Using Multiple Criteria Decision Making Approaches to Assess the Quality of Web Sites

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Abstract **- Multiple Criteria Decision Making (MCDM) is a widely used discipline in everyday life especially to make decisions about conflict and multiple criteria that need to be evaluated and analyzed. In this paper, the aim is to explore the known MCDM techniques to assess web sites information in specific domains or identify the current developments in on-line literature. Based on applying a Systematic Literature Review (SLR) process, this paper identifies MCDM methodology and provides a comparison of existing research. Further, the analysis highlights the features and limitations of MCDM methods. In order to assess the quality of web sites, it requires a list of criteria and sub-criteria. The metrics depend on web site category that generally the decision makers choose the suitable ones. So, weighing criteria in MCDM problems are usually used to determine their importance. The evaluation with crisp MCDM methods is not largely used. The trend is to make hybridization among them or a combination with fuzzy reasoning.**

Keywords: Quality assessment, Multiple Criteria Decision Making, Preferences, Fuzzy numbers

I. INTRODUCTION

Multiple Criteria Decision Making (MCDM) is a largely used discipline to solve complex decision problems involving more than one criterion [1, 2]. MCDM also is continuously growing in fields of Mathematics, Decision Sciences, Business, Management and Accounting, Medicine, Social Sciences, Environmental Science, Economics, Econometrics and Finance, etc. Its evolution throughout the years is interesting; some limitations of the use of MCDM include modeling human judgment in a clear way (as uncertainty, imprecision), let the appearance of hybrid methods. Fig.1 shows the spread of MCDM techniques areas. It is clear that Engineering and Computer science areas have the most important part in utilizing MCDM for solving decision problems according to Scopus database.

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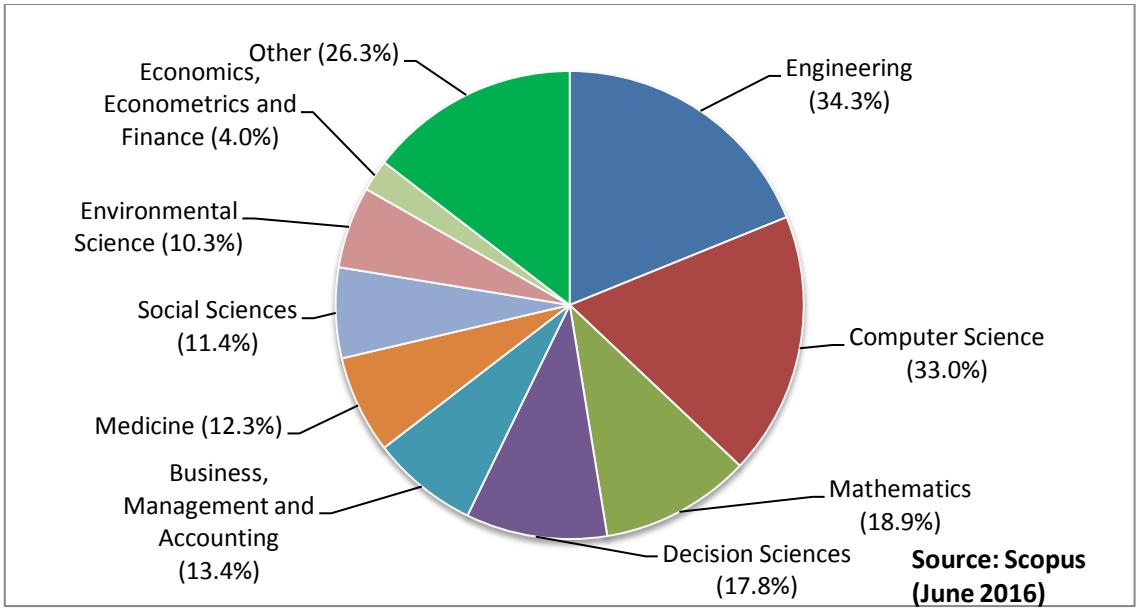

Figure 1. The spread of MCDM techniques areas

MCDM concerns the problems that need the views' point of decision makers facing multiple conflicting criteria. Unfortunately, human judgments' preferences are often unclear to express by exact numerical values. In the classical MCDM problems, certainty is required to evaluate criteria weights and ratings by crisp values. Consequently, MCDM is supported by soft computing techniques such as fuzzy sets, neural networks and genetic algorithms due to the imprecision and vagueness of decisions. Indeed, according to the proponents of fuzzy logic, it is more natural to express judgments by fuzzy numbers instead of crisp values.

The field of MCDM assessment evolves in parallel to hybrid MCDM and fuzzy MCDM to choose the best method or the most useful hybrid methods. Fig. 2 shows an evolution in the last decade related to MCDM, by number of publications according to Scopus database. Recently, development in fuzzy MCDM is becoming increasingly important. Mardani et al. [3] explored fuzzy MCDM techniques and applications between 1994 and 2014. The study presents the developments of fuzzy models of multiple criteria decision analysis.

