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MCDM Techniques Selection Approaches: State of the Art

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Abstract – **A large number of multicriteria techniques have been developed to deal with different kinds of problems. Whereas each technique has pros and cons and can be more or less useful depending on the situation, few approaches were proposed to guide the selection of a technique adapted to a given situation. This paper presents a state of the art of the existing approaches for selecting MCDM techniques. The state of the art is structured with a framework that guides the analysis of each selection approach according to its own characteristics, and to the characteristics of the MCDM techniques that the approach helps to select. The state of the art has two outcomes: a comparative analysis of the presented approaches, and a collection of requirements for a "good" selection approach.**

I. Introduction

The MCDM literature reveals a large number of techniques ranging from outranking methods, to analytic hierarchy process, multiattribute utility theory, weighting methods, fuzzy methods, or multiobjective programming (See, for example, [1] [2]). Considering the diversity of these techniques, a few attempts have been made to guide their selection.

MCDM techniques are often selected arbitrarily: sometimes the analyst is already familiar with a procedure, other times a technique is developed in an ad hoc way, it also happens that a technique is chosen simply because a software that supports it is available ([3], [4] and [5]). Experience also shows that there is no MCDM technique that is able to deal with all multicriteria problems ([3] and [6]). In fact, each situation demands specific MCDM technique. The impact of the choice of technique on actual decisions is also well known, as well as the consequences of poor decisions. While several researchers suggest the state of the art on MCDM, we did not find a well structured state of the art on selection of MCDM techniques in the reviewed literature.

Nine selection approaches ([3]…[11]) were considered to be discussed in this paper. We have two goals: on one hand to emphasize their similarities and differences and on the other hand to identify the requirements for a "good" MCDM selection approach. To achieve this, our research strategy was to develop a structured analysis framework that guides the comparison of MCDM selection approaches. A first review of the nine selected approaches revealed a number of attributes that could be gathered into different facets that formed two particular views. The first view concerns characteristics of the selection approaches. The second view is about MCDM techniques characteristics that are addressed for selection. In the first view, the analysis framework defines the properties of selection approaches themselves. In the second view, the selection of a technique must be achieved by taking into consideration the situation at hand ([3] [6] [8]) and technique's features ([5] [7]).

This paper is organised as follows: next section presents our evaluation framework, section 3 provides an overview of the nine chosen selection approaches, and our comparative analysis is reported in section 4. Our list of requirements for a "good" selection approach is presented in the concluding section.

II. Evaluation Framework

The selection approaches differ by their specific characteristics and by their ability to take into account different properties of MCDM techniques. We have defined an evaluation framework according to a in-depth analysis of the selection approaches characteristics, and of the properties of the selected MCDM techniques. For this reason, we propose to analyse MCDM techniques selection approaches according to two views:

- the first view deals with the characteristics of the selection approaches themselves;
- the second view deals with the characteristics of the MCDM techniques.

Each view comprises facets that facilitate the study of the selection approaches. Each facet includes a set of attributes (characteristics). The two views are respectively developed in the following sub-sections.

A. The "characteristics of selection approaches" view

An analysis of the nine MCDM techniques selection approaches revealed a number of characteristic attributes that we gathered under two facets: features and context.

1) The "features" facet

The feature facet deals with the attributes that characterize the selection approaches themselves: objective, comparison approach, structured algorithm, nature of the selection approach, or capitalization.

The *approach objective* concerns the goal that was adopted by the authors for MCDM techniques comparison. Initially,

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the goal is a technique selection. Nevertheless, certain authors suggest comparing the MCDM techniques in order to improve understanding and practical use. All these approaches are interesting due to their analysis of the MCDM techniques.

The *basic approach used to compare MCDM techniques* can be defined as the mechanism that allows to select and to analyse them. It reflects the degree of accessibility of the approach for the users. Some approaches are supposed to be applied by users themselves; other must exploit a tool or a third person. The approach, which is easy to apply, is more preferable in practice because it is not necessary to buy a tool. The basic approaches found through this state of the art are tree analysis, distance function model, drawing up properties lists, expert system, neural network, decision-making steps analysis and framework application.

