



HAL
open science

Potential Contribution of New Hypermedia Technologies for Man-Machine Communication in Industrial Processes

Christophe Kolski, Patrick Millot

► To cite this version:

Christophe Kolski, Patrick Millot. Potential Contribution of New Hypermedia Technologies for Man-Machine Communication in Industrial Processes. *Hypermedia Courseware: Structures of Communication and Intelligent Help Proceedings of the NATO Advanced Research Workshop on Structures of Communication and Intelligent Help for Hypermedia Courseware*, Apr 1990, Espinho, Portugal. pp.224-239. hal-03370477

HAL Id: hal-03370477

<https://uphf.hal.science/hal-03370477v1>

Submitted on 19 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Potential Contribution of New Hypermedia Technologies for Man-Machine Communication in Industrial Processes

C. Kolski , P. Millot

Laboratoire d'Automatique Industrielle et Humaine, URA CNRS 1118 - URIAH
Université de Valenciennes, France

1. Introduction

This paper presents the potential contribution of new hypermedia technologies involving man-machine communication in the field of industrial complex processes, for instance production units (electric or nuclear power plants, oil-refineries or iron and steel-works), means of transportation/transportation networks (airlines, ships, railway ...). All of these systems include a centralized control post, or control room in which the human operators perform their control and supervision tasks. These tasks involve a high level of knowledge. This paper presents first the concept of man-machine communication in these systems and secondly a global methodological approach of man-machine system design. The last part is an extended description of a user interface design methodology, outlining potential needs related to new hypermedia technology.

Communication tools are indeed in fast evolution. New programming techniques derived from Artificial Intelligence have helped designing and creating original communication products. New word processing techniques such as hypertext, or modern technologies offering simultaneous word, graphics and sound processing do indeed increase their efficiency. The evolution of knowledge in the field of interactivity does also involve their ergonomical characteristics. These communication techniques will thus definitely play an increasing part in the field of complex industrial processes.

2. The problem of man-machine communication in automated systems

Until now, automation has been used to make "self-operating" control systems. But the management of trouble-shooting is effected by operators, and this for two main reasons: (i) it is not always possible to modelize all the trouble-shootings, (ii) the solutions for correcting trouble-shootings are generally not analytical, but heuristic. These solutions are issued from a typically human skill acquired through learning or induction.

Human operator has therefore been kept to perform supervision tasks for which decisions can only be made by him. For instance, detection and anticipation of faults, diagnosis or correction of trouble-shooting. In other words, the role of human supervisor is entrusted with the system's security but only if it is deficient. Except the fact that human resources, whether cognitive or physiological, are intrinsically limited, it must be pointed out that occasional intervention in the installation implies a non-ergonomical working situation. This situation tends also to reduce the human capacities. Indeed, during the normal functioning of the installation, the human operator is in a state of work underload with two consequences:

- in the short run, a diminishing of his attentiveness and therefore of his fault-detection aptitude,
- in the long run, a degradation of his internal control model of the process and therefore of his aptitude for troubleshooting.

In return, during abnormal or disturbed process operating, the operator is subjected to a work overload, due to a large amount of information to process and action to perform, in order to diagnose and repair the defect.

The research is thus evolving from the initial concept of automatization without the human, to a concept aiming at bringing him back into the automatized system. But the human is presently considered as a "necessary harm" of which it is required to limit the errors. According to this concept, research work has been done to integrate decision aid tools in the process control and supervision systems. Formalizing analytically so as to integrate them into these decision aid tools being difficult, "knowledge-based system" approaches seem attractive, and this particularly for their capacities to explain their reasoning process.

The current tendency consists in integrating in the decision aid tools, the possible taking into account of the process so as to allow early or anticipatory interventions in the case of defect. It is the aim of on-line aid systems which require the definition of methods for representing adequate dynamical knowledge. These methods are based for instance on qualitative models [4, 10], and also on dynamical knowledge and reasoning processing methods [25].

In a parallel direction, the concept of man-machine communication must orientate itself towards a man-system cooperation in which the increasing decisional capacities of the tools must allow to set up a real collaboration between man and machine [19]. In this way, Artificial Intelligence appears like a tool allowing to providing the man with a "decisional partner". Artificial Intelligence appears also like a mean for modelizing normatively the operator's reasoning process during the design of the man-machine cooperation.

However, there are still not enough answers regarding the communication of decision aid systems and operators. There are indeed a number of compatibility problems between the human operator's mental steps and the decision aid tool's reasoning process. Our approach consists then in this workshop, in looking for new solutions in this field, and in considering to which extent the new hypermedia technologies can contribute to the man-machine communication in the industrial complex processes.

In a way to better defining the general problem, the following part presents first the global methodology of man-machine system design. The particular point of industrial imagery designing is then described, and illustrated with some questions facing the potential contribution of the new hypermedia technologies in this field.

3. Methodology of man-machine system design

The methodology includes two sequential steps (Fig. 1):

- A descending conceptual step consisting in the modelization of the man-machine system. It leads to an implementation on the site or to a simulation;
- An ascending step for evaluating the created system according to performance criteria about the process, but also according to specifically human criteria.

