REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Université Mohamed Khider – BISKRA
Faculté des Sciences Exactes, des Sciences de la Nature et de la Vie
Département d'informatique

N° d'ordre : … /M2/2020

Mémoire

présenté pour obtenir le diplôme de master académique en

Informatique

Parcours : **Génie Logiciel et Systèmes Distribués**

A fuzzy multi-criteria approach for ranking: application to e-commerce websites

---

Par :

GUESSAOUI AMIRA AICHA

Soutenu le Mettre la date de la soutenance, devant le jury composé de :

Nom et prénom	Grade	Président
Belouaar Houcine	Grade	Rapporteur
Nom et prénom	Grade	Examinateur

Thanks

This dissertation is the result of a year-long research work carried out at the University of Biskra, Department of Computer Science.

First of all, I want to thank God, the Almighty and Merciful, who gave me the strength and patience to do this work.

This thesis could not have taken place without a high quality supervision, that of Mr. BELOUAAR Houcine for having proposed and directed this subject of thesis and for his benevolent welcome and his wise advice, he was kind enough to respond patiently and kindly to my many questions. So I thank him for his invaluable and continuous help during the writing of this memoir.

I thank the honorable jury members for agreeing to be a member of my theme jury, for evaluating my work and for honoring us with their presence.

I also wanted to thank all my teachers at the Faculty of Computer Science at the University of Mohammed kheider Biskra.

Finally, I extend my gratitude to all my colleagues and friends.

Dedication

I thank God for giving me the courage to accomplish
this modest work that I dedicate:
To my dear parents for their endless advice,
and continuous encouragement.
To my brother and sisters.
To my dear friends.
To all those who are dear to me.

Résumé

Choisir un site web e-commerce parmi de nombreux sites web similaires est devenu une tâche très délicate pour le consommateur de sites Web e-commerce car ce dernier tombe dans l'embarras du choix et n'arrive pas à déterminer le site le plus approprié. La seule différence entre des sites web e-commerce similaires peut être leur qualité de service (QoS) et, plus précisément, ses caractéristiques non fonctionnelles qui ont une grande influence sur le choix de la meilleurealternative.

Encore il est parfois difficile de décrire avec précision les critères de qualité de service décrivant ces sites web e-commerce car les critères sont parfois imprécis et parfois incertains et ambiguëscar les données quantitatives sont insuffisantes pour modéliser des situations réelles.

Notre travail vient pour remédier ce genre de problème en présentant les critères de qualité de service en termes linguistiques ce qui facilite la valorisation des différents critères par les clients et encore proposer une méthode MCDM de classement.

Enfin nous proposons une approche multicritère basée sur la logique floue pour classer les sites web e-commerce.

Summary

Choosing an e-commerce website among many similar websites has become a very delicate task for the consumer of e-commerce websites because they are spoiled for choice and cannot determine the most suitable site. . The only difference between similar e-commerce websites may be their Quality of Service (QoS) and, more specifically, its non-functional characteristics which have a great influence on choosing the best alternative.

Still it is sometimes difficult to describe with precision the quality of service criteria describing these e-commerce websites because the criteria are sometimes imprecise and sometimes uncertain and ambiguous because the quantitative data are insufficient to model real situations.

Our work comes to remedy this kind of problem by presenting the quality of service criteria in linguistic terms which facilitates the valuation of the various criteria by the customers and also to propose an MCDM method of classification.

Finally, we propose a multi-criteria approach based on fuzzy logic to classify e-commerce websites.

Glossary

*** TOPSIS:** The Technique for Order of Preference by Similarity to Ideal Solution.

*** FNIS:** the fuzzy negative ideal solution.

*** FPIS:** the fuzzy positive ideal solution.

*** MCDM:** Multicriteria Decision Making.

*** MADM:** Multiple attribute Decision Making.

*** MODM:** Multiple Objective Decision Making.

*** QoS:** quality of service.

List of Figures

Contents

General Introduction

MCDM is an operations research sub-discipline that allows for the explicit assessment of several conflicting criteria in decision-making (both in everyday life and in settings such as business, government, and medicine).

In our daily life, we usually weigh several criteria implicitly and we can be comfortable with the consequences of those decisions which are made on the basis of intuition. On the other hand, when the stakes are high, it is important to structure the problem well and explicitly assess multiple criteria.

Structuring a complex problem well and considering multiple criteria explicitly leads to more informed and better decisions.

MCDM involves these four key components:

1. Alternatives (or individuals) to be ranked or chosen between

2. Criteria by which the alternatives are evaluated and compared

3. Weights representing the relative importance of the criteria

4. Decision-makers (and, potentially, other stakeholders), whose preferences are to be represented.

It is sometimes difficult to define with precision the criteria of quality of service because the qualities of the services related to a set of alternatives are imprecise and sometimes uncertain and ambiguous due to the mental state and the lack of information on the alternatives and also on their QoS. Again, the values and weights of QoS attributes (notably qualitative QoS) are not easy to define with precision, therefore, it is therefore preferable that QoS properties are in natural language (bad, average good, excellent). This presentation makes it easier for customers and experts to evaluate different alternatives. Fuzzy logic comes to enable this presentation as it supports the representation of imprecise QoS constraints.

As a case study reflecting our problem, we chose to test our solutions on the ranking of e-commerce websites

E-commerce can be defined as a subset of e-commerce, that is, the purchase, sale and exchange of goods and services over computer networks through which processes or conditions of sale are applied electronically.

With the spread of the Internet, a large number of people have become dependent on e-commerce websites to buy and sell their needs, which has led to the emergence of a large number of them, making it difficult for anyone to choose the correct site that they should use.

With this problem emerging, it became important to be able to identify the e-commerce website that meets our needs in several categories. Several proposals have been made to address this problem and several criteria have been identified..

Problem and objectives

The number of e-commerce sites that offer the same function on the web is steadily increasing, and a customer can get hundreds of responses or even thousands of what the customer feels embarrassed for and faces. To the problem of choosing between similar e-commerce sites re-order.

The ability to access a business website efficiently is required. Moreover, since it is expected that e-commerce sites with similar functionality will be provided by competing sellers, the main challenge is to design optimization strategies to find the "best" e-commerce website.

In addition, in many cases, it may be difficult to determine the value of the quality of service criteria precisely because the characteristics of the services related to the consumers of e-commerce sites are inaccurate, sometimes uncertain, and vague due to the mental state and the lack of consumer information about the content of e-commerce sites as well as about the quality the service. Again, it is not easy to precisely define QoS values (especially QoS), therefore, it is preferable for the user preferences used as QoS criteria

to be fuzzy because they are more suitable for interpreting linguistic terms. Therefore, fuzzy logic can be applied to support the representation of inaccurate QoS constraints.

The objective of this work is to propose an approach of selection of e-commerce sites based on fuzzy logic.

For this, we suggest using the fuzzy TOPSIS method. This approach should firstly allow users of commercial websites to launch their inquiries in linguistic terms, and second, present various service quality standards with vague values that ultimately keep customers coming back to the lesser sites. more appropriate.

Thesis plan After a general introduction describing the context of the work, the problem and the proposed solution, this thesis is organized as follows:

The first chapter "Fuzzy Multi-Criteria Decision-Making (MCDM)" In this chapter, we have given an overview of MCDM methods, and we have analyzed and presented the different methods such as: ELECTRE, TOPSIS, AHP, ... etc.

The second chapter "Fuzzy logic" which is an approach to human reasoning. Membership functions are the heart of fuzzy logic, and the fuzzy inference system where the system takes the role of the human being and begins to reason, in three stages: Fuzzification , Inference and Deffuzification.

The third chapter "Case Study And Design" In this chapter, we present our proposed approach for the selection of e-commerce sites based on ambiguous logic. To rank similar e-commerce sites.

The fourth chapter "Implementation" In this last chapter, we will present the software and hardware environment on which the system will be built and validated, the implementation details of our application, propose a practical implementation and a presentation of the experimental results.

These four chapters end with a general conclusion which summarizes the results of our work, and presents the perspectives we wish to achieve in the future.

Chapter 1

Fuzzy Multi-Criteria Decision-Making (MCDM)

1.1 Introduction

Multi-criteria decision making (MCDM) or multi-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly assesses several conflicting criteria in decision-making.

Conflicting criteria are typical in the evaluation of options: cost or price is usually one of the main criteria, and some measure of quality is usually another criterion, easily in conflict with cost. When buying a car, cost, comfort, safety and fuel consumption can be some of the main criteria that we consider.

- it is unusual for the cheapest car to be the most comfortable and the safest. In portfolio management, we want to obtain high returns while reducing risk; however, stocks that are likely to generate high returns generally carry a high risk of losing money.

In a service industry, customer satisfaction and the cost of providing the service are fundamental conflicting criteria.

In our daily life, we usually evaluate several criteria implicitly and we can be comfortable with the consequences of such decisions which are made purely on the basis of intuition. On the other hand, when the stakes are high, it is important to structure the problem well and to explicitly evaluate several criteria.

Multi-criteria decision-making (MCDM) is a process that makes it possible to make decisions in the presence of multiple, generally conflicting standards.

MCDM problems can be classified into two broad categories:

- Multiple attribute Decision Making (MADM): MADM consists of choosing the "best" alternative from the predefined alternatives described in terms of multiple attributes.

- Multiple Objective Decision Making (MODM): MODM involves the design of alternatives that optimize the multiple objectives of Decision Maker (DM).

Multi-Criteria Decision Making is a useful tool in many economical, manufacturing, material selection, military, constructional,etc. problems specifically plays an important role in fields of investment decision, project evaluation, economic benefit evaluation, Staff appraisal and so on.So far many techniques have been proposed to solve multiple attribute decision making problems. Multi-Attribute Decision Making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker(2).

1.2 Overview of Multi-Criteria Decision Making (MCDM) Methods

Multi-criteria decision making is a branch of a general category of operational research models that deal with decision problems in the presence of a number of decision criteria. This major category of models is often called MCDM. This category is also divided into multi-objective decision making (MODM) and multi-attribute decision making (MADM).There are several methods in each of the above categories. Priority methods, leveling, distance and mixed methods are applied to many problems. Each method has its own criteria and the methods can also be classified in a deterministic, random and mysterious way. There may be a combination of the above methods. Depending on the number of decision-makers, the methods can be classified as individual or group decision-making methods.

