



Black-Box Optimization in LocalSolver 6.0

www.localsolver.com

Who we are



Bouygues, one of the French largest corporation, €33 bn in revenues
<http://www.bouygues.com>

Innovation24

Operations Research subsidiary of Bouygues
20 years of practice and research
<http://www.innovation24.fr>

LocalSolver

Mathematical optimization solver
commercialized by Innovation 24
<http://www.localsolver.com>



LocalSolver

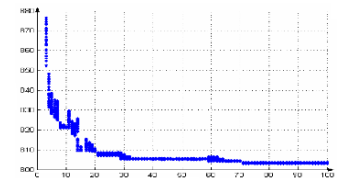
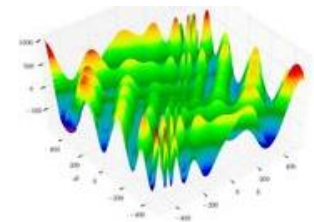
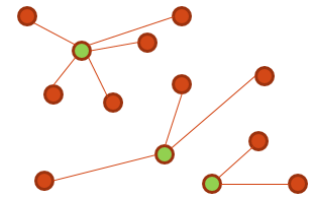
Hybrid math optimization solver

For combinatorial, numerical,
or mixed-variable optimization

Suited for large-scale
non-convex optimization

Quality solutions in seconds
without tuning

LocalSolver
=
LS + CP/SAT + LP/MIP + NLP



free trial with support – free for academics – renting licenses
from 590 €/month – perpetual licenses from 9,900 €

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Black-box optimization

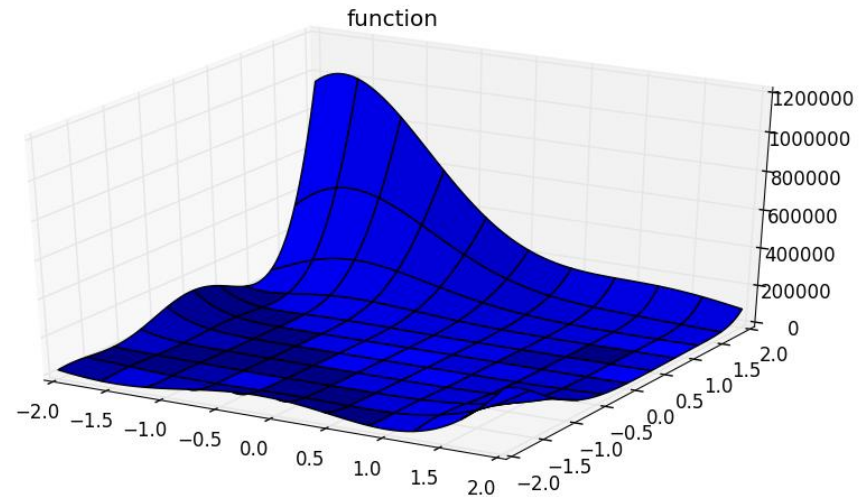
Plugging LocalSolver to numerical
or discrete-event simulators



Black-box optimization

Context

- Unknown objective (oracle)
- Costly to evaluate
- Derivative-free
- Continuous & integer decisions
- Bounds on decisions



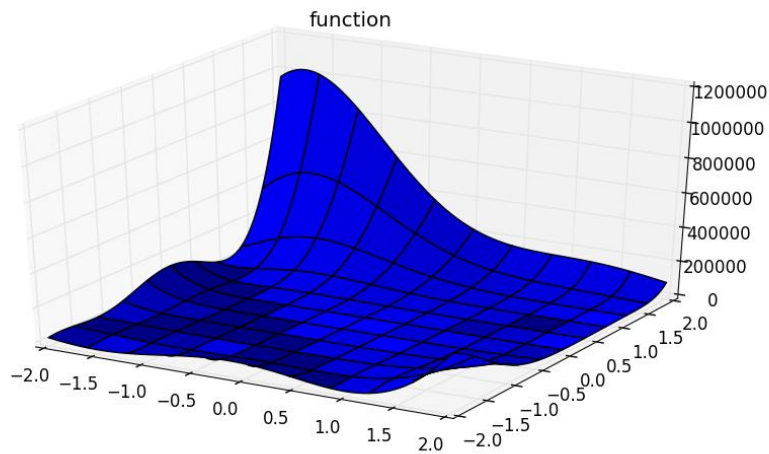
Many applications in engineering

- Multidisciplinary/parametric optimization
 - Simulation optimization (noisy, nondeterministic)
- Design optimization of materials/systems: mechanics, electricity, logistics, etc.

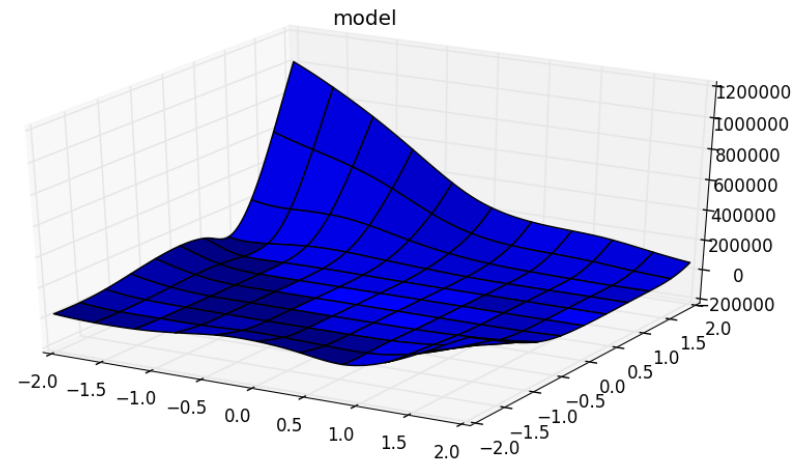


Learn the objective function landscape

- Objective landscape modeled by Radial Basis Functions
- Several models are built with different techniques/parameters
- Automatic selection of the most promising models for optimization



