

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	?	
	GAMS	several MILP solvers	NLP	Y_N	?	

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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] | $p \geq 2$ |
| 2. MOA.Dichotomy() | $p = 2$ |
| 3. MOA.EpsilonConstraint() | $p = 2$ |
| 4. MOA.KirlikSayin() | $p \geq 2$ |
| 5. MOA.DominguezRios() | $p \geq 2$ |
| 6. MOA.TambyVanderpooten() | $p \geq 2$ |

+ 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

after few words about JuMP and MultiObjectiveAlgorithms...

(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)



European conference on the Julia programming language

October 2-3, 2025 — Paris (France)

<https://juliacon.org/>

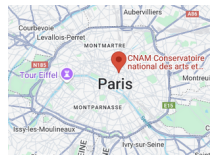
Keynote Speakers:

Laura Grigori (EPFL, Switzerland)

Ivet Galabova (HiGHS, Scotland)

Tim Besard (JuliaHub, Belgium)

Venue:



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/EUR02025>
- Xavier Gandibleux and Andrzej Jaskiewicz (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**

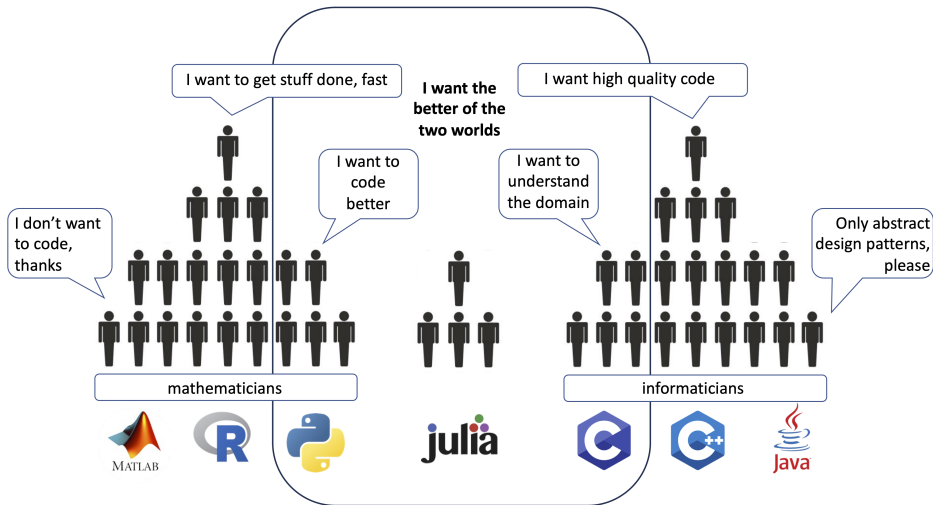
Xavier Gandibleux, Gauthier Soleilhac, Anthony Przybylski, Stefan Ruzika. vOptSolver: an open source software environment for multiobjective mathematical optimization. *IFORS2017: 21st Conference of the International Federation of Operational Research Societies*. July 17-21, 2017. Quebec City (Canada).

<https://github.com/vOptSolver>

composed of two packages:

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

A programming language for scientific computing



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>