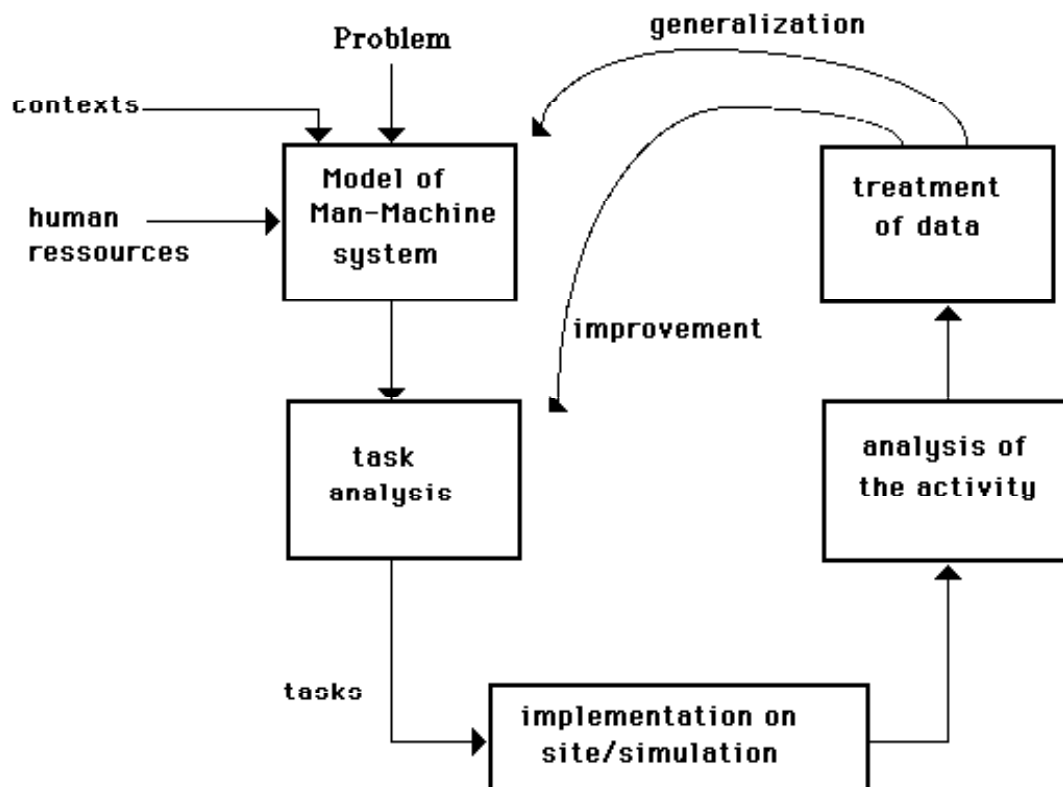


Fig. 1 Methodology of man-machine system design and evaluating

3.1. Descending conceptual step

The man-machine system's model includes a decisional model of the operator, and a model of the process and its control system.

It is necessary to extract the technical constraints from the process to the different contexts of foreseen

functionings. If the definition of this model is far from being trivial, it can nevertheless rely on well-tried methods of classical automation.

The operator's decisional model is more difficult to define. It necessitates a cooperation with other research disciplines, such as the cognitive sciences. The best thing would be to define a general model of the human's reasoning process. This model should be able to explain the individual errors of the operators. In other words, it would include individual parameters of personality, and specific parameters concerning the environment, such as technical, sociological and psychological ones. If searchers do presently begin to identify these parameters, it is still too early to hope to quantify them.

On that account the objectives are less ambitious and tend to define normative models of behaviour for a certain class of operators in specific operational contexts. Given that the tasks of manual control are progressively replaced by decisional cognitive ones, the current research tends to develop cognitive models. For instance, KARL designed by Knaeuper and Rouse [15] is an AI model which includes two knowledge bases with production rules. The first one concerns surface knowledge, and contains the expertise of a class of operators. The second one is related to deeper knowledge, and describes the structure and the functioning of the installation which must be controlled. KARL has been connected to a simulated process. The orders issued of its reasoning process have been compared with those of the operators' whose knowledge has been extracted to build its base. The results have shown that the model allows to predict the average type of behaviour of the operators from the considered class. So, even if this type of approach doesn't help explaining the individual behaviours, it does help designing man-machine system.

Johannsen, Borys et al. [14] and Sundstrm [22] have indeed used this idea and proposed GRADIENT (which is part of an ESPRIT project and aims at designing supervision interfaces). This project is related to a model of man-machine system which includes a model of the process and of the user. The latter encompasses knowledge base of the operator and simulates his cognitive resources. These two models are used to infer the tasks that the so simulated operator must perform, in different contexts of functioning (Fig. 1). For this purpose, the methods of cognitive tasks analysis, which are currently elaborated by the researchers working in the field of cognitive sciences, are very promising [13].

A study of the tasks thus deduced must then help defining the operator's informational needs in order to perform them. This study must also define the type of assistance to provide to the operator. The analysis of the informational needs allows defining the information which will be displayed on the supervision screens. Then, it allows structuring the different displays according to the operational contexts of the process. In parallel, the cognitive tasks analysis bases itself on ergonomical knowledge related to human limits. This process helps defining the proper type of assistance (for decision and/or action) for the considered class of modeled operators. This study builds more or less the schedule of conditions of the decision aid system.

Furthermore, according to the capacities of the decision aid system, it is necessary to define the role of the operator in the supervision loop, the level of automation and the modes of cooperation between the operator and "the intelligent tool":

- One could be a "horizontal" cooperation between the operator and an expert tool whose outputs are directly connected to the process. The principle is to make a dynamical repartition of the tasks using a task repartitor. The latter can be controlled either by the operator or by an optimal command algorithm, this according to a performance criterion of the "man-expert tool-process" system, and under the constraints imposed by the human limits.
- A second one could be a "vertical" cooperation, in which the operator has the responsibility of each variable of the process. He can then use the decision aid system if necessary. In extreme situations, the decision aid system can provide him with advice but, in this case, it is necessary to prevent (possible) conflicts when the operator refuses to use the advice. For this purpose, the explanatory capacities of the tool are essential [23]. In non-urgent situations, the decision aid tool can progressively guide the operator during his problem solving process, using for instance tools of intelligent simulation. This solution has a major asset: it helps maintaining and even improving the operator's operative knowledge.

New hypermedia technologies will be most useful in the "vertical" cooperation situation on account of the high level of interativity between the human and the computer, but also on account of the complexity of the knowledge available. To our knowledge, there are still very few decision aid tools which use the potential offered by the new hypermedia technologies. However we can mention the works by Boy [3] concerning the CID systems (Computer Integrated Documentation). These systems are defined by the author as intelligent aid systems which cooperate with him in order to solve problem. Furthermore, in other fields than industrial processes, it is necessary to mention some promising research which are specific to aid systems necessitating a complex representation of knowledge, such as biological modeling [21], financial auditing [8], management of knowledge used in a law firm [27], etc.

Finally, when the cooperation modes are chosen, the elements are in place to precise the interfaces of "man-expert tool-process" and/or the man-process interfaces. It is also possible to lead to a concrete implementation on site (Fig. 1).

3.2. Ascending step for evaluating the realized system

This second step is vital for assessing the system designed and realized during the previous step. The assessment criteria take into account the performances of the global man-machine system. These performances are expressed for instance in terms of variations between the real production and the objectives of the system. They can also be based on ergonomical criteria, such as the operator's workload, her/his tiredness, etc.