These methodologies share the common criteria of the conflict between incomparable standards and units and the difficulties of choosing alternatives. When making decisions with multiple objectives, the alternatives are not predetermined, but a set of substantial functions is optimized based on a set of limitations. Find the most satisfactory and effective solution. In this specific effective solution, it is not possible to improve the performance of one objective without degrading the performance of at least one other objective.In multiple attribute decision making,

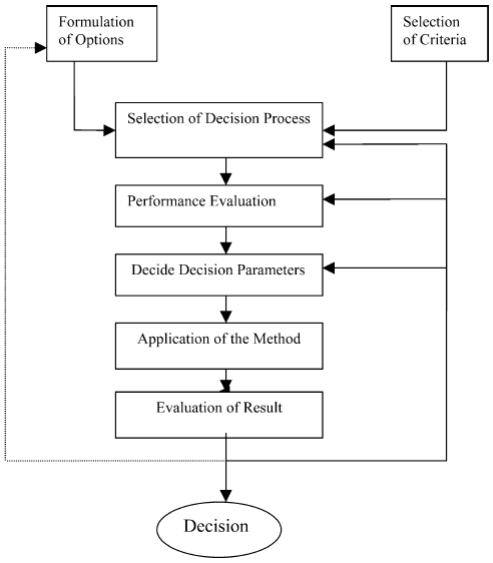


Figure 1.1: Multi-criteria decision process(1)

a small number of alternatives need to be assessed against a set of attributes which are often difficult to quantify. The best alternative is usually selected by making comparisons between the alternatives with respect to each attribute. The multi-criteria decision process is as illustrated in Figure 1.1 The different methods are described as follows(1).

1.3 Fuzzy Multi-Attribute Decision Making (MADM)

The MADM method can be classified according to whether it is non-compensatory or compensatory. The decision-maker may be of the opinion that high performance in relation to one attribute can at least partially compensate for the performance of the law in relation to another attribute, in particular if an initial selection analysis has eliminated the alternatives which do not meet the minimum performance requirements. Methods that incorporate tradeoffs between high and low performance in the analysis are called "compensatory"(1).

1.3.1 Outranking Method

ELECTRE

The basic concept of the ELECTRY method (Elimination and choice translating reality or elimination and choice translating reality) is to know how to manage the upgrade relationship using pairwise comparisons between the alternatives under each criterion separately. The upgrading relation of two alternatives,

noted Ai -¿ Aj, describes that even if two alternatives I and j do not dominate mathematically, the decision maker accepts the risk of considering Ai as almost surely better than Aj an alternative is dominated if another alternative at least outperforms it in one criterion and equals it in the other criteria. The ELECTRE method consists of a pairwise comparison of alternatives based on the degree to which the evaluation of the alternatives and the weight of preference confirms or contradicts the pair dominance relationship between the alternatives. The decision maker may state that he/she has a strong, weak or indifferent preference or may even be unable to express his preference between two compared alternatives(1).

Strengths

- Allows you to use a fuzzy analysis because of indifference and preference thresholds.

- Accepts qualitative and quantitative criteria. (3).

Weaknesses

- It is difficult to understand, due to the principles used to determine compatibility and the litigation matrices.

- The thresholds can be calculated from these metrics, but are often determined according to the opinion of the head of the department, which results in yourself(3).

PROMETHEE

The basic concept of the PROMETHEE (Preference Ranking Organization METHods for Enrichment Evaluation) The method is based on the mutual comparison of each alternative pair against each of the specified criteria. The evaluation table is the starting point for the PROMETHEE method. The alternatives are evaluated according to different criteria. These assessments mainly include numerical data. The implementation of PROMETHEE requires two additional types of information, namely:

- Information on the relative importance (i.e., the weights) of the criteria considered.

- Information on the preference function of the decision makers, which it uses to compare the contribution of the alternatives according to each separate criterion.

Strengths

- PROMETHEE (as all outranking methods) can handle both qualitative and quantitative standards simultaneously. Dozens of standards can be expressed in their own units.

Weaknesses

- PROMETHEE is experiencing a rank reversal issue when introducing a new alternative.

- PROMETHEE does not provide the possibility to really structure a decision problem. If there are many criteria and options, it may be difficult for the decision maker to get a clear view of the problem and evaluate the results(3).

ORESTE

Oreste method is one of the methods in a relatively new decision support system. This method is the development of several other methods collected in the Multi Attribute Decision Making (MADM) method. In this method there is a unit that is by adopting a Besson Rank. Besson Rank is an approach to make a priority scale of each indicator indicator, where if there is a criterion value then in the ranking it uses the average approach(4).

1.3.2 Distance Based Methods

Fuzzy VIKOR

It sets the arrangement list for compromise solutions, leveling solution and weight stability intervals to stabilize settlement solution preferences obtained using primary weights (provided). This method focuses on arranging and choosing from a range of alternatives with contradictory criteria. Provides a multi-criteria classification index based on a special measure of "closeness" to the "ideal" solution.

Strengths

- The best alternative is preferred by maximizing the utility group and minimizing the regret group.

- The VIKOR method calculates the ratio of the ideal positive and negative solution. Thus, the VIKOR method proposes a compromise at an interest rate.

Weaknesses

- The amount of performance is estimated in the form of net values.

- Under many circumstances, clear data is insufficient to model the real situation. In the event of inconsistencies or standards, the decision maker must also consider inaccurate or vague data(3).

Fuzzy TOPSIS

This method is based on the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution, and the farthest from the ideal negative solution. The ideal solution is the default solution with which all attribute values correspond to the maximum attribute values in the database that include satisfactory solutions; the ideal passive solution is the default solution with which all attribute values correspond to the minimum attribute values in the database. Thus, the TOPSIS solution provides a solution that is not only closest to best by default, but is also far from worst by default.

Strengths

- Entry takes like any number of criteria and features.

- Quite intuitive physical meaning based on the consideration of distances from ideal solutions.

Weaknesses

- Easy, it can give unreliable results.

- TOPSIS in its standard form is deterministic and does not consider uncertainty in weightings(3).

1.3.3 Pairwise comparisons based methods

Fuzzy AHP Methods

The analytical hierarchy process was mainly developed by Sate (1980). AHP is a kind of additional weighting method. Its use is supported by many commercially available software packages. Policymakers often find it difficult to simultaneously determine critical weights for a set of criteria. The higher the number of lines, the greater the results obtained when converting the problem into an even comparison series. AHP formalizes the transformation of an attribute weighting problem into a more complex problem of making a series of consistent comparisons between competing attributes. AHP summarizes the results of the mathematical comparisons in the mathematical comparison matrix. For each pair of criteria, the decision maker determines the importance of one trait more important than the other. Each comparison requires that a decision maker provide an answer to the question: "How much more important is attribute A than attribute B, compared to the overall objective?"(2).

Strengths

- The advantages of AHP over other multi-criteria methods are its flexibility, its simple appeal to decision makers and its ability to check inconsistencies.

- The AHP method supports group decision making by consensus by calculating the geometric mean of a single wise pair's comparisons(3).

Weaknesses

- This approach has the disadvantage that the number of wise comparisons to be made, may become very large (n(n-1) / 2), and thus becomes a long task.

- Another important flaw in the AHP method is the artificial limitation of using a 9-point scale. Sometimes, a decision maker may have a difficult time distinguishing between them and giving an example if one of the alternatives is 6 or 7 times more important than the other(3).

Fuzzy Analytic Network Process (ANP) Methods

In some practical decision problems, it seems that the situation differs in the local weights for the criteria of each alternative. AHP finds it difficult to manage in such a situation because AHP uses the same local standard weights for each alternative. To overcome this difficulty, Sate (1996) proposed an ANP process. The ANP allows the use of different weights for alternative criteria(2).

Fuzzy MACBETH

MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) MACBETH is an interactive approach that allows a decision maker or a decision-making group to evaluate alternatives by making qualitative comparisons of their differences in severity in the analysis of several criteria. Thus, what distinguishes MACBETH from other multi-criteria models is that it only needs specific judgments on the difference in gravity between two elements simultaneously, in order to generate degrees of numerical options for each criterion and criterion of weight(1).

1.4 Fuzzy Multi-Objective Decision Making (MODM)

In multiple objective decision making, application functions are established to measure the degree of fulfillment of the decision maker's requirements (achievement of goals, nearness to an ideal point, satisfaction, etc.) on the objective functions and are extensively used in the process of finding "good compromise" solutions. MODM methodologies can be categorized in a variety of ways, such

as the form of the model (e.g., linear, nonlinear, or stochastic), criteria of the decision space (e.g., finite or infinite), or solution process (e.g., prior specification of preferences or interactive). Among MODM methods, we can count multi-objective linear programming (MOLP) and its variants such as multi-objective stochastic integer linear programming, interactive MOLP, and mixed 0-1 MOLP; multi-objective goal programming (MOGoP); multi-objective geometric programming (MOGeP); multi-objective nonlinear fractional programming; multi-objective dynamic programming; and multi-objective genetic programming(2).

1.4.1 Fuzzy Multi-Objective Linear Programming

The original MOLP model for previous problems can be converted to the FMOLP model using the piecewise linear membership function of Hannan (1981) to represent the fuzzy goals of the DM in the MOLP model, together with the fuzzy decision-making of Bellman and Zadeh (1970). Generally, the piecewise linear membership function and the fuzzy decision-making of Bellman and Zadeh (1970) can be adopted to convert the problem to be solved into an ordinary LP problem. The algorithm includes the following steps.

Algorithm

Step 1: Specify the degree of membership for several values of each objective function

$$z_i(i = 1, 2, ..., K).$$

Step 2: Draw the piecewise linear membership function.

Step 3: Formulate the linear equations for each of the piecewise linear membership functions

$$f_i(z_i)(i = 1, 2, ..., K).$$

Step 4: Introduce the auxiliary variable L; the problem can be transformed into the equivalent conventional LP problem. The variable L can be interpreted as representing an overall degree of satisfaction with the DM's multiple fuzzy goals.

Step 5: Execute and modify the interactive decision process. If the DM is not satisfied with the initial solution, the model must be changed until a satisfactory solution is found(5).

1.4.2 Goal Programming

Lee and Moore and Aenaida and Kwak applied goal programming to find a satisfactory solution for MOTP. GP has been widely applied to solve different real-world problems which involve multiple objectives. In using GP, the DM can obtain a satisficing solution and also be able to analyze the goal levels

(aspiration levels). On the other hand, the shortcomings of GP are summarized in the following points as discussed in :

1. The naive adjustment of weights in the formulation of GP models can lead to erroneous results;

2. Misleading conclusions can be drawn from the linear objective programming model with the realization function wrongly formulated as a number instead of a vector;

3. The objective formulation of programming changes the known mathematical form of the MOTP problem;

4. Problems can arise when setting ambition levels(6).

1.5 Conclusion

In this chapter, we presented an overview on MCDM methods, we analyzed and presented the different methods such as: ELECTRE, TOPSIS, AHP,etc. We have also focused on some of the most used MCDM methods and we have shown the disadvantages and advantages of these.

