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Fuzzy to Quality: A practical application of ISO 25000 (SQuaRE), ISO 9000 and Fuzzy Logic

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Summary: *An autonomous control system allows the transfer of incoming information through the input data at the output. The answers are defined according to their functions established during their projects. Already in an intelligent system, they provide in their outputs answers or information that are often not foreseen in their projects and can also be compared in parts with biological systems.*
In human decision-making, we often deal with uncertainties and inaccuracies in solving various problems. To simulate the same form of biological reasoning in an intelligent computational machine, the fuzzy logic resources were used to solve problems that can not be solved by applying the digital logic of the current computers.
The fuzzy logic allows to aid in making decisions that approximate the deductive reasoning to infer conclusions based on the known information. This technique allows you to design systems that adapt and learn from the experience gained with your environment, and can be modified and adjusted according to your needs. Its application can be extended to analyze quality projects in production lines, services and various other areas of science and commercial applications.
In this work, the objective is to propose a new technique of applying fuzzy logic to controls of qualities and uncertainties in an intelligent machine and to assist in the analysis of critical decision making in real time. The use of the Likert scale to measure qualitative measures and quality standards 25000 SQuaRE (Systems and software Quality Requirements and Evaluation) in the quality control of services with ISO 9000 is also applied in this work.
Keywords: *Biological systems, fuzzy systems, critical decision making, real time, intelligent computational machine.*

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I. Introduction

Many software and application systems assist in storing and presenting data in the form of text, tables or graphs for problem solving, but final decision-making must be performed by man. There are situations that are not present or visible when dealing with relations between information. These connections (or relations) can often not be formalized in their entirety; moreover, their patterns can not be recognized to aid in scientific or business decision making, since they are between [0,1]. In current computational results, nebulous reasoning because they are analog can not be defined through digital logic.

Fuzzy logic techniques can be designed to develop non-binary reasoning, it is able to produce knowledge through its learning and to act in situations often not predicted in its environment of dynamic or little known action. It is also known that process modeling can be defined through: methods of experiments, mathematical modeling or heuristics. However the method adopted in this work is based on mathematical and heuristic modeling. In a development of software systems, it is known that there are several different activities, which must be integrated, specified and validated, for which quality must be prevailed.

The application of the development model of a project must be established and several stages of project management require decision making where the variables are not defined exactly. The present work has the objective of presenting a proposal for the application of fuzzy techniques, ISO / IEC 25000 (SQuaRE) and ISO 9000 standard for quality management of products and services.

II. Intelligent Sytems

Intelligent systems have attributes of coupling between the agent and its environment, because its quality is defined according to its behavior with its interaction and interaction environment, to fit the required states and actions. In mathematical modeling the behavior of an intelligent system is defined through the agent function in which the sequences of perceptions are mapped to the execution of a specific action. It also requires the concept of rationality, performance measurement, learning, autonomy, knowledge of its environment and definition of the types of agents for the definition and application of Artificial Intelligence techniques to solve their problems.

III. Fuzzy Logic and Intelligent Control

The application of fuzzy logic techniques allows the implementation in intelligent systems to be more efficient, since they allow the insertion of knowledge and human experiences. The principle of fuzzy logic is based on the concept of multivalence, logic of uncertainty and the application of intuitive logic, in addition, real numbers can be translated into percentages (%) for the representation of intelligence (through a fuzzy inference) in a machine intelligent.

A fuzzy operation allows quantitative values to be classified into qualitative values (such as: high, medium, low), which define the information required for the activities of the human brain and vice versa (qualitative and quantitative) for intelligent machines. The representation of knowledge is defined by the behavior, use of linguistic variables, relationships between these variables and the application of rules and conditions obtained by specialists or extracted from their data. We often call it expert systems and its main elements are: data entry, the fuzzifier (data that is transformed into information), a knowledge base (defined by rules and decisions) and the defuzzifier (they are the information in numerical forms).

Fuzzy logic uses linguistic variables (symbolic elements) to represent their knowledge (can be: high, medium or low) and measure a measure. They are also associated with degree of pertinence or functions of pertinence. In addition, the representation of its behavior by the variables is established by the rules of its linguistic variables of the type (If ... then), as shown in table-01.