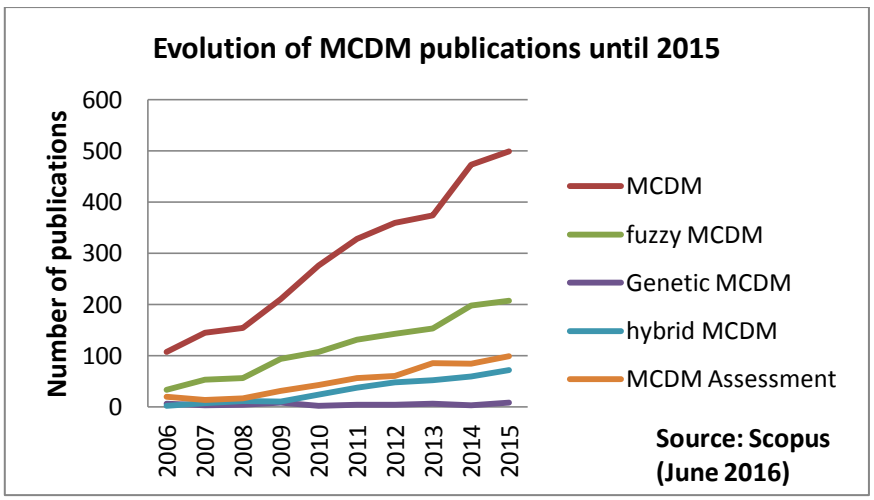

Figure 2. Evolution of publications' number related to MCDM

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Section 2 presents a background in fuzzy sets theory related to MCDM. Section 3 reports the followed method. Section 4 answers the research questions. A discussion of them and the strength and limitation of the study are presented in Section 5 and conclusions in Section 6.

II. FUZZY SETS IN MCDM

Originally, Zadeh [4] proposed the fuzzy set theory which Bellman and Zadeh [5] combined with the MCDM to solve problems that encountered limitations using conventional MCDM techniques. Usually, due to the subjectivity and imprecision, solutions given by decision makers for rating criteria can't be clearly presented by crisp data. Thus, the fuzzy MCDM approaches evolved to deal with uncertain decisions.

In crisp set theory, the membership function μ_A (characteristic function of x in A) values are 0 or 1, but nothing in between, expressed by (1).

$$\mu_A = \begin{cases} 1, & if\ x \in A \\ 0, & if\ x \notin A \end{cases} \quad (1)$$

Where X represents a universal set. A fuzzy set A in X is expressed by its membership function $\mu_A: X \rightarrow [0\text{-}1]$. Here, $\mu_A(x)$ characterized by the degree of membership of element x in fuzzy set A for each $x \notin X$. Fig. 3 presents a crisp and a fuzzy set.

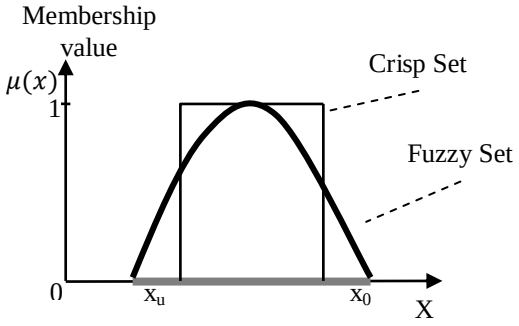

Figure 3. Crisp and Fuzzy Set

A. Fuzzy numbers

Fuzzy numbers could be used in presenting the preferences of decision makers expressed by linguistic variables. Triangular Fuzzy Number (TFN) is defined by its simplicity in both concept and computation. It is the most popular technique among different shapes used to define fuzzy number memberships.

According to the definition of van Laarhoven and Pedrycz [6], a TFN is represented with a triplet (L, M, U) for *Lower, Medium and Upper* numbers. A membership value of a triangular fuzzy number A is defined by (2).

$$\mu_A(x) = \begin{cases} \frac{x-L}{M-L}, & L \le x < M \\ \frac{x-L}{M-L}, & L \le x \le M \\ 0, Otherwise \end{cases} \quad (2)$$

Trapezoidal Fuzzy Number (TrFN) is another category of fuzzy numbers. It is applied in the multi-criteria decision making field [7]. Some discussions on TFNs and TrFNs are stated by Chen and Ku [8].

A new aggregation method to solve multi-attribute group decision using TFNs and TrFNs was proposed by Xu et al. [9]. The method is used to aggregate heterogeneous decision information into Atanassov's intuitionistic fuzzy numbers (AIFNs) for more useful information.

