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STUDY OF DYNAMIC VIEWPOINTS IN SATELLITE DESIGN

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Abstract : This work is based upon a multi-viewpoint approach of the designing. Several models of viewpoints are presented. They were applied to the study of a practical case : a space mission analysis. Then the question of the correlation of viewpoints is tackled and each viewpoints model is associated to a corresponding correlation model. We show that the concept of 'place' is worth using to answer the correlation question.

Keywords : Design, views, satellite, information analysis

1. INTRODUCTION

In designing complex systems (satellites [Tro89], [GT 92], [CGKR 94], cars, complex software, etc.), the most difficult task for the designers co-operating is to find a common framework where they could communicate in order to create, share or transmit their knowledge on a same problem to be solved. However their knowledge is always expressed according to their particular viewpoint. The problem is therefore to correlate, whenever it is possible, their viewpoints.
This work is motivated by the wish to increase the understanding of any cooperative design activity in terms of " Viewpoints " and " Correlation of Viewpoints " in order to analyse or to support it[1].

[1] This study is a summary of a research done by the authors which have been supported by the Centre National d'Etudes Spatiales (Action R&T « Etude des points de vues dynamique »

2. A SUMMARY OF THE THEORITICAL ASSUMPTIONS

We have considered technical objects (such as satellite, or probe) in the following way: Instead of considering them either in a functional or material or economical way, that is within the frame of a given specialised language (with its own syntax and semantics), we have chosen to consider them independently from a particular trade.

We decide to consider them in a more general way as signs of a meaning system. This is of course postulated within every specialised language, but in our case no particular language is taken as a reference. We situate our study within a framework where which matters is to elucidate the conditions of existence of an object –as a sign- in multi-viewpoints meaning systems. Our framework is therefore a semiotic one and not a semantic one. From empirical observations we postulate that several meaning systems coexist within the same technical universe

(in our case: spatial projects and missions). Although these systems are not incompatible, they are not totally compatible. We define any of such meaning – and semiotic- system as *viewpoints*. A viewpoint is therefore the manner attached to a person or a group to represent the technical world within which they operate. For instance in a spatial project we will find a "spatial mechanics" viewpoint, an electric viewpoint, a thermic viewpoint and so on.
In our approach we set a language about viewpoints (which therefore is a meta-semiotic language of a sort).

Views

The existence of a viewpoint stems from a phenomenological attitude toward "things" which appear to us as meaningful: the consistency of the technical world we choose to consider leads us to postulate the existence of structures which are immanent[2]to this world of "meanings". These immanent structures describe the "functioning" and the "organisation" of the viewpoint. They also describe how this viewpoint is able to produce *views*. A view manifests itself by a linguistic representation –in the most general acceptation of it. It can be a "text". It can be any concrete symbolic representation: a schema, a map, a drawing, and so on. For instance a "functional requirement" represents a view according to a "functional" viewpoint.

Confrontation and correlation of viewpoints

Whenever views are produced according to different viewpoints, they could be either totally independent from one another, or, be logically and/or semantically dependant:
Before any dependency is established, the viewpoints are said to *virtually* exist. If views produced according to these viewpoints are logically or semantically incompatible, we say that there exists a confrontation *of the viewpoints*. Eventually, after a negotiation process, compatible views can be produced. In such a case we said that the *viewpoints are correlated.*

Objects

In our " viewpoints language " objects result from a correlation of viewpoints. Indeed, when all the considered viewpoints are correlated, we say that there is an emergence of an *object*.
More precisely, in our language an object is defined with respect to viewpoints in the following way:
Whenever no view is produced the object is *virtual*.
When views are produced from the corresponding viewpoints if they are partially incompatible, the object is *actual*. When the views in presence are compatible the object is *realised*. The process of emergence of the object is exactly parallel to the process of interaction between the viewpoints we are considering

The correlation problem

In order to increase the understanding of any **cooperative design** one of the goals of the study supported by the CNES was to bring answers to the correlation problem:
Given a viewpoint modelling, how can we model the correlation of viewpoints in order to correspond to the general -meta-semiotical- language of viewpoints we have just defined above?
This modelling of correlation of viewpoint should in particular allow us to detect it whenever an object is produced in the "real world", that is should respect a principle of empiricism.

