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New Neutrosophic Sentiment Analysis Method Based on NeutroAlgebra for the Evaluation of Ethics in Companies

Lilia Esther Valencia Cruzaty[1], Adriana Mercedes Ruiz Reynoso[2], Blanca Estela Hernández Bonilla[3]

[1] Universidad Estatal Península de Santa Elena (UPSE), Santa Elena, Guayas, Ecuador. Email: lvalencia@upse.edu.ec
[2] Universidad Autónoma del Estado de México, Centro Universitario (U UAEM), Valle de México, México. Email: amruizr@uaemex.mx
[3] Universidad Autónoma del Estado de México Centro Universitario (U UAEM), Valle de Teotihuacán, México. Email: behernandezb@uaemex.mx

Abstract. Ethics is a discipline that has broken the limits of its field of study, which is related to having the right behavior towards other people, but also to respect nature and life. This has been extended to the accounting and organizational management of companies. This paper proposes a sentiment analysis method based on the NeutroGroup obtained from offuninorms defined by the combining functions in Prospector. The advantage of the proposed method is that in addition to "like" and "dislike", we obtain a result of indeterminacy that can be due either to neutrality or to a contradiction in the short informal writing. The method is illustrated with an example. The application of neutrosophy in sentiment analysis is well-known since neutrality is included in the analysis. However, for the first time, to the authors' knowledge, the indeterminacy of two different types is modeled.

Keywords: Ethics, Business Management, NeutroAlgebra, Prospector, Sentiment Analysis.

1 Introduction

In the contemporary business context, ethics has expanded beyond its traditional scope, encompassing new areas of application, including accounting and organizational management. Ethics, in its broad sense, is defined as the discipline of having the right behavior. It has also application in the accounting field involving the evaluation of integrity, transparency, and responsibility within business organizations. These ethical principles are essential for building a solid and trustworthy corporate culture that not only complies with legal regulations but also promotes morally responsible business conduct.

Integrity in organizations refers to adherence to sound moral and ethical principles, including honesty and consistency between actions and the company's stated values. Transparency, on the other hand, relates to clarity and openness in the communication of information, allowing all stakeholders to have access to accurate and understandable data about the company's operations and decisions. Finally, responsibility implies the capacity and willingness of the organization to be accountable for its actions and decisions, assuming the consequences thereof.

To address the evaluation of these ethical aspects in business organizations, neutrosophic sentiment analysis methods offer an innovative and effective approach. Neutrosophy, a theory developed by Florentin Smarandache, focuses on the principle that every idea or concept has a degree of truthfulness, falsehood, and indeterminacy [1, 2]. Applied to sentiment analysis, this theory allows for a nuanced and precise evaluation of the perceptions and opinions that exist about an organization, considering not only positive and negative feelings but also neutral and ambiguous ones [3-13].

On the other hand, sentiment analysis also known as Opinion Mining defines the processes of extraction, analysis, and identification of opinions or emotions [14]. This is becoming increasingly important due to the possibility that new technologies offer to capture customer opinions. Users must constantly and globally express their opinions or likings about a service, product, or video, among others provided online. This helps to improve the quality of these features and at the same time personalize them. In this research, we propose a framework to measure integrity, transparency, and accountability in business organizations using neutrosophic sentiment analysis methods.

The use of neutrosophic methods in this research will allow us to capture a complete and detailed vision of how these ethical aspects are perceived in business organizations. This approach will consider not only the positive and negative extremes of opinions but also the neutral and ambiguous perceptions that are often ignored in traditional analyses. This will achieve a rich and accurate assessment of integrity, transparency, and accountability, providing a solid foundation for continuous improvement in business practices.

The incorporation of ethics in accounting and business management, through the use of neutrosophic methods

of sentiment analysis, represents a significant advance in the promotion of ethical and responsible business practices. This research will contribute to the development of tools and methodologies that facilitate the evaluation and improvement of these ethical principles in organizations, promoting a fair and sustainable business environment.

This article proposes a new method for sentiment analysis using a NeutroGroup based on combining function in Prospector [15-18]. A NeutroAlgebra is an algebraic structure where the definitions, operations between elements, axioms, etc., at least one of them is satisfied by only a part of the elements. The NeutroGroup on which we base this method has been applied to solve several real-life problems [15, 16]. The idea on which we are based is that this NeutroGroup offers an operation between pairs of elements where the indeterminacy that may be due to neutrality or contradiction is included.

To achieve this objective, the article is divided into several sections. Below we will find a Preliminaries section where some basic notions of Sentiment Analysis and NeutroAlgebras are explained. The following section contains the details of the proposed method applied to ethics with an illustrative example. The last section is dedicated to giving the conclusions.