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B. Fuzzy linguistic approach

When making decisions, experts' judgment can be expressed using linguistic terms in order to reduce vagueness, imprecision of point of views and to enhance reliability and clarity of preferences. Fuzzy sets are used to deal with the qualitative aspects of linguistic values using variables. The fuzzy linguistic approach employs an interpretation of linguistic variables as fuzzy numbers. These are defined as membership functions. Consequently, the preferences of decision makers are expressed by fuzzy numbers. In MCDM, a problem of ranking fuzzy numbers is usually treated.

III. RESEARCH METHODOLOGY

Kitchenham and Charters [10] provide a Systematic Literature Review (SLR) methodology. This process is composed of three phases: planning, conducting and reporting the review. Here, Section III.A involves "planning the review" phase for developing a clear review protocol. It specifies the objective, the main raised research questions, the adopted search strategy and a set of established inclusion and exclusion criteria to select publication. Next, Section III.B treats "conducting the review" phase for executing the review protocol. A dissemination of results is presented in Section IV from extracted data of selected papers that deal with MCDM in assessing web sites quality. Some developments and purposes in this domain are revealed.

A. Planning the review

A phase of planning the review is dedicated to define the objective of the SLR which is exploring different MCDM approaches in assessment of web sites quality existing in literature and the research questions. It is also devoted to develop a clear review protocol composed by search process strategy and a definition of inclusion/exclusion criteria.

1) Research questions

According to the objective of this review, a set of three research questions include:

RQ1: What are the developments in MCDM in the field of assessment of web sites quality?

RQ2: What is the objective of recent research using MCDM in this field?

RQ3: What are the features and limitations of MCDM methods?

2) Search process and inclusion/ exclusion criteria

It is important to follow a search strategy in order to insure a convincing review conducting in the phase 2. This produces exploring scientific publications within the domain. The search focuses on related journals and conferences using Elsevier's Scopus database. It is necessary to define search criteria based on key concepts as selection words. Indeed, some words are considered such as "MCDM", "multiple criteria", "multi-criteria", "decision making", "assessment", "assessing", "evaluation", "quality" and "web sites". A combination of these terms should be done to enlarge the scope of searching for better results.

Since all collected papers cannot be included in the SLR, some inclusion and exclusion criteria are introduced. In order to select the most relevant ones, the criteria that specify whether a study will be included or excluded are determined. The first inclusion criterion based on terms appeared in the titles, abstracts and keywords in studies by browsing computer science discipline; an identification of relevant ones was established. However, papers published before 2009 and languages other than English written studies were excluded. In

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addition, some sub-disciplines as "Web services" not related exactly to the topic of assessment were excluded. After obtaining a large set of papers, a step of eliminating short ones (up to 4 pages) was performed.

B. Conducting the review

An initial search on Scopus database returned 4321 document. That figure was reduced to 1041 by limiting the search to subject area of "Computer Science", (written in English) and published between 2009-2015. This was further refined to 758 by excluding keywords that do not respond to the topic such "Web services". From this 578 accessible documents rescanned to consider other inclusion/exclusion criteria, such as short papers and articles that deal with MCDM techniques. Finally, 18 papers were reviewed to contribute to the research. Some of them exist in the other scientific e-sources. Fig. 4 illustrated the SLR process.

