Chapter 1

INTRODUCTION

"There is more religion in men's science than there is science in their religion."

Henry David Thoreau,
A Week on the Concord and Merrimac Rivers.

In a loose formulation a decision making problem could be stated as follows:

given a set of alternatives,
choose a feasible alternative, which according to (1.1)
decision making circumstances is the most preferred.

To survive in risky environments and to quell the nature, human beings possess brains capable of making decisions the vast majority of which are correct. Otherwise *homo sapiens* would perhaps still dwell in wild.

Every day people make myriads of decisions. When there is no time for reflection, decisions are made subconsciously and automatically. When time for reflection is limited, decisions can be made consciously but still quite automatically. Finally, there are also decisions, which result from thorough, time-spanned analysis.

Nowadays decision making is a field of active research in neurology, psychology, and behavioral science. If there is no need to decide instan-

taneously and the context is intricate, decision making becomes also a branch of applied mathematics and computer science, which is where this book belongs.

We still do not know how we make decisions. Although the advances in brain research are spectacular, there are few firm hints how to mimic brain analytical capacity. Reactions to simple stimuli can be correctly foreseen. But how decisions are made in more involved settings remains a mystery. Consequently, there are no general rules available on how to construct automated decision making devices able to replace human beings in their creative capacity. At best we can be provided with tools for supporting decision making by suitable data structuring and data processing. The need for such a support is evident in the class of problems we are concerned with in this book. We are concerned with problems in which each *feasible alternative* is evaluated against a set of at least two quality *criteria*. Such problems are known as *multiple criteria decision making* (MCDM) problems.

As any decision making process, MCDM processes are composed of four phases:

- problem intelligence,
- model design,
- solution choice,
- problem review,

(cf. Figure 1.1). This book concentrates on the third phase, which is technically the most involved.

More specifically, this book concentrates on *complex problems*. By complex problems we mean problems, which to be efficiently handled need to be captured by a formal model and investigated with the help of optimization methods.

The algorithmic approach to MCDM problems provides algorithms supposed to mimic the *decision maker* (DM) if he behaves consistently with a number of assumptions. There is an inherent trap in this approach, because verification of the DM consistency with respect to assumptions is a problem at least as involved as the decision making problem itself. To give an example, it is quite common to assume that the DM is consistent with the assumption of transitivity, which states that if the DM prefers alternative a to alternative b, and alternative b to alternative c, then necessarily he prefers a to c. Many examples can be given that it is not always the case. But as decisions have to be taken this or that way,

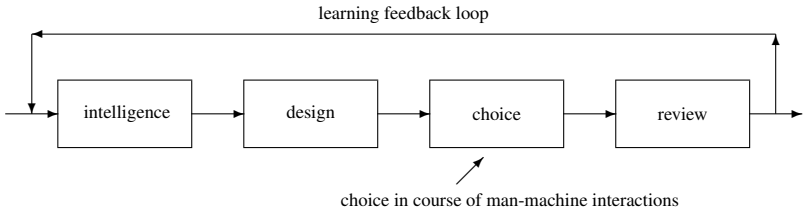

Figure 1.1. Four phases of decision making processes.

some DMs facing a complex decision making problem are tempted to make use of available decision making algorithms without paying much attention to the underlying assumptions.

In simple instances of decision making problems with a few alternatives DMs are often (but by no means always) quite convinced which alternative is the most preferred. Thus, in such cases, there is no need for using any decision making algorithm.

In other problems complexities can be of various sorts, ranging from problems where feasible alternatives given in the form of a list are just too numerous for their mutual relations to be fully perceived by the DM, to highly structured and mathematically modeled problems. A sort of decision making support is then required.

The strong form of the algorithmic approach assumes that the DM selects the most preferred alternative by evaluating alternatives against a scoring system defined by a function. Moreover, it is assumed that such a function, called *value function*, is known in an explicit form. Given the value function the decision making process reduces to finding a feasible alternative which maximizes that function. But the existence of a value function is guaranteed only by fulfillment of some rigid assumptions about DM's preferences, whose verification is a problem in itself.

In a real business environment it is hard to imagine the DM consenting to undergo a test for his consistency with a set of assumptions. Findings of tests conducted in laboratory environments on volunteers or students, when transferred to a practical setting can be misleading or even not valid. The fact that consistency of the assumptions cannot be tested and

therefore assumed, puts a question mark on the practical usefulness of the strong form of the algorithmic approach to decision making.

Another, and by no means insignificant, problem is the construction of the explicit value function, a process which calls for a far reaching cooperation between the DM and an analyst. It can hardly be believed that the real DM (say, a company manager) will reveal his preferences in full. This might have a devastating effect on his ego and career because as soon as he permitted his role to be reduced to a set of rules known to the public, he would become vulnerable to critics and vultures. He could even fear for his job position.

For these reasons MCDM methods have drifted over time from the strong form of the algorithmic approach to softer schemes. This has been happening with healthy competition from other soft decision making methodologies such as neural networks, fuzzy and rough sets, artificial intelligence, and last but not least, heuristics.

The soft form of the algorithmic approach to MCDM is *interactive decision making* (interactive MCDM) and nowadays MCDM problems are usually tackled in this way. With this approach MCDM problems are solved via a sequence of "man-machine" interactions. At one interaction the DM expresses his partial preferences (the "man" phase) and, using the underlying formal model of the problem, a feasible alternative is selected which fits those partial preferences best (the "machine" phase).