Chapter 2

Fuzzy logic

2.1 Introduction

Classical logic plays a huge role in various fields, and its structure can only express facts as "true" or "false" which limits its field of work in technologies and applications such as artificial intelligence, unconfirmed data decisions,etc. Who wants to imitate human logic and spirit. This means, techniques based on uncertainty for their proper functioning. The logic is precisely designed to solve this problem, to allow the elements to be described in a "progressive" manner. Our perception of the real world is imbued with concepts that have no clearly defined boundaries, for example, tall, much taller than young people,etc. This is only relatively correct and to some extent false. These concepts can be called vague or vague concepts, and the human brain works with them, unlike computers.Natural languages, whose level is much higher than programming languages, are ambiguous while programming languages are not. The usefulness of fuzzy sets lies in their ability to model uncertain or mysterious data, which they often encounter in real life. The idea of fuzzy logic is similar to the process of human perception and reasoning. The term fuzzy logic was introduced with the 1965 suggestion of fuzzy group theory by Lotfi Zadeh in 1965 at the University of Berkeley as an extension of logic based on his mathematical theory of fuzzy groups, which is the generalization of classical group theory. By introducing the notion of degree in the verification of a condition and thus allowing the condition to be in another incorrect or erroneous state, vague reasoning gives too much flexibility in the reasons for which you use it, making it possible while taking into account inaccuracies and doubts(7). Fuzzy logic is a type of modeling that focuses on predicting a "subjective" class variable in the sense that it cannot be embodied.

2.2 History of fuzzy logic

Man has long sought to master doubts and errors inherent in his nature.The first real appearance of the will to formalize the observance of uncertain knowledge was the development of probability theory from the seventeenth century.But the possibilities cannot control psychological and linguistic doubts.So we witnessed the development of theories of self-probability (in the 1950s) and then evidence (in the 1960s).Then a mysterious logic appeared in 1965 and then in 1978 with the theory of probabilities.These two theories now form what is called fuzzy logic.Fuzzy logic makes it possible to formalize inaccuracies due to the global knowledge of a very complex system and the expression of the system's behavior in words. Consequently, it makes it possible to standardize the system description and data processing, whether numerical or symbolic, expressed in language qualifications(8).

In 1985, Seiji Yasunobu and Soji Miyamoto from Hitachi appeared. The simulation showed the superiority of Sendai's mysterious railway systems.Their ideas were adopted and unregulated systems were used to control acceleration and braking when the line opened in 1987.

Also in 1987 at an international meeting of disorganized researchers in Tokyo, Takeshi Yamakawa demonstrated the use of fuzzy control, through a set of custom fuzzy logic chips, in the "Inverted Pendulum" experiment. This is a classic control problem, as the car tries to install a pole mounted on its top hinge by moving back and forth.

Observers were impressed by this demonstration, as well as the subsequent Yamakawa experiments in which he swallowed a glass of wine containing alaqah i.e.The system maintained stability in both cases.Yamakawa eventually organized his own Fuzzy Systems Research Laboratory to help him exploit his May patents(7).

2.3 Definition of fuzzy logic

Several definitions have been discussed for the fuzzy logical word. in the following, we will give some definitions:

Definition of Zadeh: Fuzzy logic is interested in the formal principles of approximate reasoning, with precise reasoning considered as limiting. it aims to model the imprecise reasoning method which plays an essential role in the remarkable human capacity to make decisions in an environment of uncertainty and imprecision(7).

Definition from Wikipedia: Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1 both inclusive. It is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. By contrast, in Boolean logic, the truth values of variables may only be the integer values 0 or 1.

another definition: Fuzzy logic is a problem-solving methodology that provides a simple way to draw definitive conclusions from vague and imprecise information(9).

2.4 Fuzzy logic vs classical logic

In classical logic, the managed variables are Boolean. That is to say that they only take two values 0 or 1. The purpose of fuzzy logic is to reason from imperfect knowledge which opposes resistance to classical logic. For this, fuzzy logic proposes to replace boolean variables with fuzzy variables(10).

2.5 Is there a need for fuzzy logic

Fuzzy logic has a much higher global level than bivalent logic. The generality of fuzzy logic is what underlies fuzzy logic. Among the important contributions of confused logic are the following:

∗ Circulating FL. Any theory based on bivalent logic, T, and thus its improvement can be generalized, by adding concepts and techniques derived from fuzzy logic to T. Examples: fuzzy control, fuzzy linear programming.

∗ Variables and grammar are vague if. The formalities of linguistic variables and ambiguous grammar if in reality are a powerful modeling language widely used in fuzzy logic applications. Essentially, formalism works as a way to synthesize and compress information through the use of granulation.

∗ Intense precision. Fuzzy Logic has high resolution. This power is necessary to formulate common definitions of scientific concepts and formalize human-centered areas such as economics, linguistics, law, conflict resolution, psychology, and medicine.

∗ NL-Calcul (word computing). Fuzzy logic is the basis for NL calculation, i.e. calculation with information shown in natural language. NL-Calculus is directly related to the mechanization of understanding natural language and arithmetic with inaccurate possibilities. In general, an NL calculation is necessary to address second degree uncertainty, i.e. uncertainty about uncertainty or short-term uncertainty(7).

2.6 Theory of fuzzy logic

2.6.1 Fuzzy subsets

Fuzzy logic is based on the theory of fuzzy sets, which are a generalization of the theory of classical sets. By abuse of language, according to the literature, we will use the terms fuzzy subsets and fuzzy sets interchangeably. Classic sets are also called net sets, as opposed to fuzzy, and even classical logic is also called boolean or binary logic(10).

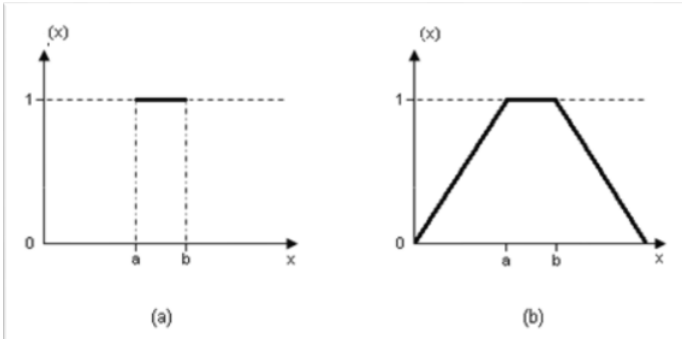


Figure 2.1: Membership function characterizing a classical set (a) and a fuzzy set (b).

2.6.2 Basic operations on fuzzy subsets

The mathematical theory on fuzzy subsets defines many operations on these subsets and on the membership functions that make these notions usable. We present here only the basic operations of this theory(11).

If A and B are two fuzzy subsets and μ(A) and μ(B) their membership function, we define:

- The complement of A,by the membership function μ(A) = 1 - μ(A)

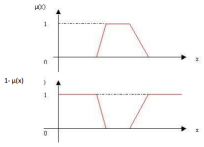


Figure 2.2: Membership function

- The subset A and B, by the membership function:

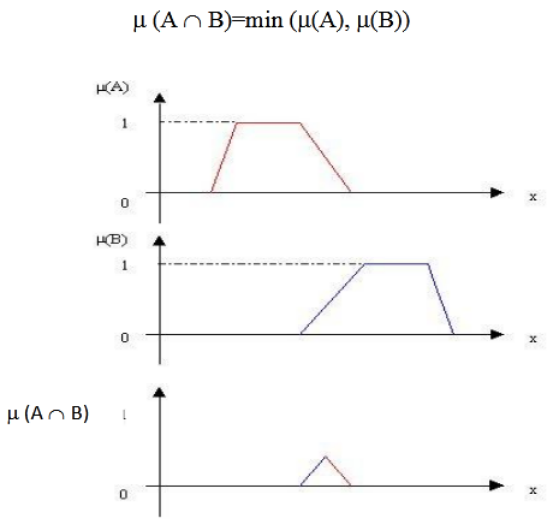


Figure 2.3: Intersection of membership functions

- The subset A or B, A ∪ B, by the membership function:

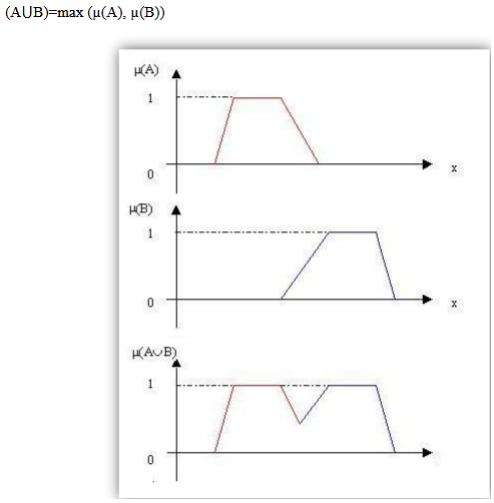


Figure 2.4: Union of membership functions

These definitions are the most commonly used, but sometimes, in some cases, others are more appropriate. For example, the intersection can be defined by the product of the membership functions and the union by the arithmetic mean

of the membership functions. These different calculation techniques generate an enormous capacity for adapting fuzzy reasoning(11).

2.7 Linguistic variable

A linguistic variable is a variable whose value is an expression of natural language referring to a certain interest. Linguistic variables are used in ordinary daily activities. These natural language expressions are then in turn names of fuzzy sets made up of the possible numerical values that the amount of interest can take. A word or a word sentence is the main difference between a linguistic variable and a numeric variable(7).

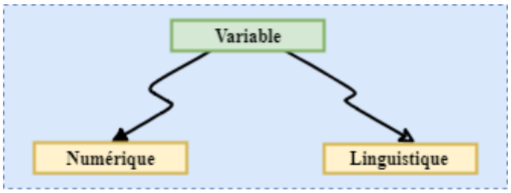


Figure 2.5: Linguistic variable

2.8 Definition of membership functions

A fuzzy set is defined by its membership function which corresponds to the concept of criteria function in classical logic, it allows to measure the degree of belonging of an element to the fuzzy set. In general, a membership function of a fuzzy set is called par A (x).The argument relates to the criteria variable, while the index indicates the set concerned. The membership functions can take different forms (8):

a) Triangular membership function:

$$\begin{cases} 0 & if \quad x < 0 \\ \frac{x-a}{b-a} & if \quad a \leq x \leq b \\ \frac{c-x}{c-b} & if \quad a \leq b \leq c \\ 0 & if \quad x > c \end{cases}$$

where a, b, c are real numbers and (a ¡b ¡c)

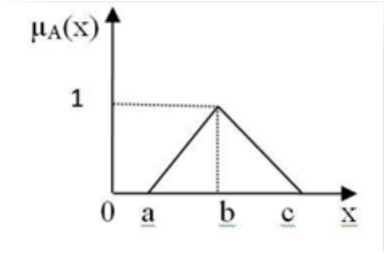


Figure 2.6: Triangular shape

b) Trapezoidal membership function:

$$\begin{cases} \frac{x-b}{b-a} & if \quad a < x \leq b \\ 1 & if \quad b \leq x \leq c \\ \frac{b-x}{b-d} & if \quad c \leq x \leq d \\ 0 & if \quad other. \end{cases}$$

Where a, b, c and d'are real numbers and (a ≤ b ≤ c ≤ d)

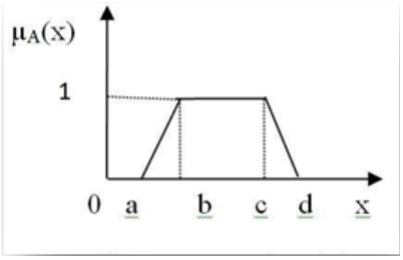


Figure 2.7: Trapezoidal shape

c) Gaussian membership function: $u_A(\mathrm{x}) =$

$$exp^{(-\frac{1}{2}(\frac{xm}{\sigma})^2)} \tag{2.1}$$

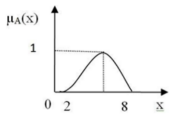


Figure 2.8: Gaussian form

2.9 Fuzzy inference system

The principle of a fuzzy system is to be able to calculate output parameters by providing the system with a set of rules formulated in natural language. To implement a fuzzy inference system, three steps are necessary(7).