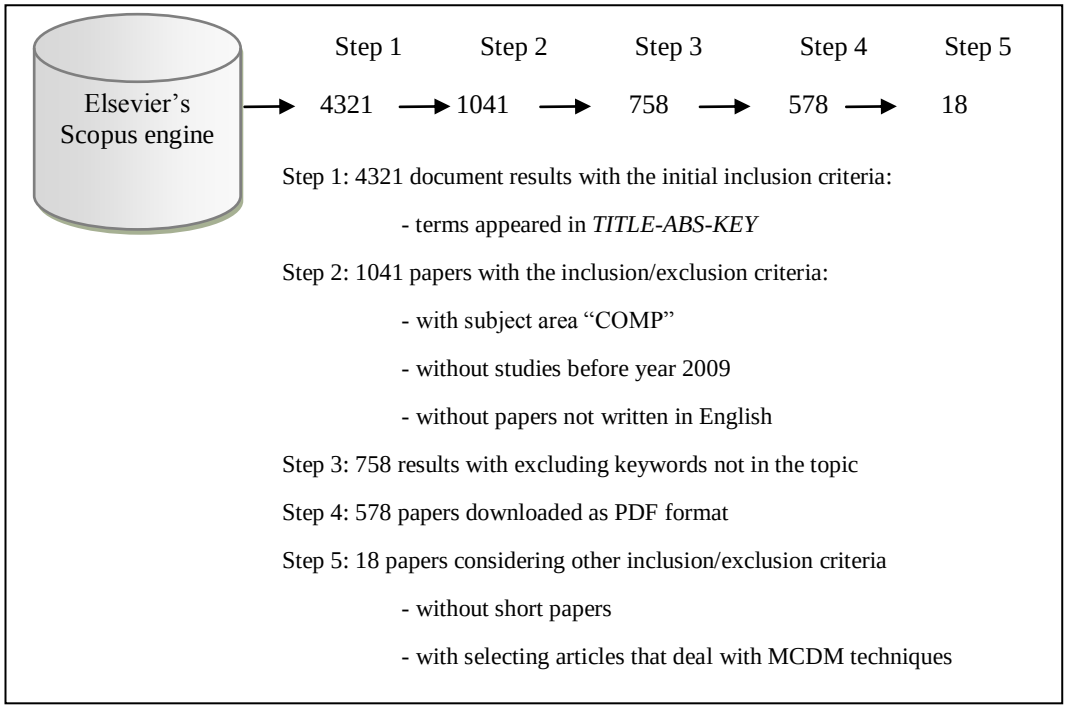

Figure 4. Paper selection process

IV. EXISTING RESEARCH

A. RQ1: What are the developments in MCDM in the field of assessment of web sites quality?

MCDM methods are increasingly being used in the last decade. In order to evaluate web site quality, any process goes through a step of specifying certain criteria. The distribution of criteria importance and ranking web sites are generally solved by MCDM techniques. There are many methods as AHP, ANP, TOPSIS, VIKOR, PROMETHEE, ELECTRE; choosing the best method is, it-self, a multi-criteria decision making problem. They are cited below in case of comparing and selecting criteria for the evaluation of quality of websites. Rekik et al. [11] provided an overview of MCDM assessment methods in the field of assessment of web sites quality.

1) Crisp hybrid and non-hybrid MCDM methods

A web site is evaluated according to a set of criteria but they do not have the same importance to highlight the quality. They differ also according to the web site category. Weighing criteria using crisp MCDM are used as Analytic Hierarchy Process (AHP) developed by Saaty [12] and applied by Akincilar and Dagdeviren [13] in

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evaluating the quality of hotel web sites. Moreover, among recent studies, Cebi [14] presents an integrated MCDM method to find out the web site design parameters with Delphi method. The study focuses on determining the importance degrees of those parameters and their interactions according to the type of web site with the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. They have discussed those parameters to help the designers building a good web site in order to satisfy users' needs. DEMATEL method is generally used to determine interrelations among criteria as in [15].

Ranking alternatives also can be solved by Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) presented by Brans and Vincke [16]. Akincilar and Dagdeviren [13] apply it to rank web sites. The study considered so hybrid MCDM for weighing criteria and ranking web sites to provide results for customers and enterprises. Kostoglou et al. [17] assess the quality of universities web sites using AHP method for ranking, despite its limitation.

2) Fuzzy hybrid and non-hybrid MCDM methods

Hu [18] proposes a genetic algorithm based learning method for distributing automatically the degrees of importance of criteria. The evaluation concerns electronic Service Quality (e-SQ) of travel web sites characterized by multiple criteria. It deals with the respondents' subjective decision represented by fuzzy numbers. The decision problem is modeled by a hierarchical structure. The motivation is to find critical criteria concerned by customers to attract them for making transactions on the web site. Hu and Liao [19] based on the same last learning method of weighing criteria evaluate internet banking services' quality.

Chou and Cheng [20] use a hybrid fuzzy MCDM approach which is composed by Fuzzy Analytic Network process (FANP) to weight criteria and Fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje (FVIKOR) to rank professional accounting firms web sites in a linguistic terms. Basically, ANP developed by Saaty [21] to deal with interrelationships and feedback among criteria. While VIKOR introduced by Opricovic and Tzeng [22] to make a compromise ranking from a set of alternatives.

Kaya [23] evaluates E-business category using an integrated fuzzy AHP-TOPSIS method. Fuzzy AHP is applied to distribute weights for criteria in order to select highest ones and fuzzy TOPSIS to rank web sites. Originally, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) proposed by Hwang and Yoon [24] to solve MCDM problems.

Dey et al. [25], Yu et al. [26] interested by B2C E-commerce web sites based on AHP to structure the problem as a hierarchy and distribute weights for criteria. Then, fuzzy TOPSIS is used to rank alternatives. In the same category of evaluation, Aydin and Kahraman [27] propose a fuzzy AHP process for weighing alternatives including quantitative and qualitative factors allowing multiple decision makers view points. They compare the results with fuzzy VIKOR. Sun and Lin [28] suggest fuzzy TOPSIS to determine weights for criteria in order to know the most important factors of shopping web sites which are security and trust.

Hsu et al. [29] treat the multiplicity of criteria for e-SQ of travel web sites by applying consistent fuzzy preference relations method as a first phase to distribute weights (without considering interdependence perspective). They propose ANP technique for the degree of influence for criteria and sub-criteria as a second phase and to determine their weights in a third phase considering interdependence perspective. Based on the furnished results, they confirm that criteria and sub-criteria relevant to e-SQ are interdependent.

