Computing Inventive Activities in an Industrial Context New Scientific Challenges and Orientations

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Abstract. In light of the increasing computerization of the world, the innovation activity in the industrial context seems to be lacking of tools to improve its performance. Since 2004, the 5.4 working group has been devoted to studying the computerization of this activity in industrial environments, coming up against, throughout its history, the underlying complexity of tackling a theme that is eminently complex because it is multidisciplinary and often in competition with human creative reasoning. However, the rebirth of artificial intelligence and the 4.0 paradigm are now pushing us to reconsider our research axes, as well as the scope of action in which our research must be situated. This article proposes an analysis that aims to refocus our research around a more realistic topic, more in tune with today's world, in line with our understanding of the issues in which our contribution can be deployed and on which scientific foundations.

Keywords: Computer-Aided Innovation, Inventive Problem Solving, Applied Artificial Intelligence, R&D 4.0.

1. Introduction: the new challenges around the activity of innovation in the context of industry

1.1. Digitization of the business world

As regularly in its history, a company has to renew itself or risk disappearing. With each technological or societal upheaval, a radical change followed by a necessary adaptation often takes place under the constraint of discomfort and the uncertainty that this causes regarding its survival in the short or medium term. Currently, and for less than a decade, the paradigm of digitization has posed itself to the company with its share of difficulties and the realization that while all companies in all industrial sectors have undertaken these changes, none can escape them.

Whether it is called "Industry 4.0", "Industry of the Future" or "Factory of the Future", this paradigm can be understood as a necessary evolution on how digitalization and so-called "intelligent" management of the physical operations of the company are carried out. It is therefore natural that workshops, assembly lines, quality departments and shipping were the sectors of the company that were the first to be affected by this change. Today, with sensors (IoT), robots, locating effectors, immaterial devices sending and receiving digital signals from parts, machines, tools, etc., the company's operations are dependent on the versatility of customer orders.

There is, however, one department of the company that has been carrying out this digital transformation for decades: it is Research and Development. The role of the R&D in a company is thus and for a long time, assisted by tools of modelling, calculations, simulation and informational management of its piloting (of its information systems). It then seems logical, in schematizing this situation, to perceive that the physical means are catching up with the intellectual means in the company. However, the connection is not being made and we are still far from a total and digital continuum from customer demand to delivery. Our observations of this continuum reveal a missing link, a gap in computerization on the "intelligent" nature of creative and inventive thinking in R&D. Indeed, while the CAD, calculation or even the recent CAI tools that our group considers as research objects, none of them have taken on the heavy task of operating artificially creative reasoning. Probably because this scientific "leap" is frightening to a society that sometimes stands in the face of unbridled innovation that it perceives as negative for the future of humanity.

The challenge posed by the computerization of creative reasoning is therefore legitimately questionable. If this last bastion of the role of the human being in business gives way, would it not be the advent of an endless creative loop driven solely by the consumer appetite of a society that is bulimic of novelty?

Our choice on this aspect is to move forward while avoiding the thorny pitfall of creativity by approaching this theme through a first link: the (inventive) resolution of problems. If the disciplinary field of Problem Solving is no longer debatable, it is to establish a digression towards "inventive" problem solving, which by definition only deals with what goes beyond the boundaries of the field where the problem arises, to extend to a field that is implicitly distant and unknown at the start of the solving process.

To sum up, we are now moving towards the search for algorithmic forms of knowledge processing to intelligently accompany the reasoning behind the resolution of problems in the design of technical systems, of any size and any level of complexity, from the domain where the problem arises to any other domain likely to contribute to its resolution.

1.2. The second life of AI and its promises

The intelligent nature of the algorithms that populate today's processors owes much of their effectiveness to the renewal of Artificial Intelligence. Indeed, the oldest among us probably remember that many attempts have been made to bury Artificial Intelligence because of its inability to compete with the incredible capabilities of human reasoning. Yet over the decades, AI research has grown, the information processing capacity of processors has increased almost exponentially, and the advent of the cloud and a space populated by available and limitless knowledge has now opened new perspectives to the world of research and more broadly to society at large. Today, there is no large company, state or nation that does not define itself through the challenges and prospects that AI offers for its future. It must therefore be noted that all the disciplinary variations of AI, its associated techniques, and its often free and open-source tools, are generating an increase in research in this field, which means that it is now up to everyone to appropriate them and use them to reach the "intelligent" stage of a tool, a method, an algorithm, a technical system or a company.

