Neutrosophy, a possible method of process analysis uncertainties solving

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Abstract

This paper presents the importance of neutrosophy theory in order to find a method that could solve the uncertainties arising on process analysis. The aim of this pilot study is to find a procedure to diminish the uncertainties from automotive industry induced by manufacturing, maintenance, logistics, design, human resources. We consider that Neutrosophy Theory is a sentiment analysis specific case regarding processing of the three states: positive, negative, neutral. The study is intended to identify a method to answer to uncertainties solving in order to support automotive managers, NLP specialists, artificial intelligence researchers and business man in general.

1 Introduction

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

In fact the novelty of neutrosophy consists of approaching the indeterminancy status that we can associate to neutral or objective class of sentiment analysis (SA) known from the classification of texts into two classes: *objective* and *subjective*, most often more difficult to undertake than polarity classification (Mihalcea et al., 2007) on neutral class of sentiment analysis known as *objective* (Gîfu and Scutelnicu, 2013). As a matter of fact, we found for SA different terms, mentioned in chronological order: *subjectivity* (Lyons 1981; Langacker 1985); *evidentiality* (Chafe and Nichols 1986); *analysis of stance* (Biber and Finegan 1988; Conrad and Biber 2000); *affect* (Batson, Shaw, and Oleson 1992); *point of view* (Wiebe 1994; Scheibman 2002); *evaluation* (Hunston and Thompson, 2001); *appraisal* (Martin and White 2005); *opinion mining* (Pang and Lee 2008), and *politeness* (Gîfu and Topor, 2014).

We believe that such as method would be useful for automotive managers, NLP specialists, artificial intelligence researchers, other scientists interested to find a method of uncertainties solvinving.

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 algebric structures, section 4 presents some indicators of process stability and finally section 5 depicts some conclusions and directions for the future.

2 Preview work

According to the neutrosophy theory, the neutral (uncertainty) instances can be analysed and accordingly, reduced. There are some spectacular results of applying netrosophy in practical application such as artificial intelligenge (Gal et al, 2011). Extending this results, neutrosophy theory can be applied for solving uncertainty on other domains; In Robotics there are confirmed results of neutrosofics 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 process analysis taking into account all sources that can generate uncertainty, from human being (not appropriate skill), logistics concept, lack of information, programming automation process according requirements, etc.

3 The Fundamentals of Neutrosophy

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

Two decades later, Atanassov introduced the degree of nonmembership/falsehood (f) in 1986 and defined the intuitionistic fuzzy set. He said 0<= t+f <= 1 and 1-t-f would be indeterminacy, their sum would be 1.

Why was it necessary to extendthe *fuzzy logic*?

Because a paradox, as proposition, can not be described in fuzzy logic; and because the neutrosophic logic helps make a distinction between a 'relative truth' and an 'absolute truth', while fuzzy logic does not.

As novelty to previos theory Smarandache introduced the degree of indeterminacy/neutrality (i) as independent component, defining 0<= t+i+f <= 3;if sum t+i+f < 1 we have incomplete information; if sum t+i+f =1 we have complete information (and get intuitionistyic fuzzy set); if sum t+i+f > 1 we have paraconsistente information (contradictory). This theory was revealed in 1995 (published in 1998) and defined neutrosophic set. He has coined the words "neutrosophy" and "neutrosophic".

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, etc., that's why the neutrosophic logic can be used also in quantum physics. If the Dynamic Neutrosophic Calculus can be used in psychology, nutrosophics 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			
Same 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.

In process analysis can appear a situation like this: a work station endowed with robots which process different parts with appropriate auxiliary parts for LH and RH these representing option. Operator must take the right aux part and to put on robot tool.

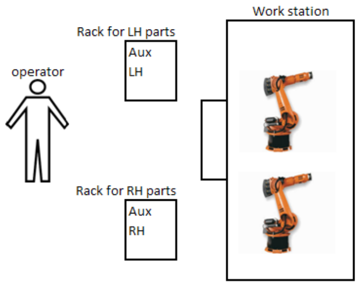

Fig.1 Work station

If operator chooses the right aux part of 2 possibilities:

Oper	NT	value	SA
O1	T	75%	positive
	I	50%	neutral
	F	0%	negative

The robot can process tha part and to send it forward, .n cycle time,

If the same operator chooses the wrong part of 2 possibilies:

Oper	NT	value	SA
O1	T	10%	positive
	I	50%	neutral
	F	90%	negative

The robot cannot process the part, for it uncertainty is error, so machine is in waiting attention, manual intervention, indicators like OEE, MTTR, MTBF are alterated, efficiency decrease.
If the same operator chooses the wrong part of 3 possibilies, suppose options of color in harmony with inner:

Oper	NT	value	SA
O1	T	10%	positive
	I	70%	neutral
	F	90%	negative

Percentage of wrong choice increase, it is important to solve/eliminete the uncertainty.