Carrasco et al. [30] define an implementation of a Linguistic Multi-Criteria Decision Making model (LMCDM), using IBM SPSS Modeler to obtain a scale for attributes by feedback of guests that makes in

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evidence service quality in tourism. Del Vasto-Terrientes et al. [31] propose a method ELECTRE-III-H for ranking web sites of tourist destination brands based on the outranking relation interpreted as a fuzzy relation. The method based in decomposing the problem into multi-level sub-problems. It helps the decision maker to analyze hierarchically structured criteria by allowing the propagation of results upwards in the tree. Ip et al. [32] suggest a fuzzy AHP approach for evaluating hotel web site functionality to avoid decision makers' uncertainty in establishing the relative weights of each criterion. Its purpose is to know the most important criterion which is according to the results "Reservation Information" to inform hotel industry about users' preferences for criteria.

Büyüközkan et al. [33] apply Fuzzy Axiomatic Design (FAD) for the evaluation of e-learning web sites. They compare its results of weighing and ranking criteria using experts' opinion with fuzzy TOPSIS.

Kabak and Burmaoğlu [34] use a hybrid MCDM methodology that combines the Fuzzy Decision Making Trial and Evaluation Laboratory (FDEMATEL) to make relations between criteria, the fuzzy ANP to determine weights of criteria. The evaluation concerns the performance of e-procurement web sites.

Markaki et al. [35] treat the assessment of quality of e-government web sites with fuzzy AHP as a Multi-Attribute Decision Making (MADM) method to know the service levels that should be provided by sites and to inform government administrators with it.

B. RQ2: What is the objective of recent research using MCDM in this field?

The methods described above are based on fuzzy decision making for weighing and ranking criteria or web sites. Some others focused on structuring the problem as a hierarchy or making interrelations between criteria. In Table 1, a classification of the above works that consider the use of MCDM techniques according to the purpose of evaluation is established.

TABLE 1.
SUMMARY OF LITERATURE ON MCDM METHODS TO ASSESS WEB SITES QUALITY

Method Objective	Method	References
Ranking web sites	Fuzzy TOPSIS	Kaya, 2010 [23] Yu et al., 2011 [26] Dey et al., 2015 [25]
	Fuzzy VIKOR	Chou and Cheng, 2012 [20]
	AHP	Kostoglou et al., 2014 [17]
	PROMETHEE	Akincilar and Dagdeviren, 2014 [13]
	ELECTRE-III-H	Del Vasto-Terrientes et al., 2015 [31]
Weighing criteria	Fuzzy TOPSIS	Sun and Lin, 2009 [28] Büyüközkan et al., 2010 [33]
	Genetic Algorithm based learning method	Hu, 2009 [18] Hu and Liao, 2011 [19]
	Fuzzy AD	Büyüközkan et al., 2010 [33]
	AHP	Kaya, 2010 [23] Yu et al., 2011 [26] Akincilar and Dagdeviren, 2014 [13] Dey et al., 2015 [25]
	Fuzzy AHP	Büyüközkan et al., 2010 [33] Markaki et al., 2010 [35] Ip et al., 2012 [32] Aydin and Kahraman, 2012 [27]
	Fuzzy ANP	Chou and Cheng, 2012 [20] Kabak and Burmaoğlu, 2013 [34]

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	Consistent fuzzy preference relations method	Hsu et al., 2012 [29]
	Fuzzy VIKOR	Aydin and Kahraman, 2012 [27]
	DEMATEL	Cebi, 2013 [14]
	Linguistic MCDM	Carrasco et al., 2014 [30]
Structuring the problem as a hierarchy	Fuzzy MCDM	Hu, 2009 [18] Hu and Liao, 2011 [19]
	Fuzzy AHP	Markaki et al., 2010 [35] Ip et al., 2012 [32] Aydin and Kahraman, 2012 [27]
	AHP	Yu et al., 2011 [26] Akincilar and Dagdeviren, 2014 [13] Dey et al., 2015 [25]
Making relations between criteria	ANP	Hsu et al., 2012 [29]
	Fuzzy ANP	Chou and Cheng, 2012 [20]
	FDEMATEL	Kabak and Burmaoğlu, 2013 [34]
	DEMATEL	Cebi, 2013 [14]

C. RQ3: What are the features and limitations of MCDM methods?

According to previous analysis of RQs, a classification of MCDM methods is proposed into four categories which are scoring methods, compromising methods, outranking methods and other methods. This classification can be useful for future works to select appropriate method for solving MCDM according to the nature of the problem.

1) Scoring methods

Major approaches include scoring (or utility) theory. Its fundamental feature is to express the decision maker's preference via a score or utility. Popular methods in this category are the AHP [12], ANP [21] is also a generic form of AHP that treats dependencies between criteria. Indeed, AHP structures the problem as a hierarchy while ANP structures it into a network. These methods have the ability to check inconsistencies of decision makers. Their disadvantage is that the decision maker finds difficulty to express his opinion using the 9 point scale [12]. This limitation can be solved by using fuzzy numbers as presented in Table 2. In the following, fuzzy AHP is described by its fundamental steps.