The 4.0 paradigm fits particularly well with the progress of AI since computerization generates omnipresent information flows in the company that are just waiting to be better managed and optimized. In this context, our inventive problem-solving activity can only be conceived by evolving from a formally described state (see our previous work on ontologies) to an intelligent form where AI techniques contribute to reproducing human inventive reasoning to better assist navigation in the near-infinite ocean of knowledge.

1.3. Genesis of the activity of the Computer-Aided Innovation Group

When our group clustered into a SIG (Special Interest Group) in 2004 under the impetus of Professor Noel Leon together with Professor Gaetano Cascini, we felt it was necessary to understand how the advent of a new generation of tools called CAI would penetrate the industrial world and what research would be necessary to accompany these new tools. A few commercial leaders of the time, such as Invention Machine or Ideation, were then facing each other in a field almost devoid of tools, where only CAD tools reigned supreme. The arrival on the scene of a major CAD player (Dassault Système) and his interest in linking CAD and CAI by joining forces with Invention Machine was to some extent the starter of our group's adventure.

Subsequently, the formulation of our objectives and their scientific orientations would allow us to build a small community that was constantly questioning its role in the computerization of Innovation. Through its collections of articles and its scientific productions, the WGCAI has contributed to questioning various disciplinary fields of science such as engineering sciences, information sciences or management sciences.

However, it has to be said that what was already being debated in the early days is still being debated, and it is still legitimate to question the extent of our contributions to the views of the small size of our group. Are we contributors to a pipeline called Innovation? Or doesn't the assertive industrial and engineering inventiveness of our group and its members require us to work in a more targeted spectrum of innovation, the inventive activity, upstream of it? If we look back at the arguments of the debates at the time, we find the decisive element that made us call ourselves "innovation": we had to extend the spectrum of potential research because it was in its infancy and we did not know at the time whether it would contribute more upstream than downstream of innovation.

Today, the observation made in the first two paragraphs of this article shows that even the narrower field of invention poses a set of challenges that is sufficiently broad for a group like ours, composed essentially of scientists from the engineering sciences, to find a favourable ground for the deployment of its research.

1.4. Towards new directions and a new scope of research

We are therefore facing a new life cycle for our group and the trends that are emerging on its reorientation are of 3 orders:

A refocusing of our scope of action on invention, upstream of a broader innovation process to which we contribute, but focusing on the formalism of its inventive phases. Such phases range from the management of tacit or explicit knowledge, resulting from the fruit of experience, or observed from reliable sources made available, to the production of inventive ideas or concepts when these are outside the scope of what is known in a given field; to reducing the uncertainty of the technical feasibility of these ideas by a formal description, pre-dimensioning, calculation, optimization, a digital or physical prototype allowing the downstream phases of the innovation process to be initiated.

A particular effort will be placed on the role of artificial intelligence techniques in the evolution of our information processing algorithms. This is to improve the parameters for evaluating the accomplishment of invention tasks in terms of completeness, speed and timeliness of information, whether it comes from expert questioning, texts, images, videos, audio transcription, sensors or IoT.

The digitization paradigm of society, and particularly of enterprises, will be at the heart of our concerns. Here we intend to work on aligning our tools with existing tools in the context of the Factory of the Future, especially when these are included in the scope of R&D decisions.

2. At the origins of Group 5.4 is the TRIZ theory, its incipient computerization and its academic research

2.1. Some failures for the computerization of TRIZ

Let us go back to the origins of our group: the arrival on the international scene of TRIZ-based digital innovation assistance tools. If we look at the headlines of some newspapers of the time, we can read "the tool of the 21st century", certainly in a journalistic style, but the exaggeration of this title reflects the hopes that industrialists placed in a tool (Invention Machine). Two decades later, the conclusion is clear: no tool that claims to be from TRIZ has made a breakthrough in the international industrial scene. No digital tool has supplanted an expert approach led by a human. There are even relatively few TRIZ experts who are willing to work with a digital tool. Our reading of this situation reveals 3 reasons that could partly explain this failure.

The first is that the inventive activity underlying TRIZ is an intimately human activity and that the human cognitive mechanism associated with its creativity is not yet sufficiently challenged by digital intelligence. Even though computations and databases have long since overtaken humans, creative thinking involves the billions of neural connections between synapses in the brain. The act of expanding into timely connections that produce the unexpected is therefore even more intellectually prolific than artificially so. Nevertheless, in the context of finding a solution to a problem and in the perspective of sharing knowledge across disciplines in industry and basic science, digital assistance makes sense and opens up important perspectives.