Logistics represents the department that supply the chain just in time (JIT) and just in place (JIP). If on line arrive wrong part (another code), in the wrong place, parts with defects, it is obvious that the operator induce at his turn confusion/uncertainty. In this situation it is a great concern who, what, how to intervene to diminish the confusions/uncertainties.

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 write *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:

x1(t1, i1, f1)* x2(t2, i2, f2) = max{x1, x2}(min{t1, t2}, max{i1, i2}, max{f1, f2})

which is a neutrosophic commutative semigroup with unit element 3(1, 0 ,0).
Clearly, if *x*, *y* ϵ *M*, then *x***y* ϵ 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 is a *(T, I, F) - 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 = undefined (indeterminate).
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 Indicators for process stability measuring

In automatical systems equipments operates in cycles time defined as sum of status: cycling time (machine is in cycling/operating), starved time (machine finished cycle tine but previous station cannot deliver part), blocked time (machine finished cycle time but cannot delivery the part to the next station because it is in cycle), waiting aux part time (machine process the part in addition with an auxiliary part that is not present), waiting attention time (machine is in fault and wait for operator to make decision), repair in progress (machine is in repairing), emergency stop (general stop for whole station), bypass (station is not operating, skip), tool change (machine needs to change tool), setup (time for parameters changes), break time (break for operators lunch time), no communications (network communication error) (Fig. 2).

These statuses are defined in PLC (programmable logic controller) for process analyse and evaluation. Related on these statuses are proceeded also the maintenance indicators.

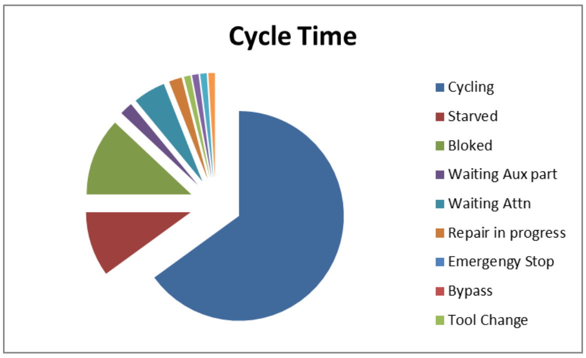

Fig.2 The structure of a machine cycle time

The OEE is measured as:
`(Availability) * (Performance) * (Quality)`
where:

- **Availability** is OEE Metric that represents the percentage of scheduled time that the operation is available to operate. Often is referred as Uptime.
- **Performance** is OEE Metric that represents the speed at which the Work Center runs as a percentage of its designed speed.
- **Quality** is OEE Metric that represents the Good Units produced as a percentage of the Total Units Started.
- **Definition of a failure** - failure is declared when the equipment does not meet its desired objectives. Therefore, we can consider any equipment that cannot meet minimum performance or availability requirements to be “failed”. Similarly, a return to normal operations signals the end of downtime or system failure, is considered to be “non-failed”.

Mean Time to Repair (MTTR)- is the mean time of the facility in the status of “Repair”, and it is calculated as:

MTTR = Repair in Progress Time (min)/ Repair in Progress Occurrences

Mean Time Between Failures (MTBF)- shows the amount of time the machine spends in production time as a percentage of all the states except Break and No Communications.

