Evolutionary Multi-Objective Optimization in Real-World Applications

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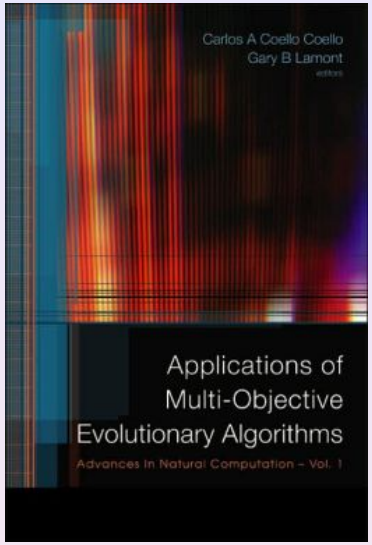
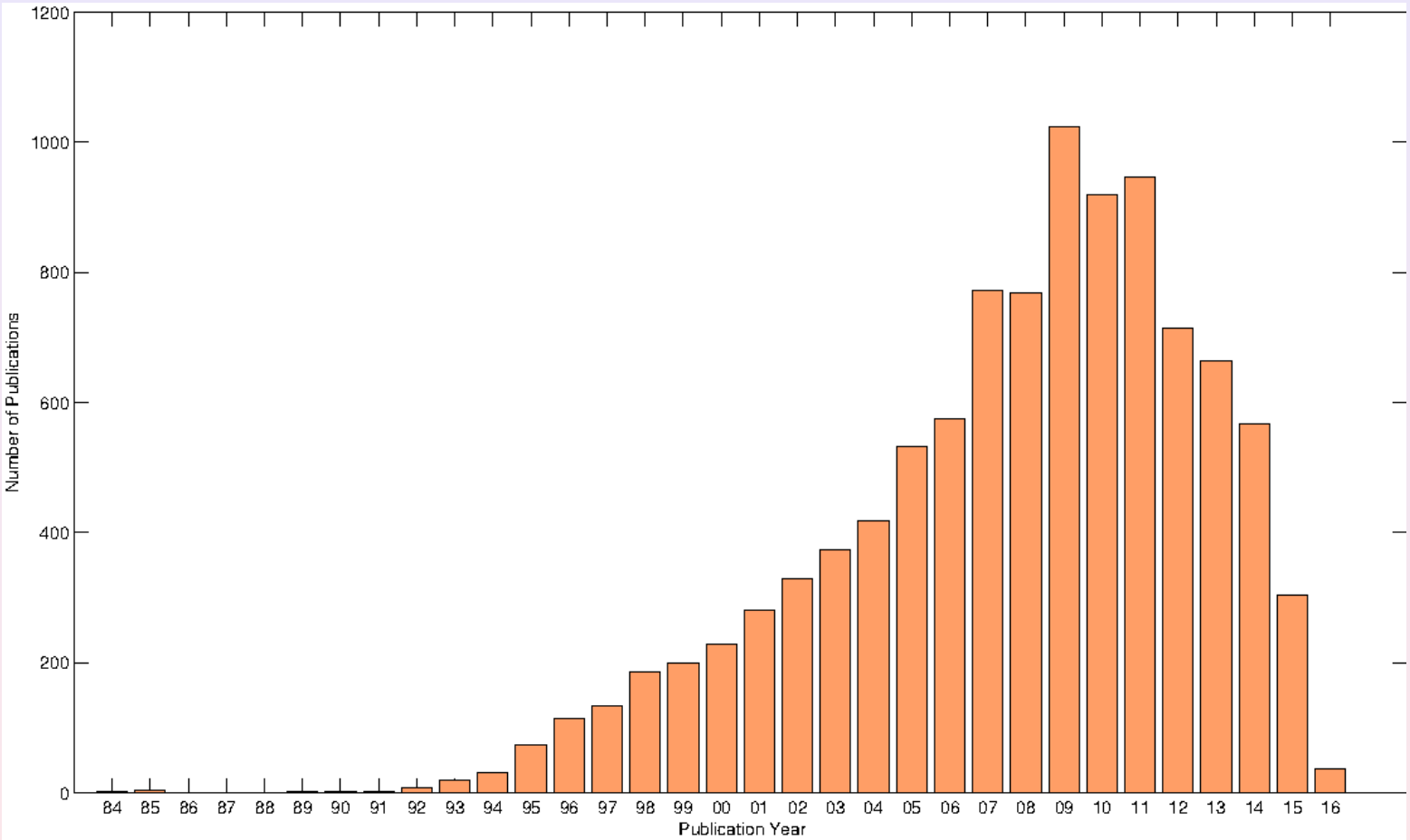
Evolutionary Multi-Objective Optimization



