# Against fashion: a travel survival kit in “modern” MCDA

C. Antunes(*), A Tsoukiàs(+)
(*) INESC - Coimbra, Rua Antero de Quental, 199
3000 COIMBRA, Portugal, e-mail: cantunes@inescc.pt
(+) LAMSADE, Université Paris Dauphine,
75775 Paris Cedex 16, France, e-mail: tsoukias@lamsade.dauphine.fr

**Abstract**. Computer Science is going through a period of exciting new technological achievements which appear with increasing frequency. Multi-Criteria Decision Aid (MCDA), as any decision support activity, is heavily affected by such evolution, since MCDA methods are implemented and/or integrated in complex computer based information systems.

The paper provides an eclectic (by no mean exhaustive) survey of some new technological achievements (fuzzy sets, multimedia, distributed computing, expert systems, object oriented programming, neural networks, the world wide web) and tries to explore their specific relevance for the MCDA field. The basic thesis claimed in the paper is that while we consider that “modern” and “new” technologies may be positively used in creating decision support systems integrating MCDA methods, very few improvements can be obtained as far as the theoretical core of MCDA is concerned.

## 1 Introduction

When the editor asked us to contribute a leading paper on the subject of multicriteria decision analysis and new technologies we initially felt embarrassed since “new technologies” is a very large concept perceived in different ways by different people due to different backgrounds. It is therefore difficult to establish which are the relevant areas of this subject for our research field. After some reflection we opted for a “fashionable” presentation. In other words we decided to choose some “keywords” which are fascinating and “modern”. Keywords that statistically are easy to find in the titles of papers and in the keyword section of abstracts.

We identified seven such key-words which are:
- fuzzy sets;
- multimedia;

- distributed computing;
- expert systems;
- object oriented programming;
- neural networks;
- the world wide web.

Such keywords correspond to specific areas of computer science (therefore adopting the equivalence new technology = computer science), with the partial exception of the first one, which have been more or less recently adopted by the MCDA area despite their effective scientific age. Normally there is a relevant time gap between the appearance of the specific technological achievement and its use in the MCDA area.

Our brief analysis of each of these keywords includes an informal introduction to the domain, some issues about their relevant and NOT relevant application in MCDA and some open questions for the future.

We definitely do not consider exhaustive our presentation neither of the "new technology" nor of the seven specific subjects. Our aim is to help to clarify the use of these tools and ideas, to argue against their trivial or indiscrimimate use, justified only by fashion reasons, and to provoke discussion about them since we do not claim that our point of view has to be shared by the MCDA community.

## 2 Fuzzy sets

The idea of a fuzzy set (see Zadeh 1965) is a very simple one and therefore a very powerful one. Considered any set $A$ we can define a membership function $\mu : A \mapsto [0, 1]$ which associates to each element of $A$ a number of the real interval $[0, 1]$ representing the degree by which an object could be in $A$ (membership degree). Such a degree can be viewed under different points of view, but there are two basic approaches.

1. The degree is seen as a measure of uncertainty due to the imperfect knowledge about the elements of $A$. The best known theory associated to this approach is possibility theory (see Dubois and Prade, 1988) which introduces the concept of "possibility distribution" which is an ordinal measure of uncertainty with an axiomatization weaker that the one of probability.

2. The degree is seen as the result of the vague character of the set $A$ and it measures the "credibility" of the membership of any element in

$A$. Such a degree can be therefore seen as a truth value in a system with infinite completely ordered truth values (see Goguen, 1969).

The application of such ideas in multicriteria analysis is straightforward. Decision problems are normally affected by uncertainty (much more when information is multidimensional), the relevant information may be poor or ambiguous, the decision objectives may be more or less vague. However we want to emphasize some points.

- When a fuzzy set approach is used it should be clarified if it is an uncertainty representation or a vagueness representation. Since the calculus could be significantly different in the two cases it is not allowed any arbitrary use.

  For instance, an uncertain preference is not the same as a vague preference. In the first case we have a membership degree due to the imperfect knowledge of the decision maker, while in the second case we have a membership degree due to the vague nature of the preference relation. In the latter if we adopt a "preference intensity" point of view we need a cardinal representation which is impossible using a possibility distribution.