This data is assessed using activity analysis methods. These methods are applied to different operators belonging to the same class, and consist in analysing the man-machine system in predefined contexts (chosen at the previous stage). The inputs/outputs of each operator are also measured and memorized, and his workload, visual strategies (using oculometric methods [1], displacements, etc., studied).

This analysis must take into account the solicitation level of the operator during his tasks and reflect the trouble he can have performing them, even if his performances are correct. For this purpose, subjective methods, such as questionnaires or approaches using a model, can be used [18, 19]. The set of measures is then analysed and if need be presented to the operators to obtain complementary explanations on their behaviour. The results of this analysis can be either directly used to improve the interfaces (for instance if some information is missing or ill presented) or processed through by data analysis methods aiming at improving or generalizing the initial conceptual model (Fig. 1).

The following paragraph presents a sub-problem included in the man-machine system design: imagery design. This presentation brings out several potential needs related to new hypermedia technologies. We do matter of fact think that they can contribute not only to optimizing the imagery design phase, but also to improving man-machine communication in industrial complex processes.

4. User interface design methodology

The operator's needs for performing correctly supervisory tasks depend on the different operation modes of the process. During normal operation it is necessary to present a subset of the variables which need to be monitored. These variables supplied by the supervisory computer must be significant of the safe operation mode and make the occurrence of a defect obvious. On the other hand, during abnormal operation, the set of information which must be communicated to the operator is coming both from the supervision computer and from the decision aid system. This information concerns for example alarms, diagnosis, or preventive advice. According to the information available, the first aim of the proposed methodology is to specify the interface which needs to be developed in order to assist the operator in performing the different tasks corresponding to the current operation mode of the process.

The methodology of the interface design can be broken down into five sequential steps (Fig. 2). The first two steps correspond to the ergonomic conceptual stage, which consists in defining the lay out and the content of the set of views that will be developed. Then the following steps deal with the development of the interface and correspond to the ergonomic realization and correction stage. These steps are now described.

Basic questions concerning the potential contribution of hypermedia technology will be associated to each step.

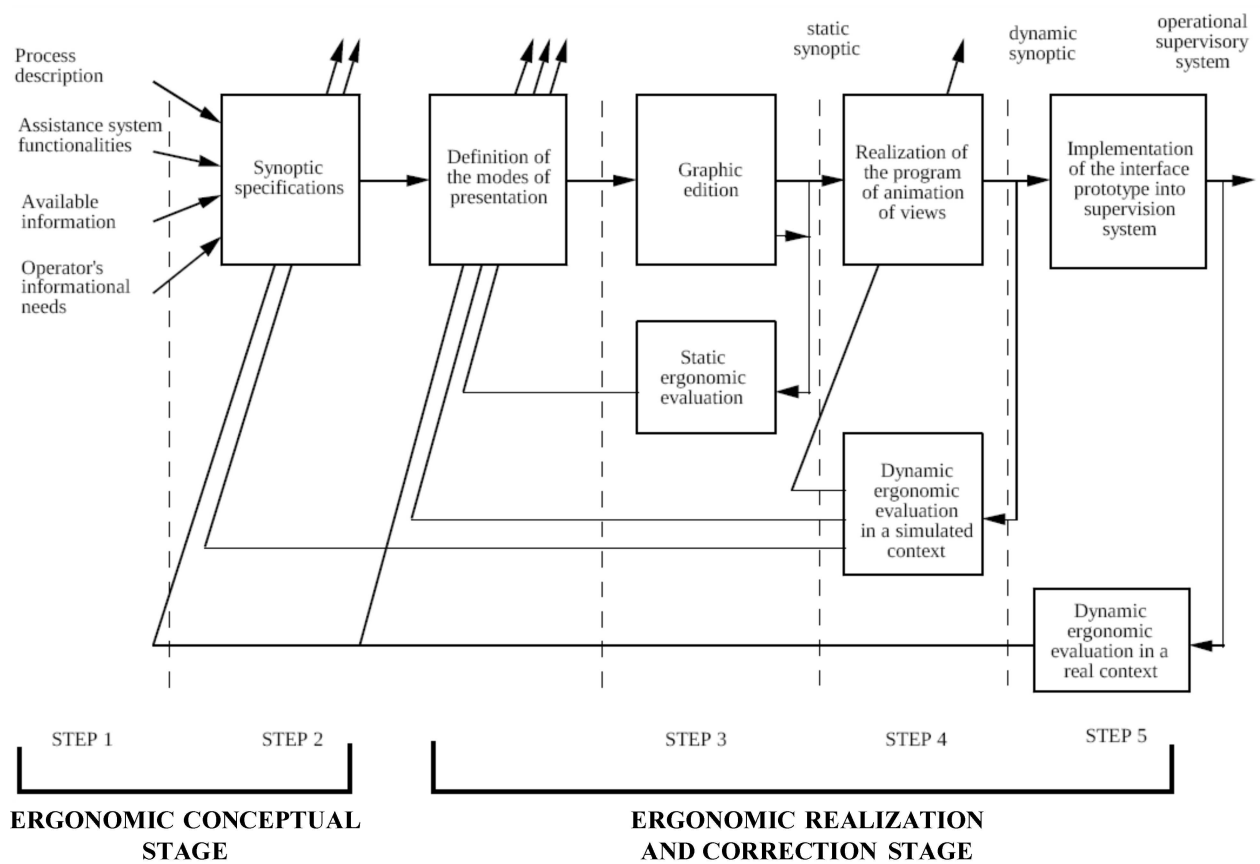


Fig. 2 The different steps of the methodology for designing the interface between an operator and a decision aid system

4.1. First step: preliminary works to become acquainted with the application process

The different tasks performed by the human operator and the constraints associated with their performance depend on the type of process being controlled. Thus, the designer must analyze the operation context in which the supervisory tasks take place, and this to define the operator's informational needs. So the first step of the methodology concerns the study of the process itself, and the analysis of the operator's supervisory tasks (Fig. 2).

The study of the process must allow the interface designer to understand the operation of the different sub-systems constituting it. The operation of some sub-systems is based on complex physical, chemical or thermal mechanisms. So, to allow operators to supervise these sub-systems, it is often necessary to adopt originally adapted modes of representation. But the designer has to be familiar with the working of the process to develop them.