Multi-objective optimization using evolutionary algorithms is currently a very hot research topic. Multi-objective evolutionary algorithms (MOEAs) have been applied in a wide number of disciplines, and expertise in this area is, with no doubt, of great importance these days, in order to establish collaborations with industry.

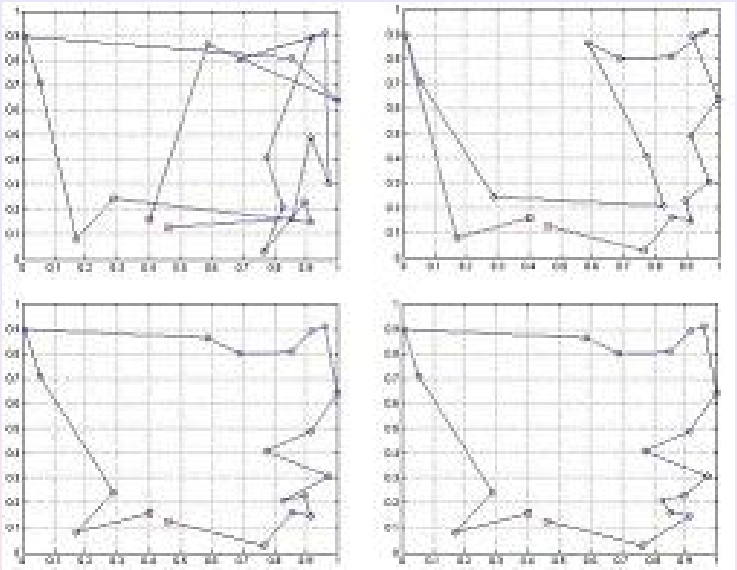
Number of papers published per year (mid 2016)



What do we need to know about EMO?

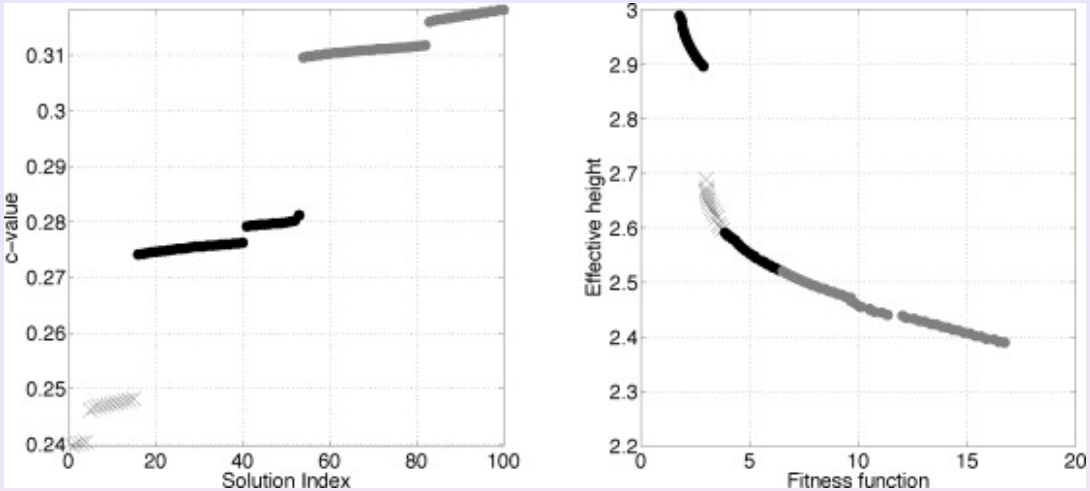
- Algorithms (e.g., NSGA-III, MOEA/D, SMS-EMOA, μGA).
- Constraint-handling techniques.
- Incorporation of user's preferences (few solutions or only one are required in most real-world applications).
- Knowledge of some basic multi-objective optimization concepts and methods (e.g., ideal and Nadir points, ε-constraint method, etc.).
- Use of surrogates, parallelization and/or fitness approximation techniques may help as well, when dealing with computationally intensive applications.
- The incorporation of domain knowledge may also be useful, when possible.