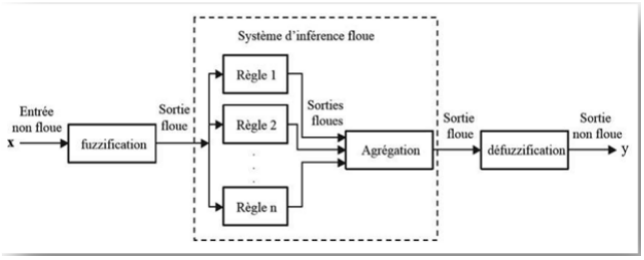


Figure 2.9: Gaussian form

1.Fuzzification: Convert classic data or digital data to fuzzy data or membership functions;

2. Fuzzy inference process: Combine membership functions with control rules to derive fuzzy output;

3. Defuzzification: which consists in criteria the linguistic variables used in the system. It is therefore a transformation of the actual entrances into a fuzzy part defined on a representation space linked to the entrance. This representation space is normally a fuzzy subset. During the fuzzification step, each input and output variable is associated with fuzzy subsets.

2.10 Conclusion

Fuzzy logic is an approach to human reasoning. In this chapter we have seen the most common steps and methods for the realization of a system based on fuzzy logic. The membership functions are the heart of fuzzy logic, and those that set the difference between classical (Boolean) logic and fuzzy logic. The inference is where human experience determines the reasoning of the system. And aggregation is where the system takes on the role of a human being and begins to reason and defuzzify in order to give results.

Chapter 3

Case Study And Design

3.1 Introduction

The number of e-commerce websites in the world is constantly growing.Choosing the best site has become a delicate task for the customer.This problem brings us back to asking the following question:

"How do you distinguish and choose the best commercial site from the list of similar business websites?" This becomes a big problem to solve.

As a case study reflecting the previous chapters, we have chosen e-commerce websites which are a very good example for ranking similar alternatives because all e-commerce websites represent a field of expertise for ranking (Set of similar alternatives criteria by the same criteria which are quantitative or qualitative).

Most methods are found in the literature depending on choice of commercial sites based on job descriptions, but these commercial websites may not be able to provide the same quality of service. The choice of commercial sites based on the non-functional aspects mainly depends on the Quality of Service (Qos) standards, which are measured using several measures (cost, implementation time, reliability, availability, reputation, etc.). However, these criteria are sometimes inaccurate, not confirmed, and vague due to the user's mental state. Fuzzy Logic translates this evaluation by providing appropriate quality standards for the user. The use of fuzzy logic makes it possible to support inaccurate representations of QoS constraints and provide user preferences such as Qos features obscure because they are better suited to interpreting terms on linguistic form. The goal of our work is to classify a set of e-commerce websites criteria by a set of criteria using a fuzzy method.

3.2 Définition et types de l'e-commerce

3.2.1 Definition

E-commerce or electronic commerce, a subset of e-business, is the purchase, sale and exchange of goods and services over computer networks (such as the Internet) through which operations or the conditions of sale are exercised electronically. Contrary to popular belief, e-commerce is not just on the web. In fact, e-commerce was alive and well in business-to-business transactions before the web in the 1970s through EDI (Electronic Data Interchange) through VAN (Value-Added Networks). E-commerce can be divided into four main categories: B2B, B2C and C2C(12).

3.2.2 types

• **B2B (Business-to-Business)** Electronic business-to-business exchange, often referred to as B2B, refers to a business-to-business electronic business relationship or between a business and its supplier based on the use of electronic media(13).

• **B2C (Business-to-consumer)** E-commerce for individuals B to C is the first type of e-commerce to be developed. E-commerce for individuals, or B to C that defines the relationship between the company and the general public (individuals) who have a relationship that is not limited to the act of selling. But it covers all exchanges the company can make with its clients from requesting quotations to after sales service. These are commercial websites, and type of remote shopping. And compared to B2B, B2C trading is undoubtedly less complicated because it does not require the establishment of a department to verify the purchase. But it also requires safety in terms of when the customer pays online(13).

• **C2C (Consumer-to-Consumer)** There are many websites that offer free classified ads, auctions, and forums where individuals can buy and sell online through the payment system, or people can easily send and receive money online. . EBay Auctions is a good example of personal trading, with transactions conducted every day since 1995. Companies that use intranets to provide their products and services to their employees online - not necessarily in the online on the Internet - participate in B2E e-commerce (business to employee)(12).

3.3 Advantage and disadvantage of e-commerce

3.3.1 Advantage

• **More customers:** neither a local shop nor a company established in several cities can reach as many people as an e-commerce. Being able to buy and sell

from anywhere in the world greatly expands the target audience and leads to more customers.

• **No hours:** unlike traditional shops, which are rarely open 24 hours a day, e-commerce has no hours. The website remains open and accessible to the public throughout the day, so the customer can shop at any time.

• **Lower costs:** being able to do without a physical establishment makes it possible to reduce costs compared to operating a traditional business. And if e-commerce works by putting suppliers in contact with buyers, there will not even be any production costs (in the case of dropshipping, which we told you about above).

• **More margin:** reducing costs and increasing the number of customers makes it possible to reach a greater margin than with a traditional trade, even by lowering prices. We sell more and we earn more money.

• **Scalability:** in an e-commerce, you can sell to one or a thousand people at the same time. In a physical business, there is always a limit to the number of customers you can serve at one time; in e-commerce, the limit is your ability to attract visitors. And of course, that of your computer server(14).

3.3.2 disadvantage

• **Lack of confidence:** although gateways and payment methods have made huge strides and are now as secure as in physical stores, many people still do not fully trust online transactions. To help them gain more trust, it is possible to use an SSL certificate (https) which encrypts the information transferred, as well as other certificates which guarantee the security of the client.

• **Products and services you can't see or touch:** as customers, we like to feel like we're making a good purchase. We like to see the product and touch it to realize its quality and this cannot be done in an e-commerce. How to overcome this disadvantage? Thanks to complete product sheets, including images, videos and a very detailed description of the product (links in English).

• **Internet connection essential:** it is obvious, but in order to sell and buy on the internet, a device connected to the internet is necessary. This does not concern the majority of online activities, but may represent a problem for certain sectors where the target audience is older or less familiar with new technologies.

• **Technical difficulties:** dealing with unknown themes is the daily life of entrepreneurs, whether offline or online. In the case of e-commerce, the technological part requires a minimum of technological knowledge, which not everyone

has. The best way to solve this difficulty is to delegate this part, although this obviously has a cost.

• **Competition:** the economic entry barrier for creating e-commerce is not as high as for physical commerce. Competition is therefore more important, and you have to be more competent than the others.

• **Time to get results:** when a physical business opens its doors, the customers who pass by see it. Getting visibility for an online business is more difficult than it seems. Indeed, you can have a very good product and be present on a good platform, but if you do not work to gain visibility, nobody will notice you(14).

3.4 Website features

In order to better understand the level of website commitment to managing the quality of customer service and more specifically in building an online relationship, it is necessary to understand the functionality of the site in terms of the electronic distribution that the service relationship and the website are part of the service system. Many companies use the Internet and the web to make the relationship with their customers more interactive and personal. Site standards such as portability, responsiveness, and appropriate content are the dimensions necessary to improve customer interaction(15).

3.4.1 Functional features of the website

The peculiarity of this approach is essentially close to taking into account self-awareness, both in terms of site content and in terms of structure. This perception, which varies with the experience, cognitive abilities, and goals that the Internet user seeks, makes it possible to study comfortable browsing conditions: ease of reading and the page hierarchy so that the Internet user is placed in the best possible conditions to continue to purchase and maximize the rational or emotional content extract, design Page (easy identification of links, “cutting the page into meaningful units” and reducing “frames”, Ladwein 2000), the presence of an internal search engine on the site or the need to explore a specific search and hopefully search and final exploration and explore availability. Here it can be classified into two categories. The first category relates to the analyzed object that distinguishes site content from its structure (”design”). For example, for Huizingh (2000), it includes content (14):

• the informative content, the site having for primary objective to deliver commercial information (institutional and products) but also non-commercial (sponsored events, localization, ...).

• transactional content (order, request for proposal), which increases with the size of the site.

• entertainment (games, jokes, images, comics, music videos, animations) As for the structure of the site, it consists of:

• the navigation tree (hypertext links), which depending on whether it is imposed or not to influence navigation, can take respectively the form of hierarchical or network structures, the best structure being for Huizingh (2000) "somewhere between the tree and the total network ".

• the internal site search function, correlated to the size of the site.

• protected information, almost nonexistent except in the financial sector.

The second category of research focuses more on "building a medium capable of combining several factors that explain success" (Reix, 2003). This is how Rex (2003) focused on outstanding research that focuses on the quality of information that focuses more on "ease of use", which is defined by ISO (International Organization for Standardization) as "the extent to which a specific product is used by specific users to achieve Specific objectives with effectiveness, efficiency and satisfaction in a specific context of use.

3.4.2 Relational characteristics of a website

• **Personalization:** Often mentioned as a key feature of an effective relationship, personalization represents the ability of a retailer to identify a customer and then provide products, services, and expertise that meet his criteria (Srinivasan et al., 2002). Therefore, it must include customization of recommendation systems, promotional emails, website pages, links, a variety of products and services, as well as web portal design (Toufaily and Perrien, 2006).

This allocation is largely an indication of the complexity as some researchers have succeeded in proving that the simpler a site is, the more it adapts to the needs of its user (Nantel, Mackie-Barrada and Bressolles (2005).

• **Value-added information:** is relevant, accurate, reliable and tailored to the customer's needs. The added value of the information not only ensures customer feedback, but also provides opportunities for online retailers to increase joint sales and profitability. In addition, the continuous availability of information on the site has a positive impact on the trust and commitment that the customer develops in the business relationship.

• **The quality of communication:** Morgan and Hunt (1994) Commitment and Compliance Theory in Relationship Marketing shows the importance of communication in developing relationships. It is defined as the formal and informal exchange of relevant and periodic information between partners (Anderson and Narus, 1984). In fact, the more the company maintains interactive and communicative relationships, the more positively affected customer retention (Duncan and Moriarty, 1998). But in order to build customer trust and loyalty, two-way communication through mutual information exchange must emphasize the importance of the concept of reciprocity (Crosby, Evans and Cowles, 1990).