Functional adequacy and linguistic variables	"X" OU "( )"	Punctuation	Relevance (μ)	Assigned values
Totally disagree (DT)	( )	10	[0,1]	
Disagree (D)	( )	20	[0,1]	
Indifferent (I)	( )	30	[0,1]	
I agree (C)	( )	40	[0,1]	
Totally Agree (CT)	( )	50	[0,1]	

Tabela-01 Regras e variáveis linguísticas.

IV. Logical Reasoning, Information and Knowledge Base.

Logical Reasoning

Reasoning according to classical logic defines the principle of reason is the way to make an inference based on propositions considered valid. It is known that the types of reasoning can be classified into: verbal, spatial and abstract reasoning. In addition, the main synonyms for reasoning are: argumentation, judgment, pondering, and intelligence.

A logical reasoning is the way one structures and organizes the thought to reach an objective and solution of some problem, applying rules and norms acquired over time. Lets make inferences, argue, analyze, justify and prove their accuracy.

Information

It is known that an information is the result of the manipulation and processing of the data, besides its organization of qualitative and quantitative form of the input data received. However the information received is individual, since the value of this information can vary according to the need of each person. It is known that information can be classified into stimulus information for the senses, pattern, message, transformation, data or record.

Knowledge Base

For the area of artificial intelligence the representation of knowledge and reasoning are part of the study center of the science of autonomous automation for action and interaction with its environment. This is because often these interactions are not observable and can not be described. Logic and learning, as well as knowledge, may be the only way to represent it, for it is necessary to create a knowledge base.

It is known that a knowledge base is formed by a set of sentences and relations between them. In addition, they should be able to be added, consulted and inferred. A sentence can be formed by syntaxes, semantics, logical relations, operations on the relations and some algorithm for its handling of its rules and restrictions established by specialists of the subject of each area to be carried out and according to the needs of the moment.

V. Software Quality Control, Likert scale, ISO / IEC 25000 standard (SQuaRE) and ISO 9000 model

Dealing with the fundamentals of quality requires a lot of complexity because it is not just about following some specification or description of the development needs of a product or meeting the requirements of the customers. Often the key quality features are not clear when it comes to services or qualitative metrics. The key steps in service management can be classified into assurance, planning and quality control. As ISO 9000 standards, quality management, are sets of standards that can be applied within various organizations to develop products or services.

According to ISO 9001, the generic model of quality processes and definitions of standards and procedures that should be part of an organization. The main areas defined by ISO 9001 for quality assurance are specified in Figure-01.

Model ISO 9001					
Management	System Quality				
Control of non-compliant product	Project Control				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Handling, storage, packaging and delivery purchases	shopping				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Products Provided to the Buyer	Identification and ease of product tracking				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Process control	inspection and test				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Inspection and testing equipment	Inspection and test status				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Contract Review	Corrective action				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Document control	Quality records				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Quality internal audits	Training				
	Totally disagree	Discordo	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
Provision of services	Statistical techniques				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )

Figure-01 ISO 9001 model for quality assurance.

VI. ISO Standard 25000 (SQuaRE)

The ISO 25000 (SQuaRE-Systems and software Quality Requirements and Evaluation) is a combination of several model standards to define models of software development qualities, in addition to defining processes and products to follow their evolution. The main ones of this model are divided into: quality of management, models, metrics, requirements and evaluations.

ISO / IEC 25000: 2014, provides 5 divisions which are: quality management (2500n), quality model (2501n), quality measurement (2502n), quality requirements (2503n) and quality evaluation (2504n). Figure-02 shows the ISO / IEC 25010 Software quality system model for the application of the main quality features.

Model ISO/IEC 25000:2014					
Quality Model Division	*SQuaRE*				
ISO/IEC 25010	Funcional adequacy				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Performance Efficiency				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Compatibility				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Usability				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Reliability				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Safety				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Maintenance / Maintainability				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )
	Portability				
	Totally disagree	Disagree	Indifferent	Agree	Totally Agree
	( )	( )	( )	( )	( )

Figure-02 ISO / IEC 2510 model.

