Resistance, sensitivity and risks bonded to knowledge

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Abstract - the mobility of the experts to the inside and out of the company, the modification of the parameters relating to the product or its manufacturing process, the market trends, the multiplication of the sites of production are as many causes to the difficulties of the companies of capitalizing, of managing and of perennialized their knowledge and their know-how. The problems of the robustness of knowledge vis-à-vis the technical and economic risks are posed then.
We propose in this article a way of modelling of the criteria of robustness by supporting us on concepts resulting from the fields of engineering from knowledge and data processing.

Keywords: Robustness, Knowledge, Knowledge Based System, criteria of robustness

I. INTRODUCTION

In order to capitalize their knowledge and their know-how, the companies call in particular upon the tools and the methods resulting from engineering of knowledge. But this activity of safeguarding of knowledge [GRU, 95] is carried out in a context changing, due to the social, economic or technical evolutions of order.

So the concept of robustness of the knowledge modelled within the knowledge bases of the company can play an important part in particular for reasons of reactivity of manufacturers vis-à-vis markets unceasingly in evolution.

In this article, we initially approach the various existing approaches of the concept of robustness of knowledge. We propose then a definition of the concept of robustness from a temporal point of view and a point of view of the use of the knowledge bases. Then we present criteria allowing evaluating the robustness of knowledge. Finally we will use will illustrate ourselves the use of one of these criteria by means of algorithms and a tool for visualization of the robustness of knowledge.

II. PROBLEMS

The conservation of knowledge of the company became a crucial stake to ensure their perpetuation. The companies are thus based in particular on the engineering of knowledge which provides a whole of tools and methods for capitalization.

Knowledge can be obtained mainly in two manners. Methodologies (MASK [ERM, 01]…) propose to use the experts of the company as source of knowledge. But it is also possible to obtain knowledge starting from documents resulting from the activity of the company [BOU, 96; ASS, 98; BIE, 99].

Knowledge is thus modelled starting from a sight on the field of knowledge at a given moment and according to a methodology. This fact a divergence between the field of knowledge and its model (the knowledge base) can appear.

Two sources of divergence can be observed:

A first source of divergence can come from the evolution of field of knowledge [BEN, 01]. Because of the technical evolutions, social and economic, knowledge is not solidified and evolves in time. This evolution must be taken into account (see Fig. 1).

One can consequently wonder:

If the base is not intended to evolve or, which risk does one take did not evolve yet to use at a knowledge base which is in divergence with the field of knowledge?

If the base is intended to evolve, which modifications are necessary to carry out on the basis of knowledge to take into account the evolution of the field of knowledge?

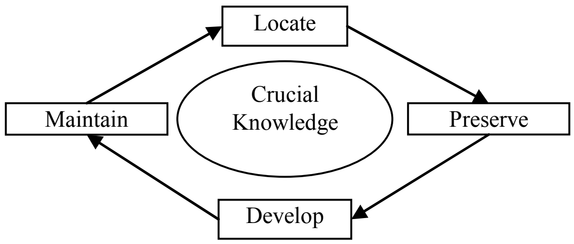

Fig. 1. Cycle life of knowledge [GRU, 95]

One second source of divergence can come from a bad modelling of the field of knowledge, from where the existence of methods for validation of the knoweldge based systems [PRE, 01]. Errors in the choice of the documents or experts source of knowledge, the use of an unsuited method can lead for example to inconsistencies or lacks within the knowledge base. These errors will thus have consequences on the quality of the exploitation of the knowledge base.

One can thus wonder in which proportion modelling influences the results of the use of the knowledge base by the users.

There are at the present time two approaches in connection with the concept of robustness of knowledge. The first [HSU, 98] is interested in the robustness of rules of know-how and second [GRO, 00] is focused on the robustness of knowledge based systems (KBS).

Within the framework of the relational databases, Hsu [HSU, 98] is interested with knowledge allowing to optimize the requests sent by the users a database.

The level of robustness of knowledge is a function of the probability that a transaction carried out on the basis of data returns invalid knowledge.

The model suggested by Hsu [HSU, 98] is not easily transposable on other knowledge based systems because the evaluation of the robustness applies to the knowledge represented by rules and does not take into account the notes represented by other types of formalisms such as for example the semantic networks.

