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Multiobjective Optimization: A Thematic Analysis of Analysts' Perspectives on Decision-Support

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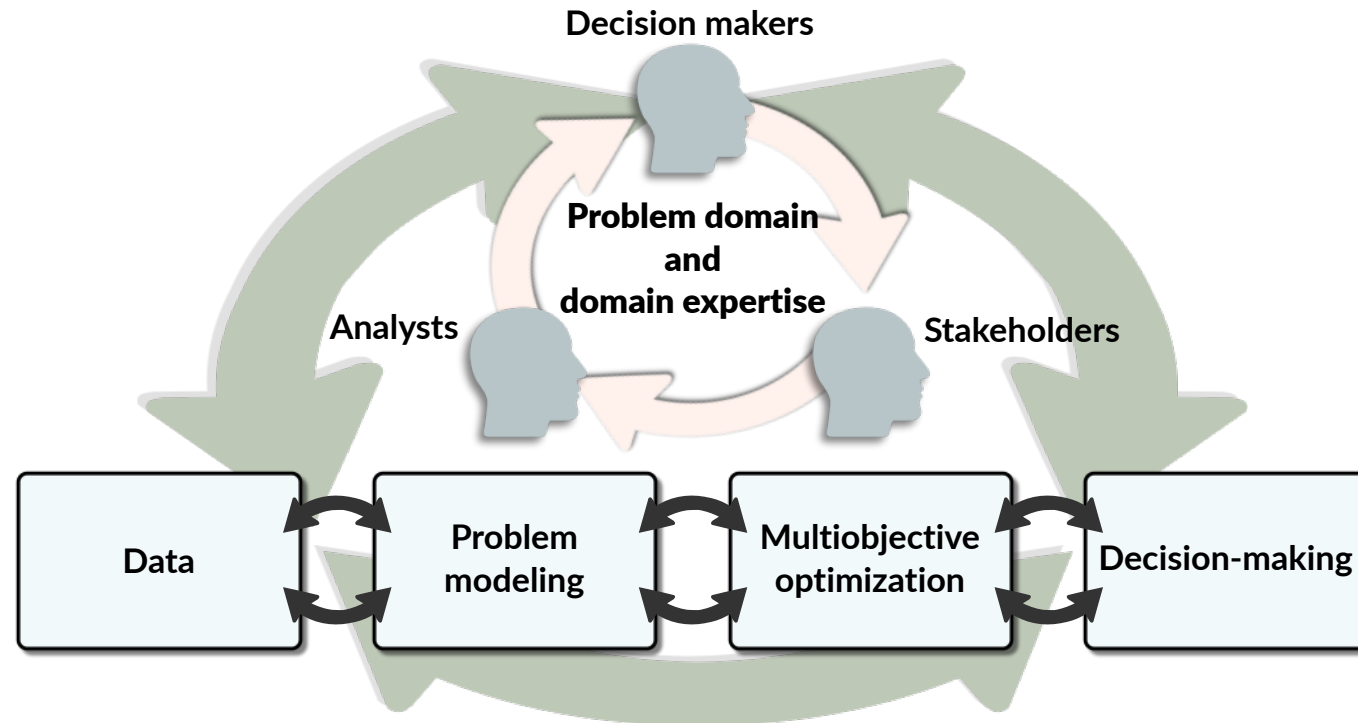
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Multiobjective Optimization Is More Than Algorithms



- Real-world problems involve multiple conflicting objectives: cost vs. quality, profit vs. environmental impact...
- Multiobjective optimization can help solve these problems, but applying multiobjective optimization in practice is a socio-technical process, a seamless chain.

