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DESDEO 2.0: The New and Improved Open-source Framework for Interactive Multiobjective Optimization

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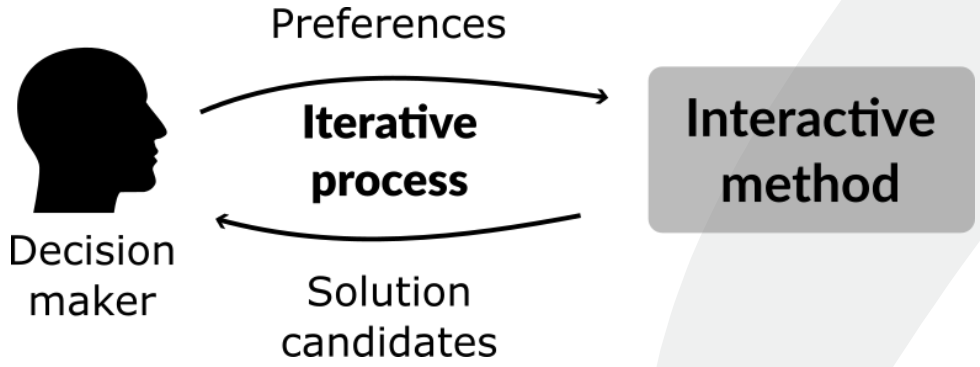
What is DESDEO?

- DESDEO is an **open-source** framework for **interactive multiobjective optimization**.
- Its main principles include **modularity, extensibility, and practical applicability**.
- Intended users of the framework are **researchers, students, and practitioners**.
- Developed mainly at the University of Jyväskylä in the Multiobjective Optimization Group.
- DESDEO development started in 2015 (**a decade ago!**).
  - Development of interactive software goes much farther back.

Misitano, G., Saini, B. S., Afsar, B., Shavazipour, B., & Miettinen, K. (2021). DESDEO: The modular and open source framework for interactive multiobjective optimization. *IEEE Access*, *9*, 148277-148295.

Why interactive multiobjective optimization?

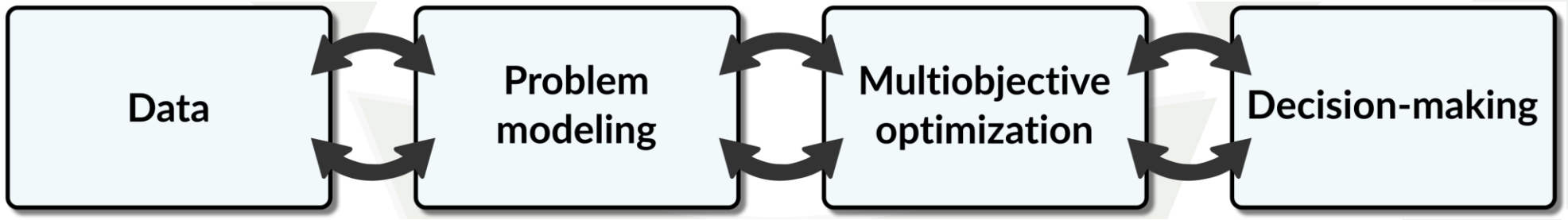
- Real-world problems involve **trade-offs between conflicting objectives**.
- Decision makers have the responsibility to choose the **best Pareto optimal solution**.
- By **gradually and iteratively** incorporating preferences, interactive methods allow decision makers to **explore and learn** about the problem being solved.
- Interactive methods are **human-centric** by nature.



Miettinen, K., Nonlinear Multiobjective Optimization (1999), Kluwer Academic Publishers, Boston.

Why software for interactive methods is needed?