The second part of the work concerns task analysis. It aims first at recognizing the different variables observed by the operator in order to perform supervisory tasks. To carry out this analysis, it is necessary to study the operator's activities in the control room in order to identify his needs and the different problem solving strategies he can use [6]. This analysis must also emphasize the temporal constraints associated with performing supervisory task. So, the first step, which includes a study of the process and an analysis of the supervisory task constitutes a preliminary work meant to get the interface designer used in the different aspects of the process application, and lead him to defining the functionalities of the interface which needs to be developed.

Questions:

Can hypermedia technologies contribute to making easier the registering and classifying of the tasks which must be performed by the operator?

Is it possible to optimize the description of the process in terms of inter-connected variables?

4.2. Second step: specification of the supervision views

After defining the interface's functionalities, the next step deals with the specifications of the views (Fig. 2). These specifications must take into account the fact that the views which must be developed correspond to both the normal and the abnormal operation modes. We can break this specification step down into two parts; the first one concerning the content and the organization of the views, and the second one dealing with the choice of the modes of presentation of the information:

(i) **Definition of the content of the views:** this part involves the designers of the decision aid system who must describe the different functionalities of the system and establish the amount of information that can be deduced. For example a diagnosis functionality can deduce different hypotheses of faults among a predefined set, and for each of them calculate a credibility factor. Then, the second step consists in identifying among the set of information previously defined that which agrees with the operator's needs, and in specifying under what conditions the information has to be presented. For example a piece of information will be useful to the operator only if a particular fault has been detected. Finally, this second step leads to specifying the organization of the views which ensure the presentation of the set of useful information (identified above) to the operator. This phase is crucial because the specified organization sets the future cooperation between the decision aid system and the human operator. Solving possible conflicts, which can occur if the operator does not agree with the advices provided by the computer, depends on this cooperation. In this case, the system must lead the operator to checking the results corresponding to the different steps of his reasoning process, in order to find the origin of the conflict. A possible solution would be to analyse in parallel the human and the system's problem solving processes, this would provide the operator with relevant information according to different justification levels, with a view to finding a consensus as quickly as possible [24]. After the organization of the different views has been completed, the designer must then define the different presentation modes which should be adopted for each piece of information displayed on these views.

Questions:

How can hypermedia techniques contribute to facilitate the description and the organization of the synopsis into a network of views?

How can the association of pertinent information with each of these views be made easier?

(ii) **Definition of the presentation modes:** The definition of the presentation modes of each piece of information must take several ergonomical specifications into account, for instance:

- the organization of the views according to a multi-window structure. This structure is similar for all types of views and each window is allocated to the same type of information so as to faster reading automatisms;
- ensuring consistency between the chosen presentation modes and the set of other existing supervision views in the control room;
- finally the adoption of symbolic presentation modes in order to facilitate a rapid and non-ambiguous interpretation of the information.

During this phase it seems important to let the operators expose their preferences concerning particular representation modes. Their experience can indeed influence (in a right way) the final result, and their participation can moreover foster their acceptance of the decision aid system in the control room.

Questions:

How to facilitate the association of graphical representation modes with each pertinent piece of information?

More precisely, is it possible to adapt the graphical representation mode of each variable according to the usage context of the latter?

4.3. Third step: graphic edition and static assessment of views

Once the characteristics of the views have been defined, the third step concerns the drawing of these views, generally by means of graphic editors. Editing views leads to a primary set of views, called synopsis. The ergonomic quality of this set must be assessed in order to improve the legibility of the information. So it is necessary to apply a set of ergonomic criteria with respect to the human information acquisition capacities. These criteria concern especially:

- the choice of the representation modes of the information according to its context of use, i.e. bar-graph vs. curve, dials vs. numeric counters, etc.;
- the choice of the shapes of the different symbols which can be used for displaying the process components in order

- to enhance the interpretation by the human operator;
- The appropriate size and colour for the information and the contrasts with its environment aiming at insuring a correct legibility and perception;
- the localization of the different items composing each view, and the arrangement of the windows on the screen;
- The maximum number of information the operator can process at a time.

The ergonomic criteria applied are generally expressed in terms of rules in design guidelines. However if a number of rules are general, ones some are specific to a particular industrial area. This is the case for the nuclear area in which specific design norms must be applied. Presently, research works tend to define methodologies or create tools with a view to fostering a better consideration of these criteria for designing the synopsis [9, 16-17, 20].

Questions:

Can the use and the functionalities of the graphical animated control view editors be improved by using hypermedia techniques?

Is it possible to interface a hypermedia data base describing the modes of presentation of each information with an ergonomical knowledge base so as to assess this data?

4.4. Fourth step: realization of a prototype of the interface

After the synopsis has been drawn, a prototype of the interface must be built in order to ensure the development of the program of animation of the views. The assessment of the program requires the process operation simulation. This assessment requires an important work, but it leads to an interface prototype close to the final one. Thus it reduces the work for integrating the interface in the real supervisory system on site which needs generally to stop the production process or which disrupts the production.

Questions:

If a hypermedia approach is possible to represent graphically each variable of the process, can these variables have a dynamical behaviour according to the process state?

Is "the static philosophy" of the hypermedia system not in opposition with such a behaviour?

Are the present material technologies able to ensure an "ergonomically satisfactory" response time to such a system?

4.5. Fifth step: implementation of the interface in the supervision system

The fifth step concerns the implementation of the interface on line and then its evaluation under real conditions. The importance of this assessment stage can be limited if the fourth step has lead to an achieved prototype. The evaluation aims at enhancing the content of the views (especially the lack of information), and at verifying its agreement with the operator's cognitive activities. For instance, it is important to allow the operator to evolve among the different abstraction levels of the process so as to solve a given problem [11]. Indeed at the higher abstraction level, the operator bases his reasoning process on general concepts related to the goals of the system. At intermediate levels, he considers the physical processes and functions related to each elementary component. Finally, at the lower level, he considers the structure of the installation as the links between the components.

