Software for modeling and solving multi-objective optimization problems in 2025

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* Speaking in personal capacity. Views and opinions expressed do not necessarily reflect those of NU&LS2N

RAMOO'2025

September 2025 — TU Munich @ Straubing, Germany

https://github.com/xgandibleux/RAMOO2025

Mathematical Program Software for Multi-Objective Optimization in 2025

Existing MP Software for MOO in 2025

Seminal:

ADBASE		×	LP		1975	

Full* open-source (LP/*):

BENSOLVE	file	GLPK	.	Y_{SN}	2014	last rev 2017
polySCIP	ZIMPL	SCIP	MIP	Y_N	2016	last rev 2017
inner	file	GLPK	.	Y_{SN}	2016?	last rev 2024
vOptSolver|MOA	JuMP	several MILP solvers	MIP/NLP	Y_N	2017	last rev 2025
PaMILO	file	Gurobi/CPLEX	MIP/Q	Y_{SN}	2020?	last rev 2025
	api	HiGHS	MIP	1	since Ver1.10?, 2025?	
	CVXPY	several MILP solvers	MIP/C	1	?	

Commercial (LP/MIP/*):

Matlab	aml	(meta)heuristics	NLP	Y_R	?
	api	Gurobi Optimization	.	1	since Ver7.0, 2016
	api, OPL	IBM ILOG CPLEX Optimisation	.	1	since Ver12.7, 2016
	api	FICO Xpress Optimization	.	1	since Ver9.0, 2022
	aml	Hexaly Optimizer	.	1	since Ver12.0, 2023
	api	Cardinal Optimizer (COPT)	.	1	since 2025?
	AMPL	several MILP solvers	NLP	1	?
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JuMP

+

vOptSolver | MultiObjectiveAlgorithms

+

MP solvers

for

MOLP/MOMIP

From `vOptGeneric` to `MultiObjectiveAlgorithms`

2015: Kick-off of vOpt ANR/DFG project

2017: Introduction of vOptSolver (vOptGeneric, vOptSpecific)

2018: Julia 1.0

2019: End of vOpt project

2019: First discussions on discourse/new design of MOO in JuMP

2022: JuMP 1.0

2023: Introduction of `MultiObjectiveAlgorithms.jl`

2023: End of `vOptGeneric.jl`

From `vOptGeneric.jl`:

- part concerning the MO model → `JuMP.jl`
- part concerning MO algorithms → `MultiObjectiveAlgorithms.jl`

Workflow for users for modeling and solving a MOP

▸ Formulate a MOP problem	Julia (JuMP)
▸ Provide the data	Julia
▸ Select the solver to use	Julia (*)
▸ Select the algorithm to apply	Julia (MOA)
▸ Solve the given MOP problem	Julia (MOA)
▸ Query the efficient solutions & nondominated points	Julia (MOA)
▸ Analyze the results	Julia

*among: GLPK, HiGHS, SCIP, CPLEX, Gurobi, Xpress, COPT...

Examples of algorithms currently available (v1.6.0)

1. MOA.Lexicographic() [default] $p \geqslant 2$
2. MOA.Dichotomy() $p = 2$
3. MOA.EpsilonConstraint() $p = 2$

4. MOA.KirlikSayin() $p \geqslant 2$
5. MOA.DominguezRios() $p \geqslant 2$
6. MOA.TambyVanderpooten() $p \geqslant 2$

+ optimization attributes coming with a given algorithm

Discussion of two implementations

Discussion of two implementations

A detailed look at:

1. the Augmented Weighted Chebyshev scalarizing function
2. the Dächert-Gorski-Klamroth (2012) algorithm

(switch on the notebook)

Final discussion

To...

- all users:
  your experiences and feedback
- advanced users:
  integration of (your) published MO algorithms

are welcome !