- Because of its human-centric nature, interactive methods are **not just algorithms.**
- There is a lot of information that needs to be conveyed to decision makers to support them in decision-making. **Not just text on a screen.**
- They are means for a decision-support process, which requires interactive **visualizations**, user **interfaces**, and **services to enable interaction**.
- Interactive methods cannot live in a vacuum **but must be applied and studied in a holistic way**.
- This poses **significant challenges** when developing interactive methods: **method implementations need to be available!**

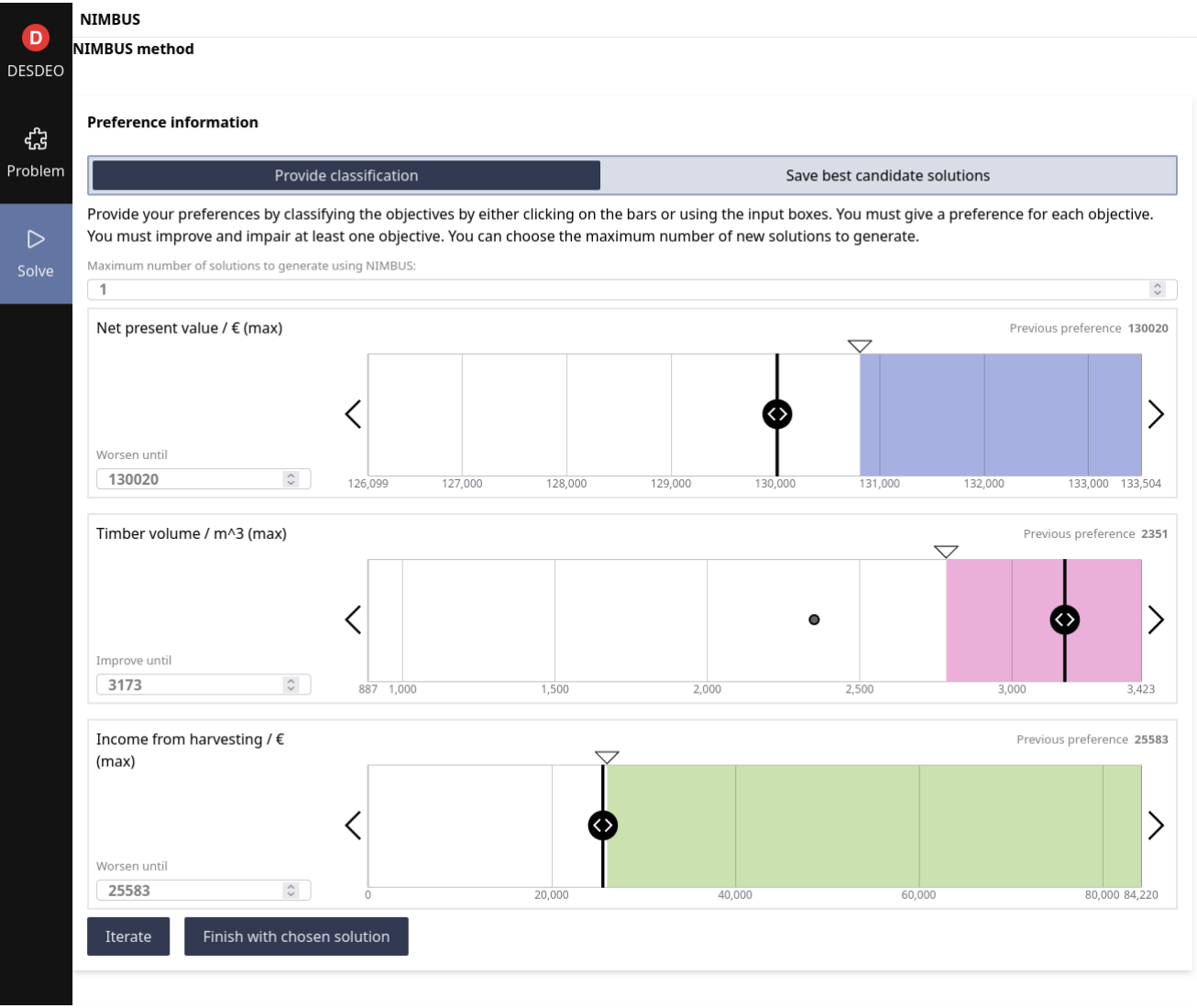


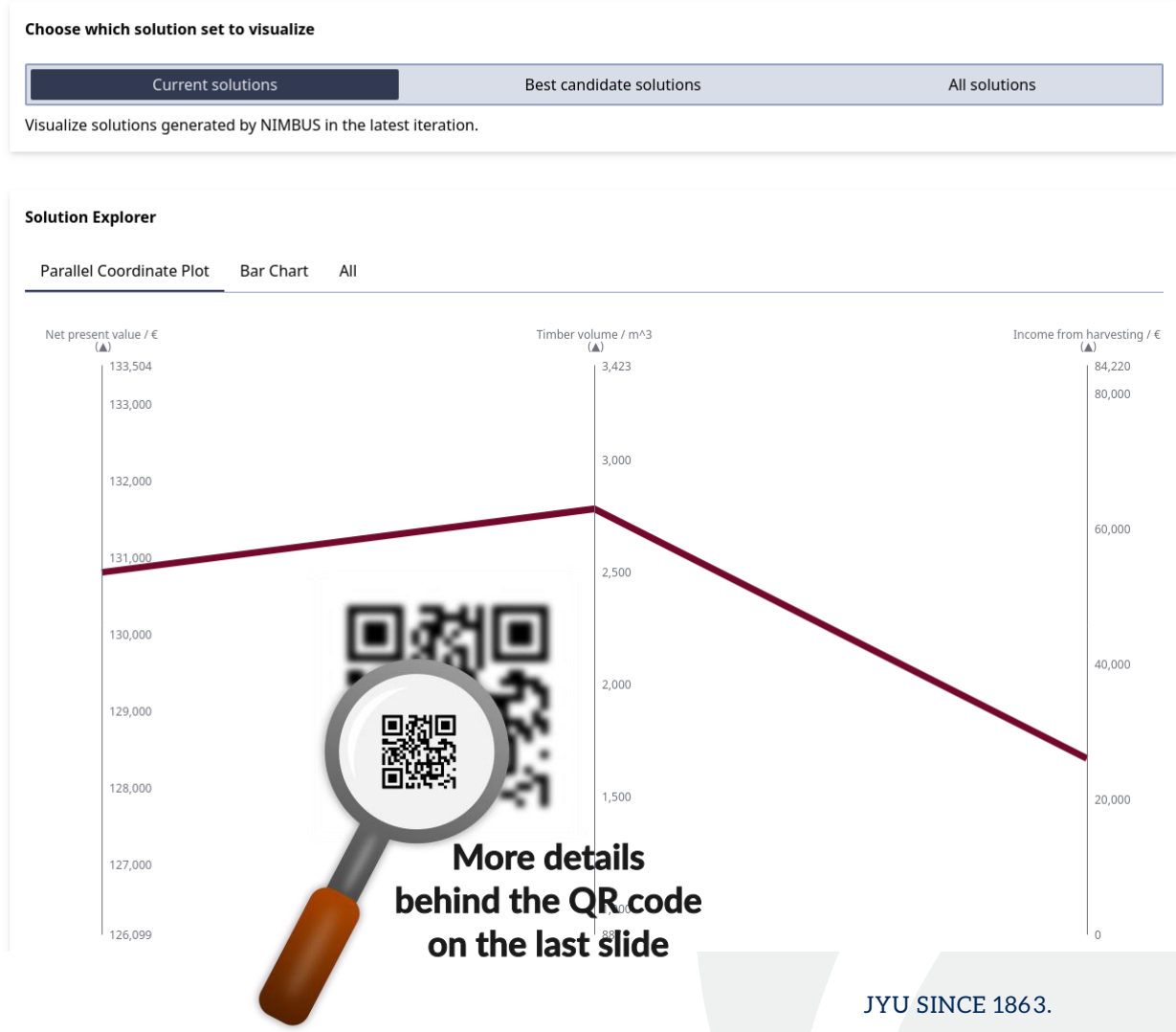
Afsar, B., Miettinen, K., & Ruiz, F. (2021). Assessing the performance of interactive multiobjective optimization methods: A survey. *ACM Computing Surveys (CSUR)*, *54*(4), 1-27.

Why DESDEO 2.0?

- Because the previous version of **DESDEO could not address all the needs** of researchers and decision makers.
  - Feature creep, issues rooted in fundamental design choices, lessons learned…
- DESDEO has been **completely restructured** and designed to address the **needs emerging from applying interactive methods in real-life in version 2.0.**
- Many of the choices made in the restructuring are motivated by our refined understanding of the **needs and requirements of researchers, practitioners (analysts), and decision makers**.
- The restructuring is a culmination of **years of experience**.
- Despite its shortcomings, the previous version of DESDEO has been used in a variety of research and teaching.

