Neutrosophy, a sentiment analysis model

Abstract

This paper describes the importance of neutrosophy theory in order to find a method that could solve the uncertainties arising on discursive analysis. The aim of this pilot study is to find a procedure to diminish the uncertainties from public discourse induced, especially, by humans (politicians, journalists, etc.). We consider that Neutrosophy Theory[1] is a sentiment analysis specific case regarding processing of the three states: positive, negative, and neutral. The study is intended to identify a method to answer to uncertainties solving in order to support politician's staff, NLP specialists, artificial intelligence researchers and generally the electors.

1 Introduction

This study is the first step of a research that points out the uncertainties solving in discursive analysis. The research is based on Neutrosophy Theory (Smarandache, 2005), a new theory of states treatment with a generous applicability in sciences, like artificial intelligence (Vladareanu et al, 2014).

In fact the novelty of neutrosophy consists of approaching the indeterminacy status that we can associate to neutral or objective class of sentiment analysis (SA) (Gîfu and Scutelnicu, 2013), known as *opinion mining* (Pang and Lee 2008). Actually, SA is a very important task of Natural Language Processing (NLP), the most known SA classification of texts being in two classes: *objective* and *subjective* most often more difficult to undertake than polarity classification (Mihalcea et al., 2007).

We believe that Neutrosophy Theory seen as SA model would be useful for NLP specialists, linguistics, journalists, politicians, PR, and other scientists interested to find a method of uncertainties solving.

The paper is structured as follows: after a brief introduction, section 2 describes the background related to neutrosophy applicability; section 3 discusses the annotations regarding neutrosophy theory described in transposed in algebraic structures, and finally section 4 depicts some conclusions and directions for the future work.

2 Background

According to the neutrosophy theory, the neutral (uncertainty) instances can be analyzed and accordingly, reduced. There are some spectacular results of applying neutrosophy in practical application such as artificial intelligence (Gal et al, 2011). Extending these results, neutrosophy theory can be applied for solving uncertainty on other domains; in Robotics there are confirmed results of neutrosophics logics applying to make decisions when appear situations of uncertainty (Okuyama el al 2013; Smarandache 2011).

The real-time adaptive networked control of rescue robots is another project that used neutrosophic logic to control the robot movement in a surface with uncertainties for it (Smarandache, 2014). Starting of this point, we are confidence that neutrosophy theory can help to analyse, evaluate and make the right decision in discursive analysis taking into account all sources that can generate uncertainty, of not informed electors, lack of information in candidates' politic campaign, not a strong candidate's propaganda, etc.

3 The Fundamentals of Neutrosophy

The specialty literature reveals Zadeh introduced the degree of membership/truth (t), so the rest would be $(1-t)$ equal to f, their sum being 1, and defined the fuzzy set in 1965.

In 1986, Atanassov introduced the degree of non-membership/falsehood (f) and defined the intuitionistic fuzzy set.

if

$$0 \le t+f \le 1$$

and

$$0 \le 1-t-f$$

would be interpreted as indeterminacy

$$t + f \le 1$$

Why was it necessary to extend the *fuzzy logic*?

[1] This theory was revealed in 1995 (published in 1998) and defined neutrosophic set. He has coined the words "neutrosophy" and "neutrosophic".

The indeterminacy state, as proposition, cannot be described in fuzzy logic, is missing the uncertainty state; the neutrosophic logic helps to make a distinction between a 'relative truth' and an 'absolute truth', while fuzzy logic does not.

As novelty to previous theory, Smarandache introduced and defined explicitly the degree of indeterminacy/neutrality (i) as independent component, where:

$$0 \le t+i+f \le 3$$

a) if

$$t+i+f < 1$$

we have incomplete information;

b) if

$$t+i+f = 1$$

we have complete information (and get intuitionistyic fuzzy set);

c) if

$$t+i+f > 1$$

we have paraconsistente information (contradictory).

In neutrosophy set, the three components t, i, f are independent because it is possible to get from a source (t), from another independent source to get (i) and from the third source to get (f).

Smarandache goes further, he refined the range (Smarandache, 1995)

a) The n-Symbol-Valued Refined Neutrosophic Logic

In general:

T can be split into many types of truths:

$$T_1, T_2, \ldots, T_p,$$

and I into many types of indeterminacies:

$$I_1, I_2, \ldots, I_r,$$

and F into many types of falsities:

$$F_1, F_2, \ldots, F_s,$$

where all

$$p, r, s \ge 1$$

are integers, and

$$p + r + s = n.$$

All subcomponents T_j, I_k F_l are symbols for $j \in \{1,2,\ldots,p\}$, $k \in \{1,2,\ldots,r\}$, and $l \in \{1,2,\ldots,s\}$.