Fuzzy relevance functions

The main functions of fuzzy pertinence are z, type π, type λ and type S. These are the functions in which they define the degree of pertinence (μ) for a given linguistic term, which can vary between 1 (100% of relevance) to 0 (0% relevance), however it is known that there are other types of membership functions. Figure 3 shows the graphical model for the description of the "triangular" type membership function, in which it was used to exemplify the use of ISO 90001 and ISO / IEC (SQuaRE) models with fuzzy logic. The figure-04 is the definition of the linguistic variables.

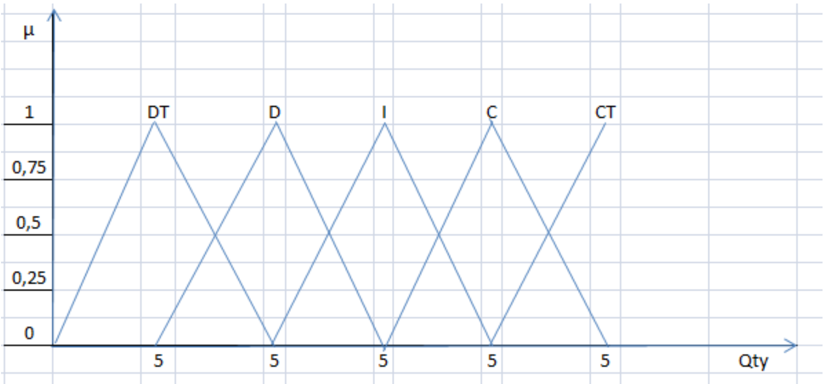

Figure-03 fuzzy graphic

DT (Totally Disagree)
D (Disagree)
I (Indifferent)
C (Agree)
CT (Totally Agree)

Figure-04 Linguistic variable.

Figure-05 shows the aggregation table of the linguistic variables for the management of the activities of the ISO 9001 model. The main linguistic variables defined are: DT (totally disagree), D (Disagree), I (Indifferent), C (I agree) and CT (I totally agree).

Table of aggregation of linguistic variables					
Management	DT	D	I	C	CT
Control of non-compliant product					
Handling, storage, packaging and delivery purchases					
Products Provided to the Buyer					
Process control					
Inspection and testing equipment					
Contract Review					
Document control					
Quality internal audits					
Provision of services					

Figure-05 Totalization table of the linguistic variables for the ISO 9001 model.

Figure-06 shows the aggregation table of the linguistic variables for the management of the activities of the ISO / IEC 25000: 2014 (SQuaRE) model.

Table of totalization Model ISO / IEC 25000: 2014 *(SQuaRE)*					
Quality model division	DT	D	I	C	CT
Funcional adequancy					
Compatibility					
Usability					
Confiability					
Safety					
Maintenance / Maintainability					
Portability					

Figure-07 Totalization table of the linguistic variables for ISO / IEC 25000: 2014 (SQuaRE) model.

VII. Application and analysis of fuzzy logic, ISO 25000 (SQuaRE) and ISO 9000

Figure-08 presents the results of an analysis and application of fuzzy logic with the ISO 9001 model for the management of its activities and descriptions of services and products. Linguistic variables, rules and risk levels were defined through the fundamentals of fuzzy logic. The structure of the forms can be used as a standard for the application of fuzzy logic to the models of quality standards of services and products.

In this work were simulated with 10 specialists from the areas of product development and service rendering to analyze the quality of software. The values assigned to the linguistic variables show the results of 10 tokens filled out by experts in the area. Next, you present the mean and compare the risk levels. The risk level values were applied: fuzzy inference, fuzzification and defuzzification, function of pertinence and type of function, for the application of the ISO 9001 model and fuzzy logic, for quality assurance.

The result of the application compares the results of the means with the levels established by the rules that are defined by the specialists of each management area. Similarly, the procedures for the results presented in figure-09 of ISO / IEC 25000: 2014 (SQuaRE) with fuzzy logic were performed. These results are transformed and stored in the form of knowledge or fuzzy subsets associated with each linguistic variable and its fuzzy set operations.