The presented approaches differ from each other by the *presence of a structured algorithm*. Some of them suggest a mechanism to carry out the selection. Others only rely on a verbose comparison of the selected techniques. A structured algorithm guides users more systematically and pro-actively. In the other hand, textual approaches have the advantage of being easily adoptable and adaptable in practice when they are simple.

Some authors such as [7] or [9] envisage the problem of MCDM technique selection as a multicriteria problem itself. In this case, the *nature of the selection approach* is multicriteria. Other researchers [3] and [5] consider that this understanding generates a “vicious circle”. They usually accept that it can be taken as a MC problem, but they are against using a particular MC technique for selection. In this case, the nature of the selection approach is not multicriteria.

Often, the same problem appears repeatedly from one decision cycle to another. In this case, the decision-making may use two ways of working: restart all procedure from scratch to obtain a new result, or adapt the previous solution to the new conditions. Adaptation is possible thanks to the *capitalization*. The approaches may contain or not a possibility to capitalize on the selection results.

2) The “context” facet

The contextual facet corresponds to attributes that deal with the context of the MCDM technique selection: application domain, problem specification, decision making steps taken into account, or tool.

Some selection approaches were created to be used in specific domains requirements while others were generalized to suite any domain. Consequently, the approach *application domain* attribute can be defined as generic or specific. The generic approach is, of course, interesting because of its adaptation to any context of MCDM technique selection. However, specific approaches have the advantage to be well fitted to the given decision problem.

Different selection approaches consider different collections of *MCDM techniques*. Some authors suggest comparing all major groups, other only one or several groups.

The characteristic of *problem specification* indicates if the authors have mentioned that MCDM technique selection depends on problem situation and if the authors have specified its characteristics. In fact, not all approaches intend to select a technique depending on problem. The possible values of this attributes are: "no" – then the approach does not take into account the problem specificity; "yes, not specified" – then the approach indicates the necessity to analyse the problem specificity but does not propose problem characteristics typology; and "yes, specified" – then the approach includes such typology.

All MCDM techniques are employed in the context of a process that involves decision-making. In order to understand the role of MC techniques, their contribution on different *decision-making steps* must be highlighted.

The presence of a *tool* facilitates the adoption of the MCDM techniques selection approaches. However, tools can be costly and are not always adapted to the specific problem situation. Besides, purchasing a tool is only interesting when intended to be used several times.

B. The “characteristics of MCDM techniques” view

Three basic concepts are generally used to define multicriteria problems (MCP) [1]: the problem, alternatives (potential actions), and criteria collections. Given that our state of the art deals with MCDM technique selection, we believe a fourth concept is needed to characterize techniques in the context of their selection, namely the usage in practice. These concepts form four facets: problem, potential actions, criteria and MCDM technique usage. Each selection approach is analyzed in order to show if whether takes into account the characteristics of MCDM techniques. Therefore, the possible values for these characteristics are yes or no.

These facets are discussed in the following subsections.

1) The “problem” facet

Two kinds of attributes can be used to characterize an MCDM problem: the type of decision problematic and the problem scale.

The *type of decision problematic* [1] can be defined by the result expected from an application of the selected MCDM technique. When the result consists in a subset of a potential alternatives (most often one alternative) then it is a *choice problematic.* When the result consists in the potential alternatives affectation to some predefined clusters, then it is a *sorting problematic.* When the result consists in a potential alternatives ordered collection, then it is a *ranking problematic*. Given that each decision-making technique is able to support a specific type of decision, it is important to know which type of decision is faced to select the appropriate decision-making technique.

The *problem scale* characterizes MCDM techniques according to the size of the problem with which they are able to deal. For example, in the context of an enterprise the problem to consider can concern a workplace, a department, the enterprise or its corporation as a whole. Of course, the amount of resources and of organizational efforts needed to deal with the decision problem will be different in each case.

2) The “potential actions” facet.

A set of alternative potential actions (in short “alternatives”) may vary from one situation to another. We propose to use the following attributes in order to characterize the collections of potential actions that are considered in the selected MCDM techniques: number of alternatives, ability to consider new alternatives, incompatibility and conflicts, organization of the alternatives, and nature of alternatives set.