The second approach, suggested by Groot [GRO, 00] is not directly related to the robustness of knowledge. This approach rests on the evaluation of the robustness of the knowledge based systems.

Groot proposes to measure the variation of the quality of the exits of a knowledge based system according to the quality of the entries. The criteria used to evaluate the quality of the exits are the precision and the exhaustiveness of the answers. The study of the variation of the quality of the exits according to the quality of the entries makes it possible to determine the robustness of the system.

The model suggested by Groot [GRO, 00] has as principal advantage of being able to be used on several types of systems bases on knowledge. Unfortunately its approach does not make the distinction between the robustness of the knowledge based system and the robustness of knowledge.

It is thus a question on the one hand of analyzing the evolution of the quality of the knowledge base in the course of time. It is necessary in addition to analyze the evolution of the quality of the answers resulting from the exploitation of the knowledge base, while concentrating only on the influence of the knowledge base with respect to the quality of the answers.

The concept of robustness of knowledge is thus articulated around two axes: a temporal axis and an axis relating to the use and the exploitation of the knowledge base.

III. PROPOSAL

A. Definition of the robustness

We propose to analyze the problem of the robustness of knowledge according to two points of view. The temporal point of view makes it possible to take into account the divergence between the knowledge base and the field of knowledge due to the evolution of this last. The contextual point of view makes it possible to take into account the divergence between the knowledge base and the field of knowledge because of the errors of modelling.

1. Temporal robustness

One is interested here in the capacity at the knowledge base to resist the evolutions of the field of knowledge.

The field of knowledge to model within the knowledge base is depending on the evolution of the real world. The evolutions of the technical, social and economic environment can call into question the current knowledge and know-how.

The knowledge base is built according to the state of the field of knowledge, being able to be represented by documents or knowledge of the experts. But after the modelling of this knowledge, the filed of knowledge continues to evolve. A stage of maintenance is then necessary to preserve the integrity of the knowledge base vis-à-vis the field of knowledge.

Ideally, a modification of the field of knowledge should result in a modification of the knowledge base. This dynamics can be difficult to set up because it can be difficult to have access and to detect these evolutions.

A robust knowledge base makes it possible to limit the effects of the modifications of the field of knowledge. It can preserve a sufficient quality in spite of the evolutions of the field of knowledge and without maintenance of the knowledge base.

2. Contextual robustness

A knowledge base robust from the contextual point of view and exploited through an inference engine provides the answers awaited by the user.

We suppose here that the inference engine is of sufficient quality. Consequently the quality of the provided answers, defined for example by their exhaustiveness and their precision by Groot [GRO, 00], is dependant on the quality of the knowledge base. Thus the variation of the quality of the answers does not define any more the robustness of the knowledge based system but makes it possible to directly evaluate the robustness of the knowledge base.

So a knowledge base is robust if it makes it possible to maintain the quality of the provided answers, some is the context of use.

Temporal dimension does not intervene here. The evaluation of the contextual robustness is carried out only on the current state (or at a moment given *T*) of the knowledge base.

IV. TO DEFINE MEANS TO EVALUATE THE ROBUSTNESS OF KNOWLEDGE

With an aim of evaluating the robustness of knowledge, we wish to define and set up a certain number of criteria of evaluation. Each criterion makes it possible to evaluate an aspect of the robustness of knowledge but does not allow estimating in a total way the robustness.

We propose to organize the criteria in three classes of abstraction corresponding each one to a different point of view of analysis (see Fig. 2).

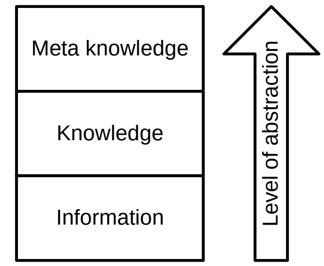

Fig. 2. Level of abstraction of information towards the meta knowledge

A. Criteria dependant on the level information

The criteria dependants on the level information are evaluated and are based on the activity around the knowledge based system.