2 Preliminaries

2.1 Sentiment Analysis

Sentiment Analysis refers to the use of natural language processing, text analysis, and computational linguistics to identify and extract subjective information from resources [14]. Regarding text mining, Sentiment Analysis can be dedicated to the task of classifying the polarity of information massively.

For sentiment analysis, there are key categories that are: lexical affinity, statistical methods, and concept-level techniques. However, we cannot escape the complexity involved in the task of measuring the feelings of a person or a group of people, due to the subjectivity that is an intrinsic part of the problem. This is because there are affective states that are temporary and that can be reflected in one way in a survey, but that moments later can change to a different state.

Specialists agree that one of the elements that cannot be missing from the measurement scale is neutral opinion, because the person is not able to discern their opinion between a negative or positive state, or because their opinion or feeling is in a neutral state that is neither positive nor negative. This is why the use of Neutrosophy is pertinent, since neutrality is part of this theory, in addition to the positive and negative. This can also be useful in studying the connotation of words within the text, which makes the task even more complex.

2.2 Neutral Algebra generated by the combining function in Prospector

For a certain natural number $n > 0$, NeutroGroup is defined from the combining function of Prospector. Prospector is the well-known Expert System used to model mining problems [17, 18]. The NeutroGroup set consists of all integers between $-n$ and n in addition to the symbolic element I to represent indeterminacy. This is $NG_5 = \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, I\}$ and $\oplus_5$ is used. This is defined according to the following Cayley table:

$\oplus_5$	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	I
-4	-5	-5	-5	-5	-4	-4	-4	-4	-3	-2	0	5
-3	-5	-5	-4	-4	-4	-3	-3	-2	-1	0	2	5
-2	-5	-5	-4	-3	-3	-2	-2	-1	0	1	3	5
-1	-5	-4	-4	-3	-2	-1	-1	0	1	2	4	5
0	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
I	-5	-4	-3	-2	-1	I	I	I	I	I	I	I
1	-5	-4	-2	-1	0	1	I	2	3	4	4	5
2	-5	-3	-1	0	1	2	I	3	3	4	5	5
3	-5	-2	0	1	2	3	I	4	4	4	5	5
4	-5	0	2	3	4	4	I	4	5	5	5	5
5	I	5	5	5	5	5	I	5	5	5	5	5

Table 1. Cayley table corresponding to $\oplus_5$. Source: [18].

$\oplus_5$ satisfies the properties of commutativity, and associativity and has 0 as the null element. Additionally, it satisfies each of the following properties:

- If x, y < 0 then $x \oplus_5 y \leq min(x, y)$,
- If x, y > 0 then $x \oplus_5 y \geq max(x, y)$,
- If x < 0 and y > 0 or if x > 0 and y < 0, then we have $min(x, y) \leq x \oplus_5 y \leq max(x, y)$.
- $\forall x \in G, x \oplus_5 0 = x$.
- $(-5) \oplus_5 5 = 5 \oplus_5 (-5) = I$.

3 New Neutrosophic Sentiment Analysis Model

The sentiment analysis method in this research uses neutrosophy to evaluate integrity, transparency, and accountability in business organizations. Through this theory, opinions and perceptions are analyzed considering degrees of positivity, negativity, and indeterminacy. This allows for capturing not only positive and negative but also neutral and ambiguous feelings, providing an accurate and nuanced assessment of business ethics, and improving the understanding of how these ethical aspects are perceived within organizations.

The aspects to measure in the sentiment analysis for ethics within the company are the following:

1. Integrity: The company and its members present themselves to others in a dignified manner. There is self-control over the behavior of each member personally and of the company as an entity.
2. Honesty: Evaluation of the perception of truthfulness and sincerity in the company's communications and actions.
3. Congruence: Analysis of the alignment between the values declared by the company and its actual practices.
4. Ethical Compliance: Measurement of adherence to recognized ethical standards and legal regulations.
5. Transparency: The members of the organization respond and express themselves openly to any question or demand from other members of the company. The company also maintains the data of its financial and economic management in public within the established limits.
6. Information Clarity: Evaluation of the accessibility and understanding of the information provided by the company.
7. Access to Information: Measurement of the availability of relevant information for interested parties.
8. Open Communication: Analysis of the openness and frequency of communication between the company and its interested parties.
9. Responsibility: The members of the organization and the company respond to their duties and obligations and in case of error they assume the consequences of them.
10. Accountability: Assessment of the company's willingness to take responsibility for its actions.
11. Incident Response: Measurement of effectiveness and transparency in response to problems or incidents.
12. Social and Environmental Impact: Analysis of the company's actions about their impact on society and the environment.

The other step to perform appears in the article [19]. The method we propose is applied to short informal texts, as in the case of the technique that appears above. A set of words must be determined that are classified as positive, negative, or neutral with a strength value that is evaluated in a range of -5 to 5 or indeterminate.