The selection of techniques depends primarily on the *number of alternatives*. In fact, several MCDM techniques are not adapted to a large number of alternatives. In addition, the number of alternatives is crucial when choosing a technique accompanied by a tool: it is more reasonable to purchase a tool when the number of alternatives is large because it allows to avoid a considerable amount of manual work.

The need to be *able to consider new alternatives* results from the fact that the potential actions collection is not stable and may evolve from one moment to another, in particular when decisions to be revised. New potential actions may appear, certain potential actions disappear, and others change their properties. In practice, cases of repetitive and cyclic problems are frequent. MCDM techniques handling the possibility to deal with repetitive problems facilitate the decision-making.

In some situations, considered alternatives have interconnections, incompatibility and conflicts. Therefore, the chosen MCDM technique must take into account *incompatibility and conflicts of alternatives*.

Potential actions may form a hierarchy. In this case, the approach of MCDM techniques selection must take into account *alternatives' organization.*

Last, *set of alternatives* could have a continuous or discrete *nature*.

3) The "criteria" facet

Looking at MCDM techniques selection approaches showed us that four attributes characterize decision criteria: data type, measure scale, criteria weighting, and criteria interaction.

There are two kinds of *data types*: quantitative and qualitative. Certain techniques deal with two kinds of data type (e.g. outranking methods) while others require a quantification of qualitative values (e.g. weighting methods) that deforms the initial information.

Criteria must be measured. A *measure scale* therefore characterizes them. Types of scales depend on nature of the relationship between criteria values. These are nominal, ordinal (restricted or unrestricted), interval, ratio, and absolute. B. Roy indicates that two kinds of scales are more usually used in MCDM: nominal and ordinal [1]. Some techniques take into account criteria with different measure scale; others do not.

Some MCDM techniques comprise *criteria weighting*, the others do not. This aspect must be taken into account for selecting a technique.

The criteria may be independent, cooperative, and conflicting. For this reason, it is important to analyze possible *interactions between criteria*.

4) The "usage" facet

Five attributes were gathered under the usage facet to characterize the intended context of use of the MCDM technique while a decision maker undertakes selection. These are tool, approach for giving partial and final evaluations, easiness of use, cost for implementing and decision maker preferences.

The presence of a *tool* is an important selection criteria for practitioners who are concerned with rapid application of selected techniques.

Approaches for giving partial and final evaluations. Partial evaluations are estimates of potential actions corresponding to each criterion and final estimations present a synthesis of the partial evaluations. Partial evaluations are for instance simple measuring or pairwise comparison. Final estimations can, for instance, be carried out by outranking or sum.

Characteristic "*easiness of use*" is more difficult to deal with as it is vague and can cover different aspects such as easiness to understand, rapidity of appropriation by users or even easiness to implement in a house-made software tool. This is again an important characteristic for decision makers, which have different preferences regarding the difficulty of using MCDM technique.

Another important characteristic is *costs for implementing* a method [4]. Costs include costs for implementing technique, for purchasing tool and costs for training decision makers.

Decision maker preferences include him (her) understanding of different techniques, their skills to use these techniques, and habits to use a given MCDM technique.

III. Overview of the Reviewed Selection Approaches

The objective is to present a state of the art of the approaches, which allow multicriteria techniques selection. There is a limited number of selection approaches. For this reason, in our analysis, we used the approaches aimed not only to select one technique but also to simply compare them with regard to various criteria.

The approaches adopted for the comparison are:

A. Laaribi's approach [3],
B. Hanne's approach [4],
C. Ulengin et al.'s approach [5],
D. Salinesi and Kornyshova's approach [7],
E. Vincke's approach [8],
F. Felix's approach [9],
G. Ozernoy's approach [10],
H. Olson et al.'s approach [11],
I. Ballestero and Romero's approach [6].

A. Laaribi's approach.

The central element of Laaribi's approach [3] is a "correspondence frame" allowing establishing links between characteristics of problem and characteristics of MCAP. To carry out the analysis of correspondence frame, the author proceeds according to the following steps.