• **Social presence:** Social presence is defined as the extent to which the channel allows its users to feel a psychological presence with others. This presence, of relational type, will have a social, if not emotional, dimension and should be included in a virtual merchant site. As a result, companies that integrate the social and friendly interface to the site stimulate the positive sentiments of their customers. This stimulus is created by designing a warm, personal and social website, thus creating a sense of human contact.

• **Virtual communities:** Social interaction through virtual communities affects trust and loyalty via the Internet through shared interests and social relationships that a customer can build in such a community(15).

3.5 Web sites e-commerce criteria

The website is a special case among technological self-service technologies. The use of this medium by a growing number of consumers has brought to light a recent literature which allows us to present the supposed constitutive dimensions of perceived quality(16).

3.5.1 utilisation facility

Cited in many studies, ease of use seems to be a very important factor for Internet users. This term can be defined as the ability of the interface to be efficient and easy to use.

Ease of navigation depends on several elements The degree of stickers stripping, respect for customer logic, provision of navigation aids, download time (for example that can have a negative impact on the site's evaluation), but also the time the user needs to access a product / service or information presented on the site.

3.5.2 accessibility

The accessibility dimension can be defined as the ease and continuity with which customers can access the service they are looking for. This accessibility covers

the idea of perpetuity of service on the web and depends in part on the technical performance of the site. It is important not to confuse accessibility with availability of information.

3.5.3 Aesthetics and dimensions of the site

The aesthetic experience is related to the visual and / or acoustic appearance of the site. The web allows the use of graphics, animations and sounds that make the service experience more enjoyable. We'll define this term as the interface's ability to generate fun and enjoyment.

According to Paulayer and Matthew (2000), there are five navigation aspects related to explaining the fun dimension of the site:

• **Fun:** the site's ability to provide fun and entertainment to the user.

• **Escape:** the site's ability to provide a "cut" to the user, either as an escape from its daily life, or an escape from the real world.

• **Awakening and sensory stimulation:** the site's ability to awaken the user's senses.

• **Relaxation:** The feeling of relaxation is defined as the ability of the site to provide relaxation and relaxation to the user.

• **Control:** the feeling of control corresponds to the feeling of power, ingenuity and control, among other things, over technology by the Internet user.

3.5.4 the quality of the offer

Studies indicate the quality of a company's product or service offering as an important component. Customers come to the site to learn about products, services, consumption or demand. It seems they want the widest possible offer. Basic service can be completed through Terminal Services. Several criteria of the offer are mentioned: the bid price (meaning competitive bid), and its extent in terms of variety or rarity (unique or rare product offering).

3.5.5 quality of information

Internet users certify the quality of the information. It can be defined as the extent to which the site provides information on the criteria and price of products / services, in a precise and complete manner, by offering the possibility of making comparisons. Some studies (Jalan and Sabadi, 2001) emphasize the clarity and accuracy of the presentation information and the most important concepts because it is unlikely that a salesperson will help them in their approach.

3.5.6 reliability

It is linked to the seller's ability to keep his promises on the Internet and to respect the exchange conditions which correspond to the degree of respect for the promised service in terms of quality, quantity, price and time. Merchant sites must respect the articles to which you subscribe, quickly correct errors and guarantee the accuracy of operations.

3.5.7 confidentiality of personal data and security

Sites that implement confidentiality of personal data and secure payment mechanisms help reassure the Internet user and influence the perceived quality of the online shopping experience. The term security sometimes covers the idea of transaction security in the financial sense, but it also includes the security of personal data and the protection of personal information (respect for private life).

3.5.8 interactivity and customization

Online interaction results in the ability to send an email to the webmaster, formulate an opinion, criticism, dialogue in discussion forums, create a private site, etc. Always with a view to interacting, companies online can make online help tools available to customers (virtual assistant, messaging, advice, and customer service online or over the phone, FAQ section, order tracking) to inform and direct them all throughout the purchase or consumption process. The Internet also provides the possibility of social interaction. Website users can interact with others who have common interests Commercial websites can encourage the creation of user groups and thus create a community atmosphere of belonging and learning about the site, by facilitating personal contacts and activities.

3.5.9 credibility

Using the Internet to make a purchase means mutual trust between the seller and the buyer in order to overcome psychological barriers due to the distance and the difficulty of identifying the company that has been officially processed. Merchant sites must therefore reassure consumers in order to reduce the uncertainty associated with this mode of distribution and to encourage the development and growth of online shopping. Reliability differs slightly from reliability in that it is not related to service but to the brand of the company or product.

3.5.10 customer assistance

It seems that taking into account any errors or problems encountered during the transaction plays an important role in raising awareness of the quality of service. Recent studies in the field of marketing recovery services confirm this claim. Service recovery is defined as "any service related to an accident or a problem (real or perceived) to the consumer during the service experience with

the company". The concept of "after-sales service" only covers management in accordance with the law on purchases and tends to be interpreted as the contractual concept of "guarantee" Very restrictive.

3.6 An approach to the selection of e-commerce websites based on fuzzy logic

This solution consists of a new e-commerce website selection model based on fuzzy logic. The use of fuzzy logic in our approach is essential, with this logic, we present the values of e-commerce website quality criteria relating to e-commerce websites with linguistic value: for example instead of giving a single numerical value at parameter C1, for example, we attribute: bad, average, good and excellent.

Example: if we have the cost criterion, it can be presented in this way:

Coût	
Terme linguistique	**Nombre flou triangulaire**
Moins cher	[0 1 5]
Acceptable	[4 7 10]
Cher	[9 12 20]

Figure 3.1: Representation of the fuzzy cost parameter

3.7 Approach description

Before applying the ranking method, it is important to go through three steps:

1.Form a committee of decision makers: We assume that we are a group of k Decision Makers (D1,D2,. . . ,Dk) with m possible websites (WSE) which are evaluated against n criteria (C1,C2,..,Cn).These decision makers can be experts in the field of e-commerce as they can be customers of e-commerce websites.

2.Evaluate the ranking of each criterion according to their importance: Each DM assigns a linguistic value to each criterion according to the importance it judges.Two different DMs can give different values for the same criterion.

3.Normalize the aggregated fuzzy importance weight for each criterion: Based on the values assigned by the MDs to the various criteria, the weight of each criterion is calculated.

The important step in this approach is called Fuzzification, the purpose of the fuzzification step is to transform a numeric data into a linguistic variable. For that, we have to create membership functions which define the degree of membership of a numeric data to a linguistic variable. The inputs to fuzzification are the quality of service (QoS) parameters whose values are quantitative.

For each criterion, we can create several membership functions, namely: Triangular, trapezoidal or Gaussian function. If the web services that we want to test are published with the criteria: reliability, availability and response time: each of this data will have several membership functions. For example: If we want to transform reliability into a linguistic variable. We can find several linguistic values qualifying these numerical data: low, medium and high. Same principle for the other two criteria: the availability can be presented by the following linguistic values: low, medium and high and the response time criterion can be presented by the linguistic variables: cheap, medium and expensive.

Note that this step is mainly carried out on the basis of statistical observations (or by learning to group the values of a variable into homogeneous categories) or on the advice of experts.

In short, the first step is to present the criteria qualifying SWEs in linguistic terms.

Since we have chosen the triangular membership function to present our linguistic information, the following tables are an example showing criteria in linguistic values:

Linguistic Term	Triangular fuzzy number
Interface	
Low	[0 0 25]
Fair	[15 30 50]
Good	[35 50 70]
Very good	[60 80 100]

Figure 3.2: Interface parameter in fuzzy representation

Linguistic Term	Triangular fuzzy number
Content	
Low	[0 0 25]
Fair	[15 30 50]
Good	[35 50 70]
Very good	[60 80 100]

Figure 3.3: Content parameter in fuzzy representation

Linguistic Term	Triangular fuzzy number
Responce time	
Low	[20 20 450]
Medium	[300 600 900]
High	[700 900 1200]
Very high	[1000 1300 1500]

Figure 3.4: Response time parameter in fuzzy representation

Linguistic Term	Triangular fuzzy number
Reliability	
Low	[0 0 25]
Fair	[15 30 50]
Good	[35 50 70]
Very good	[60 80 100]

Figure 3.5: Reliability parameter in fuzzy representation

The triangular membership functions of each variable are presented as follows:

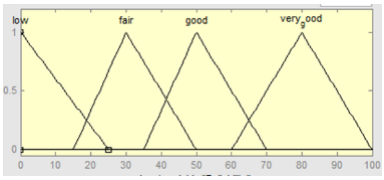


Figure 3.6: Interface linguistic variable

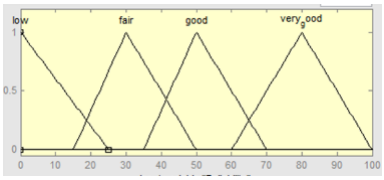


Figure 3.7: Content linguistic variable

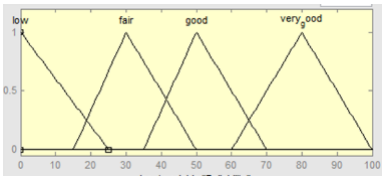


Figure 3.8: Reliability linguistic variable

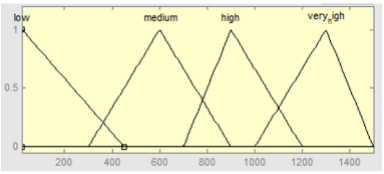


Figure 3.9: Response time linguistic variable

Once the fuzzification is complete, we end up with a fuzzy matrix which will be as input to our ranking system. This system uses a fuzzy multi-criteria method to classify the set of alternatives made up in our case of e-commerce websites. The result of this approach is the assignment of scores to the different alternatives. The best score that matches the highest value will be the best ranking.