3. VIEWPOINTS ABOUT VIEWPOINTS

The definitions we gave above allow different manners to tackle the problem of viewpoints and of their correlation. All those « manners » are acceptable provided they can be correlated. Indeed, even if a semiotic theory of viewpoint is plausible, it would not be necessarily easy to apply it to real situations: (perhaps) too long, too expensive to use. Therefore different approaches of viewpoints have been proposed in this study.
One approach [Tro 98] is based upon modelling of the activities of the designers;
One approach is based upon statistical methods[3] apply to a corpus of texts;
One approach uses a multi-agent paradigm where viewpoints are considered as agents. In practice this model is instantiated using a statistical methodology.

The two first types of approaches correspond to two dimensions of the concept of viewpoint:
The first type of approach (1) [Tro 98] is that any activity implies argumentative dimension (and activity). The second type of approach (2) admits that the way terms are associated within discourses characterises the viewpoints that produce these discourses. A viewpoint is altogether a *system of terms* and a *process of argumentation* to see the world, or make the others see the world, in a particular way. The third type (3) is in practice based upon the same paradigm as (2).

The approaches we are now to present take the same corpus as a practical reference for their illustrations and empirical justification. This corpus is a transcript of the very first steps of the designing of mission analysis of a nano-satellite (i.e. < 50kg). Three designers were recorded for three hours during this activity. The corpus was divided and indexed by minutes. Th, T, and F designate the designers.

[2] *Immanence* means for instance that a map of a building is immanent to any house we can observe.

[3] These methods are justified by linguistic and semiotic hypothesis.

3.1 Argumentative approach of Viewpoint Management for Cooperative Design

In this approach [Tro98] summarised in this section, the fundamental hypothesis is the assumption of different **interaction spaces** that the different actors of a designing activity share. This hypothesis is supported by empirical evidences as well as by the strong linguistic position about the importance of argumentation within language: as far as semantics is concerned language is the place of argumentation, that is fundamentally rhetorical.
These interactions spaces can be classified into an *argumentation space* where inference competencies are activated, a *communication space* where social competencies are also activated, and a *solving problem space* where the corresponding ability is used.
The soil out of which these different spaces can emerge is constituted by **topoï**, or elementary argument (see for instance [AN 95]). Topoï are both the argumentative bricks of any argumentation and meeting places from which it is plausible to built larger places and shared spaces. Topoï are argument of the form "the more… the more…" or "the more… the less…" and so on. For instance the following argument is a topos: " The more the mission is of a planetary type, the more one should stay on a geostationary orbit".
We then use the semantic concept of *isotopy* in order to give an account of the iterativeness of *semes* which give a discourse its homogeneity.

In this modelling isotopies are identified with *viewpoints*.

In order to take into account the heterogeneity of the group of designers, we propose a model of Viewpoint based on an argumentative approach of the design activity [TC 94].

In our Viewpoint model, we propose five types of thematical referentials (or isotopies) for any design activity as following:
Work (W) (related to efficient cause)
Fashion (F) (related to the formal cause)
Purpose (P) (related to final cause)
Aesthetic Form (E) (related to material cause)
Representation (R) (related to the " fifth " cause of the quintessence [OT 94][4].

Our assumption is that we can find these five types of isotopies (or viewpoints) in any design of complex systems Although the design activity needs all these five design viewpoints, some design communities give more importance to one viewpoint than another does. For example, some designers are more interested in the design process (problem solving model, scientific or technical knowledge useful in the design process, technological or economical resource allocation, design management, etc.) and then give more importance in **W**.
Figure 1 presents an example of a structured view of these five types of design viewpoints.

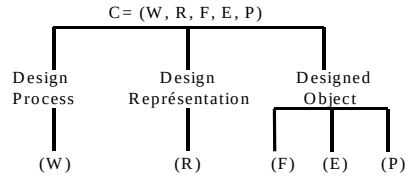

Figure 1 : Structuring the five Design Viewpoints

For each Design Viewpoint (W, R, F, E, P), we could define a hierarchy of isotopies first with different shared isotopies in a specific domain and/or application and secondly, for each shared isotopy, private isotopies (or viewpoints) of the designers.