What do we need to know about EMO?



It is worth noticing that the solution of multi-objective combinatorial optimization problems can be done in a more efficient and effective way using MOEAs of a completely different type (see for example (Ehrgott, 2004)).

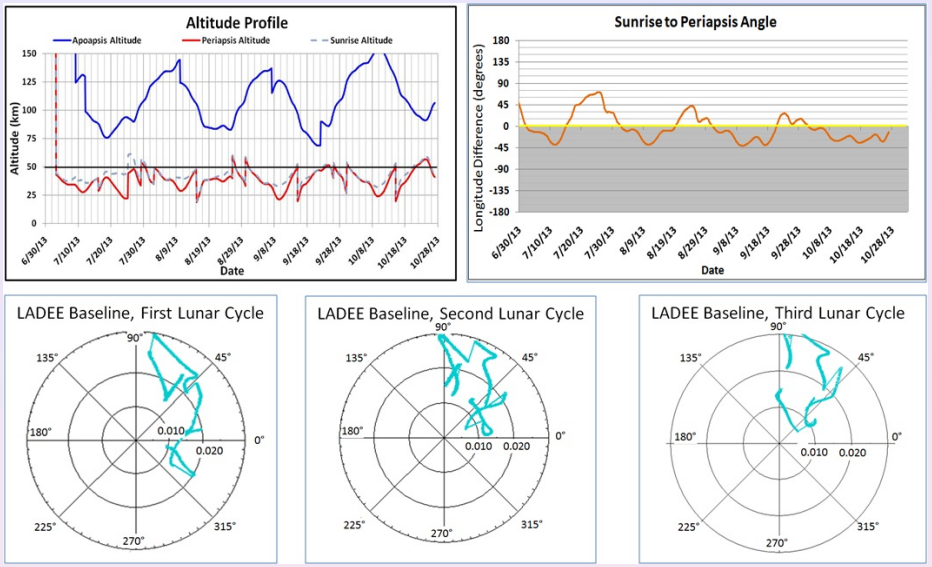
What do we need to know about EMO?



Innovization

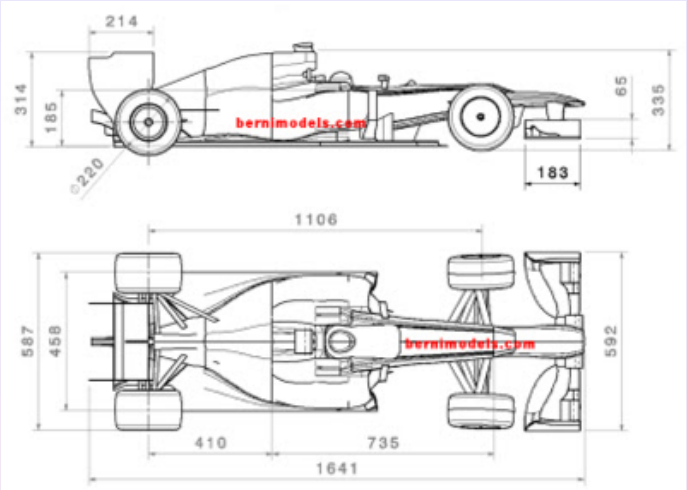
Deb (2006,2012) has proposed methodologies to find new design principles by means of optimization techniques. The idea is to perform some post-optimality analysis in which the relationship between design variables and objectives is undertaken, aiming to unveil certain design principles that can be further exploited by the user. This can be useful in certain types of applications.

