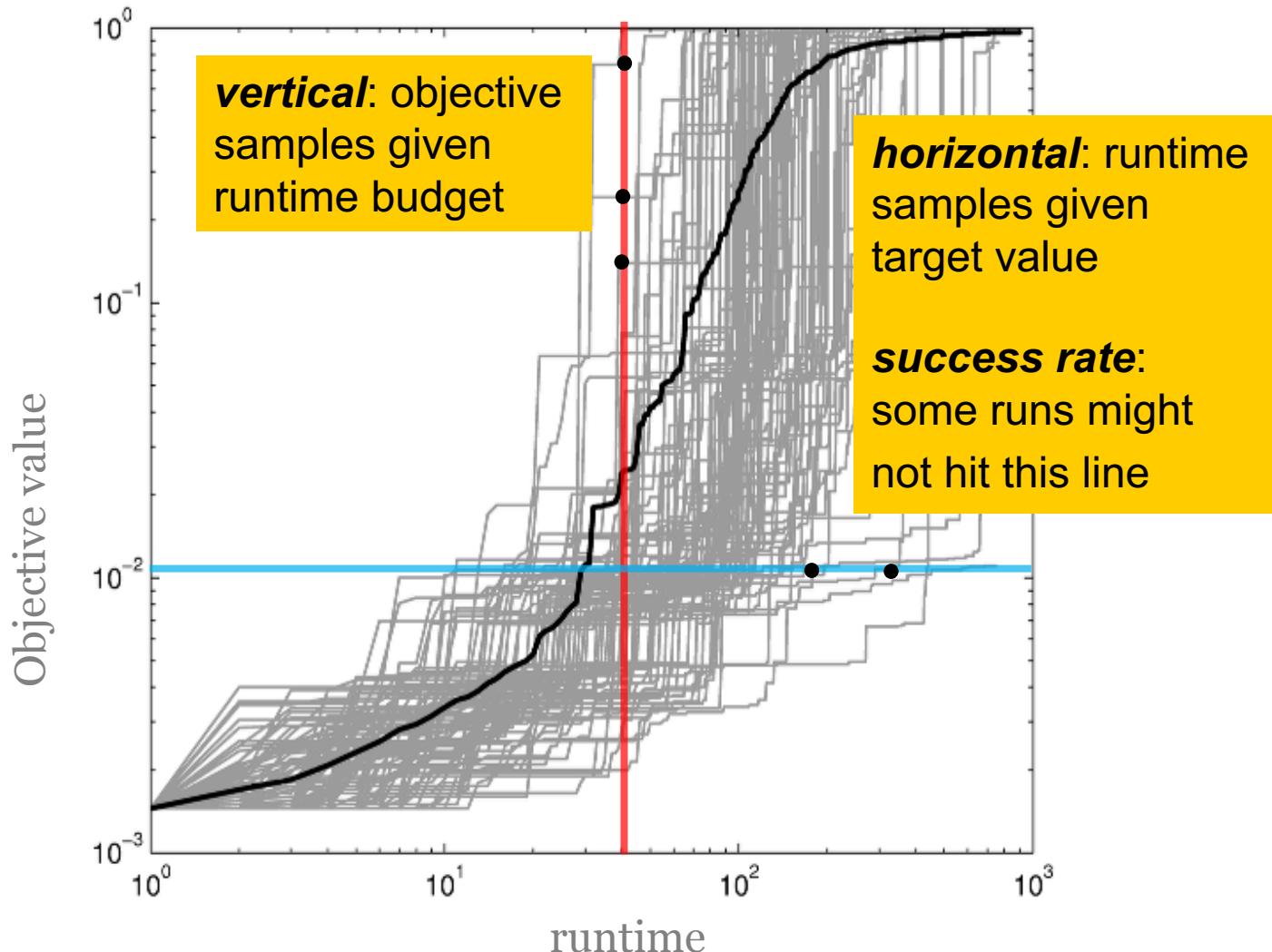
✓

```
"algId", "target", "mean", "median", "sd", "2%", "5%", "10%", "25%", "50%", "75%", "90%", "95%", "98%", "ERT", "runs", "ps"
"(1+(\lambda,\lambda)) GA", 600, 2378, 2360, 209.07, 1988, 1988, 1988, 2250, 2360, 2461, 2651, 2651, 2690, 2378, 11, 1
"(1+1) EA_>0", 600, 2114.27, 2116, 213.32, 1797, 1797, 1797, 1907, 2116, 2275, 2330, 2330, 2457, 2114.27, 11, 1
"gHC", 600, 575.45, 574, 6.65, 566, 566, 566, 569, 574, 579, 583, 583, 587, 575.45, 11, 1
"(1+10) EA_{r/2,2r}", 600, 4964.91, 4956, 442.67, 4086, 4086, 4086, 4714, 4956, 5084, 5362, 5362, 5832, 4964.91, 11, 1
"(1+10) EA_>0", 600, 3391.55, 3396, 155.01, 3076, 3076, 3076, 3266, 3396, 3483, 3557, 3557, 3582, 3391.55, 11, 1
"(1+10) EA_logNormal", 600, 4251.82, 4093, 643.14, 3489, 3489, 3489, 3804, 4093, 4464, 4998, 4998, 5539, 4251.82, 11, 1
"(1+10) EA_normalized", 600, 3162.18, 3173, 179.59, 2827, 2827, 2827, 3036, 3173, 3310, 3369, 3369, 3374, 3162.18, 11, 1
"(1+10) EA_var_ctrl", 600, 3080.91, 3096, 131.21, 2913, 2913, 2913, 2963, 3096, 3141, 3221, 3221, 3342, 3080.91, 11, 1
"(1+1) FGA", 600, 2933.18, 2935, 306.38, 2435, 2435, 2435, 2728, 2935, 3036, 3078, 3078, 3653, 2933.18, 11, 1
"(30,30) vGA", 600, 358746.91, 347996, 31706.41, 322774, 322774, 322774, 332515, 347996, 380811, 405370, 405370, 409037, 358746.91, 11, 1
"RLS", 600, 1566.27, 1600, 109.04, 1392, 1392, 1392, 1415, 1600, 1642, 1653, 1653, 1700, 1566.27, 11, 1
```