Table of aggregation of linguistic variables										
Management	DT	D	I	C	CT	Rules	Risk: Adequate or low	Risk: Medium and High	Risk: Inadequate	Average
Control of non-conforming product	2 (1)	1 (.5)	2 (1)	3 (.33)	4 (.25)	<.5	[.0, .2]	[.25, .8]	[.75]	.61
Handling, storage, packaging and delivery purchases	3 (.33)	4 (.25)	0 (.0)	3 (.33)	3 (.33)	>.7	[.0, .2]	[.25, .8]	[.75]	.23
Products Provided to Buyer	1 (.5)	1 (.5)	4 (.25)	3 (.33)	1 (.5)	>0,9	[.0, .2]	[.25, .8]	[.75]	.41
Process control	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	>0,9	[.0, .2]	[.25, .8]	[.75]	1
Inspection and Testing Equipment	1 (.5)	2 (1)	2 (1)	3 (.33)	2 (1)	1	[.0, .2]	[.25, .8]	[.75]	.76
Contract Review	2 (1)	1 (.5)	3 (.33)	4 (.25)	0 (.0)	1	[.0, .2]	[.25, .8]	[.75]	.41
Document Control	2 (1)	3 (.33)	3 (.33)	1 (.5)	0	1	[.0, .2]	[.25, .8]	[.75]	.43
Quality internal audits	2 (1)	2 (1)	2 (1)	1 (.5)	3 (.33)	1	[.0, .2]	[.25, .8]	[.75]	.96
Provision of services	3 (.33)	2 (1)	1 (.5)	1 (.5)	3 (.33)	1	[.0, .2]	[.25, .8]	[.75]	.53

Figure-08 Result of ISO 9001 x fuzzy model management for quality assurance.

The results presented in figure-08 are composed of the assignment numbers for the cells of the linguistic variables assigned to each datasheet distributed to each specialist in each area, and the pertinence values for each cell are given below with the summation in decimal numbers (or percentages). Next, the values of the rules of fuzzy inference, as defined by the experts of each area, are assigned. The risks according to the fundamentals of fuzzy logic in adequate (or low), medium and high and inadequate levels (in situations that are not part of the analysis) are also defined. The weighted average of the membership functions is calculated and then compared with the risk levels for each activity of the standards. The result is the presentation of the analysis according to the definitions made by the experts.

Table of totalization Model ISO / IEC 25000: 2014 *(SQuaRE)*										
Quality model division	DT	D	I	C	CT	Rules	Risk: Adequate or low	Risk: Medium and High	Risk: Inadequate	Average
Funcional adequancy	2 (1)	2 (1)	2 (1)	3 (.33)	1 (.5)	>0,9	[.0,.2]	[.25,.8]	[.75]	.76
Compatibility	1 (.5)	1 (.5)	1 (.5)	4 (.25)	1 (.5)	>0,9	[.0,.2]	[.25,.8]	[.75]	.45
Usability	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	>0,95	[.0,.2]	[.25,.8]	[.75]	1
Confiability	2 (.5)	3 (.33)	1 (.5)	1 (.5)	3 (.33)	>0,9	[.0,.2]	[.25,.8]	[.75]	.53
Safety	2 (1)	1 (.5)	1 (.5)	4 (.25)	2 (1)	1	[.0,.2]	[.25,.8]	[.75]	.65
Maintenance / Maintainability	3 (.33)	1 (.5)	1 (.5)	1 (.5)	4 (.25)	1	[.0,.2]	[.25,.8]	[.75]	.35
Portability	2 (.5)	2 (.5)	2 (.5)	4 (.25)	0 (.0)	0,95	[.0,.2]	[.25,.8]	[.75]	.65

Figure-09 Result of the ISO / IEC 25000: 2014 or SQuaRE model, for Division fuzzy quality model.

The application of the logic and reasoning is inserted by the specialists of each area, during the establishment of the rules and inferences for the decisions of levels of risks for the definition of all the activities described by standards and quality models ISO 9000, ISO 25000 and Likert scales , for the definition of linguistic variables and fuzzy logic inferences. The classification of pertinence values is calculated by the values of each level established by each cell of its linguistic variables. The information of the variable "Average" describes the information of the results of the level of risk in relation to each of the activities of the division of the quality model.