3.2 An approach of viewpoints based upon statistical association of terms: The SEMIOLEX™ method

SEMIOLEX takes into account methodological principle of structural semiotic in the context of statistical treatment of lexical networks. It assumes intelligent data retrieval from patterns and profiles research. Instead of isolate keywords (as most of data retrieval systems) it find profiles and makes scenarios with them, taking into account strategic objectives of the user and tactical circumstances.
In order to assume this we use infometric and semiotic analyses techniques: lexicometric analyses, lexical networks, profile analyses and scenarios management.
The available tools allow an easy recomposition of samples so those scenarios are constructed in an incremental way. The approach consists to identify strategic questions formulated by the user and then to define a tree of topic references (the dictionary) which gather the access and answer modes to this strategic question.

Clusterisation
Clusters are constituted by aggregating co-occurrent words. In the following figure 2. bolt lines means internal solidarities between words (represented by boxes) and small lines indicate external links with others clusters.

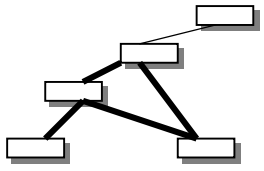
Figure 2: Clusters

AFT profile construction
A semiotic analysis grid allows the characterisation of the respective position of **A**ctors, **F**unctions and **T**opical contents in the clusters. Eventually these characteristics - with respect to the context in which they occur - are taken as pertinence signs and as an indication of the quality of exchanges and results.

[4] *For example, a designer: W - designs/ plans to DO X;F - in order to create/ product a HOUSE; P - conceived and realised in order to serve a FAMILY; E - (and to give the feeling) of a nice HOME; R - and who) shows/ represents with a schema or a PLAN.*

Scenarios production
The evolution of profiles and its interpretations offered by the Semiolex method allows to build the scenarios of profile production

Viewpoints
In this approach viewpoints correspond to trajectories through these clusters. Several clusters must be considered in order to define an individual viewpoint.

3.3 A multi-agent paradigm approach: a diachronic model

Principles
Here, we present a model whose principal aim is to show the evolution along the time of the confrontation of several viewpoints in a design activity. First this model allows the tracability of previous confrontations, but it is possible to use this model as a predictive one in order to better master the design process.
As for the semiotic model above, this model propose a general frame (the generic model) which has to be instantiated in each concrete situation. Each model contains :
A descriptive part which is composed of a static description of the objects to be manipulated and a dynamic part which describes how these objects evolves during the process.
A calculation and drawing mechanism description : the model engine.

The generic model
Then the descriptive part of the generic model is composed of a set of viewpoint agents, a communication type, a perturbation measure and a distance measure.
Each viewpoint agents is composed of a viewpoint holder identifier, a viewpoint domain (a formalism and a content) and a set of view of the viewpoint (instant, content).

In order to instanciate this model we must define viewpoints domains. We choose to produce these domains using the Alceste methodology. This methodology is applied to natural language texts and produces semantic classes of terms, "lexical worlds".

The Alceste methodology
Alceste [Rei 90] is a tool which allows analysis of data presented as free text. The aim is to identify the main topics which occur in a text. In order to do that Alceste achieve a Factorial Correspondences Analysis combined with a hierarchical descending classification of sentences and then words of the text.
Concerning the case we study, Alceste was able to identify four classes[5].

As a matter of fact we can verify that this classification supply classes which can be clearly interpreted. For example the first class contains words as *how much*, *apogee*, *year*, *bit*, *hundred*, *number* ... which cover the quantitative aspects of the discussion.
Moreover Alceste furnish the more characteritical sentences of each class and so helps the interpretation od the classes.
In this approach Alcest's classes are identified with viewpoints since they represent "lexical worlds".
The point is they cannot be attached individually just to one actor since they emerge from a collective discussion. They correspond more exactly to objective and external viewpoints, namely to viewpoints of who is interpreting it.

An instance of the model
In the case of the design discussion which we study the effective model is the following:
Viewpoint agents name of the three designers and one of the class A,B,C ou D as calculated by the Alceste Software
perturbation: the number of words of a class divides by all the words pronounced
distance: difference between the tendency curves

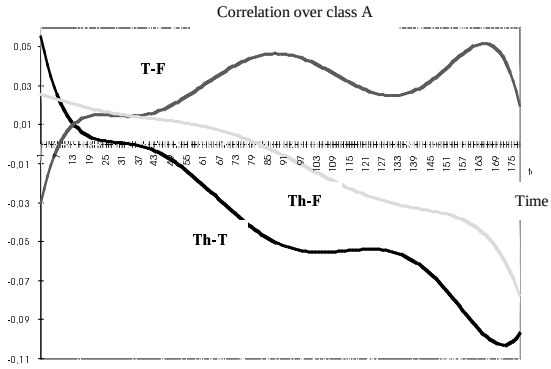

Figure 3.: Interpretation of the evolution of the classes

We present here an example of curves corresponding to the three designers on the quantitative topic.