The level information does not ask for a high level of abstraction and it is thus easier to obtain the evaluation of the criteria related to this level. In the other hand, these criteria do not make it possible to define the robustness of knowledge directly, but make it possible to obtain indices as for the evolution or the localization of the zones of robustness.

The evaluation is carried out starting from the histories of use of the systems related to the knowledge base. The inference engine makes it possible to obtain traces on the use of the knowledge base. The basic editor of knowledge allows obtaining statistics in connection with the maintenance of the knowledge base. The information system manages the documents of the company of which documents forming the corpus. One obtains by his intermediary of information on the evolution of the documents of the corpus.

B. Criteria dependant on the level knowledge

The level knowledge asks for a higher level of abstraction. Knowledge necessary for the evaluation of the criteria of robustness of this level can be provided by an expert. Knowledge thus obtained forms a model partial of the field of knowledge which it will be a question of comparing with that contained in the knowledge base.

The criteria of this level make it possible to obtain an evaluation based on the direction with contrary of the criteria of level information which offer a statistical evaluation. However the evaluation of these criteria can be less controllable because of intervention of the expert. Moreover considering the possible size of a knowledge base, it would be illusory to entrust to only one expert the task to evaluate the whole of the criteria, especially if this task must be often repeated.

It would thus be necessary to choose several experts for this task of evaluation, which poses problems of methodology for the choice of the experts and the distribution of the work of evaluation between them.

The evaluation of the criteria of robustness is carried out thanks to the judgments of the experts. The experts being always in activity in the company, their knowledge evolve at the same time as knowledge of the field of knowledge. Thanks to the experts, it is also possible to take into account the tacit notes on the level of the evaluation of the criteria of robustness.

C. Criteria dependant on the level meta knowledge

The level meta knowledge asks for the most level of abstraction. This meta knowledge can be stated are forms of rules to check in an automatic way the knowledge base. They can be provided by the experts who have enough retreat on their field of knowledge to provide this type of rule.

The analysis on the level meta knowledge makes it possible to evaluate robustness in the automatic and systematic way on the unit of the knowledge base. However obtaining the rules can be difficult considering the level of knowledge which they ask on the field of knowledge.

The analysis of the robustness with these rules consists in analyzing the knowledge base how complies with these rules. The analysis can relate for example to the frequency of errors on the basis of knowledge or the frequencies of error compared to a given rule.

Consequently, taking into account the three points of view of evaluation of the robustness described previously, the criteria of evaluation can be positioned in a reference frame of analysis two axes made up on the one hand robustness contextual and temporal in X-coordinate and on the other hand levels of information, knowledge and meta knowledge in ordinate (see Fig. 3). This reference frame makes it possible to clearly position each criterion according to a particular aspect of the robustness of knowledge.

IV. Frame of reference

To obtain data on the activity related on the field of knowledge and the use of the knowledge base, we suppose to have a frame of reference. The evaluation of the criteria is carried out starting from the analysis of the data resulting from the activity of the frame of reference. It is thus necessary to have the adequate tools to observe the activity of the frame of reference.

To satisfy the sources of information for the three classes of criteria and to place our tool for evaluation of the robustness within this system, we propose the system composes of the following elements:

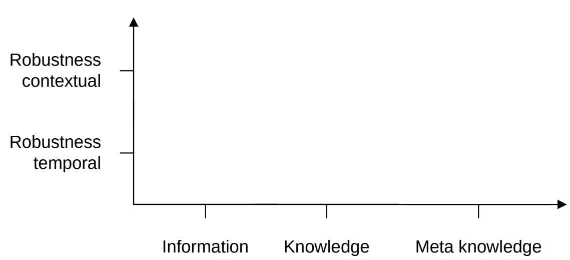

Fig. 3. Reference frame of description of the criteria of robustness

The information system, for example a system of management of the cycle of life of the product, makes it possible to obtain traces of the activity around the field of knowledge. It allows the conservation of the documents of the corpus and the activity around these documents.

The tool for validation and checking makes it possible to analyze the knowledge base according to rules. This tool provides the traces of the activity of validation and allows the evaluation of the criteria of robustness of the level meta knowledge.