Sample Applications of MOEAs



- Design of a vehicle door (Fang et al., 2013).
- Preliminary space mission design under uncertainty (Croisard et al., 2010).
- Computer communication network topology design (Khan & Engelbrecht, 2012).
- Cost optimization of a combined power and water desalination plant (Hosseini et al., 2012).
- Conceptual ship design (Hart, 2010).

What is missing?



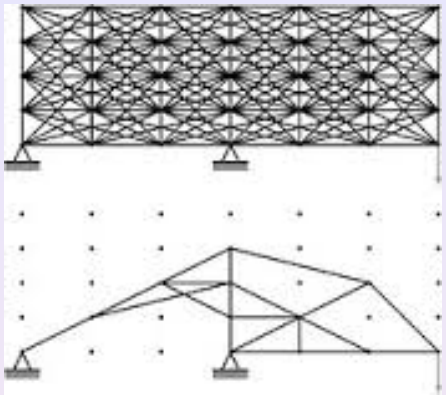
As of today, we don't really have MOEAs that can properly work in preliminary design, although there has been some work in that direction. For example, Wallace et al. (1996) presented an approach that attempts to emulate the way in which specifications are used by product designers in a concurrent design environment. The idea of this approach is to allow designers to formulate optimization problems in terms of design specifications.

What is missing?

Parallel MOEAs

Although MOEAs can be parallelized in a relatively straightforward way, there are few approaches that attempt to exploit the particular features of MOEAs when implementing them in a parallel architecture (e.g., the change of granularity adopted in MRMOGA (Jaimes & Coello, 2007). We are also missing implementations of MOEAs in GPUs and in hardware (FPGAs).

What is missing?



Scalability

Another interesting issue is scalability, both in decision variable space and in objective function space. Many-objective optimization deals with the latter and some indicator-based MOEAs seem to be a good choice for such problems. However, until very recently, few attempts had been made to design MOEAs for large-scale problems (having hundreds or even thousands of decision variables). Coevolutionary MOEAs seem to be a suitable choice for large-scale optimization, but the work in this area is still very scarce.

What is missing?

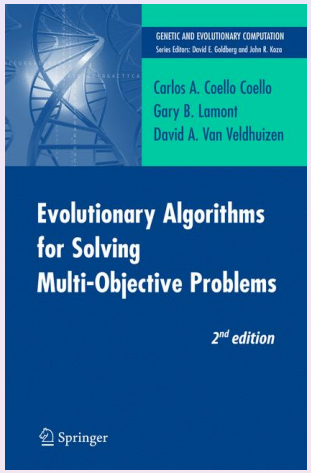
Many other issues

There are several other issues related to the use of MOEAs in real-world applications for which relatively little work has been done: dynamic problems, robustness, hierarchical design, multidisciplinary design, etc. In spite of that, there are several examples of the successful use of MOEAs in design.

To Conclude

- Knowing about evolutionary multi-objective optimization is certainly an advantage if you are interested in developing real-world applications.
- It is impossible to keep track of all the things that are going on in this field, but there are public-domain resources available that can certainly help (e.g., the EMOO repository).
- EMOO researchers are normally open to help people who are interested in solving challenging problems and can also point out relevant papers to practitioners interested in a specific topic.
- Having benchmark problems for validating MOEAs based on real-world applications would reduce the gap between academia and industry.

To know more about evolutionary multi-objective optimization



Carlos A. Coello Coello, Gary B. Lamont and David A. Van Veldhuizen, **Evolutionary Algorithms for Solving Multi-Objective Problems**, Second Edition, Springer, New York, ISBN 978-0-387-33254-3, September 2007.

To know more about evolutionary multi-objective optimization

Please visit our EMOO repository located at:

http://delta.cs.cinvestav.mx/~ccoello/EMOO

with a mirror at:

http://www.lania.mx/~ccoello/EMOO

To know more about evolutionary multi-objective optimization

The EMOO repository currently contains:

- Over 10,230 bibliographic references including 293 PhD theses, 51 Masters theses, over 4720 journal papers and over 3800 conference papers.
- Contact information of 79 EMOO researchers.
- Public domain implementations of SPEA, NSGA, NSGA-II, the microGA, MOGA, ϵ-MOEA, MOPSO and PAES, among others.