The second is that the foundations on which TRIZ was born are empirical. Altshuller was an electrical engineer and although he was a visionary, he did not provide the scientific basis for his theory that would have made it more formally usable by others. His method of construction was centralized and based on pedagogical and circumstantial exploitation: does the approach bring a plus in a person's ability to go beyond what they would have produced without the method? This not very robust way of developing a body of knowledge has long been a brake on the evolution of TRIZ in the various learned societies that have long seen TRIZ as a tool rather than as a disciplinary field opening up new perspectives. Information science has thus so far shown little interest in TRIZ, as the mechanisms underlying the theory appear to be rather obscure and not very formal.

Finally, the third reason is linked to the versatility and impatience of the expectations of users of IT tools. All attempts to computerize the TRIZ have come up against what a user expects from such tools: a quick answer and a reduced time to ask a question. However, the existing tools that make use of TRIZ all implicitly require a compilation of the knowledge needed to characterize the initial situation. And since they have not been automated to any great extent, these phases are carried out by the users themselves.

We are therefore faced with the need to automate a maximum of human mental tasks of two distinct orders, formulating and solving:

- **Formulate**: seek information that characterises the problems. It is then necessary to classify this information in data silos after a preliminary interpretation in harmony with a formal ontology that codifies how we have to differentiate what is useful, superfluous, false or indispensable for creative thinking. But how can we approach this aspect of the problem without thinking about the time-consuming side of this activity? One of the reasons why TRIZ is not widely used in industrial circles is the time-consuming side of its use, especially in the analysis of the initial situation.
- **Solve**: starting from a problem formulated canonically, extend the search for information likely to solve it beyond the perimeter of knowledge of the field where the problem arises. But starting from the postulate that human knowledge in all fields is almost infinite, a relevant search that breaks with human intuition poses a set of research problems that we intend to address.

This constitutes a new line of research that is on the borderline between artificial intelligence and engineering. To be successful, this research must involve researchers in information science and engineering science. The challenge is to be able to imitate the inventor's reasoning by teaching the machine to reason like an inventor. If we envisage supervised learning in this framework, it is, therefore, a few thousand humanly constructed expert cases that must be grasped by annotating texts that contain accounts of inventive situations to find a posteriori the cognitive mechanism that occurred during the inventor's creative reasoning in the sense of the TRIZ theory. Thus, if we can find in recent writings the tacit expression of inventive principles inherent to the inventors' thinking. We could then in real-time associate any new information, as soon as it appears publicly on the Internet, with a TRIZian mechanism automating the relationship between a problem model and a solution model. The user in an invention situation would thus be augmented in his reflections by new (recent) knowledge that is distant from his field of origin, such as to trigger the inventive mechanism that Altshuller studied and depicted in his work with the TRIZ theory.

Finding information, whether by questioning experts or reading texts is, therefore, a time-consuming step in the computerization of TRIZ, which relegates it to the rank of an improved notebook. This is demonstrated by the success of the simplification tools which, by a simple query in the form of a word or an expression, gives access to databases whose content is then more or less skillfully filtered.

The 4 types of texts which constitute for us privileged targets where the expert, scientific and technical knowledge likely to assist the inventive act resides are patents, scientific articles published in international journals and scientific news sites of a journalistic nature.

- **Patents** contain (according to the EPO) 80% of mankind's technical knowledge, even if no proof has ever been provided for this assertion, we can nevertheless reasonably believe that patents contain a large part of the written traces of human inventiveness. It remains for us to free ourselves from their intrinsic legal character by classifying those parts of their content that are likely to populate the ontology of Inventive Design and thus feed a database structured to feed the scheme of inventive thinking.
- **International journal articles** have the advantage of being peer-reviewed and therefore constitute first-rate information with credible content and written according to a certain framework. By targeting certain journals where inventive information from a variety of industrial fields is located, we have a second choice textual target.
- Then **journalistic-style websites** where news related to the invention are updated on a much more regular basis are also a good target. The versatile nature of scientific and technical information means that the emergence of novelty is both rapid (inventive novelties every second) and ephemeral (constantly renewed). The journalistic style (as opposed to the legal style) is deliberately made explicit so that it can be quickly assimilated by as many people as possible. Its syntactic forms are therefore particularly simple and its computer processing is equally simple.
- Finally, we will place in a separate category the **Wikipedia site** which alone contains a large part of the knowledge of humanity. If we limit the parts of Wikipedia dedicated to fundamental scientific knowledge, we have here information of a different nature since it displays very little recent news but rather records fundamental knowledge of all kinds.