In general, the proposed solution can be presented as follows:

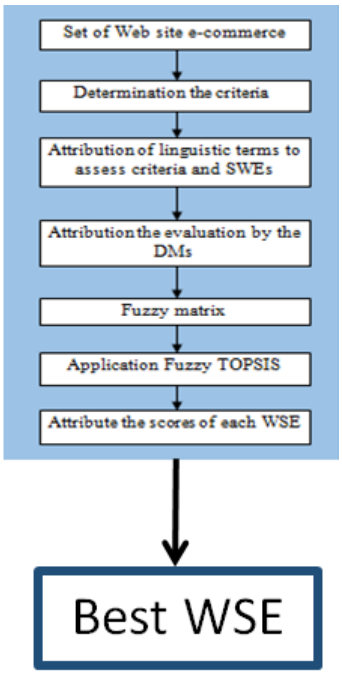


Figure 3.10: The proposed solution

3.8 Fuzzy TOPSIS method

The TOPSIS method (technique for order preference by similarity to ideal solution) is one of the most widely used multi-attribute methods for solving multi-criteria decision support problems thanks to its ease of assimilation and application. Indeed, its principle is based on the search for the alternative more of ideal reference point (ideal reference point) noted IRP (i.e., the alternative which minimizes cost criteria and maximizes benefit criteria) and the more extension point of reference anti-ideal (anti-ideal reference point) noted ARP (i.e., the alternative that maximizes cost criteria and minimizes benefit criteria). In other words, the TOPSIS method is based on(17):

1. The notions of IRP and ARP.

2. The measurement of the distance (in general Euclidean) between the alternatives and the two points of IRP and ARP.

3. The axiom of choice of Coombs (1958).

In the classic version of TOPSIS, the evaluation and the weights of the criteria are known with precision. However, in order to model real situations with often vague and ambiguous human judgments, the fuzzy set theory is used. In the fuzzy version of TOPSIS (Fuzzy TOPSIS), all assessments and weights are defined using linguistic variables. We summarize the different steps of the fuzzy TOPSIS method as follows(8):

Step 1 : Define scores for standards and services and calculate ambiguous aggregate opinions. All expert opinions are expressed in mysterious triple numbers, and we assume that we have a decision group of k members and n e-commerce website $(S_1, ..., S_n)$ which are assessed according to the criterion $C_j(j = 1, ..., m)$.expert assessment K_th for the service S_i according to the criterion C_j is noted: $\tilde{X}_ij^k = (a_ij^k, b_ij^k, c_ij^k)$ the weight of the criterion C_j is noted $W_ij^k = (W_j1^k, W_j2^k, W_j3^k)$ Based on fuzzy notation, aggregated fuzzy values X_ij alternatives for each criterion are given by

$X_ij = (a_ij, b_ij, c_ij)$ or $a_ij = \min\{a_ij^k\}, b_ij = \frac{1}{K}\sum_{K=1}^{K} b_ij$ and $\max\{c_ij^k\}$

Aggregate fuzzy weights $\tilde{w}_ij$ for each criterion is calculated by:

$\tilde{w}_j = (w_j1, w_j2, w_j3).w_j1 = \min_k\{w_j1^k\}, w_j2 = \frac{1}{K}\sum_{K=1}^{K} w_j1$ and $w_j3 = \max_k\{w_j1^k\}$.

Step 2 : Calculate the normalized fuzzy decision matrix. The normalized fuzzy matrix $\tilde{R}$ is given by:

For positive criteria: $\tilde{r}_ij = (\frac{a_ij}{c_j^*}, \frac{b_ij}{c_j^*}, \frac{c_ij}{c_j^*})$ and $c_j^* = \max_i\{c_ij\}$.

for negative criteria: $\tilde{r}_ij = (\frac{a_ij}{c_j^*}, \frac{b_ij}{c_j^*}, \frac{c_ij}{c_j^*})$ and $c_j^* = \min_i\{a_ij\}$.

Step 3 : Calculate the weighted normalized decision matrix

$\tilde{V} = [\tilde{V}_ij]_{mxn}$ where $\tilde{V}_ij = \tilde{r}_ij.\tilde{w}_ij$.

Step 4 : Calculate the positive fuzzy ideal solution (FPIS) and the negative fuzzy ideal solution (FNIS):

The FPIS is calculated by: $S^* = (\tilde{V}_1^*, \tilde{V}_2^*, ..., \tilde{V}_3^*)$ where $\tilde{V}_j = \max_i\{v_ij3\}$

The FNIS is calculated by: $S^- = (\tilde{V}_1^*, \tilde{V}_2^*, ..., \tilde{V}_3^*)$ where $\tilde{V}_j = \min_i\{v_ij1\}$

Step 5 : Calculate the distance between each alternative to FPIS and FNIS:

$d_i^* = \sum_{j=1}^{n} d(\tilde{V}_i j, \tilde{V}_j^*)$ where $i = (1, 2, 3, ..., m)$

$d_i^- = \sum_{j=1}^{n} d(\tilde{V}_i j, \tilde{V}_j^-)$ or $i = (1, 2, 3, ..., m)$

$d(\tilde{X}, \tilde{Y})$ is the measure of distance between fuzzy numbers $\tilde{X}$ and $\tilde{Y}$.

Step 6 : Calculate the coefficient for each e-commerce website S_i ; This coefficient represents the distance of the positive ideal solution S^* and the negative ideal solution S^-: $CC_i = \frac{d_i^*}{d_i + d_i^*}$

Step 7 : Classify e-commerce websites.

3.9 Example of Fuzzy TOPSIS

Step 1:Alternative assessments by decision makers Here we have two alternatives such as A1 and A2 to compare with four criteria such as C1, C2, C3 and C4 and we have two decision makers which are DM1 and DM2. Now the decision makers write down the alternatives as shown in the table.

Criteria	A1		A2	
	DM1	DM2	DM1	DM2
C1	F	F	G	G
C2	VG	VG	G	VG
C3	P	F	P	P
C4	F	F	P	P

Figure 3.11: Alternative Assessment

Step 2: weight of decision makers' criteria

Criteria	DM1	DM2
C1	H	M
C2	VH	H
C3	VH	H
C4	M	L

Figure 3.12: weight of criteria

Step 3: apply fuzzy numbers (fuzzy evaluations of linguistic variables)

Fuzzy number	Alternative Assessment	QA Weights
(1,1,3)	Very Poor (VP)	Very Low (VL)
(1,3,5)	Poor (P)	Low (L)
(3,5,7)	Fair (F)	Medium (M)
(5,7,9)	Good (G)	High (H)
(7,9,9)	Very Good (VG)	Very High (VH)

Figure 3.13: fuzzy evaluations of linguistic variables

Criteria	A1		A2	
	DM1	DM2	DM1	DM2
C1	F(3,5,7)	F(3,5,7)	G(5,7,9)	G(5,7,9)
C2	VG(7,9,9)	VG(7,9,9)	G(5,7,9)	VG(7,9,9)
C3	P(1,3,5)	F(3,5,7)	P(1,3,5)	P(1,3,5)
C4	F(3,5,7)	F(3,5,7)	P(1,3,5)	P(1,3,5)

Figure 3.14: fuzzy numbers for alternative notation

Step 4: Decision matrix based on the alternative and the aggregate criteria weights (fuzzy numbers for alternative notation)

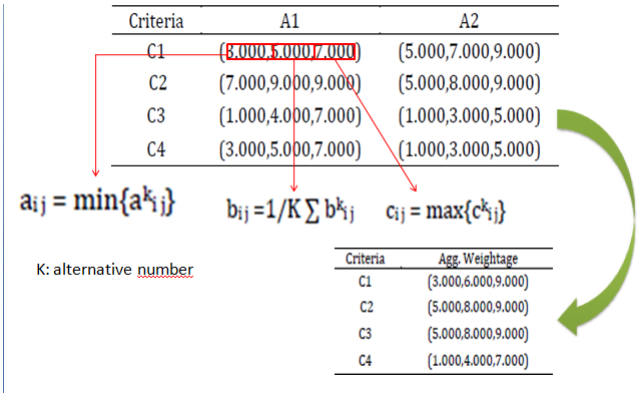


Figure 3.15: Fuzzy aggregate decision matrix for criteria weight

Step 5: fuzzy multicriteria group decision making (GDM) and normalization process

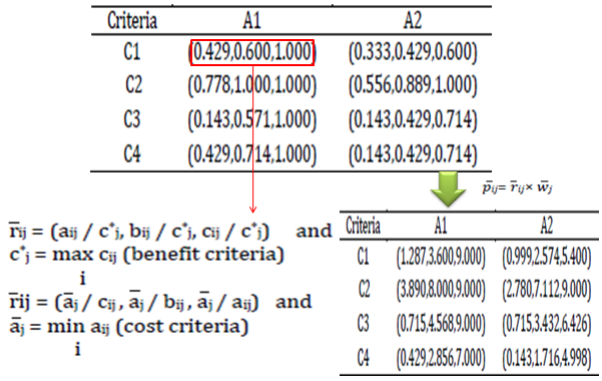


Figure 3.16: weighted normalized fuzzy decision matrix

Step 6: FPIS and FNIS

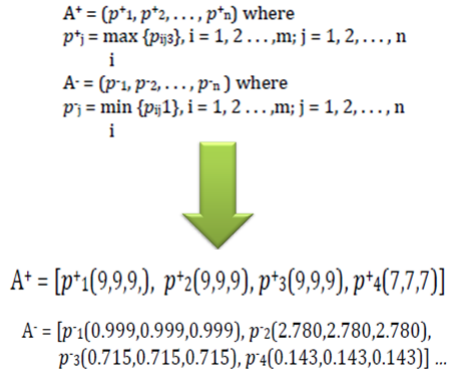


Figure 3.17: FPIS And FNIS

Step 7: FPIS and FNIS for each criterion

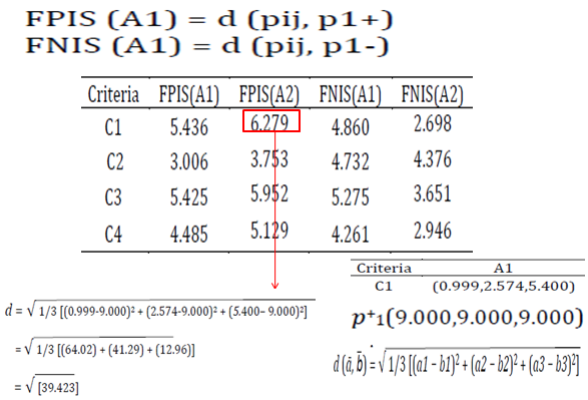


Figure 3.18: FPIS and FNIS for each criterion

Step 8: the distance of each weighted alternative

$$d_i^+ = \sum_{j=1}^{n} d(\bar{p}_{ij}, p_j^+)$$
$$d_i^- = \sum_{j=1}^{n} d(\bar{p}_{ij}, p_j^-)$$
$$d_1^+ = 18.352 \quad d_2^+ = 21.113$$
$$d_1^- = 19.128 \quad d_2^- = 13.671$$

Figure 3.19: the distance of each weighted alternative

Step 9: closing coefficient of each alternative

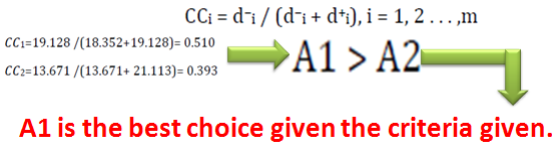


Figure 3.20: closing coefficient of each alternative

3.10 Conclusion

In this chapter we presented our proposed approach for the selection of e-commerce websites based on fuzzy logic. For the classification of similar e-commerce websites, we have integrated a Fuzzy TOPSIS Multi-criteria Decision Method (MCDM). It is used to rank all e-commerce websites in order of choice based on a set of fuzzy criteria. This conceptual study presents the general architecture of our approach. In the next chapter, we will present the implementation of a prototype to show the feasibility of our approach.