- The use of fuzzy sets should not be trivial. For instance, to associate a membership function to a set $A$ and then "cut" the function to a certain value obtaining immediately a crisp set is trivial.

- The use of "valued" binary relations (that is binary relations seen as fuzzy sets) for preference modeling and aggregation purposes should be done in a coherent way. There exist now sufficient axiomatizations in literature (see for example Perny and Roy, 1992 and Fodor and Roubens, 1994)) which outline the foundation of this approach.

- The use of a fuzzy set as an uncertainty distribution instead of a probability one should be justified and argued. The two approaches have a different axiomatization (and therefore a different calculus) which should be compared with the information provided and with the kind of uncertainty present in the decision process (see also Slowinski and Teghem, 1990).

Some open questions about the use of fuzzy sets in MCDA include, but are not limited to:

1. the extension of the expected utility theory under qualitative uncertainty distributions like the possibility one (see Dubois and Prade, 1995);
2. the enhancement and improvement of the "valued binary relations" approach;
3. the analysis of the links between the concept of "preference intensity" and its fuzzy representation.

## 3 Multimedia

The evolution of multimedia equipment is a result of the development of new computer devices and software. The increasing storage capacity of computer memory, the high performance of new processors, combined with appropriate operating software enables to store and manipulate any kind and very large amounts of numerical data including images, sound etc., besides the usual texts. Therefore it has been possible to conceive workstations able to manipulate and integrate different kinds of information sources. The development and improvement of (tele)communication systems enabled also to establish different size and nature networks (last, but not least the internet). This is not really a revolution since these are all achievements inside the genetic structure of conventional computer systems. It is a result of a quasi optimal usage of their potentialities. From a decision aid point of view there are different levels of integration of multimedia equipment in decision support systems (see Chang and Holsapple 1994, Maybury, 1994, Bieber, 1995).

- Conceive individual decision support systems that integrate visual modeling facilities improving the user interface and the man-machine interaction. The integration of different information sources may also improve decision support systems using data and knowledge under synthetic representations and/or visual ones.
- Conceive collective decision support systems (groupware, negotiation support systems etc.) which use such facilities in order to improve communication among the participants of the decision process. Moreover it is possible to integrate in the system, geographical information systems, large data bases, monitoring networks etc..

Concerning the use of multimedia equipment in the MCDA field we can make the following observations.

1. There is nothing specific in the development of such facilities concerning multicriteria decision analysis. The technological advantages offered by such equipment are the same for any decision support theory branch and although specific technical solutions have to be used when a multicriteria model is at stake these concern the hardware and software and not the model itself.

2. The use of multimedia equipment does not alterate the weakness or strength of the decision aid approach included in the decision support system created. In other words when a specific decision model is chosen the use of such facilities may improve the way information is collected and results are presented, but it will not affect the contents and quality of the result neither from a theoretical point of view nor from an operational point of view. A weighted sum is always a weighted sum under any kind of computer dress.

3. The most promising direction, to our point of view, in the use of multimedia equipment is to explore the possibility to provide a decision support during the whole decision aid process (enhancing interactivity, improving learning etc.), while presently decision support is conceived in a rather static manner.

## 4 Distributed Computing

This section is strongly linked to the previous one as it is a pure technological achievement. The idea of distributed computing is the one to substitute the old centralized edp systems with networks of workstations enabling users to work autonomously sharing only some facilities. The development of multimedia equipment has been a further improvement in this direction.

An interesting extension of this idea is to conceive decision support systems as a network of distributed autonomous agents each of them facing and solving a specific problem. Under this point of view different multicriteria models and methods can be integrated in the same system.

Our observations are practically the same ones as in the previous section. Last, but not least, a confusion that may occur is between distributed and parallel computing. The latter consists in an alternative hardware architecture using parallel processors for the execution (in a parallel way) of algorithms (namely large scale problems can be decomposed is parts that can be solved in parallel). It is well known however that the computational improvement obtained by this technology does not affect the computational complexity of the algorithms.