MTBF = (Time in Auto / Total Time) x 100

where:

Time in auto = Cycling Time + Blocked Time + Starved Time + Waiting Auxiliary Time + Bypass Time

and

Total Time = Cycling Time + Blocked Time + Starved Time + Waiting Auxiliary Time + Bypass Time + Tool Change Time + Waiting Attention Time + Shutdown Time + Emergency Stop Time + Set Up Time

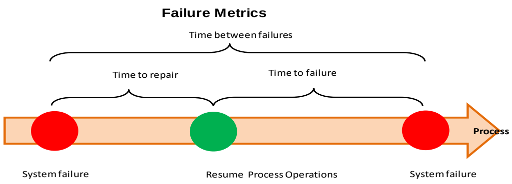

Fig.3 Failure milestones

A process is stable when there is no variability in the system, when the outcome is by design, as expected. The systems variation we are talking about in this study refers to uncertainty, confusion that can occur in various situations in the manufacturing process that, can lead to another product than expected one, or a scrap.
In a process, practically can occur such situations when we are put in a position of uncertainty that leads the process variation to instability, to errors. Below are presented two methods of analysis, evaluation and correction of the process: the Ishikawa diagrams and Pareto chart.
Ishikawa diagrams (also called fishbone diagrams, cause-and-effect diagrams) are causal diagrams created by Kaoru Ishikawa (1968) that shows the causes of a specific event (Womack, James P, Daniel T. Jones, and Daniel Roos,1990; Holweg, Matthias 2007). Common uses of the Ishikawa diagram are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of process variation. Causes are usually grouped into major categories to identify the sources of variation such as: people, methods, machines, materials, measurements, environment (Ishikawa, Kaoru, 1976).

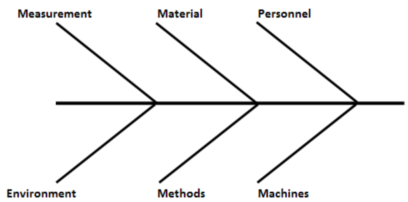

Fig.4 Ishikawa diadram

Related to these categories can be extended to detailed items like anyone involved with the process, how the process is performed and the specific requirements for doing it, policies, procedures, rules, regulations and laws, any equipment, computers, tools, etc. required to accomplish the job, raw materials, parts, pens, paper, etc. used to produce the final product, data generated from the process that are used to evaluate its quality, the conditions, such as location, time, temperature, and culture in which the process operates (Juran J. M., & Gryna F.M., 1970).

Pareto analysis is a statistical technique in decision-making used for the selection of a limited number of tasks that produce significant overall effect. It uses the Pareto Principle (also known as the 80/20 rule) the idea that by doing 20% of the work you can generate 80% of the benefit of doing the entire job.

Step 1: Identify and list problems – that occur in manufacturing process with the highest frequency and concern the process.

Step 2: Identify the root cause of each problem – for each issue it is important to identify the fundamental cause. The used methods can be: Brainstorming, 5 Whys, Cause and effect analysis, and Root cause analysis.

Step 3: Score problems – scoring each problem depends on the sort of problem that it has to be solved, for quality, safety, efficiency, and cost.

Step 4: Group problems together by root cause – similarly problems belong to the same group.

Step 5: Add up the scores for each group – assign scores to each group of problems.

Step 6: Take action – is the moment to deal with the top priority problem, group of problems and also the purpose that you want (Montgomery, 1985).

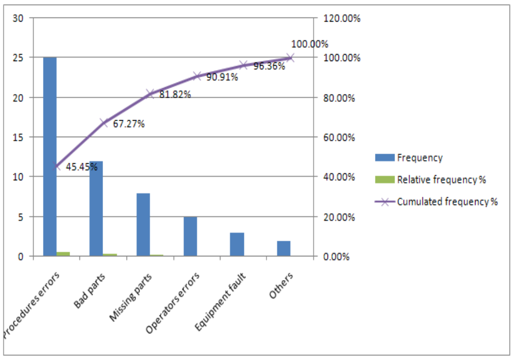

Fig. 5 Pareto charts

In this example there are few issues that appear in process analysis. Examining "Operators errors" we can make the decision that human errors can be diminished by an IT application, automatisation, to reduce human decision. It is true that in a process analysis in which can appear confusion of choicing the appropriate part (for example between left and right), it can generate errors. Automatization of process can avoid human error, sustained by appropriate IT applications, andons, operators training. Analyzing a cause that generates 20% of errors, and eliminate it by investing in process, it can solve 80% of issues.

5 Conclusion and future wotk

We presented a way of correcting the uncertainties arising in process analysis applying neutrosophy theory in relation with sentiment analysis.

This result can drive us to use the neutrosophy theory for solving the uncertainty, extended in IT applications, logistics, human resources

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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