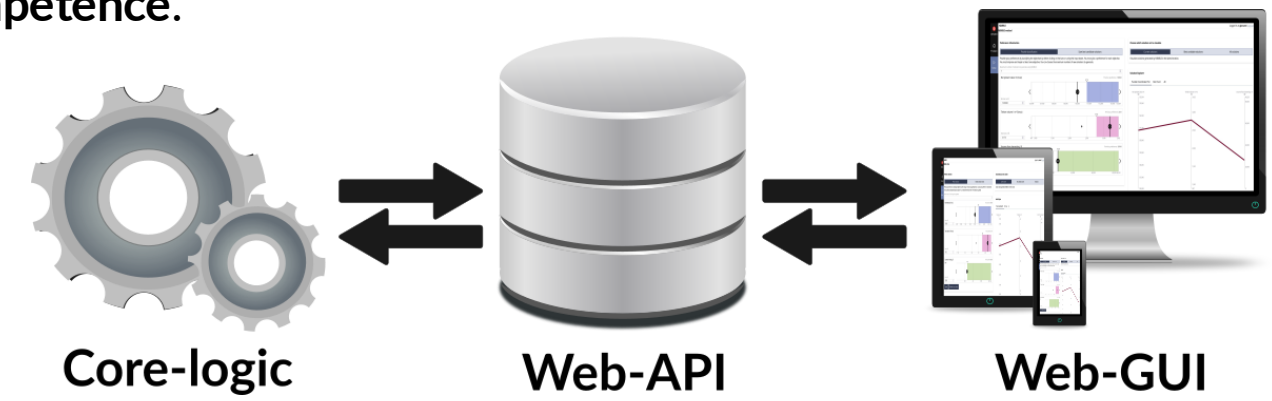
Goal: Accessible interfaces for interactive methods





DESDEO 2.0's three main components

- **The core-logic** is implemented in Python and contains **means to model multiobjective optimization problems** and **solve them using interactive methods**.
- **The web-API exposes the functionalities of the core-logic**, allowing external application to interface into DESDEO, and utilize it. And it provides the needed services to build applications for interactive multiobjective optimization.
- **The web-GUI provides a web-based graphical user interface** for modeling and solving multiobjective optimization problems using interactive methods. It also provides a multitude of interactive visualizations and components.
- DESDEO 2.0 has been designed as a **full-stack application**. These systems are rare in out field, and they **require versatile competence**.



The core-logic

- Designed from the beginning to **meet the needs of the web-API and web-GUI**.
- **JSON-based problem modeling language**, which supports many kinds of problems, including data- and simulation-based problems.
- **A problem needs to be modeled only once**, after which it can be solved using any suitable method available in DESDEO.
- Both **scalarization (MCDM) and population (EMO) -based** interactive methods are available.
- Interactive methods have been implemented so that **reusing their components is easy**.
- We provide many **interfaces to existing optimization algorithms**. We do not wish to reinvent the wheel.