The result of the information "Average" is obtained through the relations of the linguistic variables, rules and the levels of risks. By storing this information in the knowledge base, we establish the degrees of intensity between the relationships in which they represent the levels of values of that information. In this way it is possible to store and retrieve the behavior recorded at the time of its capture, through space, action and time, simultaneously in three dimensions of the space plane, as shown in figure-10. In view (A), the spatial allocation of the 3 dimensions is observed, whereas in the view (B), it shows the execution of the activities, variables and the information generated.

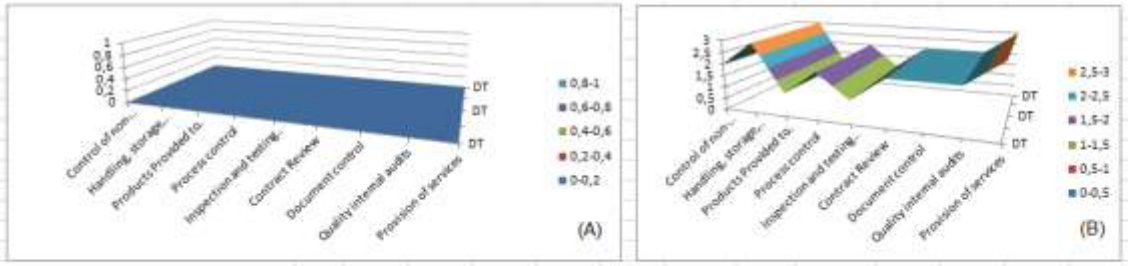

Figure-10 spatial view of the three dimensions and relationship between variables.

Figure 11 shows a spatial distortion for an unsupported value for a linguistic variable in document control. It is observed that the intensity of the relationship changes the results of the information and the general behavior of these relations.

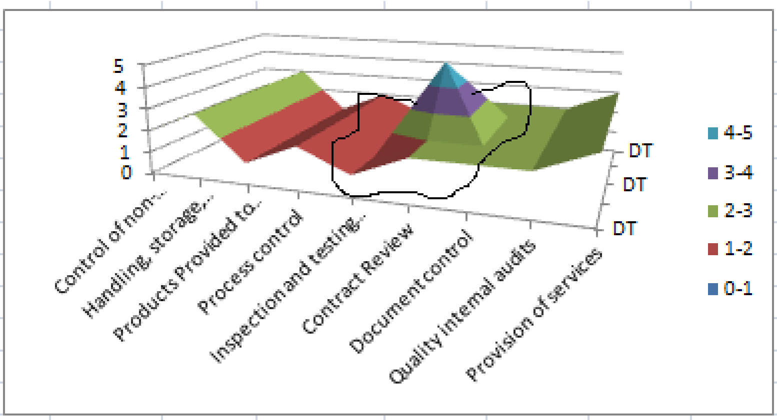

Figure-11 Spatial distortion for incompatibility of the document control variable for language variable DT, level 4.

Figure 12 shows the new level adjustment of the space for new knowledge base learning. The behavior of knowledge registers the new changes and dimensions of the current states. Represents the new information acquired in real time.

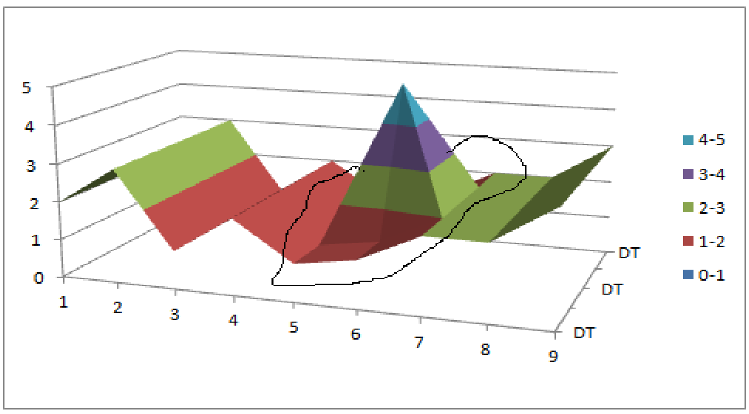

Figure-12 Graph of the new learning space, adjusted for a new situation.

