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Built utilizing DESDEO: the modular and open source framework for interactive multiobjective optimization [3]

desdeo.it.jyu.fi

This research is being conducted in the Multiobjective Optimization Group at the University of Jyväskylä

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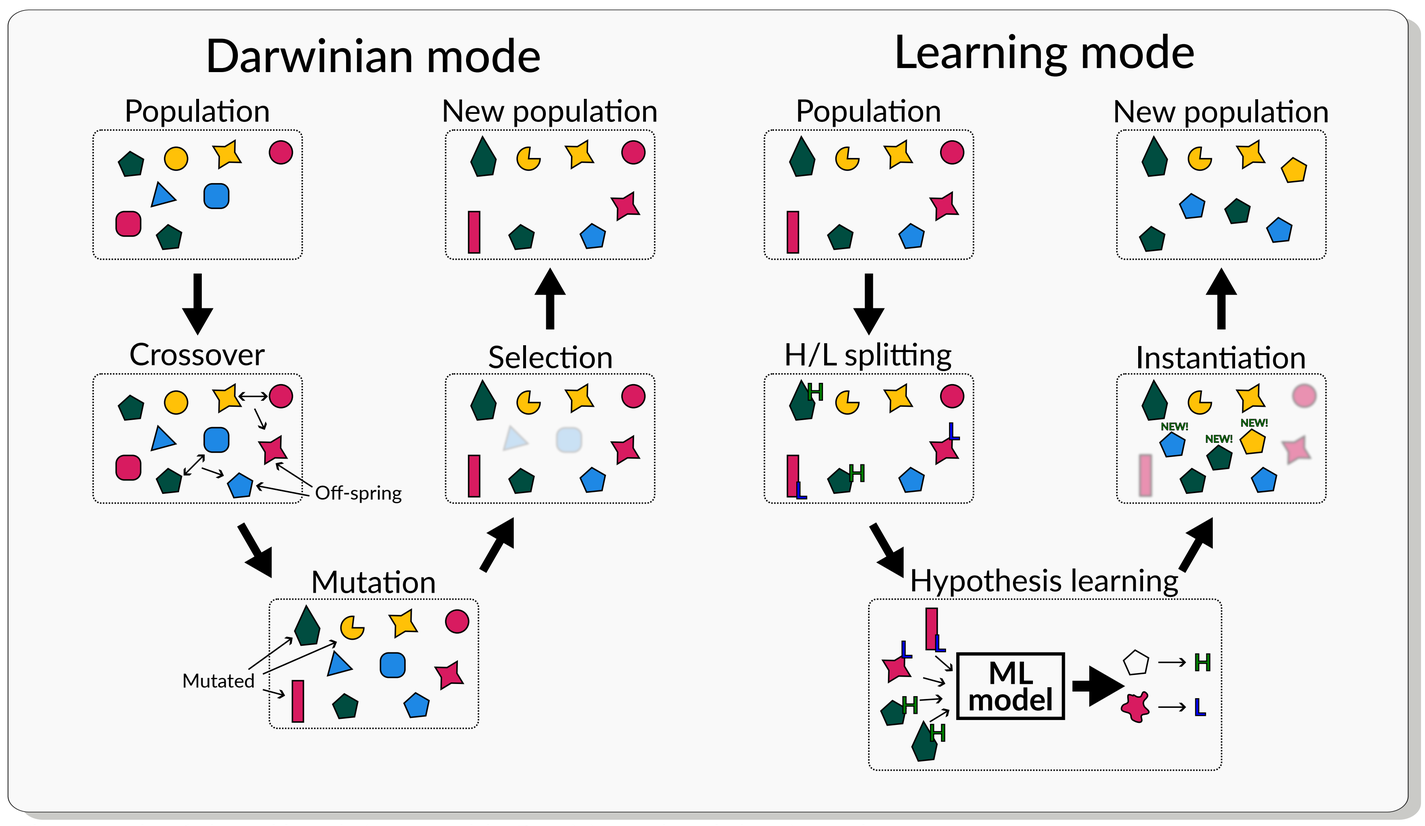
Explainable and learnable multiobjective optimization

ABSTRACT

Multiobjective optimization problems have multiple, incomparable solutions. These problems can be solved utilizing evolutionary algorithms, which take inspiration from Darwinian evolution. This is called evolutionary multiobjective optimization, where a population of solutions is evolved concurrently by utilizing various evolutionary operations, such as crossover, mutation, and selection. While this is an efficient way to solve many kinds of multiobjective optimization problems, they are heuristic (random) in nature.

In learnable evolutionary models, the evolutionary operations are enhanced by incorporating machine learning to learn what sort of population member constitutes a good solution to the multiobjective optimization problem. On top of this, if explainable machine learning is utilized, we are able to also learn additional information about the multiobjective optimization problem. We therefore propose a new kind of methods that are explainable and learnable .