Problem modeling

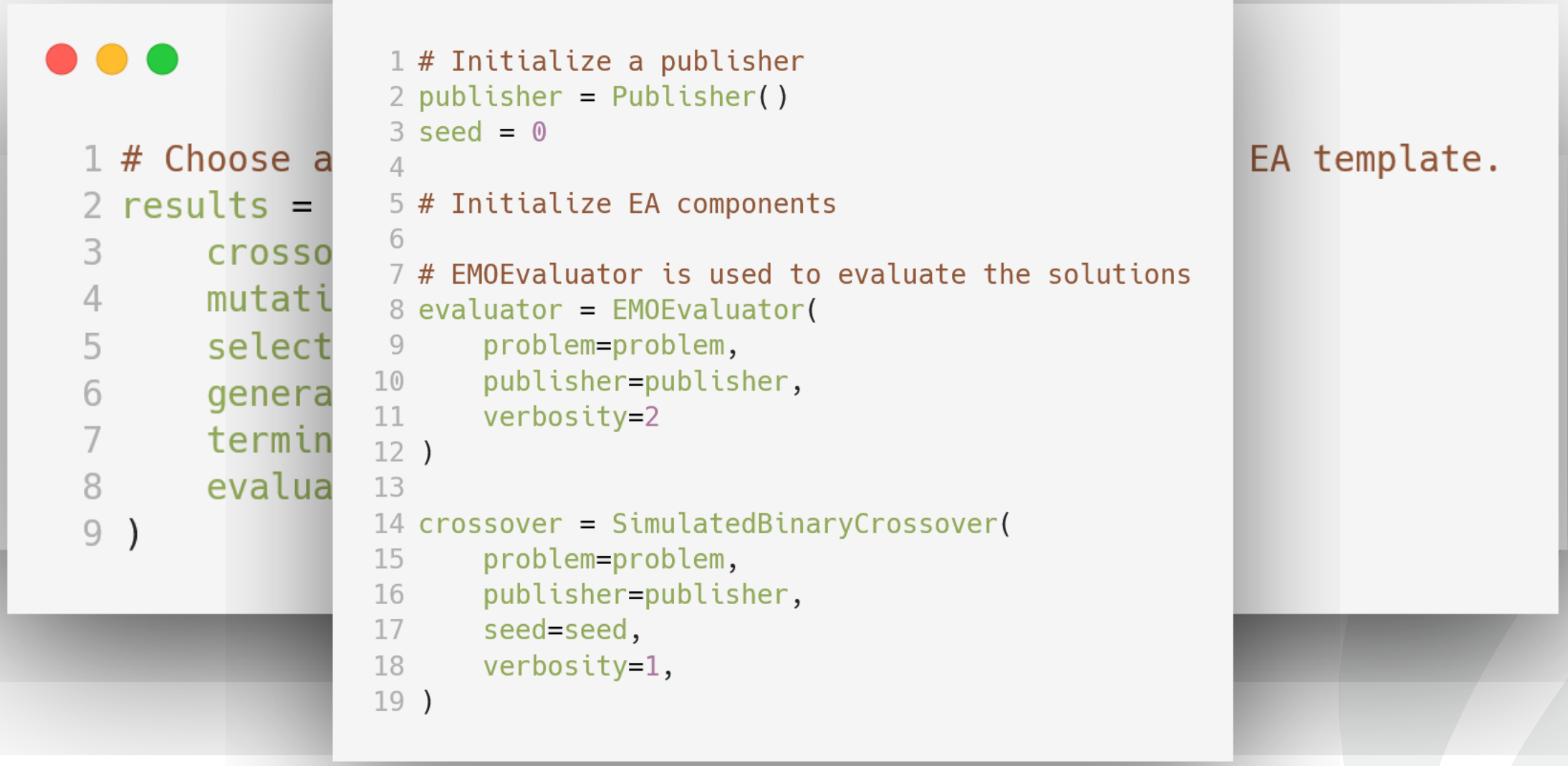
```
from desdeo.problem import P

vehicle_design_problem = Pro
    name="Vehicle design pro
    description="Vehicle des
constraints.",
    variables=[x_1, x_2, y],
    constants=[ideal_n_cylin
    objectives=[cost, emissi
    constraints=[fuel_effici
)
```

```
{
  "name": "objective example",
  "symbol": "f",
  "unit": null,
  "func": [
    "Add",
    "x",
    1
  ],
  "simulator_path": null,
  "surrogates": null,
  "maximize": false,
  "ideal": null,
  "nadir": null,
  "objective_type": "analytical",
  "is_linear": true,
  "is_convex": false,
  "is_twice_differentiable": false,
  "scenario_keys": null
}
```

Interactive methods

- MCDM methods are implemented in a **functional fashion**.
  - For each method, multiple functions are defined, which fulfill its various steps.
  - These functions are independent and can be combined freely.
- EMO methods are implemented based on **EMO components**:
  - Components follow a publish-subscribe pattern, which allows combining them in a multitude of ways.
  - Some templates are also available, which define a receive on how evolutionary components should interact, leaving the user the choice of choosing the specific components.
- Hybridization of methods is readily possible. **Combine MCDM and EMO methods** in a modular fashion!