Advertisement (1/2)

juliacon LOCAL PARIS 2025

European conference on the Julia programming language
October 2-3, 2025 — Paris (France)
`https://juliacon.org/`

Keynote Speakers:

Laura Grigori (EPFL, Switzerland)
Ivet Galabova (HiGHS, Scotland)
Tim Besard (JuliaHub, Belgium)

Venue:

Advertisement (2/2)

JuMP-Dev 2025

co-located with the 57th ORSNZ

November 17–20, 2025 — Auckland, New Zealand
`https://jump.dev/meetings/jumpdev2025/`

Contact: Oscar Dowson

JuliaCon Global 2026

August 10-15, 2026 — Johannes Gutenberg Univ. Mainz, Germany
`https://juliacon.org/2026/`

Contact: Valentin Churavy

Thanks!

- Jeff Bezanson, Alan Edelman, Stefan Karpinski, Viral B. Shah (2017). Julia: A Fresh Approach to Numerical Computing. *SIAM Review* 59, 65–98.

  Julia:
  `https://julialang.org/`

- Miles Lubin, Oscar Dowson, Joaquim Dias Garcia, Joey Huchette, Benoît Legat, Juan Pablo Vielma (2023). JuMP 1.0: Recent improvements to a modeling language for mathematical optimization. *Mathematical Programming Computation*.

  JuMP:
  `https://jump.dev/`

- Oscar Dowson, Xavier Gandibleux, Gokhan Kof (2025). MultiObjectiveAlgorithms.jl: a Julia package for solving multi-objective optimization problems. e-preprint (arXiv), `https://arxiv.org/abs/2507.05501`

  MultiObjectiveAlgorithms:
  `https://github.com/jump-dev/MultiObjectiveAlgorithms.jl`

- Xavier Gandibleux (2023)
  An introduction to Julia and JuMP for Operations Research
  ÖGOR Summer-Workshop for PhD-candidates and Post-Docs (Krems, Austria)
  `https://github.com/xgandibleux/Krems2023`

- Nicolas Forget, Elizabeth Gandibleux, Xavier Gandibleux, Valentin Guy-Deroubaix, and Awen Jacq-Bodet (2024)
  Analysis and discussion of single and multi-objective IP formulations for the Truck-to-dock Door Assignment Problem. e-preprint (optimization-online).
  `https://optimization-online.org/?p=27699`

- Xavier Gandibleux (2025)
  Use of Julia/JuMP for Multi-Objective Optimization: a tutorial
  EURO2025, 22 - 25 June 2025 (Leeds, UK)
  `https://github.com/xgandibleux/EURO2025`

- Xavier Gandibleux and Andrzej Jaszkiewicz (2025)
  Consistent and unbiased estimation of the hypervolume of an unknown true Pareto front. e-preprint (optimization-online).
  `https://optimization-online.org/?p=31635`

Why this adventure with Julia and JuMP for MOO?

2015: Kick-off of the ANR/DFG research project vOpt

Sub-task 2.2: Experimental Analysis and Prototype Development.

↳ The project of a multi-objective MILP solver was born!

Julia programming language: free, open source, multi-platform

JuMP modeling language: expressive, efficient, evolutive

2017: Introduction of vOptSolver

Xavier Gandibleux, Gauthier Soleilhac, Anthony Przybylski, Stefan Ruzika. vOptSolver: an open source software environment for multiobjective mathematical optimization. *IFORS2017: 21st Conference of the International Federation of Operational Research Societies*. July 17-21, 2017. Quebec City (Canada).