First, the decision problem is modeled as a hierarchy illustrated by Fig. 5. It is partitioned into a high level criteria $\{criterion_1..criterion_n\}$, a level for sub-criteria $\{(C_{11},C_{12})..(C_{n1},C_{n2})\}$, and a level for alternatives $\{A_1..A_m\}$.

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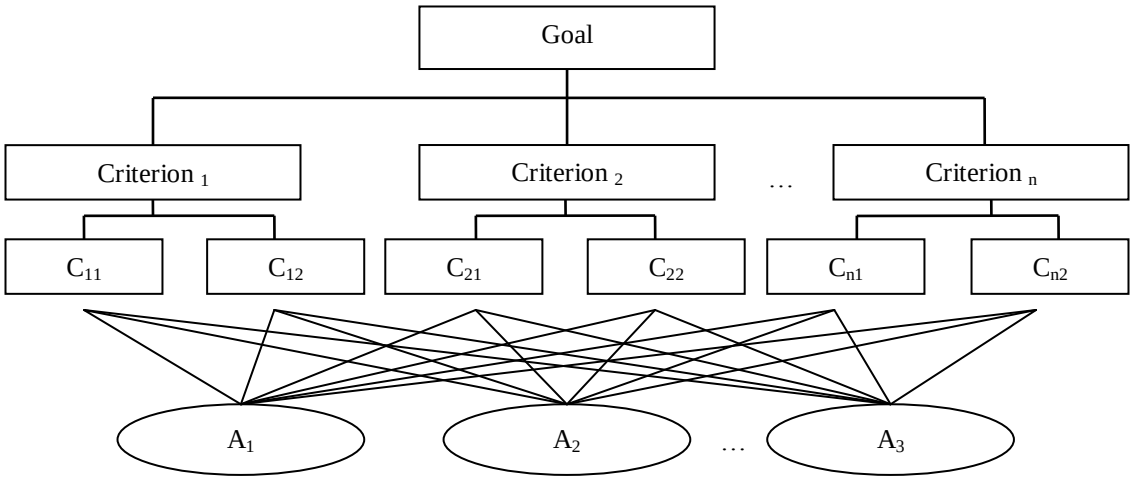

Figure 5. Hierarchy Decision Structure

The next step is to have subjective opinions of decisions makers to set up priorities for criteria, or degrees of preference, expressed by linguistic terms such as criterion$_1$ has *very strong importance* than criterion$_2$ for the evaluation. Then, a pair wise comparison matrix is constructed between each criterion with conversion linguistic terms to fuzzy numbers using a scale defined in Table 2.

TABLE 2. A scale for comparison [36]

Crisp Scale	Fuzzy Number	Degree of Preference	Membership Function
1	$\tilde{1}$	Equal importance	(1,1,2)
3	$\tilde{3}$	Moderate importance	(2,3,4)
5	$\tilde{5}$	Strong or essential importance	(4,5,6)
7	$\tilde{7}$	Very strong importance	(6,7,8)
9	$\tilde{9}$	Extreme importance	(8,9,10)

To be sure that the original preference ratings are consistent, a check of a Consistency Ratio (CR) should be done after calculating it. The comparisons are supposed to be acceptable, if the CR is less than 0.10. Then, for each decision alternative, the weighted average rating is calculated. Thus, it is obvious to determine the alternative with the highest score.

2) Compromising methods

The other category of approaches in MCDM utilizes a compromising method that finds a feasible solution for ranking problems closest to the ideal (the best compromise) and helps decision makers to reach a final solution(s). The TOPSIS and VIKOR methods are among this category. These two methods are based in different aggregating functions for ranking and combined with fuzzy sets theory for better results. Fuzzy TOPSIS and fuzzy VIKOR are widely applied as MCDM techniques. They are detailed below and compared to each other.

a) Fuzzy TOPSIS:

Step 1: Construction of the fuzzy decision matrix $\tilde{D}$, defined by (3), based on linguistic terms and assigned to criteria *C* and alternatives *A*.

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$$\widetilde{D} = \begin{matrix} \\ A_1 \\ A_2 \\ A_3 \end{matrix} \begin{matrix} C_1 & C_2 & & C_n \\ \end{matrix} \begin{pmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \vdots & & & \vdots \\ \tilde{x}_{1m} & \cdots & \cdots & \tilde{x}_{mn} \end{pmatrix} \quad (3)$$

Step 2: Aggregation of decision makers' judgments $\tilde{x}_{ij}$ according to (4).

$$\tilde{x}_{ij} = \frac{1}{k} (\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots + \tilde{x}_{ij}^k) \quad (4)$$

where k is the decision maker number and $\tilde{x}_{ij}^k$ his fuzzy judgment.