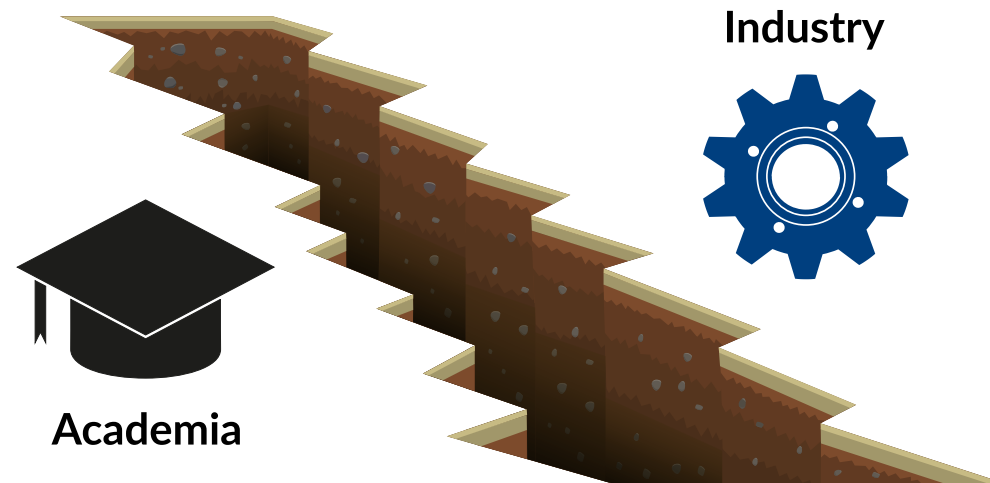


Miettinen, K., Deb, K., Jahn, J., Ogryczak, W., Shimoyama, K., & Vetschera, R. (2008). Future challenges. In J. Branke, K. Deb, K. Miettinen, & R. Słowiński (Eds.), Multiobjective optimization: Interactive and

Multiobjective Optimization Is More Than Algorithms



- This process requires collaboration between analysts, decision makers, and stakeholders.
- **Yet, most research focuses on the optimization step alone.**
- The analyst, who bridges computational methods and decision-makers, plays a central but understudied role.



What We Did



- **Research question:**
 - How do analysts experience providing multiobjective optimization based decision-support in practice?
- **Our approach:**
 - 15 semi-structured interviews with analysts from diverse domains: water management, healthcare, logistics, forestry, engineering.
 - Analyzed using reflexive thematic analysis, a rigorous qualitative method.

First study combining interviews with thematic analysis for understanding multiobjective optimization decision-support from the perspective of analysts.

Reflexive Thematic Analysis



- A qualitative research method for identifying themes that reflect meaningful patterns in data.
- **Six-phase process:**
 - 1) Familiarization with the interview data
 - 2) Systematic coding of the transcripts
 - 3) Generation of candidate themes
 - 4) Review of themes against the data
 - 5) Refinement and definition of themes
 - 6) Writing up the findings
- Two researchers coded collaboratively, using an inductive and semantic approach.
- No predefined theoretical framework: themes emerged from the data itself.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.

Four Themes Emerged



- **Theme 1: Collaboration and Communication**
 - Trust-building, decision-maker alignment, shared understanding through visualizations.
- **Theme 2: Complexity and Real-World Constraints in Problem Modeling**
 - Data limitations, uncertain objectives, bridging theory and practice.
- **Theme 3: The Decision-Making Process**
 - Preference elicitation challenges, domain expertise, navigating trade-offs.
- **Theme 4: Practical Applicability**
 - Tool usability, adoption barriers, multi-stakeholder reality.

Theme 1: Collaboration and Communication



- Trust between analyst and decision maker takes years to build through repeated collaboration.
- Communicating results is a balancing act: enough information for agency without guiding the outcome.
- Visualizations are critical, but often built ad hoc for each context.
- Interactivity fosters trust: decision makers engage more when they can explore solutions themselves.
- **Decision makers gain more confidence when presented with multiple solutions.**

"And that's constantly the balance that we're trying to strike as decision-support people—how do you give them [decision makers] enough information to help inform a policy, to help them feel like they have agency and understanding, and that you're not guiding the outcome with the choices that we're making in the model?"