If at least one

$$I_k = T_j \wedge F_l = \text{contradiction},$$

we get again the Extenics[2]

b) *The n-Numerical-Valued Refined Neutrosophic Logic*

In the same way, but all subcomponents T_j, I_k, F_l are not symbols, but subsets of $]^-0, 1^+[$, for all $j \in \{1,2,\ldots,p\}$, all $k \in \{1,2,\ldots,r\}$, and $l \in \{1,2,\ldots,s\}$.

Even more:

T, I, *and/or* F (*or any of their subcomponents* T_j, I_k, *and/or* F_l) *can be countable or uncountable infinite sets*.

If all sources of information that separately provide neutrosophic values for a specific subcomponent are independent sources, then in the general case we consider that each of the subcomponents T_j, I_k, F_l is independent with respect to the others and it is in the non-standard set $]^-0, 1^+[$. Therefore per total we have for crisp neutrosophic value subcomponents T_j, I_k, Fl that:

$$^-0 \le \sum_{j=1}^{p} T_j + \sum_{k=1}^{r} I_k + \sum_{l=1}^{s} F_l \le n^+$$

where

$$n = p+r+s$$

as above.

If there are some dependent sources (or respectively some dependent subcomponents), we can treat those dependent subcomponents together.

For example,

if

T_2 and I_3 are dependent, we put them together as

$$^-0 \le T_2 + I_3 \le 1^+$$

The non-standard unit interval

$$]^-0, 1^+[$$

used to make a distinction between *absolute* and *relative* truth/indeterminacy/falsehood in philosophical applications is replaced for simplicity with the standard (classical) unit interval $[0, 1]$ for technical applications.

For at least one

$$I_k = T_j \wedge F_l = \text{contradiction}$$

[2] Extenics is a new discipline, it uses formal model research the possibility of expand thinking and the rules and methods of opening innovation and uses to solve the paradoxical problem of science.

we get again the Extenics.

For instance:

Electing for a candidate means (t), electing black vote him means (f), or indeterminacy (non-electing, blind vote) (i).

We can refine, that is:

t_1 = people from Region1 who voted for candidate

t_2 = people from Region2 who voted candidate

and similar:

i_1= those indeterminately people from Region1

i_2 = those indeterminately people from Region2, ...;

and

f_1 = those from Region1 who voted against the candidate C1

f_2 = those from Region2 who voted against the candidate C1

Further we shall make a comparative analysis between neutrosophy and SA.

3.1 Neutrosophy vs. sentiment analysis

A logic in which each proposition is estimated to have the percentage of truth in a subset T, the percentage of indeterminacy in a subset I, and the percentage of falsity in a subset F, where T, I, F are defined above, is called *Neutrosophic Logic*.

Similarly sentiment analysis defines states as positive, negative and neutral.

Neutrosophy	**SA**
T	positive
I	neutral
F	negative

Statically T, I, F are subsets, but dynamically the components T, I, F are set-valued vector functions/operators depending on many parameters, such as: time, space, etc. (some of them are hidden parameters, i.e. unknown parameters):
T(t, s, …), I(t, s, …), F(t, s, …)
where

t = time, s = space …

that's why the neutrosophic logic can be used also in quantum physics. If the Dynamic Neutrosophic Calculus can be used in discursive analysis, neutrosophics tries to reflect the dynamics of things and ideas.
For example:
Tomorrow it will be raining.

does not mean a fixed-valued components structure.

Moment	NT	value	SA
t1	T	40%	positive
today	I	50%	neutral
	F	45%	negative

according with new evidences, sources,

t2	T	50%	positive
today	I	49%	neutral
	F	30%	negative
Tomorrow			
t1	T	100%	positive
	I	0%	neutral
	F	0%	negative

if tomorrow it will indeed rain. (Smarandache, 2005).