As explained below, we can use them to in interpret the correlation between viewpoints. The following set of three curves (figure 3) allows to discover who take into account this topic and when it occurs. Each of the three curves concerns a pair of designer. The more a curve is close to the abscise axe the more the pair concerned takes quantitative aspects into account together.

[5] Class A : Compress, How many, Year , Apogée, arrival, Tank, Bit, Cells, Hundred, Figures (numbers), Five, Fifty, Coefficient, Cube, Degree, …

- Class B : Elsewhere, Point, Really, Altitude, Analyse, Antenna, Advantage, Bilan, Box, Camera, Control, Bother, Problem, Exist, …
- Class C : Show, Transmit, Now, Aerospace, Probably, Ariane, Asteroide, Astronautic, autonomy, bitsy, onboard, Camera, Chain, …
- Class D : Know, Write, Must, Finish, Open, Can, Transform, Know (by study), Remember, See, Will, Enough, As much, At last, Some, Always, Architecture,
-

4. CORRELATION OF VIEWPOINTS

4.1 Objects and spaces

As soon as the concept of object *is not* taken for granted, space itself becomes questionable. 'Space' refers here not only to a physical entity, but to any sort of entity which is usually designated by this term. Such an entity must be considered as a product in relation with the actors and the objects present. The actors who act upon "common" objects set must necessarily share a common space. However this commonality must no longer be considered as evident (See Henri Lefebvre on the production of space (in [Lef 71] p.17))

A preliminary condition for different actors to confront their viewpoints in order to produce correlations and objects is to share a common space.

We therefore assume that any answer to the correlation problem should be able to deal with the condition under which common spaces can be produced. Since the existence of such spaces are logically anterior to the existence of objects it should imply that the study of their conditions of existence should be easier to model than in the case of the objects. And such seems to be the case.

We call this problem relative to the production of common spaces the weak correlation problem.

Places and the weak correlation problem

We assume that in order for different actors to share a common space they should *virtually* be able to build **common places**. Places correspond to the *actualisation* of their common presence within the space.

Our assumption is that a (common) **place** emerges whenever individual "logics" expressed through arguments (corresponding to the first approach we have presented) or through topical networks (corresponding to the second approach) or through reference to "lexical world" (as in Alceste methodology), correspond to a global "logic" (or interpretation) of the representation that the individuals collectively contribute to produce.

For instance let X and Y be two agents in a design activity. Let us suppose that X proposes an argument α to Y and Y reacts to it with a new argument β. We consider that a place is emerging if β is a plausible answer to and the chain $\alpha -> \beta$ is compatible with the interpretation of the global discourse that X and Y are producing together.

The estimation of the consistency of the answer of Y to X, the interpretation of the global discourse as well as the compatibility of it with the argumentative chain depend at least on an interpretative competence of the person who performs the analysis.

The practical problem is to find for <u>each viewpoint modelling</u> we propose, a procedure to assess the emergence of a place.

4.2 A correlation model in the argumentative approach

In our argumentative approach [Tro 98], the five isotopies are identified to viewpoints. It is also possible to consider it as five common places. The question of correlation is therefore to decide if (a) one of those viewpoint is dominant from a global point of view and (b) if there is a clear collective step in the solving problem level which (c) both agree with the topoï produced by individual designers. (Topoï cover both topical and solving dimension of the discourse). This can be extended to the correlation over a Communication Space (to cover the negociation dynamic)

In our model of correlation of viewpoints, we deal first with <u>two</u> interaction spaces: the argumentation space and the problem solving space. Figure 4 illustrates what we call « cooperation space : it shows how the individual isotopy W is hold by the group as a collective isotopy and how the step 2 acts as a context for the correlation of the others active isotopies to the prevailing isotopy W.