CSV

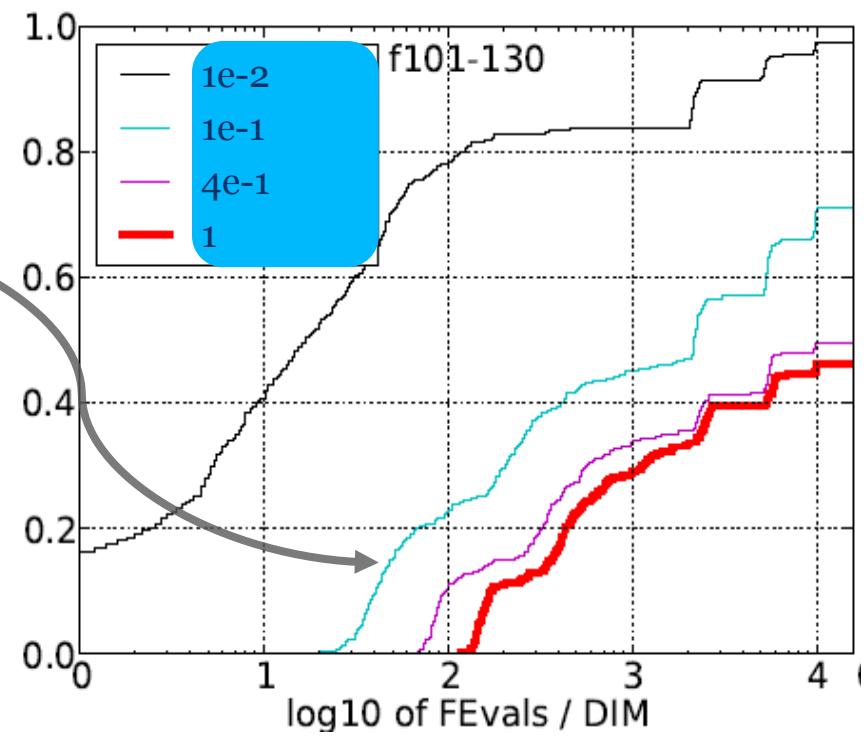
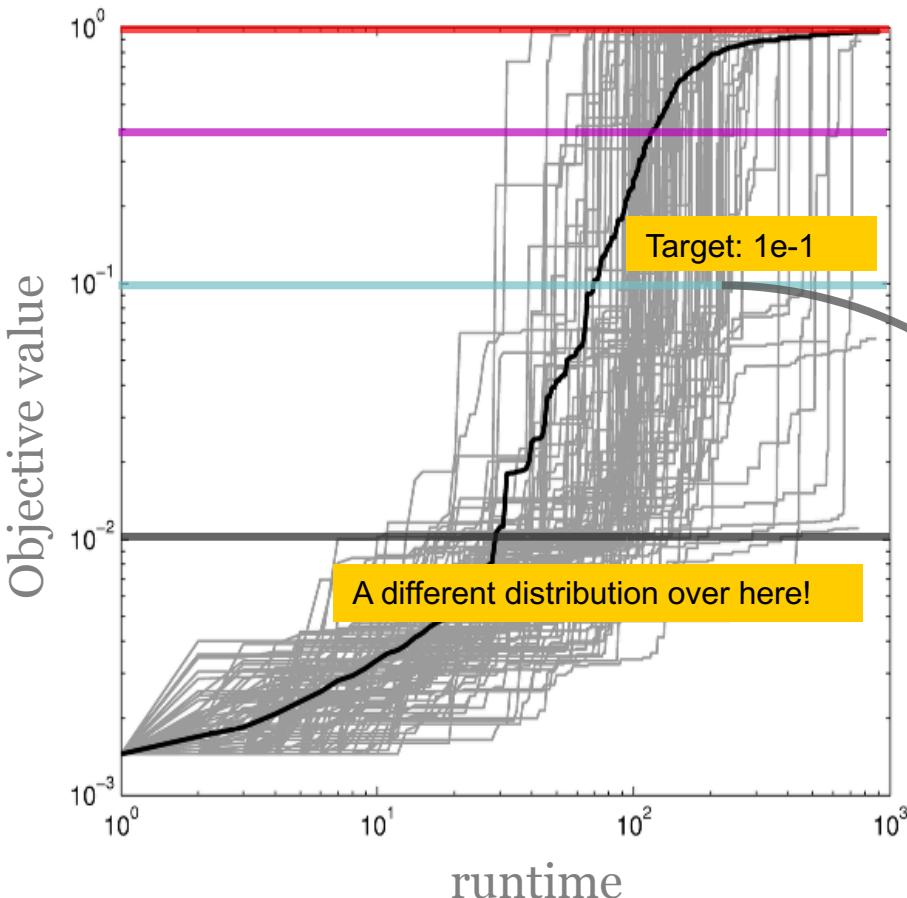
Performance Measures

- Fixed-target and fixed-budget view



Performance Measures

- Fixed-target and fixed-budget view
- *Empirical Cumulative Distribution Functions (ECDFs)*



Performance Measures

- Fixed-target and fixed-budget view
- ECDF curves
- Averages (mean), median and other quantiles, standard deviation, probability of success

algId	target	mean	median	sd	2%	5%	10%	25%	50%	75%	90%	95%	98%		
	All	All	All	All	All	All	All	All	All	All	All	All	All		
1	(1+ λ) GA	600	2378	2360	209.07	1988	1988	1988	2250	2360	2461	2651	2651		
2	(1+1) EA_>0	600	2114.27	2116	213.32	1797	1797	1797	1907	2116	2275	2330	2330		
3	gHC	600	575.45	574	6.65	566	566	566	569	574	579	583	583		
4	(1+10) EA_{r/2,2r}	600	4964.91	4956	442.67	4086	4086	4086	4714	4956	5084	5362	5362		
5	(1+10) EA_>0	600	3391.55	3396	155.01	3076	3076	3076	3266	3396	3483	3557	3557		
6	(1+10) EA_logNormal	600	4251.82	4093	643.14	3489	3489	3489	3804	4093	4464	4998	4998		
7	(1+10) EA_normalized	600	"algId", "target", "mean", "median", "sd", "2%", "5%", "10%", "25%", "50%", "75%", "90%", "95%", "98%", "ERT", "runs", "ps" "(1+ λ) GA", 600, 2378, 2360, 209.07, 1988, 1988, 1988, 2250, 2360, 2461, 2651, 2651, 2690, 2378, 11, 1 "(1+1) EA_>0", 600, 2114.27, 2116, 213.32, 1797, 1797, 1797, 1907, 2116, 2275, 2330, 2330, 2457, 2114.27, 11, 1 "gHC", 600, 575.45, 574, 6.65, 566, 566, 566, 569, 574, 579, 583, 583, 587, 575.45, 11, 1 "(1+10) EA_{r/2,2r}", 600, 4964.91, 4956, 442.67, 4086, 4086, 4086, 4714, 4956, 5084, 5362, 5362, 5832, 4964.91, 11, 1 "(1+10) EA_>0", 600, 3391.55, 3396, 155.01, 3076, 3076, 3076, 3266, 3396, 3483, 3557, 3557, 3582, 3391.55, 11, 1 "(1+10) EA_logNormal", 600, 4251.82, 4093, 643.14, 3489, 3489, 3489, 3804, 4093, 4464, 4998, 4998, 5539, 4251.82, 11, 1 "(1+10) EA_normalized", 600, 3162.18, 3173, 179.59, 2827, 2827, 2827, 3036, 3173, 3310, 3369, 3369, 3374, 3162.18, 11, 1 "(1+10) EA_var_ctrl", 600, 3080.91, 3096, 131.21, 2913, 2913, 2913, 2963, 3096, 3141, 3221, 3221, 3342, 3080.91, 11, 1 "(1+1) fGA", 600, 2933.18, 2935, 306.38, 2435, 2435, 2435, 2728, 2935, 3036, 3078, 3078, 3653, 2933.18, 11, 1 "(30,30) vGA", 600, 358746.91, 347996, 31706.41, 322774, 322774, 322774, 332515, 347996, 380811, 405370, 405370, 409037, 358746.91, 11, 1 "RLS", 600, 1566.27, 1600, 109.04, 1392, 1392, 1392, 1415, 1600, 1642, 1653, 1653, 1700, 1566.27, 11, 1												
9	(1+1) fGA	600													
10	(30,30) vGA	600													