Chapter 4

Implementation

4.1 Introduction

After presenting our approach in detail to choosing the best commercial website, taking into account the quality of service standards, with the use of the Fuzzy TOPSIS méthode in the previous chapter. This chapter will be devoted to the implementation phase, and will explain how we implemented our system. We start with a presentation of the software environment used, by showing the tools and programming language. Finally, we will introduce the graphical interfaces by describing the various functions of our application.

4.2 Development environment

Before starting the implementation of our application, we will first specify the programming language and the tools used which we found to be a good choice given the advantages they offer.

4.2.1 Hardware and software environment

The hardware used is a laptop computer described in the following figure:

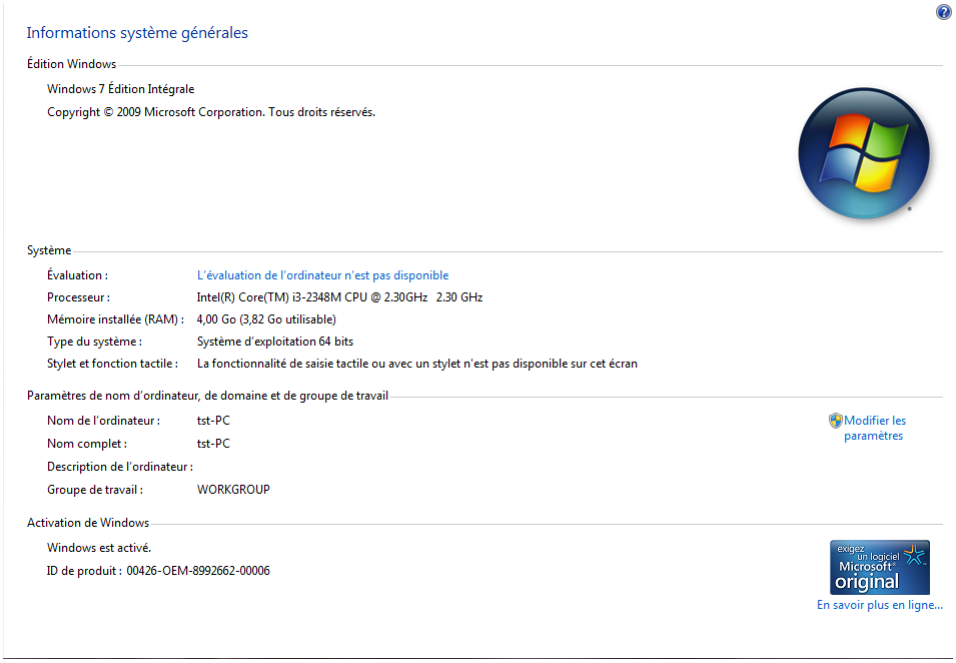


Figure 4.1: Main interface of NetBeans

4.2.2 Programming language

Nowadays there are many programming languages, more or less dedicated to this or that type of particular application. Among them, our choice focused on the JAVA language.

Java language

Java is an object oriented programming language created by James Gosling and Patrick Naught-on, employees of Sun Micro-system, with the support of Bill Joy (co-founder of Sun Micro-systems in 1982), officially presented on May 23, 1995 at Sun-World.

The Sun company was then bought in 2009 by the Oracle company which now owns and maintains Java.

A special feature of Java is that software written in this language is compiled to an intermediate binary representation which can be executed in a Java Virtual Machine (JVM) without regard to the operating system(18).

4.2.3 Tools and technologies

NetBeans

NetBeans is an integrated development environment (IDE), placed in open source by Sun in June 2000 under CDDL (Common Development and Distribution License) and GPLv2 license. In addition to Java, NetBeans allows native support for various languages such as C, C ++, JavaScript, XML, Groovy, PHP and HTML, or others (including Python and Ruby) by the addition of plugins. It offers all the facilities of a modern IDE (editor with syntax highlighting, multi-language projects, refactoring, graphical editor of interfaces and Web pages).

Compiled in Java, NetBeans is available on Windows, Linux, Solaris (on x86 and SPARC), Mac OS X or under an independent version of the operating systems (requiring a Java virtual machine). A Java Development Kit JDK environment is required for development in Java.

NetBeans is also a platform that allows the development of specific applications (Swing library (Java)). The NetBeans IDE is based on this platform(18).

Figure 4.2: Main interface of NetBeans

Data base management

MySQL

MySQL is an open source relational database server. A database server stores data in separate tables rather than putting everything together in a single table. This improves the speed and flexibility of the whole. Tables are linked by defined relationships, which make it possible to combine data between multiple tables during a query. SQL in "MySQL" stands for "Structured Query Language": the standard language for database processing(19).

PhpMyAdmin

phpMyAdmin is an administration interface for the MySQL DBMS. It is written in PHP language and relies on the Apache HTTP server. It allows the administration of the following elements(8):

- databases.
- the tables and their fields (addition, deletion, definition of the type).
- indexes, primary and foreign keys.
- database users and their permissions.

WampServer

WampServer (formerly WAMP5) is a WAMP-type web development platform, allowing PHP scripts to work locally (without having to connect to an external server). WampServer is not in itself a software, but an environment comprising three servers (Apache, MySQL and MariaDB), a script interpreter (PHP), as well as phpMyAdmin for the Web administration of MySQL databases. It has an administration interface allowing to manage and administer its servers through a tray icon (icon near the Windows clock). The great novelty of WampServer 3 lies in the possibility of installing and using any version of PHP, Apache, MySQL or MariaDB in one click. Thus, each developer can faithfully reproduce his production server on his local machine(18).

4.3 Database

To implement our prototype, we created two databases:

*** The first database (registration)** It contains two tables:

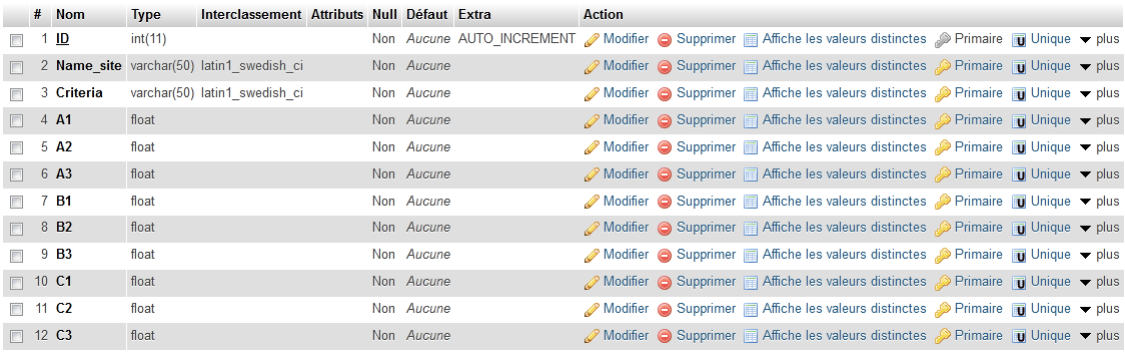
- Customer
- Provider

*** The second database (Fuzzy TOPSIS)** It contains 10 tables:

- Weighs
- Linguistic alternatives

- matrix alternatives
- normalized matrix
- weighs normalized matrix
- FPIS and FNIS
- distance negative
- distance positive
- somme
- closeness coefficient

The main table is the "Linguistic alternatives". Contains a list of e-commerce websites.



#	Nom	Type	Interclassement	Attributs	Null	Défaut	Extra	Action
1	ID	int(11)			Non	*Aucune*	AUTO_INCREMENT	Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
2	Name_site	varchar(50)	latin1_swedish_ci		Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
3	Criteria	varchar(50)	latin1_swedish_ci		Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
4	A1	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
5	A2	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
6	A3	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
7	B1	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
8	B2	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
9	B3	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
10	C1	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
11	C2	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus
12	C3	float			Non	*Aucune*		Modifier Supprimer Affiche les valeurs distinctes Primaire Unique plus

Figure 4.3: Table of linguistic alternatives

criteria used in our prototype in order to demonstrate the feasibility of our solution, we choose 4 Criteria:

Interface Customers come to the site to find out more about products, services, consumption or demand, so all information should be clarified.

Content It is the extent to which the website provides information about the characteristics and prices of the products / services, accurately and completely.

Response time the time between sending a request by a service user and receiving a response.

Reliability It is linked to the seller's ability to keep his promises on the Internet and to respect the exchange conditions which correspond to the degree of respect for the service promised in terms of quality, quantity, price and deadlines.

4.4 Presentation of graphical interfaces

We are going to limit to a few interfaces:

4.4.1 Home interface

One of the criteria that appeals to the user is the quality of the interface. From this we have tried to represent it in a good form while respecting the aspect of simplicity.

Figure 4.4: Main interface of the application

4.4.2 Main interfaces

Our system contains several interfaces that address the different use cases of e-commerce websites as follows:

Supplier Registration Interface

User must specify their status before registering as shown in the figure

Figure 4.5: supplier registration interface

Customer Registration Interface

The customer must also register in order to be able to perform his duties as shown in the figure

Figure 4.6: customer registration interface

Supplier login interface

In the case of adding a new e-commerce website to our database by a service provider, we must first authenticate the identity of the provider

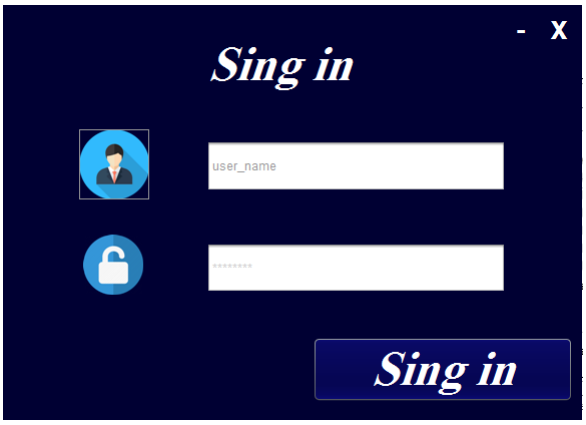


Figure 4.7: Supplier login interface

Customer login interface

A customer who requests an e-commerce website must first authenticate the identity

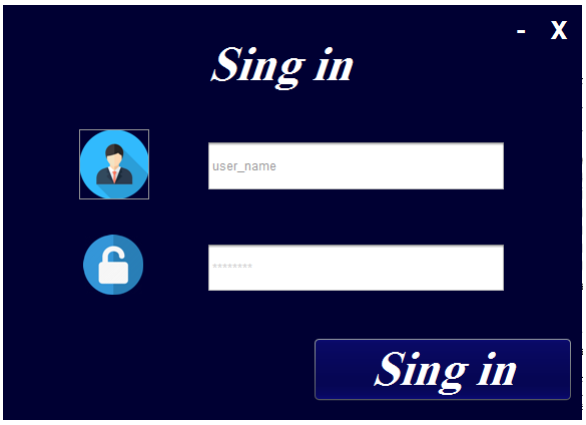


Figure 4.8: Customer login interface

4.4.3 Customer Space Interface

For the customer, once registered, he will be redirected to the “customer area”, which allows him to select the services that meet his needs via the interface shown in the figure.