Objective Function



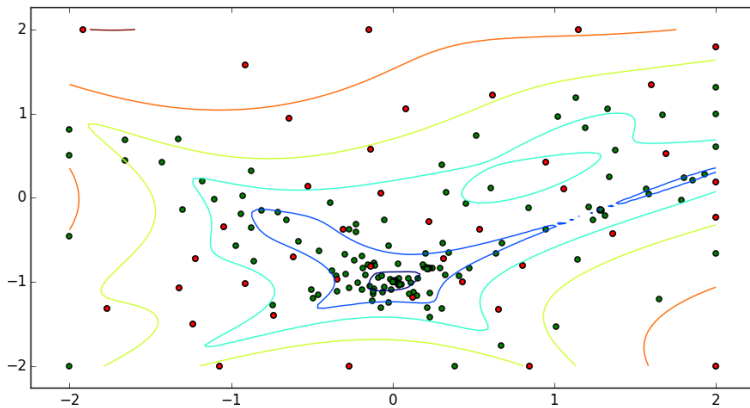
Objective Model



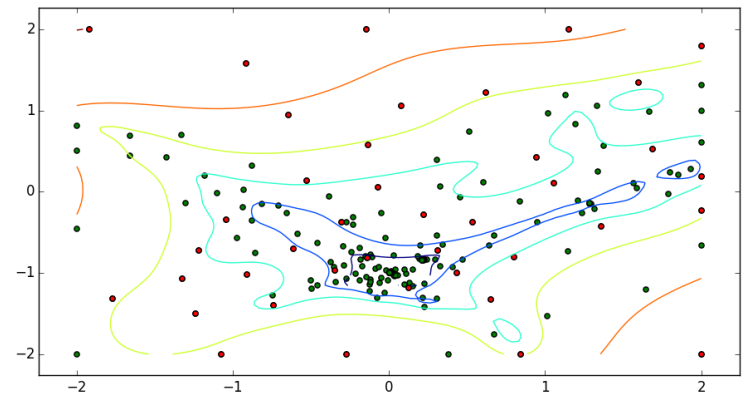
Optimization

Exploitation & diversification

- Exploitation: optimize over the objective model
 - Diversification: explore new promising regions
- NLP subproblems solved through LocalSolver techniques:
local & direct search, gradient-based line search, etc.



Objective Function



Objective Model



Benchmark

Instances

- 25 instances from the recent paper by Costa and Nannicini.
RBFOpt: an open-source library for black-box optimization with costly function evaluations. Optimization Online. (under review)
- 20 runs per instance, 150 calls max. to the black-box per run
- Numerical precision: $1e-6$

Preliminary results

- RBFOpt: 345 opt. solutions found, 82 calls avg. per run
- **LocalSolver: 310 opt. solutions found, 94 calls avg. per run**
- NOMAD (GERAD): 170 opt. solutions found



Benchmark

Instance	LocalSolver			RBFOpt			NOMAD	
	#sol	Avg. Eval	Error (%)	#sol	Avg. Eval	Error (%)	#sol	Error (%)
branin	20	23	0,0	20	31	0,0	20	0,0
camel	20	26	0,0	20	34	0,0	19	4,0
ex_4_1_1	20	11	0,0	20	14	0,0	20	0,0
ex_4_1_2	20	51	0,0	20	9	0,0	20	0,0
ex_8_1_1	20	10	0,0	20	7	0,0	19	2,5
ex_8_1_4	20	44	0,0	20	25	0,0	0	341,5
gear	20	34	0,0	20	7	0,0	0	388,0
goldsteinprice	18	122	0,1	20	53	0,0	16	450,0
hartman3	8	130	1,2	20	45	0,0	15	9,4
hartman6	8	121	11,0	17	101	5,1	0	5,7
least	0	150	1308,0	0	150	204,7	0	129,0
nvs04	20	70	0,0	19	64	194,4	4	9997,0
nvs06	16	127	1,0	0	150	13,3	9	8,7
nvs09	20	15	0,0	20	14	0,0	16	1,2
nvs16	8	138	949,0	20	49	0,0	9	885,0
perm0_8	0	150	109,0	0	150	147,2	0	412,0
perm_6	0	150	2424958,0	0	150	44134,7	0	311032,0
rbrock	20	83	0,0	5	136	10,8	0	43,2
schoen_10_1	4	145	66,7	11	139	28,8	0	119,5
schoen_10_2	0	150	96,2	14	133	1,6	0	115,7
schoen_6_1	18	101	100,8	18	101	1,8	0	51,5
schoen_6_2	10	120	28,0	16	102	32,7	0	54,2
shekel10	8	118	29,6	13	107	60,1	0	56,9
shekel5	6	127	51,6	7	126	51,7	1	46,1
shekel7	6	127	28,5	5	137	47,0	2	47,9
	310			345			170	