Showing 1 to 10 of 11 entries

IOHanalyzer – Data Upload

Load Data from Repository

Select the dataset

2019gecco-ins1-11run

Please choose the function

all

Please choose the dimension

all

Please choose the algorithm

all

load data

Upload Data

Please choose the format of your data sets

AUTOMATIC

Maximization or minimization?

AUTOMATIC

Note: when using two-column format, please select the format and maximization manually.

When the data set is huge, the alignment can take a very long time. In this case, you could toggle the efficient mode to subsample the data set. However, the precision of data will be compromised.

Efficient mode

Please choose a zip file containing the benchmark data

Browse... No file selected

Remove all the data

- Loading the data set from our repository (*left*) and uploading your data set (*right*)

IOHanalyzer – Data Summary

Runtime Statistics at Chosen Target Values

Set the range and the granularity of the results.
The table will show fixed-target runtimes for evenly spaced target values.

f_{\min} : Smallest target value

274.00

f_{\max} : Largest target value

625.00

Δf : Granularity (step size)

39.00

$f_{\min} = f_{\max}$? Once toggled, only f_{\min} is used to generate the table on the right.

Algorithms

(1+(λ, λ)) GA_1

Format

csv

 Save this table

This table summarizes for each algorithm and each target value chosen on the left:

- runs: the number of runs that have found at least one solution of the required target quality $f(x)$,
- mean: the average number of function evaluations needed to find a solution of function value at least $f(x)$
- median, 2%, 5%, ..., 98% : the quantiles of these first-hitting times

When not all runs managed to find the target value, the statistics hold only for those runs that did. That is, the mean value is the mean of the successful runs. Same for the quantiles. An alternative version with simulated restarts is currently in preparation.

Show ▾ entries

Search:

algId	target	mean	median	sd	2%	5%	10%	25%	50%	75%	90%	95%	98%	ERT
(1+(λ, λ)) GA_1	274.00	1.00000	1	0.00000	1	1	1	1	1	1	1	1	1	1.00000
(1+(λ, λ)) GA_1	313.00	12.00000	11	11.89117	1	1	1	1	11	18	28	28	32	12.00000
(1+(λ, λ)) GA_1	352.00	92.09091	101	30.31321	33	33	33	75	101	116	124	124	126	92.09091
(1+(λ, λ)) GA_1	391.00	205.09091	206	28.46561	152	152	152	179	206	227	238	238	241	205.09091
(1+(λ, λ)) GA_1	430.00	352.18182	353	26.35458	312	312	312	328	353	364	381	381	398	352.18182
(1+(λ, λ)) GA_1	469.00	556.63636	561	32.09135	506	506	506	518	561	573	591	591	596	556.63636
(1+(λ, λ)) GA_1	508.00	807.54545	797	51.48468	734	734	734	752	797	841	860	860	893	807.54545

- Descriptive statistics (e.g., mean, median, quantiles...) of running time sample from algorithms

IOHanalyzer – Interactive Visualization

Expected Runtime (ERT): single function

Range of the displayed target values

Select which algorithms to plot:

- (1+ (λ,λ)) GA_1
- (1+1) EA_>0_1
- (1+1) fGA_1
- (1+10) EA_{r/2,2r}_1
- (1+10) EA_>0_1
- (1+10) EA_logNormal_1
- (1+10) EA_normalized_1
- (1+10) EA_var_ctrl_1
- (30,30) vGA_1
- gHC_1
- RLS_1

