Satisficing Games and Decision Making

In our day to day lives we constantly make decisions that are simply “good enough” rather than optimal – a type of decision for which Professor Wynn Stirling has adopted the word “satisficing.” Most computer-based decision-making algorithms, on the other hand, doggedly seek only the optimal solution based on rigid criteria, and reject any others. In this book, Professor Stirling outlines an alternative approach, using novel algorithms and techniques which can be used to find satisficing solutions. Building on traditional decision and game theory, these techniques allow decision-making systems to cope with more subtle situations where self and group interest conflict, perfect solutions can’t be found and human issues need to be taken into account – in short, more closely modeling the way humans make decisions. The book will therefore be of great interest to engineers, computer scientists, and mathematicians working on artificial intelligence and expert systems.

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Satisficing Games and Decision Making

With applications to engineering and computer science

Wynn C. Stirling

Brigham Young University
For Patti,
whose abundance mentality
provides much more than mere encouragement
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Alles Gescheite ist schon gedacht worden; man muss nur versuchen, es noch einmal zu denken.

Everything imaginative has been thought before; one must only attempt to think it again.

Johann Wolfgang von Goethe
Maximen und Reflexionen (1829)
Preface

It is the profession of philosophers to question platitudes that others accept without thinking twice. A dangerous profession, since philosophers are more easily discredited than platitudes, but a useful one. For when a good philosopher challenges a platitude, it usually turns out that the platitude was essentially right; but the philosopher has noticed trouble that one who did not think twice could not have met. In the end the challenge is answered and the platitude survives, more often than not. But the philosopher has done the adherents of the platitude a service: he has made them think twice.


It is a platitude that decisions should be optimal; that is, that decision makers should make the best choice possible, given the available knowledge. But we cannot rationally choose an option, even if we do not know of anything better, unless we know that it is good enough. Satisficing, or being “good enough,” is the fundamental desideratum of rational decision makers – being optimal is a bonus.

Can a notion of being “good enough” be defined that is distinct from being best? If so, is it possible to formulate the concepts of being good enough for the group and good enough for the individuals that do not lead to the problems that exist with the notions of group optimality and individual optimality? This book explores these questions. It is an invitation to consider a new approach to decision theory and mathematical games. Its purpose is to supplement, rather than supplant, existing approaches. To establish a seat at the table of decision-making ideas, however, it challenges a widely accepted premise of conventional decision theory; namely, that a rational decision maker must always seek to do, and only to do, what is best for itself.

Optimization is the mathematical instantiation of individual rationality, which is the doctrine of exclusive self-interest. In group decision-making settings, however, it is generally not possible to optimize simultaneously for all individuals. The prevailing interpretation of individual rationality in group settings is for the participants to seek an equilibrium solution, where no single participant can improve its level of satisfaction by making a unilateral change. The obvious desirability of optimization and equilibration, coupled with a convenient mathematical formalization via calculus, makes this view of rational choice a favorite of many disciplines. It has served many decision-making communities well for many years and will continue to do so. But there is some disquiet on the horizon. There is a significant movement in engineering and computer science...
toward “intelligent decision-making,” which is an attempt to build machines that mimic, either biologically or cognitively, the processes of human decision making, with the goal of synthesizing artificial entities that possess some of the decision-making power of human beings. It is well documented, however, that humans are poor optimizers, not only because they often cannot be, because of such things as computational and memory limitations, but because they may not care to be, because of their desire to accommodate the interests of others as well as themselves, or simply because they are content with adequate performance. If we are to synthesize autonomous decision-making agents that mimic human behavior, they in all likelihood will be based on principles that are less restrictive than exclusive self-interest.

Cooperation is a much more sophisticated concept than competition. Competition is the natural result of individual rationality, but individual rationality is the Occam’s razor of interpersonal interaction, and relies only upon the minimal assumption that an individual will put its own interests above everything and everyone else. True cooperation, on the other hand, requires decision makers to expand their spheres of interest and give deference to others, even at their own expense. True cooperation is very difficult to engender with individual rationality.