The first step is identification of the problem characteristics. Detailed analysis of all the aspects of decisional problem is carried out in order to identify the vector of these characteristics. Next step is identification of appropriate characteristics of the MCAP in order to establish the correspondence between characteristics of decisional problem and conditions of MCAP using. The result is obtaining characteristics of the MCAP, which are adapted to decisional problem.

Then, to select an appropriate MCAP the author suggest following two steps:

1. Initially, a subset of MCAP is chosen. The author proposes a tree structure to choose a group of method. By going up the branches of the tree according to the problem characteristics, a category of techniques is selected. The tree has two branches: discrete and continue techniques. In this manner, a restricted set of MCAP is identified (while passing from a node to another according to characteristics of appropriate decisional problem).

2. Then, a particular technique is selected by taking into account MCAP characteristics. To choose a particular method the author considers the characteristics related to the MCDM techniques use in practice: easy to understand by users, inspiring the confidence of the user, easy to program and having a data-processing support.

Compared MCDM techniques are: discrete techniques: MAUT, Outranking, AHP; continue techniques: interactive techniques, goal programming.

To compare these techniques, the author proposes to analyse type of decision problematic, nature of actions set (finite, infinite), information nature to obtain on criteria (information nature: quantitative, qualitative; intra-criteria information: value function (utility function or distance function), criterion discriminatory power (thresholds and orders); inter-criteria information: relations between criteria), result of evaluation (result type: specific, distributional; inaccuracy of information: the method tolerates or not).

This approach developed for geographical information systems (GIS) carries is general and proposes a detailed algorithm of MCDM technique selection. It establishes links between characteristics of the problem and those of techniques. Characteristics taken into account are very different. However, the arborescence analysis relates only to first stage of selection. As for second stage, the author does not suggest a structured algorithm neither to analyse characteristics (such as the MCDM techniques use in practice), nor to carry out their choice.

B. *Hanne's approach*

Hanne [4] considers the problem of MCDM techniques selection as meta decision problem. He shows that this problem might be solved in two ways: by selecting one MCDM technique from a finite set of techniques or by parameters assessment.

In the first case, the author generalizes the criteria usually used for MCDM technique selection. The criteria for MCDM techniques evaluation and selection form four groups: suitability for the problem type, criteria based on solution concepts, implementation-oriented criteria, and criteria depending on the specific decision situation. He positions different MCDM techniques families according to these criteria groups.

In the latter case, the author suggests an approach for designing MCDM technique. This approach is based on "parameter assessment". The parameter is additional information that serves to adapt MCDM technique to the situation at hand. Examples of parameters are weights, achievement levels, threshold values, trade-offs, etc. A parameter optimization model permits the MCDM technique design by choosing parameters from a continuous set.

The author mentions some other approaches of MCDM techniques selection. Furthermore, he suggests a possibility to use machine learning in order to resolve the meta decision problem for repetitive decision situation.

C. *Ulengin et al.'s approach*

In [5] the authors propose a framework of "Integrated DEcision Aid model enriched by Artificial Neural Network ($IDEA_{ANN}$)". The similarity between the characteristics of the methods and the basic parameters of the decisional situation is analysed using ANN.

The approach consists of three steps:

1. *Structuring and modelling of the problem*. The decision maker constructs cognitive maps, detects loops (with a hierarchical presentation), chooses whether he takes into account all the hierarchy or just fundamental objectives. Then, $IDEA_{ANN}$ seizes characteristics of the problems: type of decision problem (choice, classification, rating); size of the problem (small and broad number of criteria and alternate); technical selection of the preference by DM (direct rating, trade-off, pairwise comparison); DM's preference structure (according to the presence of the thresholds and type of order (partial or complete); necessity for uses of relative importance (presence of weights); nature of performance values (quantitative, qualitative).

2. *Matching of the decisional situation with appropriate MCDM techniques*. Initially, a suitable cluster of techniques is selected. Decision maker chooses methods, which correspond exactly to the six characteristics of the situation of decision-making using the artificial neural network.

3. *Selecting a concrete method within a cluster* (the similar procedure is used).