Step 3: Normalization of the fuzzy decision matrix

Step 4: Computation of the normalized fuzzy decision matrix

Step 5: According to triangular fuzzy numbers (TFNs), a definition of positive and negative ideal reference points (FPI^+ and FPI^-).

Step 6: Calculation of the distance from FPI^+ and FPI^- for each alternative

Step 7: Calculation of similarities to ideal solution and ranking alternatives.

b) Fuzzy VIKOR:

Fuzzy VIKOR considers in the presence of conflicting criteria two distance measurements, based on an aggregating function in the compromising programming method in order to measure "closeness" to the "ideal" solution.

Step 1: Identifying the objective of the decision making process, determining the best values of criteria or alternatives and structuring a hierarchy.

Step2: Identification of linguistic scale for evaluation of criteria

Step3: Rating alternatives respecting judgments of decision makers as expressed by (4).

Step 4: Expression of the fuzzy decision matrix $\widetilde{D}$ defined by (3).

Step 5: Deffuzifying $\widetilde{D}$ and fuzzy weight of each criterion into crisp values. Deffuzification methods as center of area (COA) can be used to determine the best fuzzy value (BFV, f_j^*) and worst fuzzy value (WFV, f_j^-).

Step6: Computing values of S_i and R_i (i = 1, ...,m), defined by (5) and (6).

$$S_i = \sum_{j=1}^{n} w_j (f_j^* - f_{ij})/(f_j^* - f_j^-) \quad (5)$$

where S_i the separation measure of A_i from the (BFV, f_j^*)

$$R_i = \max_{j = 1,..,n} \left[w_j (f_j^* - f_{ij})/(f_j^* - f_j^-) \right] \quad (6)$$

where R_i the separation measure of A_i from the (WFV, f_j^-)

Step 7: Computing the values Q_i that represent a weight for the strategy of maximum group utility

Step 8: Ranking and selecting best alternatives as a compromise solution

Table 3 summarizes the steps of fuzzy TOPSIS and fuzzy VIKOR methods and highlights the features of each of them. Both of them belong to compromising methods as it is detailed in answering RQ3.

TABLE 3. Comparison of fuzzy TOPSIS and fuzzy VIKOR methods

Fuzzy TOPSIS	Fuzzy VIKOR
Steps	

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The same first steps: - Expression of the fuzzy decision matrix $\tilde{D}$ - Aggregation of decision makers' judgments $\tilde{x}_{ij}$ - Computation of normalized fuzzy decision matrix	
Determination of positive and negative ideal reference points (FPI^+ and FPI^-).	Determination of the best fuzzy value (BFV, $f_j^{*)}$ and worst fuzzy value (WFV, f_j^-)
Calculation of the distance from FPI^+ and FPI^- for each alternative	Computing values of S_i and R_i (i = 1, ... ,m), where S_i the separation measure of A_i from the (BFV, f_j^*) and R_i the separation measure of A_i from the (WFV, f_j^-)
	Computing the values Q_i that represent a weight for the strategy of maximum group utility
Ranking and determination of compromise solutions which are the closeness to the ideal alternatives	
Features	
Express subjective opinions of decisions makers into linguistic terms	
Used for solving ranking problems by similarity to ideal solutions	Used for multiple conflicting criteria optimization of complex systems and the obtained compromised solution can be accepted because it has maximum group utility (the majority)

3) Outranking methods

The 'ELimination and Et Choice Translating Reality' (ELECTRE) methods developed by Roy [37] and PROMETHEE for decision aid are well known belong to outranking methods [1]. ELECTRE and PROMETHEE family methods solve complex and uncertain choice problems with multiple decision makers and multiple criteria. They also deal with ranking problems in the presence of incomparability between alternatives. They consist of a preference relation called an outranking relation among alternatives based on several attributes.

4) Other methods

In the field of artificial intelligence, genetic algorithm [18, 19] in the presence of multiple criteria can identify critical criteria for the evaluation by determining degrees of criteria' importance automatically.

V. DISCUSSION OF FINDINGS

In this paper, an overview of MCDM methods for assessing web sites quality is presented by following a systematic review strategy on articles written between 2009 and 2015. In order to reveal the most important findings, a discussion about interdependencies between criteria is treated below. This purpose is not well studied in literature (see Table 1). However, criteria and their importance differ according to the web site categories. So, distributing weights for criteria needs an MCDM method as presented in Table 1 which is based on expert decision and evaluation.

A. Discussion of research questions

By disseminating results of RQ1, crisp MCDM methods are not largely used. The trend is to make hybridizations among them or a combination with fuzzy sets theory. Some of them are analyzed and compared.

The most important purposes of MCDM defined in RQ2 are weighing criteria and ranking web sites (alternatives) while the purpose of studying relations between criteria is not well explored in literature. DEMATEL and ANP are among conventional MCDM methods that deal with interactions between criteria.