Figure 13 shows the risk management information from Quality Management for the activities corresponding to Nonconforming Product Control (Medium and High Risk), Handling, Storage, Packaging and Delivery Purchasing,

Table of aggregation of linguistic variables											
Management	DT	D	I	C	CT	Rules	Risk: Adequate or low	Risk: Medium and High	Risk: Inadequate	Average
Control of non-compliant product	2 (1)	1 (.5)	2 (1)	3 (.33)	4 (.25)	< .5	[.0, .2]	[.25, .8]	[.75]	.61
Handling, storage, packaging and delivery purchases	3 (.33)	4 (.25)	0 (.0)	3 (.33)	3 (.33)	> .7	[.0, .2]	[.25, .8]	[.75]	.23
Products Provided to the Buyer	1 (.5)	1 (.5)	4 (.25)	3 (.33)	1 (.5)	>0,9	[.0, .2]	[.25, .8]	[.75]	.41
Process control	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)	>0,9	[.0, .2]	[.25, .8]	[.75]	1
Inspection and testing equipment	1 (.5)	2 (1)	2 (1)	3 (.33)	2 (1)	1	[.0, .2]	[.25, .8]	[.75]	[illegible]
Contract Review	2 (1)	1 (.5)	3 (.33)	4 (.25)	0 (.0)	1	[.0, .2]	[.25, .8]	[.75]	.41
Document control	2 (1)	3 (.33)	3 (.33)	1 (.5)	0	1	[.0, .2]	[.25, .8]	[.75]	.43
Quality internal audits	2 (1)	2 (1)	2 (1)	1 (.5)	3 (.33)	1	[.0, .2]	[.25, .8]	[.75]	[illegible]
Provision of services	3 (.33)	2 (1)	1 (.5)	1 (.5)	3 (.33)	1	[.0, .2]	[.25, .8]	[.75]	.53

Figure-13 Risk Level Information.

Figure 14 shows a flat view of ISO 9001 model management, where there is no relationship between language variables, only the presentation of data without any associated information, only data that needs to be analyzed and calculated.

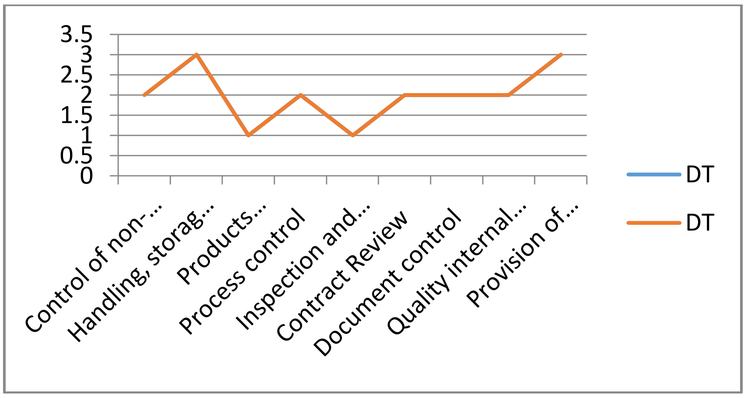

Figure-14 Data of the linguistic variables of the ISO-9001 model.

VIII. Conclusion

The main definitions for this work are based on: quality of services and products with the application of ISO 9000 and ISO 25000 (SQuaRE) and fuzzy logic. In addition, assist in the decision making and participation of specialists from each area to define the essential rules that are compatible with the business rules of each company, to meet their business goals and objectives. The applications allow to present their results in a qualitative and quantitative way to aid in decision making that often appear in nebulous or indecisive form.

The results of the proposal of this work were presented as shown in Figures-01 to Figure-13 to generate the information, knowledge base, storage form and capture of this information for the ISO 9000 model. of the proposal submitted for ISO / IEC 25000 (SQuaRE).

It can be observed that the Fuzzy to Quality research and development work has contributed to the analysis of risk levels of services and products. Through the input data indecisively or nebulously was able to transform with fuzzy logic and ISO 9000 and ISO 25000 / IEC quality models (SQuaRE), generate, store and retrieve information by applying fuzzy logic, inference rules, fuzzification and defuzzification and knowledge base formation. In this way the strategic alignment of companies with quality of services and products was carried out. For future work the proposal is in the integration with a neural network with the fundamentals of statistics and probabilities of biostatistical neural networks (RNB).

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