Interactive methods



```
# Choose a
results =
    crosso
    mutati
    select
    genera
    termin
    evalua
)
```

```
# Initialize a publisher
publisher = Publisher()
seed = 0

# Initialize EA components

# EMOEvaluator is used to evaluate the solutions
evaluator = EMOEvaluator(
    problem=problem,
    publisher=publisher,
    verbosity=2
)

crossover = SimulatedBinaryCrossover(
    problem=problem,
    publisher=publisher,
    seed=seed,
    verbosity=1,
)
```

```
EA template.
```

Other features of the core-logic

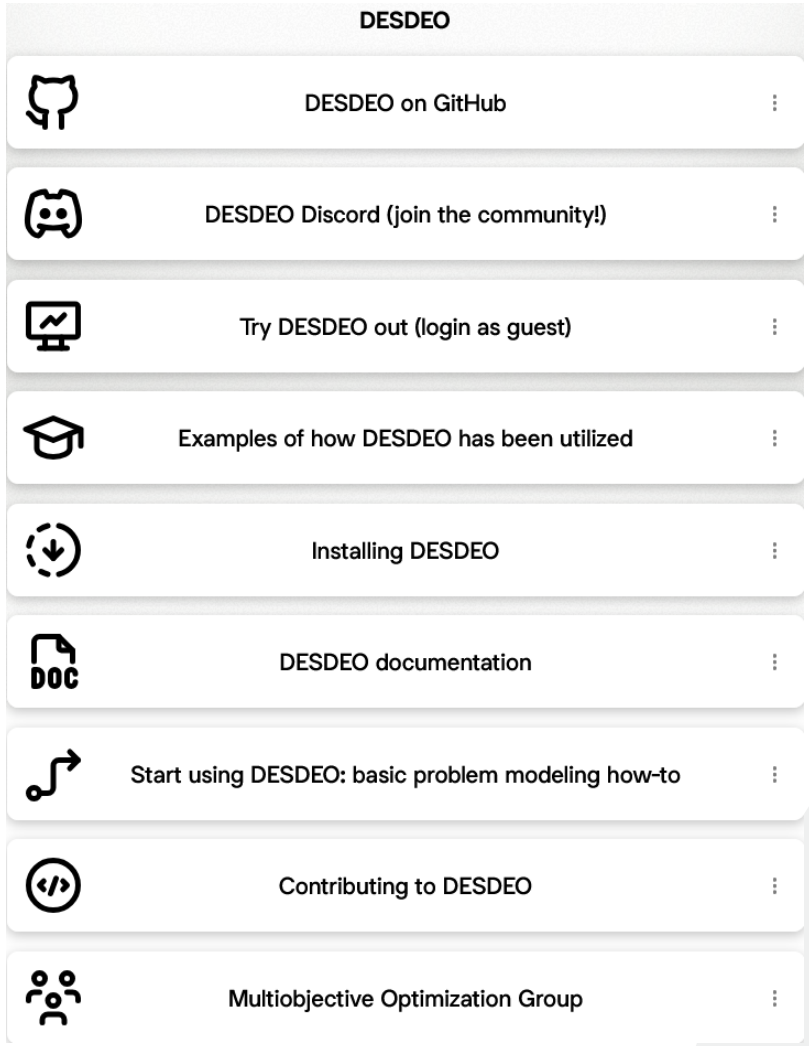
- The **core-logic is a fully independent** component of DESDEO, and can be utilized like any Python library, e.g., in a **Jupyter notebook**.
- DESDEO enables comparison of methods, switching between methods, changing the preference information style, **all in one environment**.
- Novelties! Interactive **group decision-making methods, explainability, agents, artificial decision makers**...
- **Model once, solve multiple times: once you have a Problem modeled, you can start solving and manipulating it to your liking.**

Conclusions

- DESDEO 2.0 is currently **the only open-source project specializing in both MCDM and EMO interactive multiobjective optimization methods**.
- DESDEO 2.0 is designed from the ground-up to **address the needs of an actual decision-support application**. We are aware that interactive methods are much more than just an algorithm.
- DESDEO 2.0 **is for researchers, practitioners, and students.** The web-GUI offers and will offer a way for anybody to use interactive methods through their web browser.
- Do not like our GUI? **Implement your own GUI** or integrate DESDEO into your existing application using the web-API.
- We want to build an active community around DESDEO. Anybody is welcome to contribute. **Not just academy!**

Q&A

https://linktr.ee/gialmisi



Research Council of Finland

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