f_{\min} : Smallest target value
274.00

f_{\max} : Largest target value
625.00

Show/hide ERT

Show/hide mean

Show/hide mean +/- sd

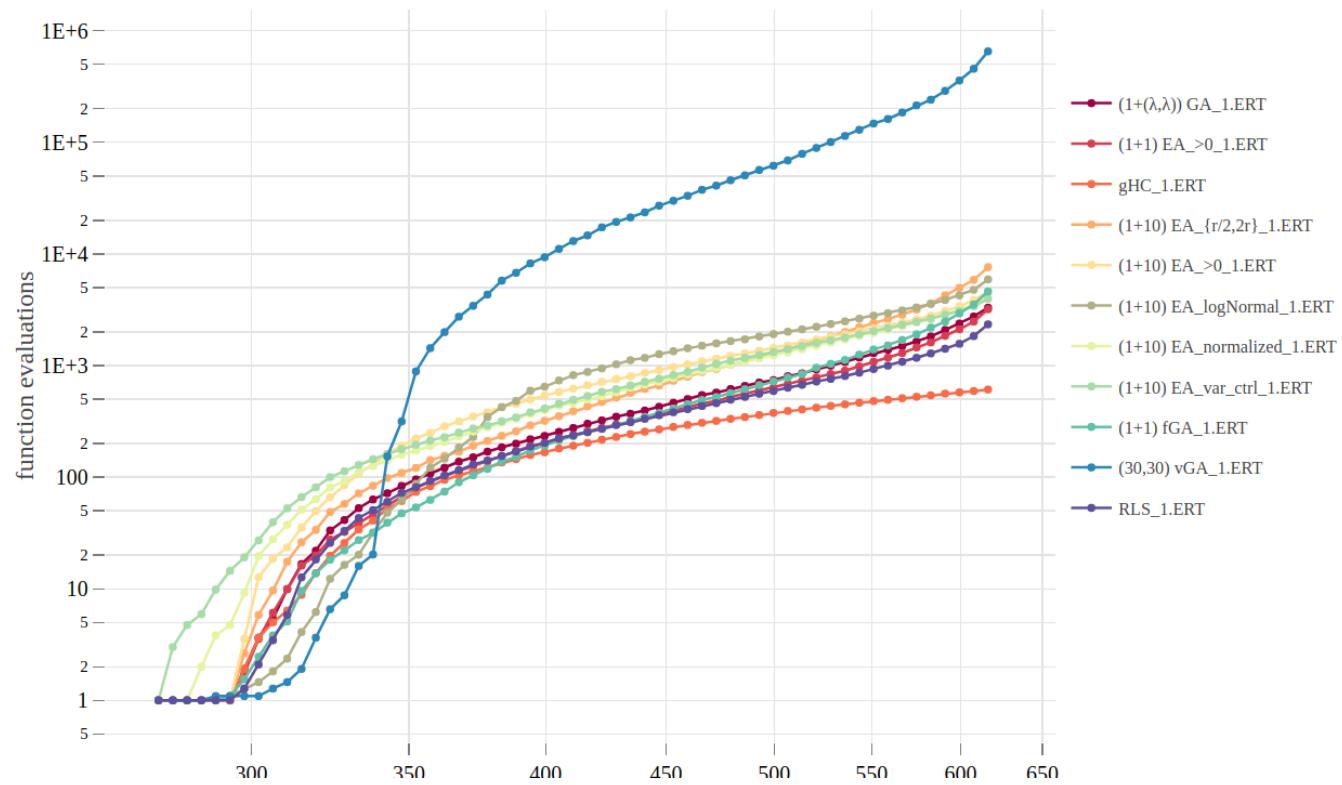
Show/hide median

Scale x axis log10

Scale y axis log10

Select the figure format

The *mean, median and standard deviation* of the runtime samples are depicted against the best objective values. The displayed elements (mean, median, standard deviations) can be switched on and off by clicking on the legend on the right. A **tooltip** and **toolbar** appears when hovering over the figure.



- The ERT (expected running time) as a function of target value reached by algorithms

IOHanalyzer – Interactive Visualization

Empirical Probability Mass Function of the Runtime

Select the target value for which the runtime distribution is shown

43.00

Select which algorithms to plot:

(1+ (λ,λ)) GA_1
(1+1) EA_>0_1
(1+1) fGA_1
(1+10) EA_{r/2,2r}_1
(1+10) EA_>0_1
(1+10) EA_logNormal_1
(1+10)
EA_normalized_1
(1+10) EA_var_ctrl_1
(30,30) vGA_1 gHC_1
RLS_1

Show runtime for each run

Scale y axis log10

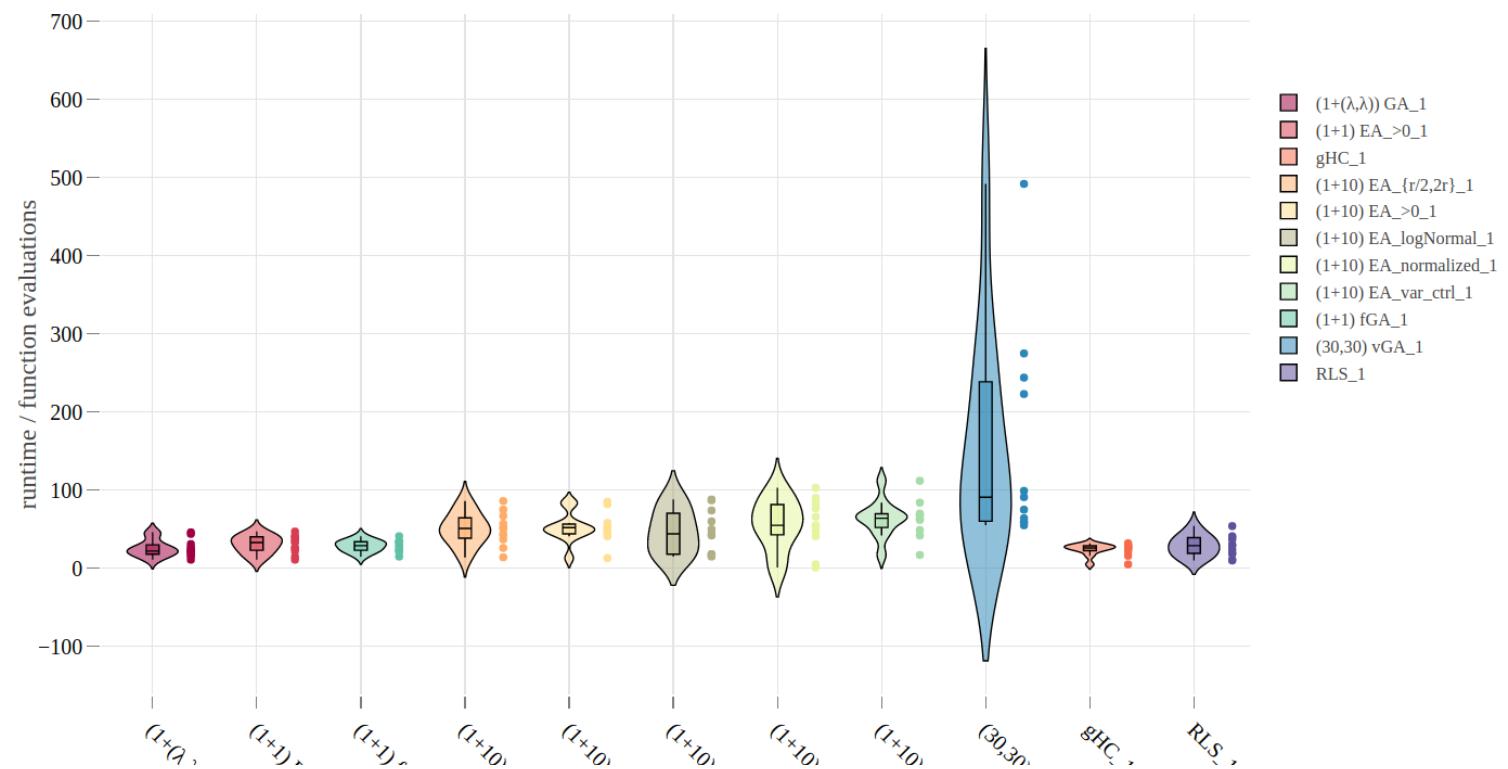
Select the figure format

pdf

[Download the figure](#)

Warning! The **probability mass function** of the runtime is approximated by treating the runtime as a *continuous* random variable and applying the **kernel estimation (KDE)**:

The plot shows the distribution of the first hitting times of the individual runs (dots), and an estimated distribution of the probability mass function. The displayed algorithms can be selected by clicking on the legend on the right. A **tooltip** and **toolbar** appear when hovering over the figure. This also includes the option to download the plot as png file. A csv file with the runtime data can be downloaded from the [Data Summary tab](#).