## 5 Expert systems

The development of expert systems is a field of Artificial Intelligence (AI). Expert systems use knowledge representation in an explicit qualitative form about a problem domain, concerning a specific area of human expertise, to support decision maker's (DM) when solving particular problem instances. Expert systems are designed to replicate the problem solving behaviour of an expert in that domain, thus acting as an intelligent assistant to the DMs. Even though in theory expert systems and DSS are different, in that the former are aimed at explicitly or implicitly replacing the DM by simulating human reasoning, in practice expert systems have been used in a decision aid role similar to that of DSS. Once knowledge (facts and rules) is elicited from an expert (knowledge acquisition), it is represented under a specific form such as production rules, frames, semantic nets (knowledge representation). The inference engine uses both types of declarative and procedural knowledge to derive conclusions (ideally the same that the expert would reach). The quality of these conclusions strongly depends on the knowledge acquisition process. However, elicitation of knowledge from experts is not a straightforward task, because experts generally have difficulty to explain their decision process as these become automatic. To this purpose Pomerol (1995) claims that "expert systems paradoxically are not suitable for simulating human expert judgment in discrete decisions" (see also Hammond 1987, Mumford 1987). Expert systems can also use case-based reasoning rather than a set of rules, that is a process of deriving conclusions based on specific examples of what has occurred in the past.

We want to point out the following observations.

- The literature is full of presentations of prototypes of trivial "expert systems" which in practice are very simple multi-criteria methods where the well known weighted sum is replaced by some heuristic decision rule which does the preference aggregation job. Obviously there is no expert knowledge represented as the heuristic is confused with knowledge.

- A severe limitation of traditional expert systems is that they perform only pure classification tasks where the situation at hand (the facts) have to be matched to a situation already described by the knowledge. In other words expert systems are essentially diagnosis machines. Often the problem is not only to classify, but also to rank, to choose, to compare and generally under different (and conflictual) points of view (which is a typical MCDA task).

- The idea that expert systems could solve any kind of problem (provided that an expert exists for any kind of problem) has been very soon rejected. Organizational decision making and other complex decision processes seem to escape from the expert systems approach (see Hatchuel and Weil, 1992 for a very interesting discussion).

The non trivial coupling of AI/expert systems techniques and MCDA methodologies has revealed, at least in theory, to be a promising research direction. It may be used to help in the choice of aggregation rules, as a tool of qualitative analysis of the results produced by the procedural components, to guide the interactive decision process by combining expert and preferential knowledge, to support the knowledge elicitation process etc. A mutual benefit can be viewed exactly in the analysis of the cognitive dimension of the decision aid process which is a problem solving process also. Finally the treatment of uncertainty is a common ground of research.

## 6 Object oriented programming

Object oriented programming (OOP) is one of the most important trends in programming methodology. It introduces a different style of programming by using the key features of encapsulation (of state and methods together) and inheritance. An object has a set of operation and a local shared memory. Encapsulation refers to the concept of combining the state of an object with the methods that manipulate it. That is, data is packaged with the operations and procedures which may access the data elements. Encapsulation means information hiding in the sense that the data structure users do not see the representation of data (which is the principle of abstract data types). Users will operate on an object using the messages provided at the implementation stage.

Inheritance is the ability to derive new objects from existing ones, by allowing the child object, besides sharing the properties and operation of the parent object, to modify or add new properties and operations. This enables code sharing, reuse and development of generic functions, encouraging a differential programming style (by successive modifications). Because of historical reasons OOP has been confused with graphical user interfaces and windowing systems. Also some dialects of conventional programming languages exist (such as C or Pascal).

Since MCDA methods are implemented as software it is reasonable to question whether OOP could be relevant or specific for the purpose of creating multicriteria based decision support systems. In fact the structure of a multicriteria decision aid method presents elements of inheritance and makes large use of abstract data types (a criterion, a preference structure etc.). We may emphasize however that:

1. the gains obtained using OOP in implementing a MCDA method do not affect the method itself, but only the way the user perceives it;

2. it is relevant to study OOP as an efficient programming language for decision support systems in general (independently of the methods used);

As pointed out by Brooks (1987), changing programming language does not solve the "core" (or essential issues) of the algorithm to be implemented. Shifting to OOP may enhance our possibilities in using software for MCDA, but it will not modify our problems.