Relaxing the demand for strict optimality as an ideal opens the way for consideration of a different principle to govern behavior. A crucial aspect of any decision problem is the notion of balance, such that a decision maker is able to accommodate the various relationships that exist between it and its environment, including other participants. An artificial society that coordinates with human beings must be ecologically balanced to the human component if humans are to be motivated to use and trust it. Furthermore, effective non-autocratic societies must be socially balanced between the interests of the group and the interests of the individuals who constitute the group. Unfortunately, exclusive self-interest does not naturally foster these notions of balance, since each participant is committed to tipping the scale in its own favor, regardless of the effect on others. Even in non-competitive settings this can easily lead to selfish, exploitive, and even avaricious behavior, when cooperative, unselfish, and even altruistic behavior would be more appropriate. This type of behavior can be antisocial and counterproductive, especially if the other participants are not motivated by the same narrow ideal. Conflict cannot be avoided in general, but conflict can just as easily lead to collaboration as to competition.

One cannot have degrees or grades of optimality; either an option is optimal or it is not. But common sense tells us that not all non-optimal options are equal. One of the most influential proponents of other-than-optimal approaches to decision making is Herbert Simon, who appropriated the term “satisficing” to describe an attitude of taking action that satisfies the minimum requirements necessary to achieve a particular goal. Since these standards are chosen arbitrarily, Simon’s approach has often been criticized as *ad hoc*. There have been several attempts in the literature to rework his original notion of satisficing into a form of constrained optimization, but such attempts
are not true to Simon’s original intent. In Chapter 1 Simon’s notion of satisficing is retooled by introducing a notion of “good enough” in terms of intrinsic, rather than extrinsic, criteria, and couching this procedure in a new notion of rationality that is termed intrinsic rationality.

For a decision maker truly to optimize, it must possess all of the relevant facts. In other words, the localization of interest (individual rationality) seems to require the globalization of preferences, and when a total ordering is not available, optimization is frustrated. Intrinsic rationality, however, does not require a total ordering, since it does not require the global rank-ordering of preferences. In Chapter 2 I argue that forming conditional local preference orderings is a natural way to synthesize emergent total orderings for the group as well as for the individual. In other words, the localization of preferences can lead to the globalization of interest.

The desire to consider alternatives to traditional notions of decision-making has also been manifest in the philosophical domain. In particular, Isaac Levi has challenged traditional epistemology. Instead of focusing attention on justifying existing knowledge, he concentrates on how to improve knowledge. He questions the traditional goal of seeking the truth and nothing but the truth and argues that a more modest and achievable goal is that of seeking new information while avoiding error. He offers, in clean-cut mathematical language, a framework for making such evaluations. The result is Levi’s epistemic utility theory.

Epistemology involves the classification of propositions on the basis of knowledge and belief regarding their content, and praxeology involves the classification of options on the basis of their effectiveness. Whereas epistemology deals with the issue of what to believe, praxeology deals with the issue of how to act. The praxeic analog to the conventional epistemic notion of seeking the truth and nothing but the truth is that of taking the best and nothing but the action. The praxeic analog to Levi’s more modest epistemic goal of acquiring new information while avoiding error is that of conserving resources while avoiding failure. Chapter 3 describes a transmigration of Levi’s original philosophical ideas into the realm of practical engineering. To distinguish between the goals of deciding what to believe and how to act, this reoriented theory is termed praxeic utility theory.

Praxeic utility theory provides a definition for satisficing decisions that is consistent with intrinsic rationality. Chapter 4 discusses some of the properties of satisficing decisions and introduces the notion of satisficing equilibria as a refinement of the fundamental satisficing concept. It also establishes some fundamental consistency relationships.

Chapter 5 addresses two kinds of uncertainty. The first is the usual notion of epistemic uncertainty caused by the lack of knowledge and is usually characterized with probability theory. The second kind of uncertainty is termed praxeic uncertainty and deals with the equivocation and sensitivity that a decision maker may experience as a result of simply being thrust into a decision-making environment. Praxeic uncertainty deals with the innate ability of the decision maker.
One of the main benefits of satisficing à la praxeic utility theory is that it admits a natural extension to a community of decision makers. Chapter 6 presents a theory of multi-agent decision making that is very different from conventional von Neumann–Morgenstern game theory, which focuses on maximizing individual expectations conditioned on the actions of other players. This new theory, termed *satisficing game theory*, permits the direct consideration of group interests as well as individual interests and mitigates the attitude of competition that is so prevalent in conventional game theory.