Four groups of discrete techniques are present in this approach: elementary methods, interactive methods, value based methods, outranking methods

The method of the authors is only to propose guidance throughout decision-making process. It is accompanied by a tool; nevertheless, it deals only with discrete techniques.

D. *Salinesi and Kornyshova's approach*

The approach proposed in [7] suggests a construction of an analysis grid and steps to follow in order to use this grid.

The assumption is that a process guiding the selection of a decision-making method should take into account several aspects of the situation at hand. Proposed approach copes with these aspects using a structured benchmarking grid.

This approach includes following steps:

1. *Initiation.* The goal of the initiation phase is to define the nature of multicriteria problem.

2. *Candidate techniques identification.* Once the problem defined, the method proposes to identify candidate methods.

3. *Candidate techniques evaluation.* The goal is to identify which candidate method satisfies all the characteristics that have been defined at step 1.

4. *Technique selection and application.* then select the most adequate technique(s).

Steps 2, 3 and 4 are iterative. The authors mean the situation when the selection result is contradictory: several techniques are selected or none of the candidate methods matches the problem perfectly. In this case, another cycle of evaluation must be achieved. Several strategies are available: either other methods are considered, or some of the required characteristics are added or removed, or the characteristics are ranked by order of importance.

Compared techniques are AHP, MAUT, Outranking, Weighting, Fuzzy methods, Expert classification.

The grid is made of 15 different facets organized into four orthogonal dimensions, namely context, process, form, and object. There are: a) context (decision problematic, treatment of a new alternative, taking into account of multi-views), b) process (approaches for defining evaluations, approaches for decision criteria weighting, taking into account of various scales of criteria, easiness of use), c) form (notation, tools), and d) object (data type, number of alternatives to be treated, treatment of incompatibility, alternatives conflicts, hierarchicality).

Thus, this approach means different techniques with a large number of criteria.

E. Vincke's approach

The author [8] suggests a methodology of comparing decision-aid techniques in order to improve their understanding and to select one.

The proposed methodology consists in defining a list of properties that should be respected and in verifying which of them are satisfied by the techniques to compare. The list of properties is complied for better understanding of the techniques.

This methodology includes following steps:

1. List of properties is established.
2. Alternative techniques are analysed in order to understand which properties they satisfy and which violate.
3. The technique that dominates other techniques is chosen (for example, we have two techniques: if one technique satisfies all the properties and the other satisfies some properties and violates the others ones).

The author remarks that it is often possible that there is no dominance between alternatives but he proposes nothing for such cases. Therefore, he foresees three cases:

a) either one method satisfying the given properties: so it is necessary to reanalyse properties,

b) or several methods are identified: classify in function of additional properties,

c) or one and only one method: deeper understanding of the method is required.

This approach is illustrated by a small example with two variants of ELECTRE II method. However, it has a general nature and may be applied to all MCDM techniques.

The author indicates the necessity of analysing the problem situation in order to select one of MCDM techniques; however, he does not give a typology of problem characteristics.

F. Felix's approach

Felix's approach [9] aims at analysing MCDM techniques, which take into account goals for alternatives comparing in decision-making process.

Therefore, the author compares two MCDM techniques (AHP and fuzzy Decision Making based on Relationships between Goals – DMRG) according to four criteria: representation of decision alternatives, representation of decision goals, role of decision priorities, and way of aggregation.

The author indicates that the choice of a MCDM technique depends on decision situation. He uses a small number of criteria that are general though.

G. Ozernoy's approach

The approach [10] is based on Expert Systems. The authors do not explain the basis of their methodology. Therefore, in this article they consider experimental comparisons and Expert Systems. Most important solution made by these researchers is that only one "best" MCDM technique of resolving all problems does not exist.

The purpose of this paper is to clarify complexities of the selection problem, and to facilitate the possibility of better understanding, evaluating, and improving decision-making.

The author justifies the need for a systematic, logical and justifiable approach. He suggests descriptions of experimental comparisons of MCDM techniques and MCDM Expert Systems. He proposes an expert system based tool in order to select a MCDM technique corresponding to the problem situation. However, the underlying methodology is not explained and problem characteristics are not specified.