As in the first step of the methodology, there are several complementary methods which can be used to carry out this assessment: cognitive task analysis methods [see 7, 26] or subjective methods (such as questionnaires) which consist in asking the operators various questions about the different characteristics of the interface, and aim at emphasizing eventual difficulties met while performing the tasks. These different methods can be completed by more quantitative ones concerning particularly the measurement of the operator's workload or performance, in order to point out some tasks which induce a high workload, and which therefore justify an improvement of the interface [19]. The choice of a particular method depends on the conditions of its application and particularly on the possible implementation of dedicated sensors in the control room, which can indeed disturb the production when the process is operational. This last step leads to a validated interface or to being sent back to the previous steps for improving the final system (Fig. 2).

Questions:

Can the operator easily and coherently evolve among the different abstraction levels of the process by using hypermedia techniques?

Is it possible to recover easily each pertinent piece of information and to use it with an adequate graphical representation?

*To which extent can the manipulations of the operator be facilitated?
Is there a risk for the operator of losing himself in the network of graphical control views?*

From the questions formulated until now, we will try to formalize progressively and more precisely some potential needs concerning imagery design and man-machine communication more generally.

5. First reflections about the possible contribution of hypermedias to imagery design in industrial process

This section concerns the possible contribution of hypermedia techniques aimed at designing industrial imagery. In order to meet the requirements of the imagery design, we present our first reflections based on the use of structured objects, and hypermedia and AI techniques. This is mainly related to the computerized checking off and description of tasks, the definition of the different displays, the definition of representation modes, and finally the graphical creation and animation of displays.

5.1. The computerized checking off and description of tasks

In complex processes, defining tasks which the operator must perform should be optimizing a great deal by making a computerized census and description of these tasks. Tasks and their chaining can thus be represented on a tree model, on which the nodes are the tasks themselves, described by structured objects, and branches the "successor" or "predecessor" type relations linking them to one another, as well as the conditions of progression from one task to another [12].

Can "hypertext" type techniques make easier the characteristic description of tasks and their chainings, according to the principle presented in Fig. 3, and this in order to help the ergonomist make these computerized census and description?

Thus, a window on the screen, helping the ergonomist to describe a task to be performed, can be in direct correspondence with the nodes and bows of an "hypertext" database. In this exemple, each task T_i (node), can be displayed and described in the window, in direct binding with other tasks, using links called $l_{i,j}$.

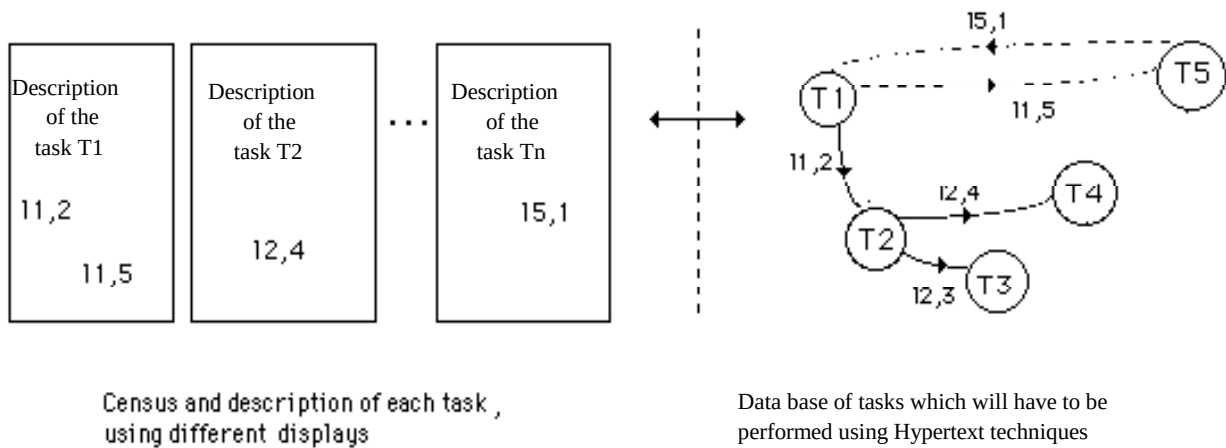


Fig. 3 Census and describion of tasks, using an "hypertext" database.

According to the same principle, each task can be associated to a node: "Informational needs list", called IN_i , in direct binding with other nodes, describing each variable of the process (Fig. 4). Furthermore, by associating an AI module, that integrates a base of description coherence rules to the "hypertext" database, it can be possible to improve this descriptive step, by extracting redundance, imprecision or inadequacy.

