# The Evolution of Optimality: De Novo Programming

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**Abstract.** Evolutionary algorithms have been quite effective in dealing with single-objective "optimization" while the area of Evolutionary Multiobjective Optimization (EMOO) has extended its efficiency to Multiple Criteria Decision Making (MCDM) as well. The number of technical publications in EMOO is impressive and indicative of a rather explosive growth in recent years. It is fair to say however that most of the progress has been in applying and evolving algorithms and their convergence properties, not in evolving the optimality concept itself, nor in expanding the notions of true optimization. Yet, the conceptual constructs based on evolution and Darwinian selection have probably most to contribute – at least in theory – to the evolution of optimality. They should be least dependent on a priori fixation of anything in problem formulation: constraints, objectives or alternatives. Modern systems and problems are typical for their *flexibility*, not for their fixation. In this paper we draw attention to the impossibility of optimization when crucial variables are given and present *Eight basic concepts of optimality*. In the second part of this contribution we choose a more realistic problem of linear programming where constraints are not "given" but flexible and to be optimized and objective functions are multiple: *De novo programming*.

## 1 Introduction

Evolutionary algorithms have been quite effective in dealing with single-objective "optimization" while the area of Evolutionary Multiobjective Optimization (EMOO) has extended its efficiency to Multiple Criteria Decision Making (MCDM) [10] as well. The number of technical publications in EMOO is impressive and indicative of a rather explosive growth in recent years [1]. It is fair to say however that most of the progress has been in applying and evolving algorithms and their convergence properties, not in evolving the optimality concept itself, nor in expanding the notions of true optimization. Yet, the conceptual constructs based on evolution and Darwinian selection have probably most to contribute – at least in theory – to the evolution of optimality. They should be least dependent on a priori fixation of anything in problem formulation: constraints, objectives or alternatives.

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The notion of optimality and the process of optimization are pivotal to the areas of economics, engineering, as well as management and business. What does it mean to state that something is 'optimal'? If optimal means 'the best', then asking 'What is the best?' remains a legitimate and still mostly unanswered question.

Any maxima or minima could be declared optimal under specific circumstances, but optima are not necessarily maxima or minima. The two concepts are different: maximizing (or minimizing) is not optimizing.

Although dictionaries commonly use optimization as a synonym for maximization, we shall develop the concept of optimality in the *sense of balance* among multiple criteria or objectives.

When there is only a single dimension or attribute chosen to describe reality, then maximization or minimization with respect to constraints is sufficient. When there are multiple criteria (measures or yardsticks), as is true in most situations, then optimality and optimization (in the sense of balancing) need to be developed.

Optimization applies to an *economic problem* only: when scarce means (constraints) are used to satisfy alternative ends (multiple objectives). If the means are scarce, but there is only a single end, then the problem of how to use the means is a *technical problem*: no value judgments enter into its solution, no balancing is needed, and no optimization can take place. Only knowledge of physical and technical relationships is needed.

In other words, if all my constraints are "given" (fixed) and if my objective function is single, then the solution is fully defined and determined by mathematical problem formulation. The solution just needs to be revealed, explicated or computed by an algorithm. No optimization is possible: all is given and fully determined.

The technical problem is not what we wish to address when dealing with optimality and optimization.

## 2 The Evolution of Optimality

Balancing of multiple criteria is about optimization, not about "satisficing". Simon acknowledged this quite simply by saying: 'No one in his right mind will satisfice if he can just as well optimize.'

Surprisingly, multiple criteria or multiple objective functions - the necessary prerequisites for optimization - were not recognized and acknowledged by the optimization sciences until the early 1970s. Optimization in the sense of balancing multi-dimensionality is not compatible with the traditional concepts of "optimality" characterized by scalar or scalarized schemes, based on unique solutions under complete information. These are rather limited in capturing the richness and complexity of human problem solving, decision making and optimization.

We must strive to understand decision making not merely as computation of the given, already-constructed world, but as a way of constructing our local world, ordering of individual and collective experience. It is necessary to acknowledge multiple concepts of optimality.