Another disadvantage of this approach is that it deals only with discrete techniques.

H. Olson et al.'s approach

The approach presented in [11] aims at defining the role of the MCDM in decision-making steps.

The importance of alternatives according to the criteria can vary on different decision-making steps (at the beginning and the end of the analysis). That is why the authors suggest analysing dynamic parameters of the decision-making that must be considered in the development of decision-making aid. Dynamic components during the analysis of a multicriteria problem are changes in criteria importance and alternatives changes.

The authors advise application of different MCDM techniques (more precisely of MAUT, AHP, Outranking, Preemptive, Preference cones) according to decision-making steps. The criteria are tools and uses, strategy, weight elicitation, score elicitation.

This approach is interesting because of its dynamic parameters analysis and relating to decision-making steps.

I. Ballestero and Romero's approach

The approach [6] tries to show relations between MCDM techniques based on distance function. The authors mean a methodology of creating technical and analytical links between various MCDM techniques. For this goal they use a mathematical apparatus, more exactly – distance function model, which allows to look for a common root.

Using mathematical operations, they obtain models of the following techniques: traditional mathematical programming, weighted goal programming, lexicographic goal programming, min-max goal programming and compromise programming.

Researchers analyse this group of techniques and affirm that they are basic techniques in the economic field. They evoke the existence of other techniques (AHP, outranking etc.), however they do not take them into account in their analysis.

The authors recognize that the relative advantages and disadvantages of MCDM techniques depend on characteristics of the problem situation. Nevertheless, this kind of characteristics is not presented in [6].

IV. COMPARATIVE ANALYSIS WITHIN EVALUATION FRAMEWORK

Table I summarizes our analysis of the nine selection approaches based on the proposed framework. The rest of this section comments approaches facet by facet.

A. Selection approaches characterization

Majority of considered approaches (in [3] [4] [5] [7] [8] and [10]) *aim* at selecting of a technique. Furthermore, Hanne suggests a technique design; Vincke means a better understanding of MCDM techniques; Felix propose a simple comparison.

TABLE I
COMPARATIVE ANALYSIS OF MCDM TECHNIQUES SELECTION APPROACHES

Characteristics	Laaribi	Hanne	Ulengin et al.	Salinesi and Kornyshova	Vincke	Felix	Ozernoy	Olson et al.	Ballestero and Romero
A. Selection approaches characterization									
1. "Features"									
a. Approach's objective	Selection	Selection, design	Selection	Selection	Selection, understanding	Comparison	Selection	MCDM on DM steps	Links between techniques
b. Basic approach used to compare MCDM methods	Arbore-scence	Textual	Neural Network	Analysis grid	Properties list complying	Textual	Expert System	DM steps analysis	Distance function
c. Presence of structured algorithm	Approach	Approach for design	Approach	Approach	Approach	Comparison	Comparison	Comparison	Comparison
d. Selection approach nature	Not MC	MC	Not MC	MC	Not MC	Not MC	MC	Not MC	Not MC
e. Capitalization	No	Yes	Yes	No	No	No	No	No	No
2. "Context"									
f. Application domain	Specific (GIS)	General	General	General	General	General	General	General	Specific (Economy)
g. Problem specification	Yes, specified	Yes, specified	Yes, specified	Yes, specified	Yes, not specified	Yes, specified	No	Yes, not specified	No
h. Decision making steps	No	No	Yes	No	No	No	No	Yes	No
i. Tool	No	No	Yes	No	No	No	Yes	No	No
B. MCDM techniques characterization									
3. "Problem"									
j. Type of decision problematic	Yes	Yes	Yes	Yes	No	No	No	No	No
k. Problem scale	Yes	No	No	No	No	No	No	No	No
4. "Potential actions"									
l. Number of alternatives	Yes	Yes	Yes	Yes	No	No	No	No	No
m. New alternative consideration	No	No	No	Yes	No	No	No	No	No
n. Incompatibility and conflicts of alternatives	No	Yes	No	Yes	No	No	No	No	No
o. Alternatives' organization	No	No	No	Yes	No	Yes	No	No	No
p. Alternatives' set nature	Yes	Yes	No	No	No	No	Yes	No	No
5. "Criteria"									
q. Data type	Yes	Yes	Yes	Yes	No	No	No	No	No
r. Measure scale	Yes	Yes	No	Yes	No	No	No	No	No
s. Criteria weighting	Yes	Yes	Yes	Yes	No	No	No	Yes	No
t. Criteria interaction	No	No	No	Yes	No	Yes	No	No	No
6. "Usage"									
u. Tool	No	No	No	Yes	No	No	No	Yes	No
v. Approaches for giving partial and final evaluations	No	Yes	Yes	Yes	No	Yes	No	Yes	No
w. Easiness of use	Yes	Yes	No	Yes	No	No	No	No	No
x. Costs for implementing	No	Yes	No	No	No	No	No	No	No
y. Decision maker preferences	No	Yes	No	No	No	No	No	No	No