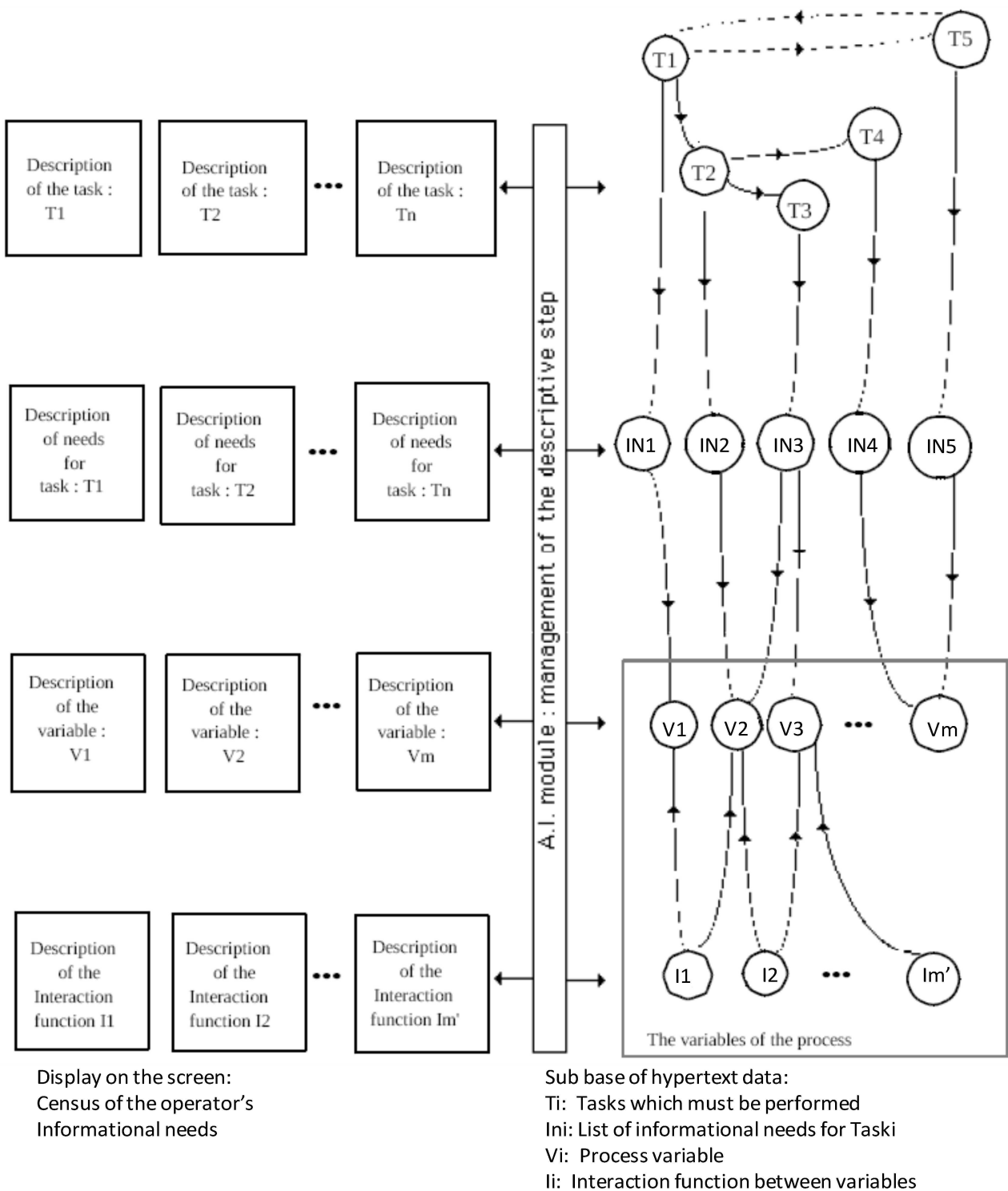


Fig. 4 Use of hypertext techniques for the checking off by the ergonomist of the operator's informational needs

5.2. View definition

According to the same principle used for the checking off of the operator's needs, can hypermedia techniques facilitate the definition of each view content by taking into account the operator's informational needs already checked off? For instance, in Fig. 5, "view₁" can be defined by the designer as containing two variables: V₂ and V_m; in the same way, "view₂" presents one variable: V₁.

This description can be assisted by a AI module managing coherence between the different views.

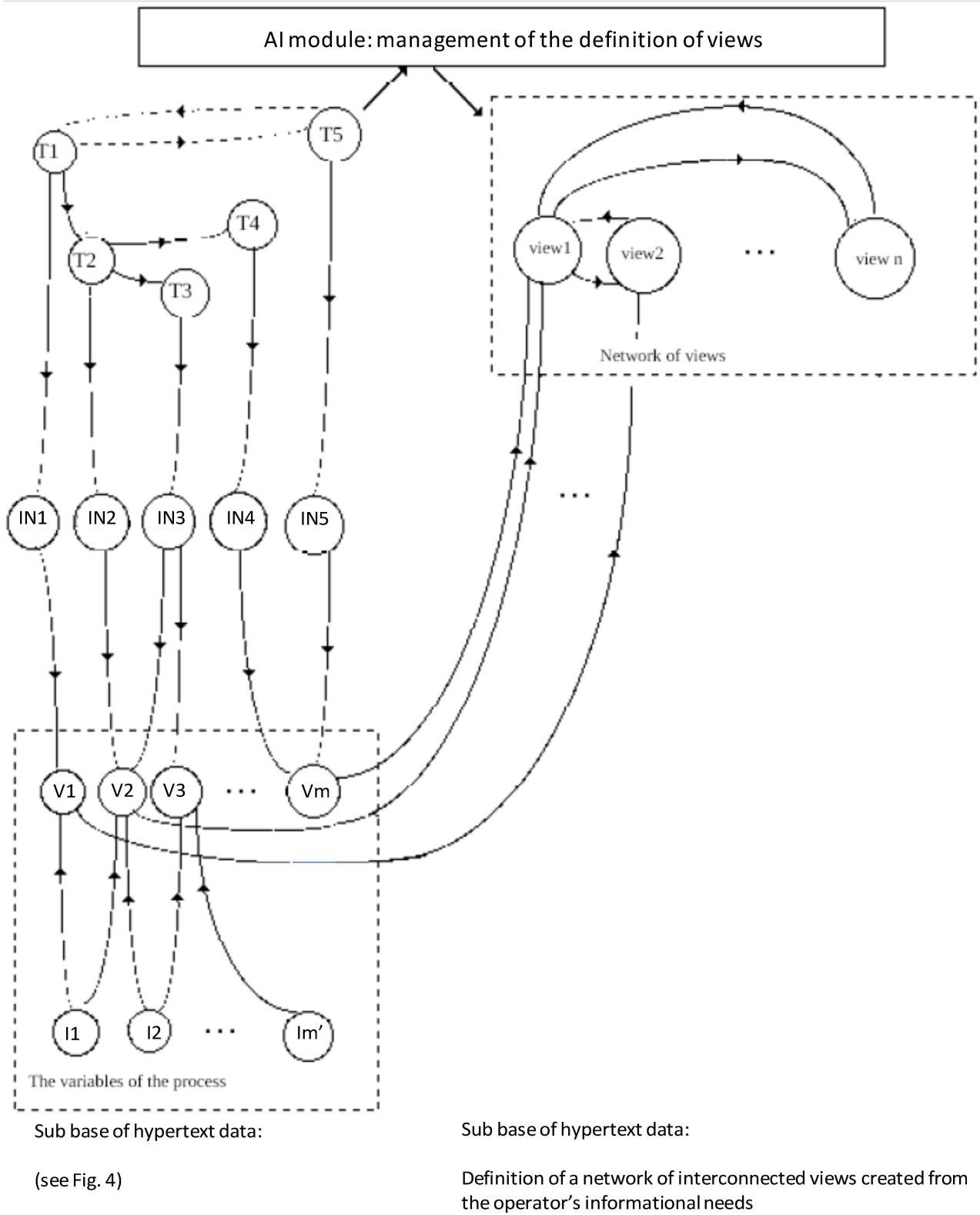
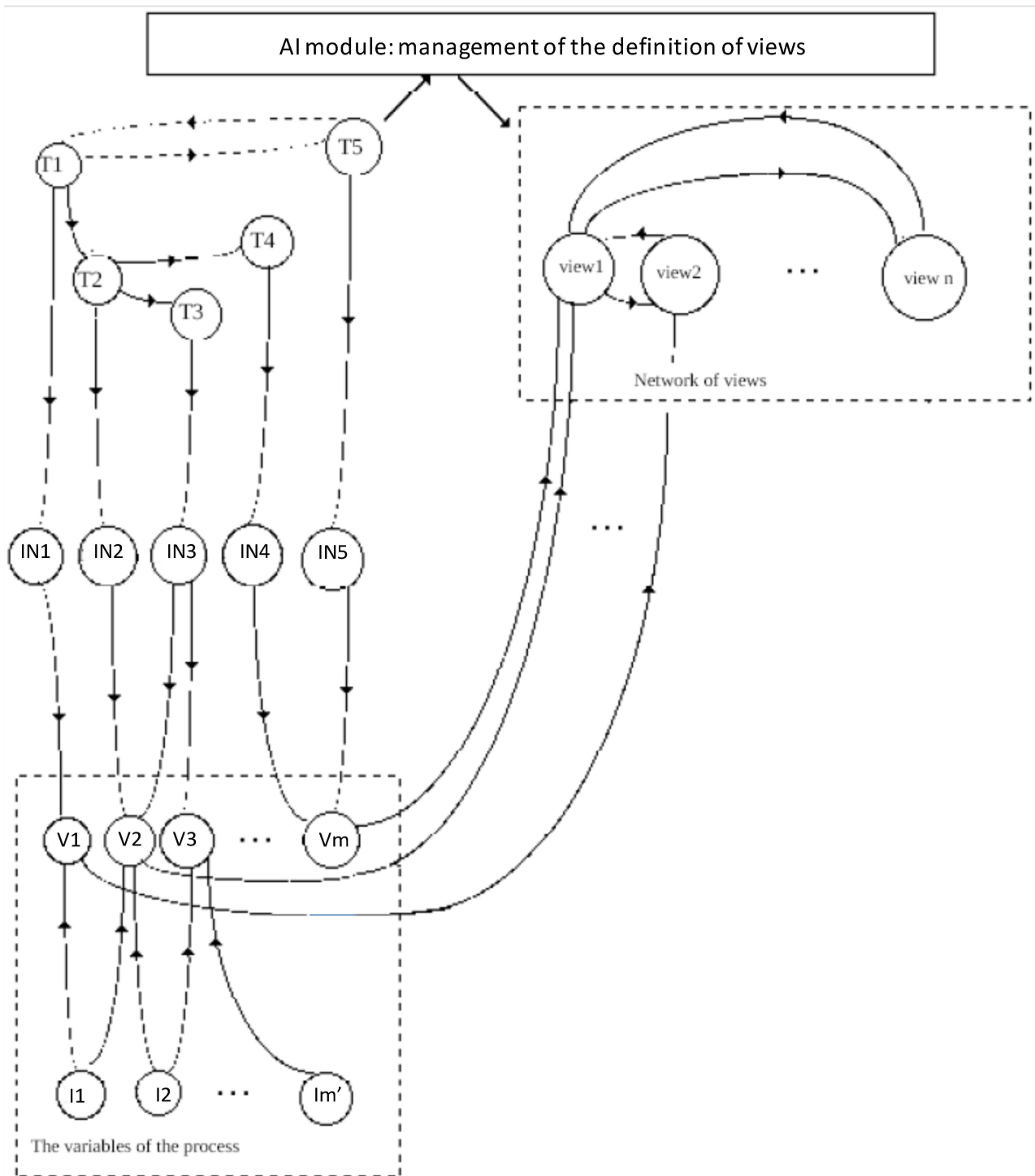