The inference engine must make it possible to obtain a return on the use of the knowledge based system. This activity can be described according to the use of the knowledge base according to the questions of the users. It can also be described by evaluations which the users with respect to the quality of the answers obtained can carry out.

The tool of annotation of the knowledge base makes it possible experts to evaluate the quality of the knowledge base. This activity of evaluation is at the level knowledge.

The basic editor of knowledge must allow obtaining traces of the activity of maintenance and modification of the knowledge base. This activity makes it possible to evaluate criteria of the level information.

Finally, the tool for evaluation of the robustness of knowledge allowing collecting the whole of the activities and the evaluations coming from the other systems. This tool calculates the value of the whole of the criteria. It can also provide a help for the maintenance of the knowledge base by providing information of robustness to the person in charge of maintenance.

V. CRITERIA

We will describe below three criteria among those which we propose. These three criteria will be used as example to illustrate the three classes of abstraction which we propose.

A. Criterion of coherence

By using meta knowledge on the modelled field of knowledge, the criterion of coherence makes it possible to check the level of coherence of the knowledge base. The meta knowledge, being able to be represented for example by rules, make it possible to check that elements within the knowledge base of are not contradicted between them.

This criterion is placed in contextual dimension, i.e. coherence influences the variation of the quality of the answers. It is also placed in dimension meta knowledge, requiring a good expertise on the field of knowledge.

The meta knowledge will be provided by the experts and will be then used by the tool for validation which will provide the traces of the activity of validation.

The criterion will be then evaluated by the analysis of these traces. Thus less one element or a zone of the knowledge base will have to comply with the rules of coherence, less this element or this zone will be robustness from the contextual point of view.

B. Criterion of exhaustiveness

The goal of the criterion of exhaustiveness is to indicate if the knowledge base or certain zones of the knowledge base is complete, i.e. if it contains all crucial knowledge of the field of knowledge.

This criterion is placed in contextual dimension. The exhaustiveness of the knowledge base has an influence on the exhaustiveness of the answers provided to the user.

It is also placed in dimension knowledge, because will be to the experts of the field of knowledge to compare their vision of the field of knowledge with that of the knowledge base and to indicate if the knowledge base is exhaustive.

The experts use the tool of annotation in order to indicate the results of the evaluation of exhaustiveness.

The criterion of exhaustiveness will be then evaluated like the average of the evaluations provided by the experts.

C. Criterion of quantity of addition

The criterion of quantity of addition makes it possible to observe which is the stability of the knowledge base in the course of time. It allows observing zones of the knowledge base which are stabilized because of maturity reached by knowledge which contain. It allows also zones which were not updated and which requires possibly a modification because of evolution of the field of knowledge. It makes it possible in order to put forward the zones of the knowledge base which requires a monitoring deepened because of great activity related to these zones.

This criterion is placed in temporal dimension. Indeed it makes it possible to evaluate the quantity of modification operated in the course of time, and thus indicates the temporal evolution of the knowledge base.

It is also placed in dimension information because it is not possible via this criterion to deduce from the activity of modification the incidences from the semantic point of view between the field of knowledge and the knowledge base.

The evaluation of this criterion is carried out starting from the traces of the activity maintenance to generate by the tool of basic edition of knowledge.

This east criterion evaluates for each element of the knowledge base. For each element, the sum of the quantity of modifications operated on the elements makes it possible to define the stability of these elements.

VI. EVALUATION OF THE CRITERION STABILITY QUANTITY OF ADDITION

A. Local evaluation

The goal of the algorithm is to evaluate the local criterion of quantity of addition (see Fig. 4). For this we have a list of elements to treat coming from the base from knowledge *LV*, the trace of the actions carried out on the basis of knowledge. The first part of the algorithm makes it possible to calculate the amount gross of the local criterion of quantity of addition. The second part makes it

```
LV is the list of the elements of the knowledge base to be treated
LA is the list of the actions carried out the knowledge base
First is indicating if the first element is treated
Min is the minimum of action of addition
Max is the maximum of action of addition
First ← True
For Each NodeSel in LV Do
| For Each ActionSel in LA Do
| | If ActionSel→IdRef = NodeSel→Id Then
| | | If ActionSel→Type = "add" Then
| | | | NodeSel→CriteriaAdd ← NodeSel→CriteriaAdd +1
| | | EndIf
| | EndIf
| EndDo
| If First Then
| | Min ← NodeSel→CriteriaAdd
| | Max ← NodeSel→CriteriaAdd
| | First ← False
| Else
| | Min ← Minimum (NodeSel→CriteriaAdd, Min);
| | Max ← Maximum (NodeSel→CriteriaAdd, Max);
| EndIf
EndDo

For Each NodeSel in LV Do
| NodeSel→CriteriaAdd ← (NodeSel→CriteriaAdd - Min)/(Max-Min);
EndDo
```