When the indeterminate form is evaluated in this way, it is because we cannot decipher what the person thinks about the topic. This may happen because the text is unintelligible or because the semantics of what the person means are not clear.

Another possibility is that in the same text, each of the previous variables is manifested with an evaluation of maximum positive degree (+5) and maximum negative degree (-5), which is a contradiction and therefore is evaluated as indeterminate I.

Let us remember that the function on which the PROSPECT expert system is based, means the degree of evidence that the expert has on a specific aspect. When this evidence is aggregated on two aspects for which there is maximum evidence of opposite degrees, then there is a contradiction. This is why we talk about the advantage of this method using this NeutroOperation, where the indeterminacy can be due to two origins.

Some aspects that we have used are taken from SentiStrength Sentiment Strength Detection Algorithm [19].

- Terms referring to each of the previous variables are classified as Positive, Negative, or Neutral in a list that is made up of linguistic values. Each of these terms is also associated with a value between -5 and 5, and even I, according to its degree of strength of how positive or negative it is. For example, the term “I like it” is modified with a greater positive value when “I like it a lot” is written, while “I don't like it” is similarly intensified with a more negative value when it is written “I don't like it very much”.

What applies is that for the word “very” or “a lot” which modifies one of the positive or negative classifying words, is used $x \oplus_5 x$, and for “too much” is used $x \oplus_5 x \oplus_5 x$, where x is the value that is associated with the word. For example, $x > 0$ results in “very” with an even more positive value. On the other hand, when $x < 0$, the result is more negative.

Additionally, the modification of “quite” is converted to $\left[sig(x)\sqrt{|x|}\right]$.

- Words that invert the meaning of what is said are also taken into account. In this case, the sign is changed. For example, “I like it” with a value of $x = 3$, when it comes to “I don't like it” it is calculated as $x = -3$, both have the same strength, but with an opposite sense.
- In this algorithm, very complex cases, where there are exclamation or question marks, are ignored, since we want to evaluate what members of the organization or clients write, in case it makes sense, about each of the twelve aspects of the ethics indicated in the previous points.
- Another aspect that is taken into account in the proposed algorithm taken from the precedent is the evaluation

of emoticons.

- Spelling correction is also applied here.

The next step is the evaluation of a short informal text written by a person. To do this, natural language processing is done where words that express feelings or opinions about each of the twelve aforementioned aspects are searched. Let us denote these aspects as: $V = \{v_1, v_2, \cdots, v_{12}\}$.

Then, within the text processing, the words referring to each of these variables are identified. These words are identified with a value of -5 to 5 or I. Let us denote this as follows, for the i[th] variable, the set X_i of evaluations of words that appear in the text:

$v_i \rightarrow X_i = \{x_{i1}, x_{i2}, \ldots, x_{im_i}\}$, where x_{ij} is the set of elements in -5 to 5 or I, used to qualify the words that refer to the i[th] variable.

Keep in mind that even the individual evaluation of each word can be complicated. For example, when modifiers like "very" appear, then the value of the modified word changes. Also when there are spelling errors that make some evaluation illegible, it is necessary to use the value I. The final value associated with each v_i is:

$$x_{total,i} = x_{i1} \oplus_5 x_{i2} \oplus_5 \ldots \oplus_5 x_{im_i} \quad (1)$$

Let us note that we consider it not convenient to obtain an aggregated ethics value for all variables since the separate value is more useful to have an idea of individual opinion or sentiment.

If we have a set of people whose opinion on ethics in the company is studied. Let us denote this set of people by $P = \{p_1, p_2, \cdots, p_l\}$, such that the values are taken into account, $x_{total,i,j}$ is the total value of the i[th] variable of ethics in the organization, according to the j[th] person.

It is calculated:

$$\bar{x}_{total,i} = \frac{\sum_{j=1}^{l} x_{total,i,j}}{l} \quad (2)$$

That is, the arithmetic mean of each of the variables is calculated.

Figure 1 represents graphically a scheme of the proposed method:

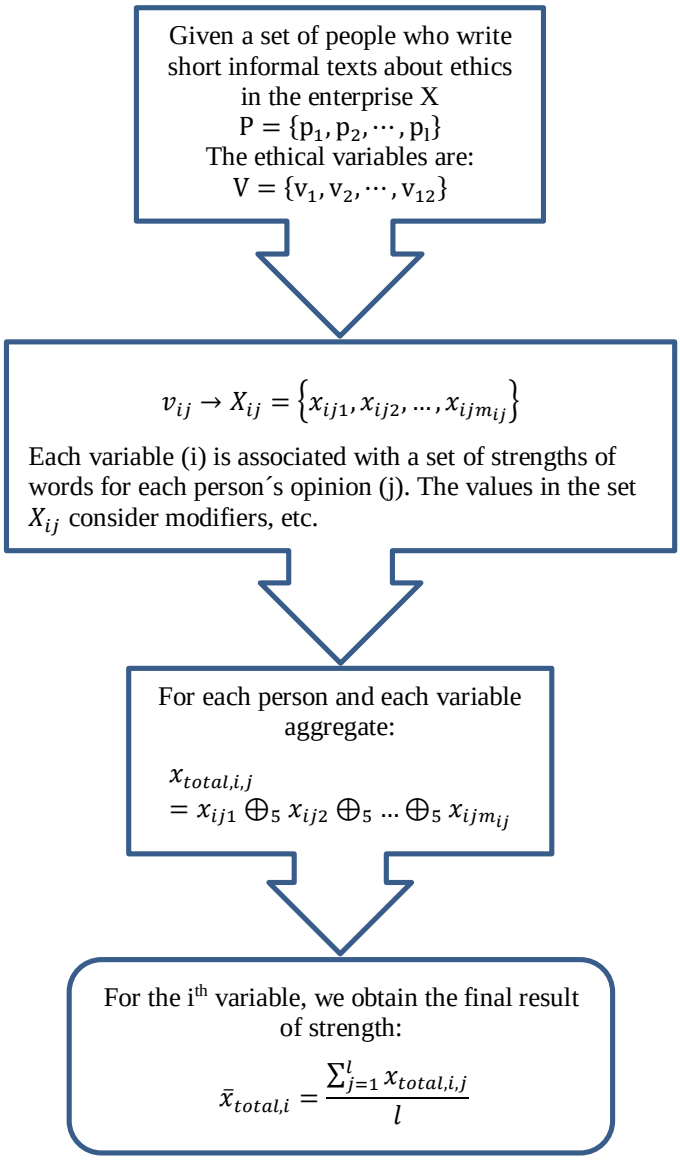

Figure 1: Schematic representation of the proposed method.

Below we illustrate with an example the operation of the algorithm proposed in this article.

Example 1. Suppose that in company X a website is enabled where workers can freely express their opinion on ethics within the company as part of internal control. Comments are expressed anonymously to ensure sincerity. The text written by the workers is processed using the method proposed in this article.

Suppose that regarding honesty, the first worker expressed in the same text that "the company's honesty is enough good" and in another part that "it is not enough good". In this case, the following is assigned to the variable v_2:

$v_{21} \rightarrow X_{i1} = \left\{\left[sig(3)\sqrt{|3|}\right], \left[sig(-3)\sqrt{|-3|}\right]\right\}$, that is, the first person feels that there is enough honesty (degree $\left[sig(3)\sqrt{|3|}\right] = 2$ because 3 is the assignment to good honesty according to the assignment of a number to each word and this is the formula to obtain a fair value), and the opposite for it is assigned $\left[sig(-3)\sqrt{|-3|}\right] = -2$ (and therefore the sign is changed to change the meaning), and then $2 \oplus_5 (-2) = 0$. That is, this result is completely canceled and any other result is taken into account. For example, if somewhere else he/she wrote that there is a lot of honesty in the company, then it is calculated $2 \oplus_5 (-2) \oplus_5 (3 \oplus_5 3) = 0 \oplus_5 4 = 4$.

Here "a lot of honesty" is understood as $3 \oplus_5 3 = 4$, according to the proposal we made.

If a second worker considers that dishonesty is maximum and honesty is also maximum; for example: "there is too much honesty" and "there is too much dishonesty", then, in this case, it is calculated:

$3 \oplus_5 3 \oplus_5 3 = 5$ for the modifier in "too much honesty" and $(-3) \oplus_5 (-3) \oplus_5 (-3) = -5$ for "too much dishonesty." So in this case they are not canceled, but rather indeterminate $5 \oplus_5 (-5) = \mathrm{I}$.

From Table 1 it is seen that this indeterminacy disappears when the operator with a third negative value is applied, for example, $5 \oplus_5 (-5) \oplus_5 (-3) = \mathrm{I} \oplus_5 (-3) = -3$. However, when the third value is positive, indeterminacy is maintained with the idea of always taking a "pessimistic" opinion.

Note also that extreme values exercise veto power over any other opinion. That is, if the opinion is 5 or -5, then any aggregation results in 5 or -5, respectively.

On the other hand, in writing where an unintelligible text about honesty appears, either due to syntactic or semantic problems, then the value I is directly assigned.

Conclusion

This paper describes a new neutrosophic model of sentiment analysis. The model is based on the NeutroGroup generated by an offuninorm [20, 21, 22] for values on a scale from -5 to 5 and also the symbolic value I to denote indeterminacy. Twelve ethics variables were set in the company and an algorithm was designed to calculate the value of each of these variables within the previous scale in the company. To do this, workers are asked to express their opinion on each of these variables according to a short informal written text. The model allows us to deal with indeterminacy both due to contradiction and because the written text does not make sense. The effectiveness of the created model was illustrated with an example.

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