Negotiation is one of the most difficult and sophisticated aspects of *N*-person von Neumann–Morgenstern game theory. One of the reasons for this difficulty is that the principle of individual rationality does not permit a decision maker to enter into compromise agreements that would permit any form of self-sacrifice, no matter how slight for the person, or how beneficial it may be for others. Chapter 7 shows how satisficing does permit such behavior and possesses a mechanism to control the degree of self-sacrifice that a decision maker would permit when attempting to achieve a compromise.

Multi-agent decision-making is inherently complex. Furthermore, praxeic utility theory leads to more complexity than does standard von Neumann–Morgenstern game theory, but it is not more complex than it needs to be to characterize all multi-agent preferences. Chapter 8 demonstrates this increased complexity by recasting some well-known games as satisficing games and discusses modeling assumptions that can mitigate complexity.

Chapter 9 reviews some of the distinctions between satisficing and optimization, discusses the ramifications of choosing the rationality criterion, and extends an invitation to examine some significant problems from the point of view espoused herein.

Having briefly described what this book is about, it is important also to stress what it is not about. It is not about a social contract (i.e., the commonly understood coordinating regularities by which a society operates) to characterize *human* behavior. Lest I be accused of heresy or, worse, naiveté by social scientists, I wish to confine my application to the synthesis of *artificial* decision-making societies. I employ the arguments of philosophers and social scientists to buttress my claim that any “social contract” for artificial systems should not be confined to the narrow precepts of individual rationality, but I do not claim that the notion of rationality I advance is the explanation for human social behavior. I do believe, however, that it is compatible with human behavior and should be considered as a component of any man–machine “social contract” that may eventually emerge as decision-making machines become more sophisticated and the interdependence of humans and machines increases.

This book had its beginnings several years ago. While a graduate student I happened to overhear a remark from a respected senior faculty member, who lamented, as nearly as I can recall, that “virtually every PhD dissertation in electrical engineering is an application of \( \dot{X} = 0 \).” He was referring to an elementary theorem from calculus that functions achieve their maxima and minima at points where the derivative vanishes. Sophisticated versions of this basic idea are the mainstays of...
optimization-based methods. Before hearing that remark, it had never occurred to me to question the standard practice of optimization. I had taken for granted that, without at least some notion of optimality, decision-making would be nothing more than an exercise in ad hocism. I was nevertheless somewhat deflated to think that my own dissertation, though garnished with some sophisticated mathematical accoutrements, was really nothing more, at the end of the day, than yet another application of \( X = 0 \). Although this realization did not change my research focus at the time, it did eventually prompt me to evaluate the foundational assumptions of decision theory.

I am not a critic of optimization, but I am a critic of indiscriminately prescribing it for all situations. Principles should not be adopted simply out of habit or convenience. If one of the goals of philosophy is to increase contact with reality, then engineers, who seek not only to appreciate reality but also to create it, should occasionally question the philosophical underpinnings of their discipline. This book expresses the hope that the cultures of philosophy and engineering can be better integrated. Good designs should be based on good philosophy and good philosophy should lead to good designs. The philosophy of “good enough” deserves a seat at the table alongside the philosophy of “nothing but the best.” Neither is appropriate for all situations. Both have their limitations and their natural applications. Satisficing, as a precisely defined mathematical concept, is another tool for the decision maker’s toolbox.

This book was engendered through many fruitful associations. Former students Darryl Morrell and Mike Goodrich have inspired numerous animated and stimulating discussions as we hammered out many of the concepts that have found their way into this book. Fellow engineers and collaborators Rick Frost, Todd Moon, and Randy Beard have been unfailing sources of enlightenment and encouragement. Also, Dennis Packard and Hal Miller of the philosophy and psychology departments, respectively, at BYU, have helped me to appreciate the advantages of collaboration between engineering, the humanities, and the social and behavioral sciences. In particular, I owe a special debt of gratitude to Hal, who carefully critiqued the manuscript and made many valuable suggestions.