In these four bases, we, therefore, have a combination of places where textual information resides that can feed representations of problems as well as elements that can be used to solve them.

To conclude this chapter, if TRIZ computerization is to have any chance of successfully serving society, it will have to automate human reasoning beyond what it is capable of producing without computing. There is therefore a place for machine learning, and the role of deep learning in this quest seems obvious. As our group is setting the limits of industrial use of such tools in the context of the intellectual demands made by research and development departments, we legitimately believe that such research, in this precise context, is in the process of blossoming and spreading in industry.

2.2. The presence of TRIZ in international publications

Earlier, we have already discussed the complicated relationship between TRIZ and scientific publications. The very first publications in quantity on the subject of TRIZ came from a site born in 1994: the TRIZ Journal. This site was not peer-reviewed, the articles were not peer-reviewed, and the scientific rigour of the writing and selection was questionable. It is also noted that the first thesis on the subject appeared in 1999 and that therefore the official scientific research on the subject of TRIZ was at first very empirical and based on a literature that was not easily accessible. It was therefore only in the mid-1990s that publications appeared in indexed journals on the subject of TRIZ, and it was a long time before some journals did not find, in the simple presence of the keyword TRIZ in a proposal, a reason for rejection. The beginning of 2010 marks an important turning point in the acceptance of TRIZ as a research topic in its own right. The ETRIA association and its scientific committee annually publishes a collection of contributions from the main laboratories that research the subject. The contributions are often taken up and published in about fifty journals indexed in ISI or Scopus. Over the past 10 years, more than 250 scientific articles have appeared each year in journals on the subject. It is therefore difficult today to contest the legitimacy of research associated with TRIZ in scientific circles.

2.3. Towards a new discipline to support the digitization of inventive activity

But let us look ahead with the data mentioned in the previous paragraphs. We have a set of scientific communities from engineering and information sciences that contribute annually to the progress of digitization of inventive activity in the context of the industry. We also have scientific tools that today are major issues for society, such as deep learning and supervised learning. More broadly, the involvement of Artificial Intelligence in research applied to the context of industry and more specifically its R&D. We are working in a new paradigm and the industry of the future is driven by a desire to intelligently digitize its functioning at all levels.

Computer-Aided Invention is thus becoming a new disciplinary field, in which computational systems have their place. They extend from the identification, monitoring and collection of knowledge in all its forms and of a nature to feed inventive thinking, to its processing, its use in the context of invention support, and end with the formalization of new concepts whose proof of feasibility is advanced to a point that allows the use of optimization techniques to move forward robustly in the innovation pipeline. The particular considerations of the alignment of a new information system in the information pipeline of a company are also studied so that bridges are possible between inventive design and routine and computational design. As is the subject of the role that a continuous flow of digital inventive concepts could play in the decision-making aspects of steering a 4.0 company.

3. New research frontiers for Group 5.4.

During the last years, we have observed a certain shift in the kind of aspects considered while talking innovation. The new topics that are more and more present include theoretical issues about innovation and creative design, sustainability and smart industry. We choose here to present a small subset of the last works of the members of WG5.4, pioneers of this innovation paradigm shift.

3.1. Theoretical issues about innovation and creative design

The theoretical issues that have been addressed during the last years include the study of the trade-off between optimisation and invention and the capitalisation of experience in inventive design but also pedagogical issues associated with creativity and inventiveness or the proposal of new paradigms for innovation.

Some authors have worked on the existing synergies between the design optimization process and the TRIZ model of contradictions, by using experimental or simulation data to automatically extract systems of contradictions [Chi18]. The same authors have proposed different ways to formulate innovation directions, from simulation to contradictions [Dub17].