- Empirical probability density function of the running time at a given target value

IOHanalyzer – Interactive Visualization

Aggregated Empirical Cumulative Distribution: All functions

Select which algorithms to plot:

(1+(λ,λ)) GA_1 (1+1) EA_>0_1 (1+1) fGA_1
(1+10) EA_{r/2,2r}_1 (1+10) EA_>0_1
(1+10) EA_logNormal_1
(1+10) EA_normalized_1
(1+10) EA_var_ctrl_1 (30,30) vGA_1
gHC_1 RLS_1

Aggregate functions

Aggregate dimensions

Scale X-axis logarithmically

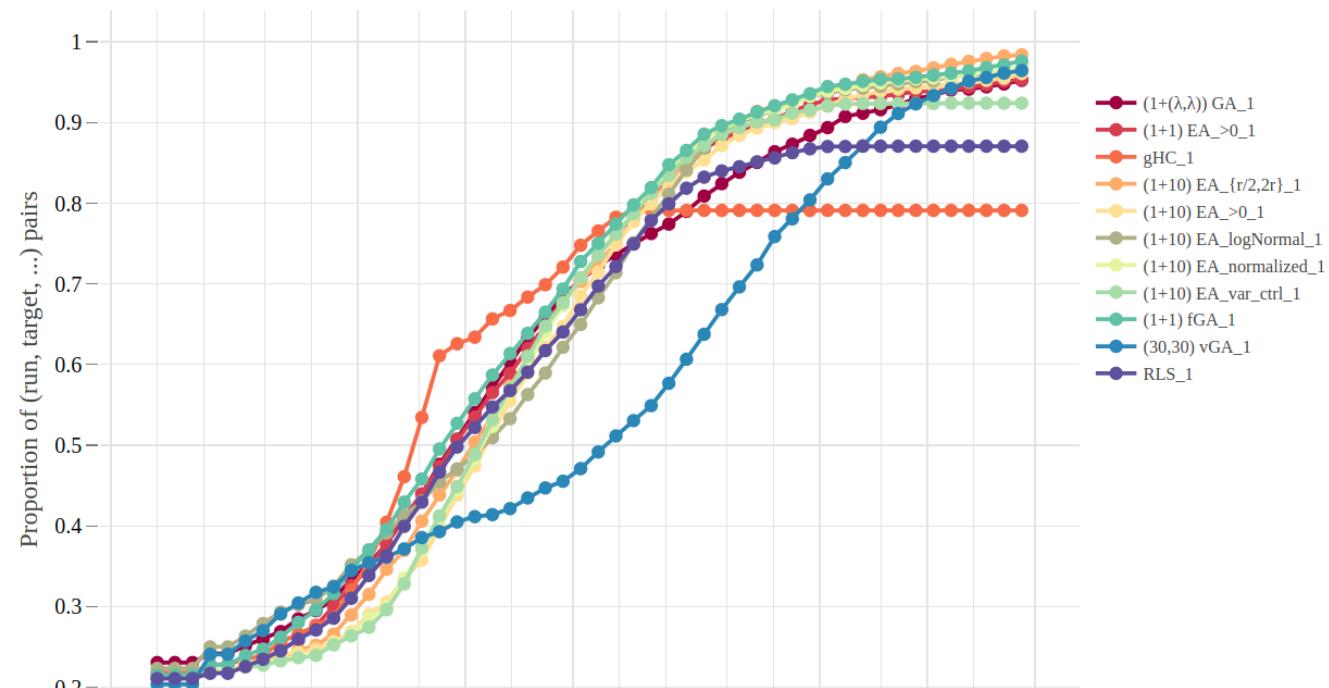
Choose whether to upload a file containing the target-values for each (function, dimension)-pair or use the automatically generated targets (see table below the plot). Please consider keeping the file format when modifying the csv given below.

[Download the example targets](#)

Please choose a csv file containing the targets

Browse... No file selected

The fraction of (run,target value, ...) pairs (i, v, \dots) satisfying that the best solution that the algorithm has found in the i -th (run of function f in dimension d) within the given time budget t has quality at least v is plotted against the available budget t . The displayed elements can be switched on and off by clicking on the legend on the right. A **tooltip** and **toolbar** appears when hovering over the figure. Aggregation over functions and dimension can be switched on or off using the checkboxes on the left; when aggregation is off the selected function / dimension is chosen according the the value in the bottom-left selection-box.



- Cumulative distribution function of running time aggregated over multiple targets and functions

IOHanalyzer – Examples of Use-Cases

CEC full papers:

1. Furong Ye, Carola Doerr, and Thomas Bäck. Interpolating Local and Global Search by Controlling the Variance of Standard Bit Mutation. CEC'19 [Wednesday, 5:00 pm in Special Session CEC-21: Theory of Bio-Inspired Computation]

GECCO full papers:

1. Carola Doerr, Furong Ye, Sander van Rijn, Hao Wang, Thomas Bäck. Towards a theory-guided benchmarking suite for discrete black-box optimization heuristics: profiling $(1 + \lambda)$ EA variants on OneMax and LeadingOnes. GECCO'18
2. Naama Horesh, Thomas Bäck, Ofer M. Shir. Predict or Screen Your Expensive Assay? DoE vs. Surrogates in Experimental Combinatorial Optimization. GECCO'19
3. Nguyen Dang, Carola Doerr. Hyper-Parameter Tuning for the $(1+(\lambda, \lambda))$ GA. GECCO'19

GECCO workshop papers:

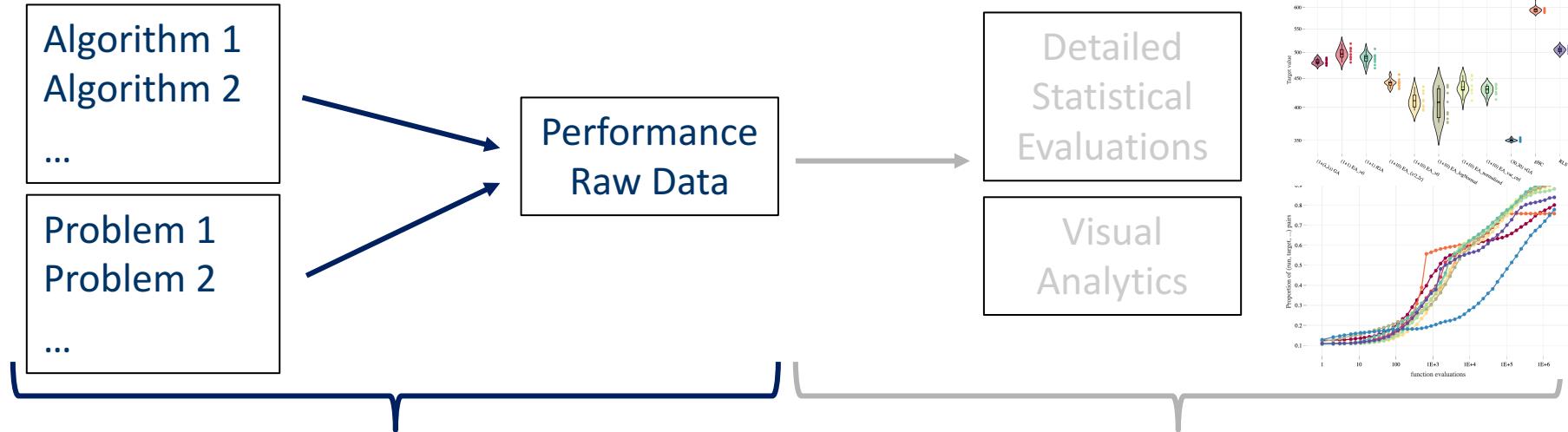
1. Carola Doerr, Furong Ye, Naama Horesh, Hao Wang, Ofer M. Shir, and Thomas Bäck. Benchmarking Discrete Optimization Heuristics with IOHprofiler. GECCO'19
2. Borja Calvo, Ofer M. Shir, Josu Ceberio, Carola Doerr, Hao Wang, Thomas Bäck, and Jose A. Lozano. Bayesian Performance Analysis for Black-Box Optimization Benchmarking. GECCO'19
3. Ivan Ignashov, Arina Buzdalova, Maxim Buzdalov, and Carola Doerr. Illustrating the Trade-Off between Time, Quality, and Success Probability in Heuristic Search. GECCO'19
4. Nathan Buskulic and Carola Doerr. Maximizing Drift is Not Optimal for Solving OneMax. GECCO'19

IOHexperimenter

--

**Standardized data generation to
track performance and evolution
of crucial parameters**

IOHprofiler: A Ready-to-Use Benchmarking Suite with 2 Modules



IOHexperimenter (data generation)

Originally built on COCO/BBOB¹ modules
now re-designed to enable interactive
functionalities

Selected features:

- easy integration of new benchmark problems
- optional transformations to generate different problem instances
- parameter tracking: *algorithm profiling*
- user-specified granularity of data records

IOHanalyzer (data evaluation)

- Standalone tool, written in R
- Generates attractive plots in common formats for your next documentation
- Independent of IOHexperimenter:
admits data from
 - IOHexperimenter
 - COCO/BBOB¹
 - Facebook's nevergrad² [in progress]
 - other sources (following some minimalistic format requirements)

IOHxperimenter

- Experimentation module for black-box *combinatorial* optimization, i.e., discrete problems $f: S \rightarrow \mathbb{R}$ with finite search space S
- Backbone: implemented in **C++** (98/03)
 - Redesign and transfer to C++11/14 are under construction
- Effective wrappers in **Python**, **R**, **Java** [in progress]
- Currently, **23** built-in combinatorial test-functions
 - Discrete transformation for instance generation:
$$af(\sigma(x \oplus z)) + b$$
 - OneMax, LeadingOnes *feat.* W-model [Weise, Wu. GECCO'18]
 - Ising models, N-Queens problem, Maximum Independent Set, Low Autocorrelation Binary Sequences
 - Extendible to any test-function following the interface
- **11** optimization algorithms implemented in C
- Wiki: <https://iohprofiler.github.io/IOHxperimenter/>

IOHexperimenter

- Wrappers enable modern *look-n-feel* in scripting languages:
- R usage:

```
R> devtools::install_github('IOHprofiler/IOHexperimenter@R')
R> library('IOHexperimenter')

R> experimenter <- IOHexperimenter(
+   dims = c(16, 100),
+   functions = c(1, 2, 19, 23),
+   instances = 1:5, algorithm.name = 'RLS',
+   data.dir = './data'
+ )

R> problem <- next_problem(experimenter)
R> while (!is.null(problem)) {
+   print(problem)
+   problem <- next_problem(experimenter)
+ }
```

Work in progress

- ✓ **Statistical tests** and **Bayesian analysis** for comparing algorithms' performance data
- ✓ Redesign/refactor of the IOHexperimenter's backbone
- ✓ Extension of benchmark problems and reference algorithms
- ✓ Constant improvements of the User-Experience (UX)
 - ✓ plots/graphics
 - ✓ Efficiency
 - ✓ Report generation?
- ✓ Supporting more programming languages, e.g., **Scala**, **Java**, etc.

Suggestions and contributions are very welcome!