Fig. 4. Algorithm of evaluation of the local criterion of quantity of addition Reference frame of description of the criteria of robustness

possible to standardize the values obtained by real numbers ranging between 0 and 1. The elements of the knowledge base contain their identifier like their value for the criteria of robustness, here quantity of addition. The actions are described by their type and the element on which they acted.

The algorithm consists in for each element of the knowledge base treating, to traverse the list of the actions carried out to count the number of actions of addition which were carried out on the treated element of the knowledge base. Once the number of actions carried out on the entered element, one evaluates the value of the local criterion of quantity of addition of the element in order to preserve smallest and the greatest value of this criterion among all the treated elements of the knowledge base.

Then each element of the knowledge base to be treated is standardized, i.e. the value of the element is modified according to the maximum and minimum value criterion of quantity of addition in order to obtain values ranging between 0 and 1 for each element of the knowledge base treated.

The evaluated criterion in this manner gives a local value. But it is possible to evaluate the criterion in a radial way.

B. Radial evaluation

```
Li is the list of the elements to be treated
Lf is the list of the treated elements
ElementInit is the element for which one calculates the criterion of quantity of addition
SearchRadius is the radius on which extends the radial evaluation from the criterion

ElementInit→Radius ← SearchRadius;
Add (Li, ElementInit);
Elt→IsTreated ← True;
While Li ≠ Empty Do
| Elt ← Li→ExtractFirstElement;
| If Elt→Radius ≠ 0 Then
| | For Each EltNeighbour in Neighbour (Elt) Do
| | | If EltNeighbour→IsTreated = False then
| | | | Add (Li, EltNeighbour);
| | | | EltNeighbour→IsTreated ← True;
| | | | EltNeighbour→Radius ← Elt→Radiuson-1;
| | | EndIf
| | EndDo
| EndIf
| Add (Lf, Elt);
EndWhile
```

Fig. 5. Algorithm of selection of element according to a central element and an operating range

C_i is the radial criterion of quantity of addition is calculated
E_i the whole of criterion C_i of the elements included in the radius of research

$$E_i = \{a_1 \ldots a_n\}$$

$$C_{radial} = \frac{\sum_{i=1}^{n} a_n}{n}$$

Fig. 6. Evaluation of the radial criterion of quantity of addition

The radial evaluation of the criterion makes it possible to take into account for each element of the knowledge base the value of the elements which surround them (see Fig. 5). Thus making it possible to decrease the extreme values and to reveal more easily of the zones where the values are identical. It is thus easier starting from these zones to select a critical zone to concentrate the efforts of maintenance.

The first stage of the radial evaluation consists in selecting starting from the central element for which will be evaluated the criterion of radial quantity of addition, which close elements will be taken into account for the evaluation.

The algorithm consists in creating a Lf list of all the neighbours of a *ElementInit* element of the knowledge base included in the *SearchRadius* radius.

From *ElementInit*, one course all the neighbours of this element and one adds them to the list of the elements to be treated. The elements added to this list are marked so that they are not treated several times. For each element present in the list of the elements at treaties, one adds the neighbours always included in the radius of research that were not treated yet. When the list Li is empty, the Lf list contains the list of all the elements close to element *ElementInit* the starting and included in the *SearchRadius* radius.

From this final list, the radial criterion of quantity of addition is calculated (see Fig. 6).

The radial criterion of quantity of addition is evaluated like the average of the evaluations of the local criterion of quantity of addition. The values taken into account for the average are that of the element to be treated and the neighbours of this element included in the radius of research.