Concerning the capitalisation of experience in innovation, several different approaches have been published. Most of them are based on the use of case-based reasoning, and we can mention one of the first works in this area by [Hou15] where the similarities and differences between the TRIZ theory and case-based reasoning are outlined. We can also mention the works of [Liu20a], who propose a novel approach of clustering of similar design cases, using fuzzy relational analysis, case-based reasoning and the C-K theory. Other approaches in this area involve the use of other technologies for experience capitalisation, such as in [Zha18], that highlights that using classical TRIZ tools to solve a specific problem requires additional knowledge such as the expert's accumulated know-how in their problem-solving practice (i.e. experience). To facilitate the use of experience, this proposal explores a new inventive problem-solving approach based on experience capitalization (Figure 1). We can also mention the works of [Zan19] that present a survey on the use of the KREM model. The KREM (Knowledge, Rules, Experience, Meta-Knowledge) model permits the capitalisation of experience in smart systems and was successfully applied in different industrial cases (Figure 2).

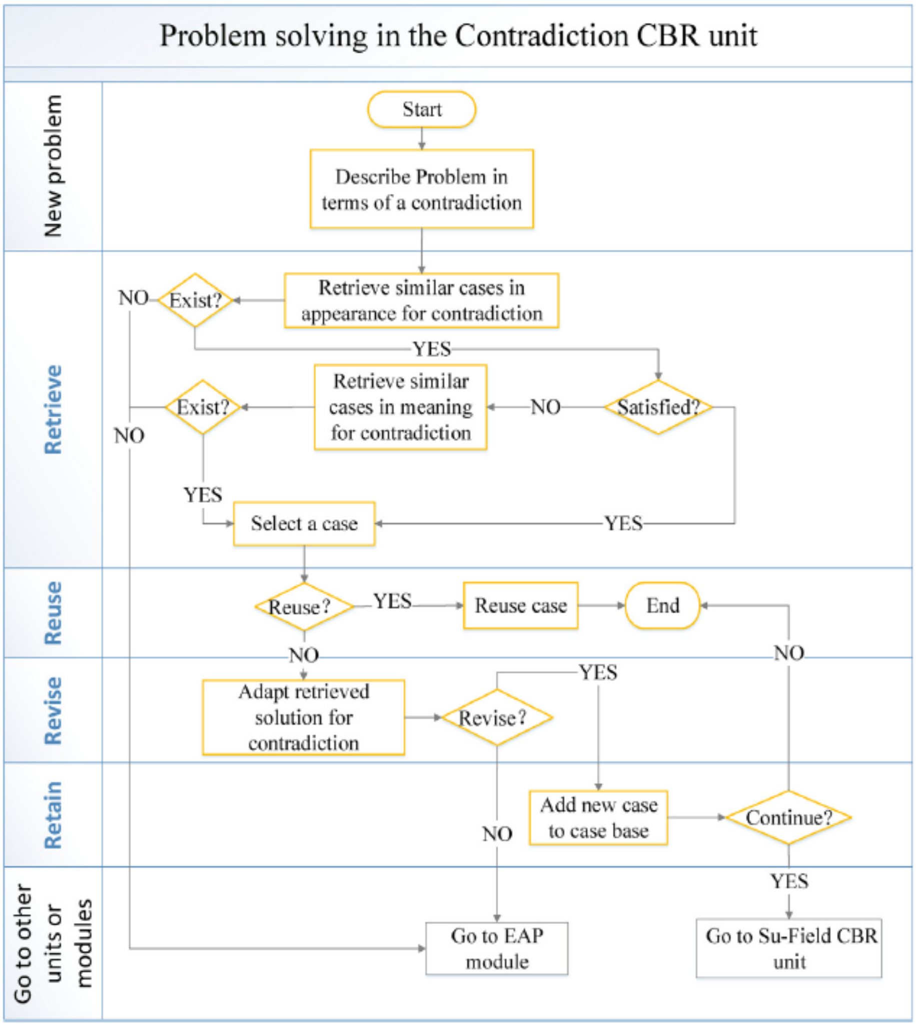

Fig. 1. Joint use of Case-Based Reasoning (CBR) and TRIZ to improve the use of experience in inventive studies

The last element of this section concerns the proposal of new invention paradigms or pedagogical aspects. The first structuring works of [Cav11] justified the emergence of new tools allowing computer-aided artefact creation, that are the base of the works of WG 5.4. It is also worth mentioning the works of [Liu19] who proposed mixed approaches with radical innovation and knowledge-based innovation and a radicality evaluation method, obtained by a regression process on two well-known radicality computing formulas, through a statistical analysis of some known design cases. On their side, [Wan20] propose a quantitative model of low-end disruptive innovation (interesting because of its simplicity, low cost, ease of use, and high maintained reliability and efficiency of the existing product) based on the OTSM-TRIZ model.