In interactive MCDM the solution to a decision making problem is the selection of the most preferred alternative which the DM arrives at by a "tour", i.e. sequence of trial alternatives. During such a tour the DM interacts with the model while directing himself by evaluations of trial alternatives and by his preferences reflecting his current state of mind. Overall DM's preference structure remains hidden even at the end of the decision making process and this corresponds well with the DM's unwillingness or inability to frame it.

Since in general it is not possible to verify assumptions about the DM's behavior, it is not practical to make any. But then what are we left with? Is there any room then for a structured supporting methodology? In a quest for the most preferred alternative, has the role of the DM to be reduced just to passively moving from one alternative to another? Is interactive MCDM in fact a form of random search?

Fortunately, we are left with a plentiful supply of riches to deal with the three basic notions of MCDM, namely *efficiency*, criteria, and *trade-offs*. In this book we exploit these notions within the interactive framework to

propose Generic Interactive MCDM Support Scheme – GIS^2 – applicable to any MCDM problem. GIS^2 is just a flexible procedure to help the DM to master the bulk of structured data in complex problems. It is not, however, intended to replace the DM in any aspect of his decision making capacity.

GIS^2 follows the interactive decision making principle, where the main role in the scheme is reserved for the DM. With GIS^2 the DM navigates *himself* through feasible alternatives with the help of the aforementioned notions of efficiency, criteria, and trade-offs, as his navigating tools. Interactions stop when the DM wishes. The primary role of GIS^2 is to support problem structure learning, while decision making necessarily follows on.

GIS^2 scheme is by no means a new invention. On the contrary, it is an abstraction of elements common in the existing interactive MCDM methods.

Presenting the GIS^2 alone would not merit a book but we propose more than that. First, we propose and exploit in GIS^2 "foreseeing" mechanisms to assess the criteria values of alternatives as well as their respective trade-offs, without the necessity to explicitly identify them. Second, we show how to eliminate optimization from MCDM processes and we extend GIS^2 to Generic Interactive MCDM Soft Support Scheme – GIS^3 – to adopt this idea. In consequence, GIS^3 is spanned over two dimensions of softness:

- soft (i.e. interactive) decision processes,
- soft computing (i.e. involving no optimization in decision processes).

Who should read the book? In the first place this book will be of interest for all those people *all this fuss is about*, namely MCDM practitioners and lay (in the sense of MCDM methodologies) decision makers. With this readership in mind great efforts have been made to make the book easy to follow.

However, this book is a research monograph and as such it should also be also of interest for research and the academic community, graduate and PhD students included, and anybody with an interest in decision making theory and in MCDM in particular. Also specialists in optimization methods, research and practice orientated, should find this book of interest to understand what their role will be with GIS^2 and GIS^3 in place.

The book is composed of nine chapters. Chapter 2 to Chapter 4 give a general map of the MCDM field. Chapter 5 to Chapter 9 form the proper research part, with new or recent ideas and results.

For readers who are actual or potential decision makers step-wise (cf. *How to read the book?* paragraph below) reading of the whole material is recommended. Readers already familiar with MCDM would probably wish to confine themselves to Chapter 5 to Chapter 9, but they may also find interest in the concise outline of the interactive MCDM field given in Chapter 2 to Chapter 4.

How to read the book? Throughout the book all formal results are given without proofs and the reader is directed to the references.

The sequence of the book can be broken down into three reading tracks. Starting with Chapter 2 each chapter begins with the introductory section "This Chapter is About ..." which presents the contents in a descriptive and informal manner. These eight sections, all with the same title, are the fastest reading track, suitable for those who want to get acquainted with the book at a glance. The second track is more demanding and is recommended for those who are interested in formal aspects of MCDM methodologies but would prefer to leave technical details to subsequent readings. Those readers should simply skip over parts of the text which start with ♣ and end with ♠. The last track is composed of the text in full.

All chapters except Introduction end with *Concluding Remarks* followed by *Annotated References* sections. We believe that grouping references in one place improves readability of the text.

The outline of the book The outline of the book is as follows.

In Chapter 2 decision problems to be investigated are formulated, both verbally and formally. Basic notions and definitions are also introduced there.

Chapter 3 presents basic algorithmic tools used in the existing interactive MCDM methods.

Chapter 4 brings a condensed overview of interactive MCDM methodologies and methods.

In Chapter 5 it is shown that the most prominent interactive MCDM methods in the "man" phases of decision making processes can be reduced to manipulations of a few standard and common items. Moreover, in the "machine" phases these methods share the same standard require-

ments for computations. Because of these observations a form of a standard interface for interactive MCDM methods is propounded.

Chapter 6 presents what we believe is the most relevant, though rudimentary, interactive multiple criteria decision making scheme, namely GIS^2, and it is demonstrated how the existing methods fit to this scheme.

Chapter 7 and Chapter 8 present the main idea of the book, namely the idea of using in interactive MCDM problems approximate rather than exact values to save on optimization computing.

Chapter 7 presents how to derive assessments of criteria values of alternatives without resorting directly to solving optimization problems (which otherwise are to be solved to give the exact criteria values).

Chapter 8 shows how to derive assessments of trade-offs of alternatives without resorting directly to solving optimization problems (which otherwise are to be solved to derive exact trade-off values).

In Chapter 9, finally, we discuss and illustrate how to enhance GIS^2 methods with the developments of Chapter 7 and Chapter 8 to eventually arrive at a soft version of GIS^2, namely GIS^3.

Annotated References

The four phased scheme of decision making has been popularized by Simon (Simon 1977).

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