VII. VISUALIZATION

The tool for evaluation of the robustness aims at providing a tool of decision-making aid. Used at the time of the stage of maintenance of the knowledge base, it

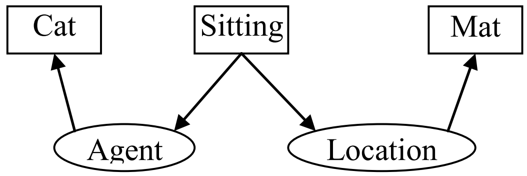

Fig. 7. Example of knowledge represented by a conceptual graph

provides a whole of means making it possible to display the result of the evaluation of the robustness.

The posting of semantic networks is carried out in two dimensions by means of rectangle, ellipses… and of features representing the bonds between the elements of the knowledge base (see Fig. 7).

The values of the criteria of robustness (local or radial criterion of quantity of addition for example) are posted by means of a code colour used to draw each node of the graph and representing the rate of robustness for nodes of the graphs.

The example below represents a graph conceptual. This graph indicates that there is a cat sitting on the carpet. This graph was not coloured yet according to the result of the evaluation of the criterion of quantity of addition.

The graph in Fig. 8 is coloured according to the evaluation of local criterion of quantity of addition. More the colour is dark is more the evaluation of the criterion indicates than the element of the knowledge base is robust from the point of view of stability. Thus knowledge on the agent cat is robust, knowledge in its position is relatively robust also but the action carried out by the agent is not robust.

The result of the evaluation of the radial criterion of quantity of addition is calculated starting from the results of the evaluation of the same local criterion (see Fig. 9). The radius chooses here is a unit. A harmonization of the results is observed. This harmonization indicates that the

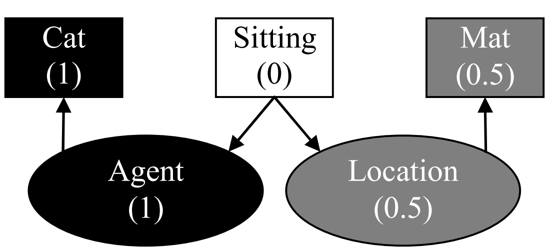

Fig. 8. Colouring of the conceptual graph according to the local criterion of quantity of addition

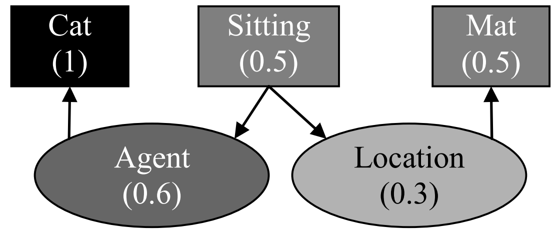

Fig. 9. Colouring of the conceptual graph according to the radial criterion of quantity of addition

conceptual graph is relatively robust overall. The radial criterion makes it possible to erase the great variations of robustness which can appear with the local criterion. The people in charge of maintenance and using our tool of decision-making aid can visualize the less robust zones in a total way. It can thus concentrate its activity of maintenance on these zones.

IV. CONCLUSION

For manufacturers, the constitution of memories of company represents an essential stage today to develop activities of innovation and creation of new products. But the formalization of knowledge is not enough. Modelled knowledge must have a certain degree of robustness which varies in economic time according to factors, technological and human.

This article treats problems of the robustness of knowledge during the evolution of the field of knowledge or its use.

We defined the concepts of temporal robustness and contextual robustness by taking of account the point of view of the use and the evolution of the knowledge base. We also proposed criteria of evaluation of the robustness of knowledge, positioned in a reference frame of analysis. This reference frame is composed of an axis relating to the level of abstraction or apprehension of knowledge and of an axis which define the type of robustness, temporal or contextual. We moreover defined a frame of reference which makes it possible to obtain the traces of the activity around the knowledge base. Finally we illustrated the use of a criterion via algorithm allowing evaluating it and of a tool for visualization allowing posting the results of the evaluation of the criterion.

The works in progress aim to define the algorithms making it possible to evaluate the other criteria of robustness which were not presented in this article. The development of a prototype of validation on real cases or starting from scenarios representing a real case is currently being studied.

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