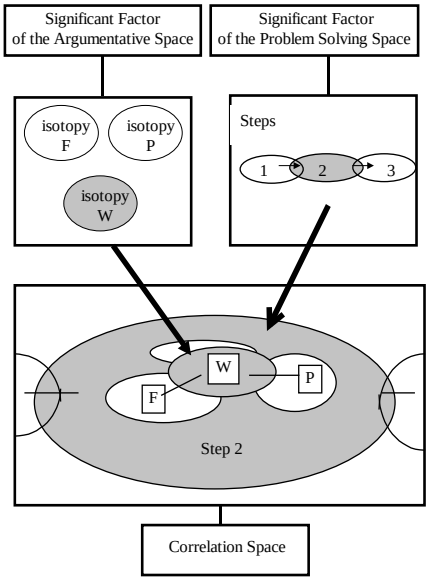

Figure 4: Our approach of the correlation space

Our model of correlation of viewpoints deals also with dynamic viewpoints. For this, we propose two modes of modification of a prevailing isotopy during the problem solving i.e. from a step to another one.

- The first mode concerns the study of the way a prevailing active isotopy is modified during the problem solving. The term « modified » must be interpreted as a collective emergence of a new viewpoint (ex: W1 $\rightarrow$ W2 or ()$\rightarrow$ W).
- The second one concerns 1) the change of perspective (i.e. when the prevailing isotopy goes up from the isotopy X to the isotopyY) and also 2) the change in the extern historical record of the prevailing isotopy from one step to another one, i.e. when the relationships between the prevailing isotopy and the others active linked isotopies change from one step to another one.

4.3 A correlation model in the lexicometrical approach

The discussion we have studied was first considered as a whole and then splited in six periods of 30 minutes with the three participants first and then for each participant.
In this approach a global representations are produced using Factorial Correspondence Analysis, Hierarchical Ascending Classification, and lexical network analysis. They are simultaneously interpreted. These interpretation are then confronted to representations derived from individual discourses (using again Factorial Correspondence Analysis and "individual" lexical network). Objective place are then established.

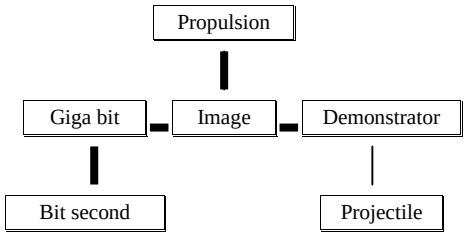

Figure 5: example of a cluster which identifies itself to a place.

For instance the analysis of the lexical networks done by considering altogether the three actors shows that the major pivots (orbit, watt and image) are both hooking points of individual contributions and of discussions. That is representation by pivots given by the analysis of the lexical network is relevant and objective both on diachronic and synchronic level (figure 5).

4.4 A diachronic Model for viewpoint correlation based on the Alceste Methodology

In this model the global variations of the curves built upon statistical classes are interpreted against the discourse of each designer and against the general movement of this discourse in terms of solving the task propose by the manager Th.

Correlation between designers on the class A (figure 3):
The difference of the importance of the quantitative problems for T and F remains in a limited interval whereas the difference of this importance between each of them and Th increase constantly. We should speak of a kind of "bifurcation" between Th and the two other designer for this topic.
We can find an explanation in the fact that Th is the manager of the group. In a first time Th explain the problem and then evocate quantitative aspects. Then T and F who have specific technical skill monopolize this topic since they try to find solutions to the problem which was exposed previously.

5. CONCLUSION

This article aimed to make the readers aware of the notion of " viewpoint " and " correlation of viewpoints " which, we think, are central for the analysis of a complex design activity (in particular for the manager of design projects), and for the specification and the design of real tools supporting designers during their cooperation - what we called " Design Groupware ", whatever their cooperation

- is direct (for example by making collectively decisions [KT 97], see CSCW, Decision Making Support Systems) :
- or indirect (for example by reusing experiences of others designers, information retrieval and navigation in technical memory, enterprise memory on internet).

In Design Groupware, our approach is based on taking into account the heterogeneity of the group of designers and developing a Viewpoint-based activity model in design in order to analyse their activity or to really support them.
The "theoritical" step was to recognized the importance of the constitution of places as a step toward the solution of the correlation problem we introduced. The approach we produced and the result we obtained, proved that this is totally relevent.

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