Fig. 5 Definition of views using "hypertext" techniques



Sub base of hypertext data:

(see Fig. 4)

Sub base of hypertext data:

Definition of a network of interconnected views created from the operator's informational needs

Fig. 6 Definition of the representation modes using "hypertext" techniques

5.3. Definition of representation modes

Can the work of representation mode definition benefit from the facilities of new techniques of information binding? Fig. 6 introduces the supplementary notion of representation mode: each variable can be literally associated by the

designer to a textual representation mode, called TM_i . For instance, the TM_1 mode corresponds to a curve, while the TM_2 one corresponds to a bargraph. Managing this definition phasis can be made easier by the intervention of an AI module. Two types of ergonomical rule can be taken into account [20]:

* **Type1:** A first knowledge base created to help the operator while he chooses the representation modes.

For example: IF *the operator has to visualize a variable tendency*
 THEN *propose a 'curve' type representation.*

* **Type2:** A second knowledge base assists the operator while he chooses graphical attributes.

For example: IF *the variable X is in a normal mode*
 THEN *use green color.*

5.4. Graphical creation and animation of displays

As regards to the graphical creation of the views, it would be interesting to associate each representation mode, called TM_i (see Fig. 6) to a graphical representation, called GM_i , (they have of course to be constituted with parameters such as colour, height, location on the screen, ...). Furthermore, a AI module can operate the step of graphical display using a third type of ergonomical rules [20]:

* **Type3:** A third knowledge base proposes - from conclusions of rules type 1 - predefined modes of representation included in data base - from conclusions of rules type 2 - and prints them on the screen.

For Example:

IF *mode of representation of type 'curve' is chosen for variable X*
THEN *print in a window (for eventual selection by the designer) the predefined curve with the parameter 'color' selected for variable X.*

The association of graphical modes of representation with textual ones helps speeding up the phase of prototyping on the one hand, and avoiding the problems of interfacing with a specific software of graphical creation on the other. Finally, each node V_i must be in direct relation with the process and be up dated according to its state. This relation must allow the graphical animation of the different views, and this in real time.

6. Conclusion

This paper has envisaged the contribution of the hypermedia technology in the man-machine communication domain in industrial complex processes. Thus, it appears that each industrial imagery designing step can benefit from the facilities of connected knowledge representation as well as from man-machine interactivity, given by these new techniques.