The problematic of evaluating web sites implies a multiple criteria decision making due to the multiple conflicting criteria for assessment. A recent study Rekik et al. [38] used association rules mining to find

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interrelations between criteria. In addition, a determination of relevant criteria was done. Web site category is also implied because criteria depend on it. A web site of E-commerce for example that supports payment mode will be not assessed as an educational one. Rekik et al. [39] studied the feedback between a set of criteria related to E-commerce category based on fuzzy ANP method. They determined weights for criteria to know the best ones. Machine learning techniques can be useful also on Knowledge Discovery in Databases (KDD) to obtain novel information, for example in marketing problems. Finding relationship between items in marketing databases is proposed by Orriols-Puig et al. [40].

The use of MCDM methods has been emerged recently and it is evolving continuously. Their application attempts to consider multiple criteria selected or extracted by experts for the evaluation. In Table 4, a summary of collected criteria from selected studies for the SLR according to the web site's category. The finding is to show the important task and step of choosing the criteria according to the web site's type in the process of evaluation.

TABLE 4. Criteria variation according to the web site's category and experts' selection

Web site category	Criteria	Reference
Institutional	Completeness, coverage, objectivity, research, web services	[17]
E-commerce	Product, design, technology, service quality, logistics	[26]
	Design and usability, product, security, service quality, fulfillment	[25]
	Ease of use, product, security, customer relationship, fulfillment	[27]
	Efficiency, practical, ease use, time-saving, communication, confident, security, trust, familiar, past experience, knowledgeable	[28]
Professional accounting firms	Accessibility, navigability, usability, privacy, relevance, understandability, richness, currency, responsiveness, reliability, assurance, empathy	[20]
Hotel	Customer oriented, technology oriented, marketing oriented, security oriented, other factors	[13]
	Hotel description, hotel facility information, reservation information, surrounding area information, user generated information	[32]
	Tangibles, reliability, responsiveness, assurance, empathy	[30]
Tourism	Usability and accessibility, visibility, brand treatment	[31]
E-learning	Right and understandable content, complete content, personalization, security, navigation, interactivity, user interface	[33]
Travel	Design, security, customer relationships, enjoyment	[29]
	Efficiency, fulfillment, system availability, security/privacy, responsiveness, compensation, contact, benefit, customization/personalization, tangibility, assurance/trust, continuous improvement	[18]
Internet banking	Efficiency, system availability, responsiveness, compensation, contact, tangibility, privacy, reliability, reputation, continue improvement, personalization, benefit	[19]
E-government	Usability, content, site quality, e-services, e-democracy features	[35]
	Navigability, speed, Standardisation, links, accuracy, richness, attractiveness, reliability, personalization, responsiveness	[34]
Any type	Usability, visual aspects, technical adequacy, content, security, communication, prestige	[14]
E-business	Relevance and currency, Understandability, Reliability, Empathy, Response speed, Personalization, Security, Price savings, Awareness	[23]

Different categories are concerned by the evaluation such as E-commerce, E-government, Hotel and Institutional. On the basis of a large set of criteria, an outranking hierarchical approach can be applied as in [31] to help the decision maker designing the decision model in a structured way and analyzing the preference relations in the set of alternatives.

The classification presented in RQ3 expounds the most important methods found in general and in the assessment of web sites quality area especially. The approaches used hybridizations of MCDM methods or combined with fuzzy sets theory as detailed in reporting results of RQ1.

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According to the reporting results of RQ2 and RQ3, the most utilized methods for weighing criteria purpose are scoring methods. As summarized in Table 1, there are studies that deal with AHP [13, 23, 25, 26], some others with fuzzy AHP [27, 32, 33, 35] and with fuzzy ANP [20, 34]. While the most utilized methods for solving ranking web sites purpose are compromising methods as the use of fuzzy TOPSIS [23, 25, 26] and fuzzy VIKOR [20] and outranking methods as PROMETHEE [13] and ELECTRE-III-H [31]. Ranking web sites can be solved also using fuzzy sets theory as in Rekik and Kallel [41, 42] by choosing a set of criteria for the evaluation.

B. Study strength, limitation and future work

The aim of this SLR is to help research community having a scope in existing research and to derive future developments. It is limited to expose MCDM methods and developments in assessing web sites quality.

As future work, a proposition to enlarge it by expanding the list of studies not only involved in solving the problem by MCDM but also studies that used other methods implied in different steps of the evaluation's process. Another ambitious goal is to know the most important categories of web sites considered for the assessment in literature and the corresponding list of criteria.

VI. CONCLUSION

This study identifies the main purposes of using MCDM in the field of web sites assessment. In addition, the features of some of them have been revealed. This review classifies the most important methods into different categories and exposes hybridizations and integration between them. Some of them are combined with fuzzy sets theory to reduce subjectivity and uncertainty of complex decision problems. MCDM methods are based on expert judgment. The decisions are expressed by linguistic variables and then presented by fuzzy numbers.

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