Analyst 3

Theme 2: Complexity and Constraints in Modeling



- Models are necessarily simplified; they miss political and institutional dynamics.
- No established best practices for applying academic methods in real settings.
- Iterative modeling with domain experts is essential.
- Understanding how the algorithm works is a recurring concern among analysts.
- **Transparency is essential for adoption. Opaque-box methods hinder trust.**

"I will assert that 'correct' means a [problem] formulation where all stakeholders come in and say, 'Yep, you have got the objectives right, you have the decision variables right, you have the constraints right. It is all good. Hit your go button and give me the answer.' But it never works

like that in reality. It is always an iterative process. In fact, over time, this iterative nature has added value to the community—because, frankly, the algorithms are neat"

Analyst 1

Theme 3: The Decision-Making Process



- Preferences are not always tied to objective values; they relate to variables, constraints, broader consequences.
- Decision makers want to understand how their preferences connect to solutions.
- Intuition and domain expertise shape how solutions are received.
- Trade-off navigation needs tailored, context-specific tools.
- **Information beyond the Pareto front matters.**

"Yeah, the decision context, because they [decision makers] often tend to think there's only one way of doing it. And that's not really valid. I would say there are many ways of managing [domain area], not just one, and it should relate to what they want. But they have a tendency to ignore that and assume there is a single correct way to manage a [domain area] which is not the case."

Analyst 11

Theme 4: Practical Applicability



- Open-source tools get developed but often orphaned after a single PhD project.
- Decision makers adapt MOO solutions as starting points, not final answers.
- Multi-level, multi-stakeholder decision-making is the norm.
- Integration requires training, workflow compatibility, and sustained engagement.
- **Trust and organizational culture shape adoption more than algorithms.**

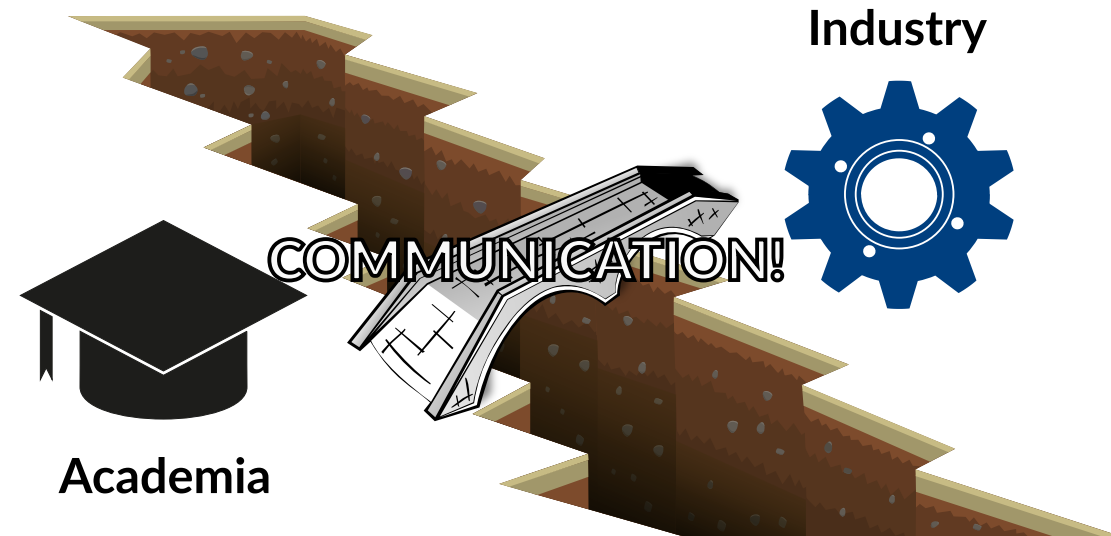
"There are so many different levels of decision-making and that is even like the analysts are making decisions and they're different types of decisions. But then you know, our project managers are making decisions and then their supervisors are making decisions and then the stakeholders are making decisions like there's so many levels of this."

Analyst 6

Nine research gaps identified



- 1) Strengthen academy-industry collaboration for MOO
- 2) Develop unified, open-source visualization tools
- 3) Ensure context-specific problem representations
- 4) Establish practice-oriented application guidelines
- 5) Address real-world complexity in MOO assumptions
- 6) Support elicitation of diverse, unquantifiable preferences
- 7) Move beyond single decision maker frameworks
- 8) Provide information beyond objective function values
- 9) Overcome limited trust and resource constraints



These gaps call for more human-centered, interdisciplinary MOO research!

MOO brings people together

MOO is a tool for solving and understanding challenging problems collaboratively. Part of our job should be to research approaches that enable collaboration to work as well as possible.



<https://linktr.ee/gialmisi>



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