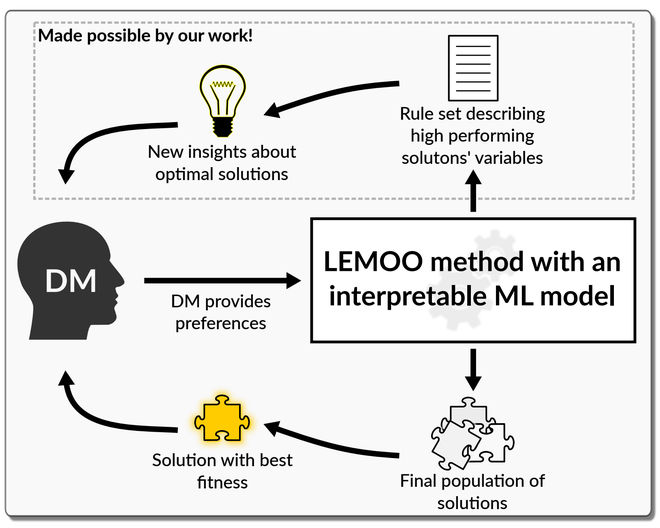


The two modes of a learnable evolutionary model: a Darwinian mode and a learning mode.

Multiobjective optimization (MOO) [1] problems have multiple conflicting objectives with various trade-offs. These problems have many so-called Pareto optimal solutions, which are incomparable mathematically. The aid of a domain expert, a decision maker (DM), must be employed to find the best, most preferred solution among the Pareto optimal ones. MOO problems can be found almost anywhere, which makes the study of decision-support tools to aid DMs in solving these problems very important.

EVOLUTIONARY MULTIOBJECTIVE OPTIMIZATION

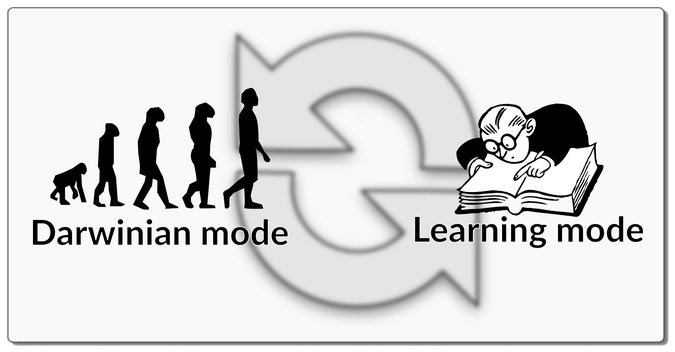
- Evolves a population of solutions of a MOO problem iteratively and concurrently.
- In each iteration, the population is improved heuristically via evolutionary operators, such as crossover, mutation, and selection.
- The fitness of the solutions is determined by a fitness function.
- The preferences of the DM can be incorporated in the fitness function. This way the evolutionary process finds solutions according to the preferences.
- Because of its heuristic nature, the solutions found by evolutionary MOO methods cannot be proven to be Pareto optimal.



Our learnable evolutionary multiobjective optimization (LEMOO) method can support a decision maker to find their most preferred solution by incorporatig preferences and providing them insights about the solutions found.

LEARNABLE EVOLUTIONARY MODELS

- Originally proposed in [2]. Combines an evolutionary algorithm with a machine learning (ML) model, which work in tandem to optimize an objective.
- Consists of a learning mode and a Darwinian mode.
- ML is used to learn a hypothesis that describes which solutions are High-performing, and which are Low-performing. This is called H/L splitting.
- Then, new solutions are instantiated and inserted into the population.
- The addition of a learning mode has been shown to boost an evolutionary optimization process.
- Could the same principle be applied to evolutionary MOO? (Yes!)



A learnable evolutionary model switches between two modes.

LEARNABLE AND EXPLAINABLE EVOLUTIONARY MULTIOBJECTIVE OPTIMIZATION

- By utilizing an interpretable ML model, we boost an optimization process and gain insights about computed solutions.
- ML is readily applicable because of the large number of solutions generated by an evolutionary MOO method.
- As an explanation, we utilize rule sets extracted from the ML model.
- Each rule in a rule set describes optimal solutions according to the decision variables and their range up to a certain accuracy.

By combining learnable evolutionary models with interpretable machine learning and evolutionary multiobjective optimization, we have created a new type of method to support decision makers in solving multiobjective optimization problems.

CONCLUSIONS

- We demonstrated the effect of adding a learning mode to an evolutionary multiobjective optimization method.
- We utilized an interpretable machine learning model in a learning mode and derive rule sets to explain the connection between objectives and variables in a multiobjective optimzation problem.
- The explanations can provide valuable insights to a decision maker when solving a multiobjective optimization problem.
- We have made our approach openly available and open source, extending DESDEO [3].
- We have paved the way towards a new paradigm in multiobjective optimization: *explainable and learnable evolutionary multiobjective optimization*.

REFERENCES

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ACKNOWLEDGMENTS

This work is a part of the profiling area Decision Analytics Utilizing Causal Models and Multiobjective Optimization (DEMO, jyu.fi/demo) at the University of Jyväskylä.

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