All approaches use different *basis to compare MCDM techniques*. We mention only, that some of approaches have a simple theoretical basis and could be applied easily in practice (for example, arborescence analysis, analysis grid, properties list complying). Others are based on more complex concepts as are expert systems or neural networks that usually require a tool to be applied.

Application domain is general in all approaches except the approaches of Laaribi [3] and of Ballestero and Romero [6]. Nevertheless, they may be applied in other areas with some considerations. For example, in [3], list of problem characteristics has to be revised.

We present the *MCDM techniques* considered by different selection approaches in Table II. The authors use these techniques in order to illustrate their approaches. The approaches of Ulengin et al. [5], of Ozernoy [10], and of Ballestero and Romero [6] are limited by presented techniques. Therefore, the others may compare a more large number of techniques.

Four first approaches ([3] [4] [5] [7]) and Felix's approach specify *problem characteristics*. Two approaches ([6] [11]) foresee a problem specification; therefore, they do not suggest a typology to realize it. The authors of [10] and [6] do not consider such a necessity.

Several *structured algorithms* for selecting MCDM technique are presented in Laaribi [3], Ulengin et al. [5], Salinesi and Kornyshova [7], and Vincke [8]. Hanne [4] presents a structured algorithm for design MCDM technique.

For other approaches, the authors suggest simple comparisons of MCDM techniques. It may guide users in MCDM technique selection, but their choice is intuitive.

The *selection approach nature* is multicriteria in [4], [7] and [9]. The other researchers do not accept this point of view.

One approach (Ulengin et al. [5]) allows the *capitalization* of selection results thanks to using of neural networks. Hanne's approach suggests too the reuse of selection results (machine learning) based on neural networks.

There are two approaches ([5] [10]), which allow *tools* in order to carry out selection. The first is based on neural network and the second – on expert systems.

TABLE II
MCDM TECHNIQUES COMPARED BY SELECTION APPROACHES

MCDM Technique	Laaribi	Hanne	Ulengin et al.	Salinesi and Kornyshova	Vincke	Felix	Ozernoy	Olson et al.	Ballestero and Romero
Outranking methods	+	+	+	+	+	-	+	+	-
AHP	+	+	+	+	-	+	+	+	-
MAUT	+	+	-	+	-	-	+	+	-
Weighting methods	+	+	+	+	-	-	+	-	-
Fuzzy methods	-	+	-	+	-	+	+	-	-
Multiobjective programming	+	+	-	-	-	-	-	-	+
Others	+	+	+	-	-	-	-	+	+

B. MCDM techniques characterization

Only four approaches ([3], [4], [5] and [7]) take into account type of result that must be obtained following the technique application. In [3], the author suggests using of *decision problematic* in two cases: in order to describe a problem situation and in order to characterize a MCDM technique. A technique will be chosen if it corresponds to type of decision problematic required in given situation. In [4] this characteristic is described as "desired solution concept". For [5], it is a problem features. In [7], this parameter characterizes MCDM techniques, which may take some values (when a technique deals with all decision problematics).

With regard to *problem scale*, only Laaribi's approach [3] describes this parameter. His aim is estimating of spatial impact in geographic area. It can take two forms: punctual or local (impacts are located) and regional or national (impacts are a large extent).