# 7 Neural Networks

An (artificial) neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use (see Hertz et al., 1991). Neural networks mimic the way in which the brain performs a particular task or function. The similarity with the brain (viewed as an adaptive machine with abilities to learn from and adapt to the environment) lays in two main processes:

- knowledge is acquired by the neuron (elementary information - processing unit) network through a learning process; and

- the synapses (structural and functional units that mediate the interactions between neurons) strengths (or weights) are used to store the knowledge.

Neural network architectures include single-layer feed-forward, multi-layer feed-forward, recurrent and lattice structures. The procedure used to perform the learning process modifies the synaptic weights of the neural network in order to attain a desired goal. In the same way weights are used in some MCDA methodologies to reflect, up to a certain extent, the DM's preferences, neuron inputs are weighted to represent the relative importance of each input to a processing element.The ability to learn and generalize can be interesting in MCDA for instance by using former decisions (in appropriate similar contexts) to tune a network of methods capable of replicate decisions (thus in an attempt to recognize patterns of decisions).

Our observations concern two points.

1. In order to have reliable and innovative applications of artificial neural networks in the MCDA context the question of the "weights" have to be seriously addressed. "Weights" have different meanings in MCDA, largely depending on the preference aggregation procedure adopted and on the nature of the different criteria. Either such a procedure is chosen externally and imposed to the network thus simply replicating well known MCDA methods or the preference aggregation procedure has to be chosen by the network introducing a meta level of reasoning for which neural networks do not seem (for the moment) very well suited.

2. It seems that neural networks are particularly suited for some classes of MCDA problems, namely the sorting ones. This is obvious since neural networks are essentially classification machines (in that being very similar to expert systems). However, it is not yet clear if there is a real advantage in using such a technique, while it is also questionable the confidence of the DM to a tool performing as a "black box". For further discussion see also Pomerol (1995).

# 8 The World Wide Web

The World Wide Web (WWW) is the "universe of network-accessible information, an embodiment of human knowledge" (as defined by the WWW Consortium), physically implemented as a (massive) "client-server" architecture. By means of a server program supporting an appropriate protocol, the information provider can offer a large range of information (such as text, pictures or sounds, and the possibility of file transfer), to which the client has access by using a browser. The most common use of the Web has been the access to a server's home page, organized in a hypertext structure in which the information is made accessible by clicking on links. This somewhat "static" approach has now begun to change. A recent Web browser named Hot-Java, developed by Sun Micro-systems, can download its own programs, called applets, and run them embedded on a Web page. Independently of its computer architecture or operating system anyone can access the same applications as long as (s)he is using a Java-enabled browser (such as Netscape 2.0). By enabling the distributed execution of programs over a network, thus acting as a kind of "universal" interface, Java lays the foundations for a more uniform and integrated collective work environment. The potential it opens is enormous, as are security issues. The possibility of providing on the Web interactive services also has important implications to be exploited in decision aid (and decision aid business).

The same observations done in the multimedia and in the distributed computing section apply here the WWW being an advanced realization of such fields. It may be useful to notice that propositions already exist to include decision support facilities in the WWW context. (see Karacapilidis and Gordon, 1995 and Karacapilidis et al., 1995).

# 9 Conclusion

So-called emerging or new technologies are very broad concepts, which are perceived in different ways by different people due to different backgrounds. Our presentation focussed on some fashionable and modern keywords (which are neither exhaustive nor mutually exclusive). A brief description of each concept is made and it is then attempted to shed some light on the use of these tools and ideas, to argue against their trivial or indiscrimimate use (justified only by fashion reasons which can have harmful effects), and to provoke some discussion about them. Nevertheless whenever properly used in context these technologies can actually add value to MCDA environments.

Using the distinction of essential and accidental issues in the MCDA field we can summarize our conclusions as follows:

- new technologies cannot affect the "quality" of the "essence" of MCDA, that is the principles of preference modelling and aggregation underlying any different MCDA method;

- new technologies can improve "accidental issues" such as user interfaces, integration of MCDA methods in more general decision support systems, construction of wide-band DSS etc;

- there is no "modern" MCDA, as it does not exist "good" or "bad" MCDA. It exists however "correct" and "validated" MCDA (see Bouyssou et al., 1993) and this could be a challenge for new technologies. Are they useful?

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