Given the large amount of ergonomical data and knowledge checked off and used during the different stages, and given the lack of formal ergonomical tools in this field, it seems urgent to study the extent to which new hypermedia techniques can contribute to the representation and exploitation of data and knowledge. At this point, there is one tool used for designing interactive application: ERGOLAB. It is a system which helps creating interactive applications, representing graphically a work station, performing dialogue chaining with the different interfaces, simulating actual work situations, experimenting and assessing with the future users, and the feeding of an illustrated manual for users [2, 5]. This system involves an on-line aid based on the "hypertext" GUIDE. The latter helps designing the cognitive activity of interfaces. According to their designers, exploring such new techniques will help giving a new dimension to on-line aid systems.

To brief, after having progressively formalized potential needs in the field of designing user interfaces, it appears that research in the designing domain can be made easier, and this by using these techniques. Conversely, this research could bring into focus some hypermedia limitations and thus play a great part in the improvement of their functionalities, particularly concerning "real-time" using and up dating.

References

1. Acier B.: Contribution à la conception et à l'évaluation d'interfaces Homme-Machines par l'analyse du comportement visuel d'un superviseur humain. Thèse de Doctorat, Université de Valenciennes, 1990.

2. Blanquet J., Gauroy P.: La conception d'interfaces: vers une aide intelligente. Actes du congrès de la SELF "Evolutions technologiques et ergonomie", Lyon, 4-6 October 1989.
3. Boy G.: Computer Integrated Documentation: a problem of knowledge acquisition and representation. ESA-ESTEC Workshop: A task oriented approach to human factors engineering. Noordwijk, The Netherland, November 21-23, 1989
4. Caloud P.: Raisonnement qualitatif: Application à l'aide à la supervision des procédés continus. Thèse de Doctorat, INPG GRENOBLE, 1988.
5. Crochart K., Damay J., Leprovost J.F., Walfard D.: Méthodologie d'utilisation d'ERGOLAB pour une meilleure implication des futurs utilisateurs dans le développement d'une application informatique. Actes du congrès de la SELF "Evolutions technologiques et ergonomie", Lyon, 4-6 October 1989.
6. De Keyser V.: Temporal decision making in complex environments. International Workshop on New Technology distributed decision making and responsibility, Bad-Hombourg, May 1988.
7. De Keyser V., Decortis F., Housiaux A., Van Daele A.: Les communications homme-machine dans les systèmes complexes. Rapport politique scientifique FAST n°8, Université de Liège, 1987.
8. De Young L.: Hypertext challenges in the Auditing Domain. Hypertext'89 Proceedings, Pittsburgh, Pennsylvania, November 5-8, 1989.
9. Elzer P., Borchers H.W., Weizang C., Zinser K.: Knowledge-supported generation of control room pictures. IFAC Workshop Artificial Intelligence in real-time control, Clyne Castle, Swansea, Great Britain, September 1988.
10. Feray-Beaumont S.: Modèle qualitatif de comportement pour un système d'aide à la supervision des procédés. Thèse de Doctorat - INPG Grenoble, 1989.
11. Goodstein L.P.: An integrated display set for process operators. IFAC Congress: Analysis, Design and Evaluation of Man-Machine Systems, Baden-Baden, September 1982.
12. Hessler C.: Use of a task model for the detection of operator errors and for flexible task allocation in flight control. ESA-ESTEC Workshop: A task oriented approach to human factors engineering. Noordwijk, The Netherland, November 21-23, 1989.
13. Hollnagel E.: Performance Improvement through cognitive task analysis. ESA-ESTEC Workshop: A task oriented approach to human factors engineering. Noordwijk, The Netherland, November 21-23, 1989.
14. Johannsen G., Borys B.B., Fejes L.: Ergonomic Knowledge support in graphical interface design for industrial process operators. Proc. 2nd Symposium on Human Interface, pp 579-584, Tokyo, The Society of instrument and control engineers, 1986.
15. Knaeuper A., Rouse W.B.: A rule-based Model of Human Problem solving in dynamic environments. IEEE SMC 15: 6, November/December, 1985.
16. Kolski C.: Contribution à l'ergonomie de conception des Interfaces Graphiques Homme-Machine dans les Procédés Continus, Application au Système Expert SYNOP. Thèse de Doctorat, Université de Valenciennes, France, 1989.
17. Kolski C., Tendjaoui M., Millot P.: An intelligent Interface Approach, 2nd Int. Conf. on "Human aspects of Advanced Manuf. and Hybrid Autom." Honolulu, Hawaii, USA, August 12-16, 1990.
18. Millot P., Kamoun A.: An implicit method for dynamic allocation between Man and computer in supervision posts of automated processes. 3rd IFAC Congress on "Analysis Design and Evaluation of Man-Machine Systems", Oulu, Finland, June, 1988.
19. Millot P.: Supervision des procédés automatisés et ergonomie. Editions Hermes, Paris, Décembre 1988.
20. Moussa F., Kolski C., Millot P.: Etude de l'intégration d'un outil expert interactif ergonomique dans la démarche de conception d'interface graphique homme-machine. Colloque, "L'Ordinateur, L'Homme et L'Organisation II", Nivelles, Belgium, 9-11 May 1990.
21. Schnase J.L., Leggett J.J.: Computational Hypertext in Biological Modelling. Hypertext'89 Proceedings, Pittsburgh, Pennsylvania, November 5-8, 1989.
22. Sundstrom G.A.: Modeling information search for design purposes: An exemple from process control. Proc. 32nd annual meeting of the human Factors Society (pp 1376-1380), 1988.
23. Taborin V.: Coopération entre Opérateur et Système d'Aide à la Décision pour la Conduite de Procédés Continus: Application à l'Interface Opérateur Système Expert du Projet ALLIANCE. Thèse de Doctorat, Université de Valenciennes, France, 1989.
24. Taborin V., Millot P.: Cooperation Between Man and Decision Aid System in Supervisory Loop of Continuous Processes. 8th European Annual Conference on "Human Decision Making and Manual Control", June 1989, Lyngby, Denmark.
25. Tang X.: Contribution à la conception des systèmes à base de connaissances "Temps réel" pour l'aide au contrôle de procédés continus. Thèse de Doctorat, Université de valenciennes, France, 1989.
26. Woods D.D., Wise J.A., Hanes L.F.: An Evaluation of Nuclear Power Plant Safety Parameter Display Systems. Proc. Human Factors, Soc. 25th Annual Meeting, 1981, 110-11.
27. Yoder E., Wettach T.C.: Using Hypertext in a law firm. Hypertext'89 Proceedings, Pittsburgh, Pennsylvania, November 5-8, 1989.