Next parameter (*new alternative consideration,*) is considered only in [7]. *Incompatibility and conflicts of alternatives are studied in* [4] and [7]. *Alternatives organization* is taken into account in [7] and [9] as alternatives hierarchy (decomposition). [4], [5] and [11] suggest taking into account the nature of alternatives set: continuous or discrete.

Quantitative and qualitative *data types* are mentioned in [3], [5], [7]. Laaribi [3] calls it information nature on criteria that is one of MCDM characteristics. It may be cardinal (quantitative) or ordinal (qualitative). In [5] and [7] the authors propose two possible values: quantitative value and qualitative or mixed value (both quantitative and qualitative). In [4] Hanne considers the discrete, integer or binary, stochastic or fuzzy variables.

Measure scale is considered in approaches [3], [4] and [7]). In [3], this is a parameter of the problem situation. For [4] criteria scale defines a MCDM technique validity. In [7], it is an ability to deal with different scales for evaluations.

Criteria weighting is taken into account in Laaribi [3], Hanne [4], Ulengin et al. [5], Salinesi and Kornyshova. [7] and Olson et al. [11]. Researchers analyse this parameter in order to know whether the MCDM techniques take into account relative importance of criteria.

Criteria interaction in considered as possible interdependency in [7] and as relationships between goals in [8]. In fact, in Felix approach [8], the goals serve to choose between the possible decisions that are characterized by their contribution to goals achievement.

The analysis of *tool* is present in [7] and [11]. For Salinesi et al. [7] this parameter means two characteristics: notation (textual explanation, mathematical formula, function), and tool to indicate if a COTS is available to support the method. For Olson et al. [11], a tool indicates the possibility to automate the major steps of decision making.

Approaches for giving partial and final evaluations are compared in [4], [5], [7], [9], and [11]. For Hanne, this parameter describes solution concepts. The approach [5] uses these features in order to describe the preference structure and preference technique used by user. Therefore, their authors do not indicate how it is related to problem situation. In approach of Salinesi et Kornyshova these parameters characterise a way of carrying out of technique and the authors relate it to problem situation. Nevertheless, this relation is not elicited and an algorithm is not suggested. Olson et al. analyzes them according to the decision-making steps. Felix analyzes the consistency of evaluations.

Easiness of use is studied by Laaribi, Hanne and Salinesi et al. Laaribi [3] suggests this parameter on second step of selection and characterises it as following: easiness to understand, to program etc. Therefore, he does not attribute the easiness degree to MCDM technique. Hanne [4] considers the ease of use as interactivity of man-machine dialogue and "user-friendliness". Salinesi and Kornyshova [7] mean three degree of easiness and give the values to candidate techniques. Both approaches do not explain how estimate the easiness of use.

The *costs for implementing* and *decision maker preferences* are considered only in [4].

V. Conclusion

This paper has presented a state of the art on approaches selection in order to choose among MCDM techniques, and it reports our analysis of the existing selection and/or comparison approaches. The analysis shows clearly that there is no single approach that matches all situations: each approach has advantages and disadvantages that may change in different contexts.

We believe, based on our analysis, that a “better” approach than the existing ones might be elaborated. Such an approach should satisfy a number of requirements that we defined according to our analysis framework:

1. Take into account the problem situation,
2. Allow a typology of problem characteristics,
3. Consider MCDM techniques specificities,
4. Take into account data diversity (types, scales etc.),
5. Consider all main groups of MCDM techniques and be able to deal with a new one,
6. Present a more precise estimation for parameters as alternatives number and easiness of use,
7. Allow selecting of MCDM technique, as well as its better understanding and adaptation to a concrete case,
8. Take into account interaction between goals,
9. Be structured,
10. Be universal as regards to application domain,
11. Permit a capitalization of selection results,
12. Suggest a tool facilitating MCDM techniques selection.

In the near future, our research program involves:

(i) validating this list of requirements for a selection approach, and

(ii) developing a repository of MCDM techniques with specific features to guide the selection and adaptation of techniques so as to match at best the situation at hand each time an MCDM technique must be selected.

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