Hands-on Session

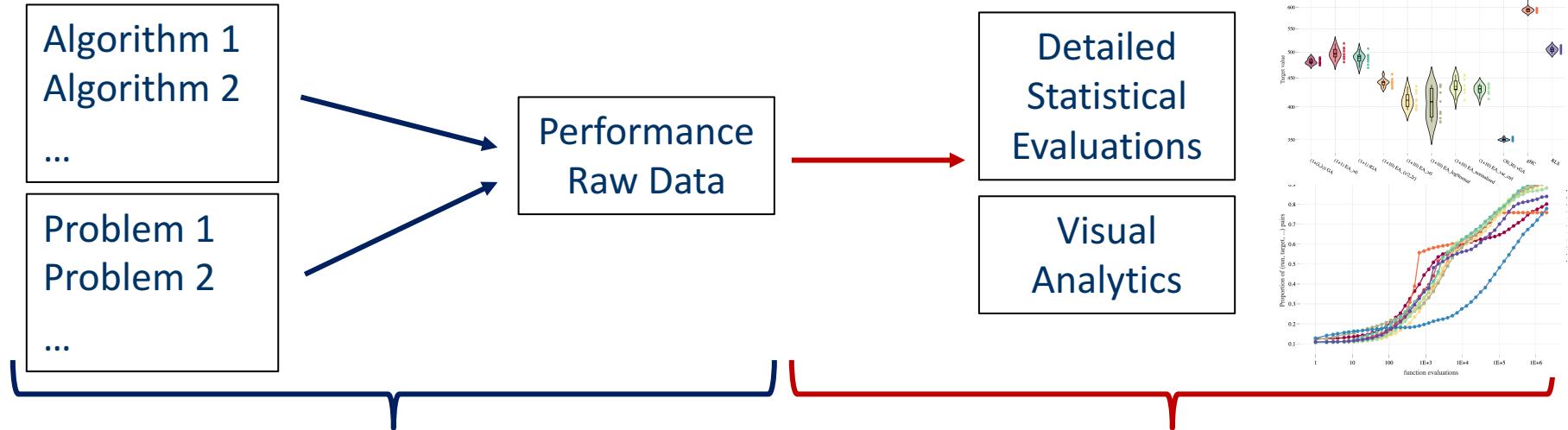
- ✓ The best way to get familiar with a software
- ✓ Online version for this tutorial: <https://35.244.102.226/>
- ✓ Practical question available physically or can be downloaded via
<https://github.com/IOHprofiler/CEC19-Tutorial>

We will go through those questions together!

WRAP-UP

(after hands-on)

IOHprofiler: A Ready-to-Use Benchmarking Suite with 2 Modules



IOHexperimenter (data generation)

Originally built on COCO/BBOB¹ modules now re-designed to enable interactive functionalities

Selected features:

- easy integration of new benchmark problems
- optional transformations to generate different problem instances
- parameter tracking: *algorithm profiling*
- user-specified granularity of data records

IOHanalyzer (data evaluation)

- Standalone tool, written in R
- Generates attractive plots in common formats for your next documentation
- Independent of IOHexperimenter: admits data from
 - IOHexperimenter
 - COCO/BBOB¹
 - Facebook's nevergrad² [in progress]
 - other sources (following some minimalistic format requirements)

Want to get involved?

You can contribute by providing (or suggesting)

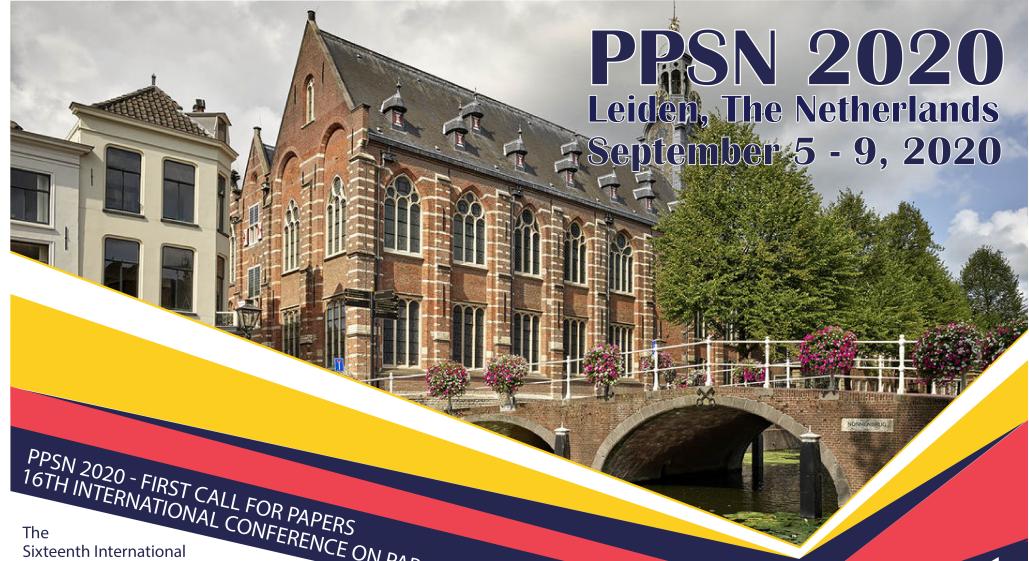
- benchmark problems
- reference algorithms
- performance statistics
- ideas how to combine performance analysis with landscape analysis
- other features that would improve IOHprofiler



... and by simply using IOHprofiler, exporting its output for your presentation/manuscript, and sharing your user-experience!

Acknowledgments

- We thank the following colleagues for contributions and feedback on IOHprofiler and/or discussions around the topic of benchmarking IOHs:
 - Furong Ye, Diederick Vermetten, Sander van Rijn from Leiden University, NL
 - Arina Buzdalova, Maxim Buzdalov, and students from ITMO University, Russia
 - Borja Calvo, Josu Ceberio, and Jose A. Lozano from San Sebastián, Spain
 - Thomas Weise from Heifei University, China
 - Naama Horesh and Assaf Israeli from Migal Institute, Israel
 - Dirk Sudholt from Sheffield University, UK
 - Anne Auger, Dimo Brockhoff, and Niko Hansen from INRIA, France
- We acknowledge financial support from
 - Chinese scholarship council (CSC No. 201706310143)
 - ANR-11-LABX-0056-LMH,
 - Paris Ile-de-France Region
 - COST Action CA15140 on Improving Applicability of Nature-Inspired Optimisation by Joining Theory and Practice (ImAppNIO)



PPSN 2020 - FIRST CALL FOR PAPERS
16TH INTERNATIONAL CONFERENCE ON PARALLEL PROBLEM SOLVING FROM NATURE

The Sixteenth International Conference on Parallel Problem Solving from Nature (PPSN XVI) will be held in Leiden, Netherlands, September 5-9, 2020. Leiden University and the Leiden Institute of Advanced Computer Science (LIACS) are proud to host the 30th anniversary of PPSN.

PPSN brings together researchers and practitioners in the field of Natural Computing: The study of computing approaches which are gleaned from natural models. The field includes, but is not limited to, areas such as Amorphous Computing, Artificial Life, Artificial Ant Systems, Artificial Immune Systems, Artificial Neural Networks, Cellular Automata, Evolutionary Computation, Swarm Computing, Self-Organizing Systems, Chemical Computation, Molecular Computation, Quantum Computation, and Machine Learning and Artificial Intelligence approaches using Natural Computing methods.