Figure 4.9: Customer space interface

4.4.4 Supplier Space Interface

Once the supplier registers, they will be redirected to their Supplier Area where they can add a commercial website, edit values, or see the steps of the Fuzzy TOPSIS method. As shown in the figure

Figure 4.10: Supplier interface

Clicking "Add an E-Commerce Website" will bring up the Add an E-Commerce Website window

Figure 4.11: Add an E-Commerce Website interface

Click on the "Show" button to bring up a window that displays a table containing all the added e-commerce sites

Figure 4.12: Show interface

Clicking "Aggregate fuzzy criteria weights" will bring up the Define Fuzzy criteria weights window

Figure 4.13: Aggregate fuzzy criteria weights interface

Clicking "Weights" will bring up a window displaying the table of weights

Figure 4.14: weights interface

Clicking on "Aggregate fuzzy decision matrix for alternatives " will bring up a window that displays the Aggregate fuzzy decision matrix for alternatives

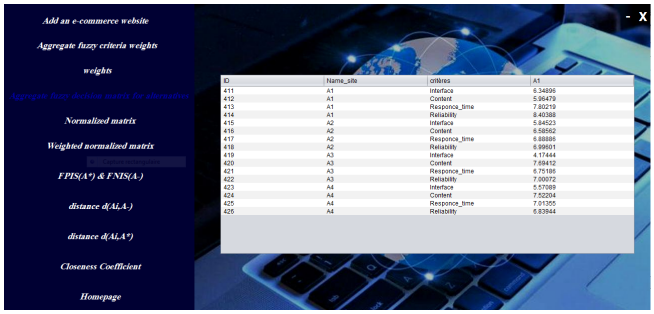


Figure 4.15: Aggregate fuzzy decision matrix for alternatives interface

Clicking on "Normalized matrix" will bring up a window that displays the Normalized matrix

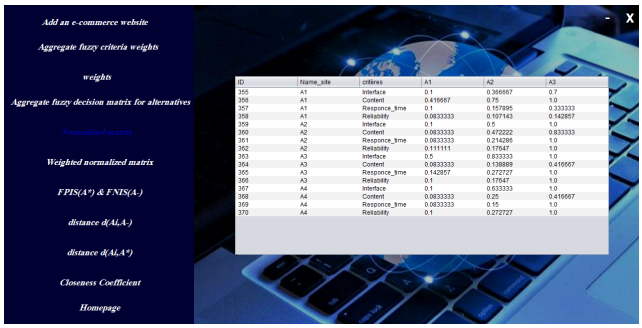


Figure 4.16: Normalized matrix interface

Clicking on "Weighted normalized matrix" will bring up a window that displays the Weighted normalized matrix

Figure 4.17: Weighted normalized matrix interface

Clicking on "FPIS(A*) and FNIS(A-)" will bring up a window that displays the FPIS(A*) and FNIS(A-)

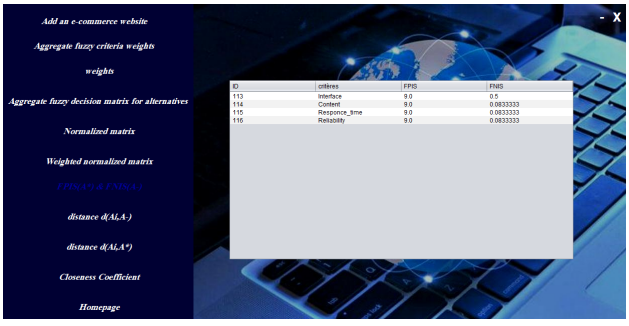


Figure 4.18: FPIS(A*) and FNIS(A-) interface

Clicking on "distance d(Ai,A-)" will bring up a window that displays the distance negative

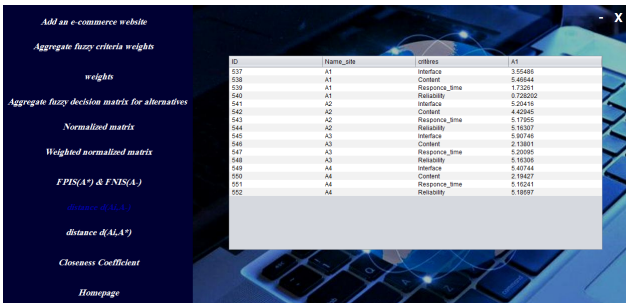


Figure 4.19: distance negative interface

Clicking on "distance d(Ai,A*)" will bring up a window that displays the distance positive

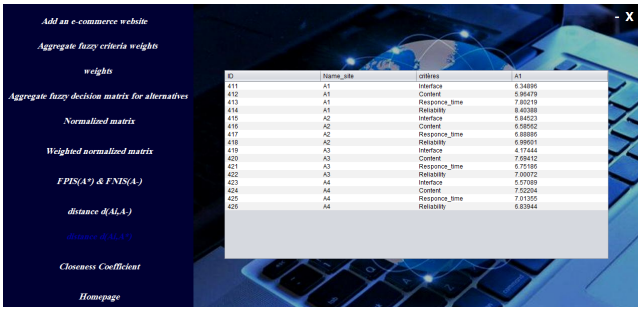


Figure 4.20: distance positive interface

Clicking on "Closeness Coefficient" will bring up a window that displays the Closeness Coefficient

Figure 4.21: Closeness Coefficient interface

4.5 Conclusion

To validate the design of the system, it must be implemented with appropriate tools. In this chapter, we provide some details about making our QoS-based business website selection application with the integration of the mysterious TOPSIS algorithm, which is to classify e-commerce websites with their criteria. By well-defined stages. From the results, we can confirm that the results are favorable and that the ambiguous TOPSIS method is very effective in choosing an e-commerce site. We have provided some details on the realization of our application and the choice of the Java programming language for its compatibility with object-oriented concepts and also for these multiple advantages of simplicity, portability and security.

General conclusion

This end-of-study project presents the fruit of our work, it allowed us to acquire a lot of new knowledge.

To achieve our goal, we started our work with a detailed presentation of Multi-criteria Fuzzy Decision Making (MCDM), which is a sub-field of process research that explicitly assesses many conflicting criteria in decision making.

We have used the fuzzy logic aspect to present the criteria for qualifying the alternatives in natural language. This technique makes it possible to properly evaluate the alternatives in linguistic terms and also makes it easier for non-experts to give their opinions or opinions better by characterizing the alternatives.

We suggest that e-commerce sites are a good example to show the feasibility of our approach and are also a good field of expertise for MCDM methods.

Right now, there are many e-commerce websites with similar functions that are provided by competing sellers, so end users need efficient methods of choosing the right site.

We have proposed a new approach for discovering online shopping sites, relying on the Fuzzy TOPSIS algorithm to set up similar services facilitating the selection of e-commerce sites based on customer needs.

Finally, we can confirm that fuzzy logic can be used with MCDM methods to present the criteria qualifying the alternatives in natural language which gives flexibility to clients and experts.

As perspectives of our work, we can apply our solution to a large Dataset of e-commerce websites and compare our approaches with other existing approaches.

Bibliography

[1] M. R. S.D. Pohekar, *Application of multi-criteria decision making tosustainable energy planning—A review.* Springer Science + Business Media, Received 1 December 2003 , accepted 19 December 2003.

[2] C. Kahraman, *MULTI-CRITERIA DECISION MAKING METHODS AND FUZZY SETS.* Taylor and Francis, 2008.

[3] R. K. Gavade, *Multi-Criteria Decision Making: An overview of different selection problems and methods.* (IJCSIT) International Journal of Computer Science and Information Technologies, 2014.

[4] M. Agustian Sinaga, A.Andri and M. I. Muhammad Fadly, *PEMILIHAN TOKO HANDPHONE TERBAIK DI KOTA PEMATANGSIANTA MENGGUNAKAN METODE ORESTE.* 2018.

[5] T.-F. L. Reay-Chen Wang, *Application of fuzzy multi-objective linear programming to aggregate production planning.* Computers and Industrial Engineering, 19 September 2003.

[6] S. M. L. Waiel F. Abd El-Wahed, *Interactive fuzzy goal programming for multi-objective transportation problems.* the international journal of management science, Received 19 June 2003, accepted 30 August 2004 Available online 19 October 2004.

[7] H. BELOUAAR, *Modélisation d'une approche basée agent et logique floue pour la qualité des servicesWeb.* universitaire biskra, 2018 – 2019.

[8] M. Europa, *Une approche de sélection des services Web basée sur la logique floue.* universitaire biskra, 6 juillet 2019.

[9] P. Amina S.Omar, Prof.Mwangi Waweru and D. Rimiru, *A Literature Survey: Fuzzy Logic and Qualitative Performance Evaluation of Supply Chain Management.* The International Journal Of Engineering And Science (IJES), 2015.

[10] B. S. BOUZID Houssam Eddine, *Application de la technique de la logique floue pour la prédiction de l'amorçage des intervalles d'air pointes-plans.* UNIVERSITÉ KASDI MERBAH, 23/06/2013.

[11] M. O. F. Z. née BILLAMI, *Classification des arythmies cardiaques par les arbres de décision flous*. Université Abou Bakr Belkaid– Tlemcen Faculté des Sciences Département d'Informatique, 06 décembre 2011.

[12] M. O. MOULKHALOUA Ali, *Conception et réalisation d'un site Web E-Commerce*. Université Abou Bakr Belkaid– Tlemcen, 27 Juin 2013.

[13] B. H. S. BENLAHCENE Sarra, *Conception et réalisation d'un site Web e-Commerce*. Université Abou Bakr Belkaid– Tlemcen, 26 Mai 2015.

[14] C. Bezes, *Evaluation des sites internet commerciaux : un état de l'art*. HAL L'archive ouverte pluridisciplinaire, Submitted on 21 Mar 2011.

[15] O. B. AROUS, *LA GESTION DE LA QUALITÉ DU SERVICE CLIENT*. L'UNIVERSITÉ DU QUÉBEC À TROIS-RIVIÈRES, DÉCEMBRE 2015.

[16] D. W.-W. Sylvie Rolland, *La qualité des sites Web marchands en distribution:proposition d'une échelle de mesure E-Qual*. HAL, 24 Apr 2007.

[17] I. IGOULALENE, *Développement d'une approche floue multicritère d'aide à lacoordinationdes décideurs pour la résolution des problèmes de sélectiondans leschaines logistiques*. UNIVERSITÉ D'AIX-MARSEILLEECOLE DOCTORALE ED 184, 02 décembre 2014.

[18] $https://fr.wikipedia.org/wiki/Java_{(}langage)$. 25-08-2020.

[19] *https://www.futura-sciences.com/tech/definitions/internet-mysql-4640/*. 2001-2020.