In this context, the dynamics reveals: the truth value changes from a time to another time

Example: In an election process with 2 candidates C1 and C2 we have options:
The neutrosophic space M1 = {$a_{11}(t_1, i_1, f_1)$, $a_{12}(t_2, i_2, f_2)$, $a_{13}(t_3, i_3, f_3)$} for candidate C1 and M2 = {$a_{21}(t_1, i_1, f_1)$, $a_{22}(t_2, i_2, f_2)$, $a_{23}(t_3, i_3, f_3)$} space for candidate C2 where the law of neutrosophic social structure is: winning the election.
Data obtained of two candidates are:

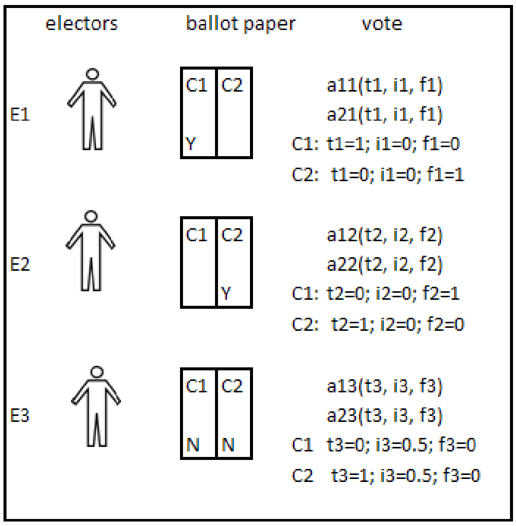

Figure 1 Election process

Analysing $a_{11}(t_1=1, i_1=0, f_1=0)$ means that elector E1 voted candidate C1

$a_{12}(t_2=0,\ i_2=0,\ f_2=1)$ means that elector E2 voted candidate C2

$a_{13}(t_3=0,\ i_3=0.5,\ f_3=0)$ means that elector E3 gave a black vote for Candidate C1 resulting uncertainty of 50%.

3.2 Neutrosophic algebraic by examples

In any field of knowledge, each structure is composed of two parts: a space, and a set of axioms (or laws) acting (governing) on it. If the space, or at least one of its axioms (laws), has some indeterminacy, that structure is a (T, I, F) -Neutrosophic Structure.

1) *Indeterminate Space (due to Unknown Element)*

Let the set (space) be

$$NH = \{4, 6, 7, 9, a\}$$

where the set NH has an unknown element "*a*", therefore the whole space has some degree of indeterminacy.

Neutrosophically, we have

$$a(0, 1, 0)$$

which means the element *a* is 100% unknown.

2) Indeterminate Space (due to Partially Known Element).

Given the set:

$$M = \{3, 4, 9(0.7, 0.1, 0.3)\}$$

we have two elements 3 and 4 which surely belong to M, and one writes them neutrosophically as 3(1, 0, 0) and 4(1, 0, 0), while the third element 9 belongs only partially (70%) to M, its appurtenance to M is indeterminate (10%), and does not belong to M (in a percentage of 30%).

Suppose M is endowed with a neutrosophic law* defined in the following way:

$$x_1(t_1, i1, f_1) * x_2(t_2, i_2, f_2) = \max\{x_1, x_2\}(\min\{t_1, t_2\}, \max\{i_1, i_2\}, \max\{f_1, f_2\})$$

which is a neutrosophic commutative semigroup with unit element 3(1, 0 ,0).

Clearly

if

$$x, y \in M,$$

then

$$x * y \in M$$

Hence the neutrosophic law * is well defined.

Since max and min operators are commutative and associative, then * is also commutative and associative.

3) Indeterminate Law (Operation).

For example, let the set (space) be:

$$NG = (\{0, 1, 2\}, /)$$

where "/" means division.

NG(T, I, F) – *is a neutrosophic groupoid*, because the operation "/" (division) is partially defined and undefined (indeterminate).

$$2/1 = 1$$

which belongs to NG;

$$1/2 = 0.5$$

which does not belongs to NG;

$$1/0 = \text{undefined}$$

So the law defined on the set NG has the properties that:

- applying this law to some elements, the results are in NG [well defined law];
- applying this law to other elements, the results are not in NG [not well defined law]; applying this law to again other elements, the results are undefined [indeterminate law].

4 Conclusions and future work

In this paper it is presented a way of correcting the uncertainties arising in discursive analysis applying neutrosophy theory in relation with sentiment analysis. The neutrosophy theory could be considered a sentiment analysis model for solving the uncertainty (neutral), extended in IT applications, logistics, and human resource.

In the future work we will be oriented to find an algorithm to achieve the objectives to improve the percentage of stable statuses, to reduce the neutrality/uncertainty.

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