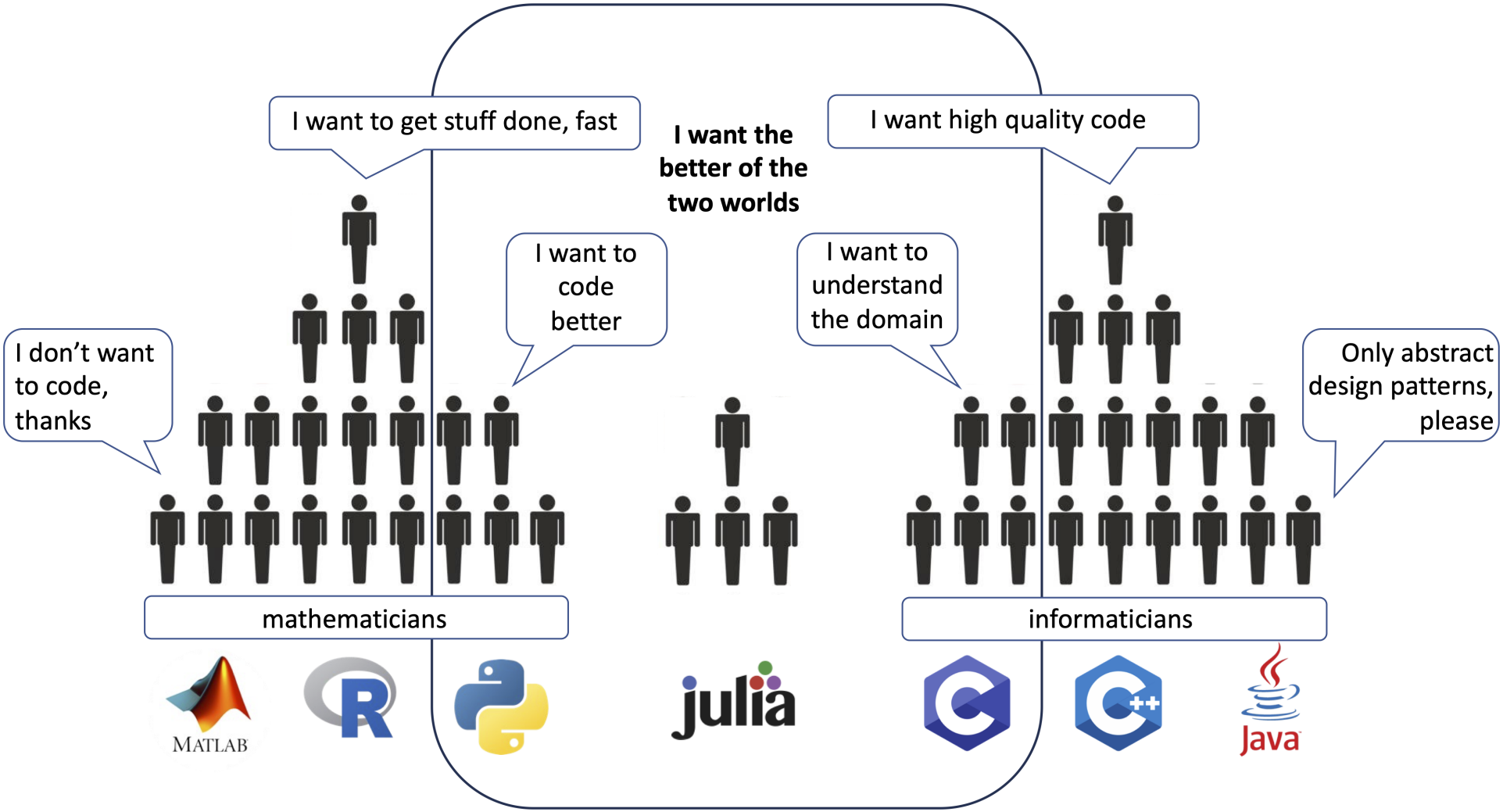
`https://github.com/vOptSolver`

composed of two packages:

- `vOptSpecific.jl`
- `vOptGeneric.jl`

Julia

A programming language for scientific computing



JuMP

An Algebraic Modeling Language (AML) among the existing ones . . .

... for mathematical optimization (linear, mixed-integer, conic, semidefinite, nonlinear) written in Julia.

... supporting 56 solvers; among the (MI)LP solvers: GLPK, Cbc, Clp, HiGHS, SCIP, CPLEX, Gurobi, FICO Xpress, COPT...

Example of material for optimizers

Book

Algorithms for Optimization
Mykel J. Kochenderfer, and Tim A. Wheeler
The MIT Press Cambridge, Massachusetts London, England
`https://algorithmsbook.com/optimization/files/optimization.pdf`