PPSN XVI will feature workshops and tutorials covering advanced and fundamental topics in the field of Natural Computing, as well as algorithm competitions. The keynote talks will be given by world-renowned researchers in their fields.

Following PPSN's unique tradition, all accepted papers will be presented during poster sessions and will be included in the proceedings. The proceedings will be published in the Lecture Notes in Computer Science (LNCS) series by Springer. Prospective authors are invited to contribute their high-quality original results in the field of natural computation as papers of no more than 12 pages plus references. The format follows Springer Verlag LNCS style.

Leiden is just 15 minutes by train from the 3rd largest airport in Europe, Schiphol Amsterdam (AMS) – which can be reached by direct flights from more than 300 destinations world-wide.

We are very much looking forward to seeing you at PPSN XVI in Leiden!

IMPORTANT DATES

<u>Workshop/Tutorial/Competition proposals</u>	November 13, 2019
<u>Workshop/Tutorial/Competition notification</u>	November 27, 2019
<u>Abstract submission</u>	March 25, 2020
<u>Paper submission</u>	April 1, 2020
<u>Author notification</u>	May 11, 2020
<u>Camera ready</u>	June 1, 2020
<u>Conference</u>	September 5 - 9, 2020

- PPSN 2020 conference
- Leiden, The Netherlands
- September 5 – 9, 2020
- <http://ppsn2020.liacs.leidenuniv.nl/>

GENERAL CHAIRS	PROCEEDINGS CHAIRS	TUTORIALS CHAIR	WORKSHOP CHAIR	FINANCIAL CHAIR
Mike Preuss Thomas Bäck	Hao Wang André Deutz	Ofer Shir	Anna Esparcia-Alcazar	Felix Witteben
PROGRAM COMMITTEE CHAIRS	COMPETITIONS CHAIR	KEYNOTE CHAIR	INDUSTRIAL LIAISON CHAIR	LOCAL TEAM
Michael Emmerich Heike Trautmann Carola Doerr	Vanessa Volz HONORARY CHAIRS Hans-Paul Schwefel Grzegorz Rozenberg	Aske Plaat	Bernhard Sendhoff	Roshny Kohabir Jayshri Murli

ppsn2020.liacs.leidenuniv.nl



APPENDIX

11 Reference Algorithms

(more to come, your contributions most appreciated!)

- gHC: Greedy Hill Climber: flip 1 bit/iteration
- RLS: Randomized Local Search: flips 1 random bit/iteration
- $(1 + \lambda)$ EAs with standard bit mutation
- $(1 + \lambda)$ EAs with normalized bit mutation and self-adjusting means [YeDB'19]
- $(1 + \lambda)$ EAs with normalized bit mutation and self-adjusting means and variance control [YeDB'19]
- $(1 + \lambda)$ EAs with log-normal self-adaptive mutation rates [BäckS96]
- fast GA from [DoerrLMN GECCO'17]
- self-adjusting 2-rate $(1 + \lambda)$ EA from [DoerrGWY GECCO'17]
- self-adjusting $(1 + (\lambda, \lambda))$ GA from [DoerrD Algorithmica'18]
- (μ, λ) “vanilla”/textbook GA

Strong focus on “textbook” algorithms and recent developments from the theory community
→ your contributions are highly welcome!

Few Details about Algorithms

1. **gHC:** A (1+1) greedy hill climber, which goes through the string from left to right, flipping exactly one bit per each iteration, and accepting the offspring if it is at least as good as its parent.
2. **RLS:** Randomized Local Search, the elitist (1+1) strategy flipping one uniformly chosen bit in each iteration. I.e., RLS and gHC differ only in the choice of the bit which is flipped. While RLS is unbiased in the sense of Sec. 3.2, gHC is not permutation-invariant and thus biased.
3. **(1 + 1) EA:**⁴ The (1+1) EA with static mutation rate $p = 1/n$. This algorithm differs from RLS in that the number of uniformly chosen, pairwise different bits to be flipped is sampled from the conditional binomial distribution $\text{Bin}_{>0}(n, p)$.
4. **fGA:** The “fast GA” proposed in [DLMN17] with $\beta = 1.5$. While in the (1+1) EA the *mutation strength* (i.e., the number of bits flipped in each iteration) follows a (conditional) binomial distribution [PD17, DYvR⁺18], its distribution follows a power-law in the fGA.
5. **(1 + 10) EA:** The (1+10) EA with static $p = 1/n$, which differs from the (1+1) EA only in that 10 offspring are sampled (independently) per each iteration. Only the best one of these (ties broken at random) replaces the parent, and only if it is as least as good.
6. **(1 + 10) EA_{r/2,2r}:** The two-rate EA with self-adjusting mutation rates suggested and analyzed in [DGWY17].
7. **(1 + 10) EA_{norm.}:** a variant of the (1 + 10) EA sampling the mutation strength from a normal distribution $N(pn, pn(1 - p))$ with self-adjusting choice of p ; was recently suggested in [YDB19].
8. **(1 + 10) EA_{var.}:** The (1 + 10) EA_{norm.} with an adaptive choice of the variance in the normal distribution from which the mutation strengths are sampled. Also from [DYvR⁺18].
9. **(1 + 10) EA_{log-n}:** The (1+10) EA with log-normal self-adaptation of the mutation rate proposed in [BS96].
10. **(1 + (λ , λ)) GA:** A binary (i.e., crossover-based) EA originally suggested in [DDE15]. We use the variant with self-adjusting λ analyzed in [DD18].
11. **vGA:** A (30, 30) “vanilla” GA (following the so-called traditional GA, as described in e.g., [Gol89, Bäc96]).

Existing Benchmark Discrete Problems

- F1: OneMax
- F2: LeadingOnes
- F3: Harmonic Linear Function
- F4-F10: W-Model² on top of OneMax
(W-model allows to scale effective dimension, epistasis, neutrality, ruggedness, fitness plateaus, etc.)
- F5-17: W-Model on top of LeadingOnes
- F18: LABS: Low Autocorrelation Binary Sequences
- F19: Ising Model: Ring
- F20: Ising Model: Torus
- F21: Ising Model: Triangular (Isometric 2D Grid)
- F22: MIVS: Maximum Independent Vertex Set
- F23: N-Queens Problem

Thousands of combinations are possible, our implementation covers the whole W model

²[Weise, Wu: GECCO'18 (BB-DOB workshop paper)]