Finally, some other authors have been working on the possibility of teaching innovative design in engineering schools, knowing that new engineers need to be at the cutting edge of technology in all areas. The authors of [Cav13] present some experiments led by them, based on the postulate that any innovation-oriented approach requires that the bases of any design action need to contain new rules of inventiveness where creativity and problem-solving have priority. Also in this pedagogical context, computer tools have their place and need to be developed beyond classical ideas collecting boxes, whether they are physical or digital, extended within a small group of persons or open to variable extents.

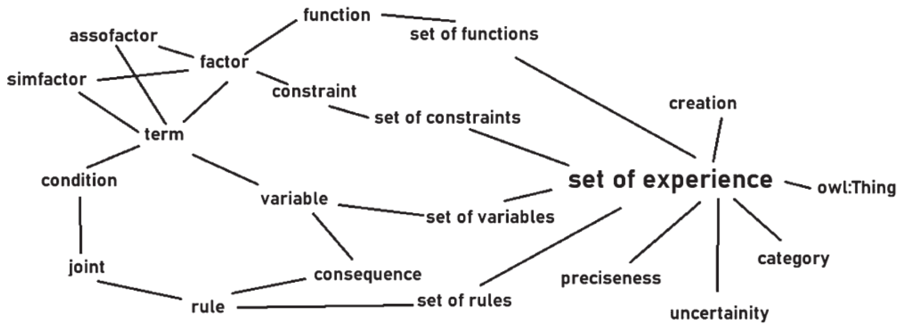

Fig. 2. Capitalization of experience using a SOEKS (set of experience knowledge structure) under its ontology representation

3.2. Sustainability

In this section, it is worth mentioning the last works of one of our members (and the associated research group), that has been working on sustainability and environmental issues for several years now.

One of the areas is waste disposal, whose methods and technologies are characterised by slow evolution. In [Rus19], the authors present a proposal of using pyrolysis for waste disposal. Pyrolysis can bring great benefits, in economic and environmental terms, when used for waste disposal because instead of just burning waste, it is possible to get products for industrial use, such as reaction gases and oils that have a high calorific value. They present some successful examples of how an Italian-French industrial group, active in pyrolysis has implemented TRIZ to develop a large-scale technology for urban waste recycling.

Another important area is the proposal of eco-guidelines for supporting designers in developing new greener products and processes. The authors of [Rus20] support their work on one of the most known systematic innovation techniques, TRIZ. They propose a rigorous ontology indicating how to apply a specific problem-solving strategy onto a specific part of the problem the designers face, trying to make the user aware of the environmental consequences of the choice of design changes. The result of this work is a set of 59 guidelines that are presented along how they were adapted concerning the original technique, and the reason about why they should generate greener solutions

3.3. Smart Industry

The concept of Smart Industry (or Industry 4.0 or even Industry of the Future) corresponds to a new way of organizing the means of production. This new industry asserts itself as the convergence of the virtual world, digital design, management (operations, finance and marketing) with the products and objects of the real world. In these new smart factories, human beings, machines and resources communicate with each other naturally taking advantage of new technologies such as the Internet of Things and Services, the Cyber-Physical Systems, the Cloud Manufacturing or the Additive Manufacturing, among others.

Some authors have taken an interest in additive manufacturing as an integral part of modern manufacturing because of its unique capabilities in various application domains, and in particular in a specific case of design, namely design for additive manufacturing (DfAM). [Ren20] propose a design framework for additive manufacturing through the integration of axiomatic design and TRIZ. This integrated approach is effective because the axiomatic design approach can be used to systematically define and analyze a design problem, while the TRIZ problem-solving approach combined with an additive manufacturing database of existing pieces can be used as an idea generation tool to generate innovative solutions for the design problem.

In another area associated with Smart Industry, the automation in different manufacturing processes has triggered the use of intelligent condition monitoring systems, which are crucial for improving productivity and the availability of production systems. To develop such an intelligent system, [Cao19] has proposed an ontology as a base to develop an innovative intelligent condition monitoring system (Figure 3). More recent works of the same group [Cao20] complete the previous works and propose the joint use of machine learning and deductive semantic technologies for that innovative development.

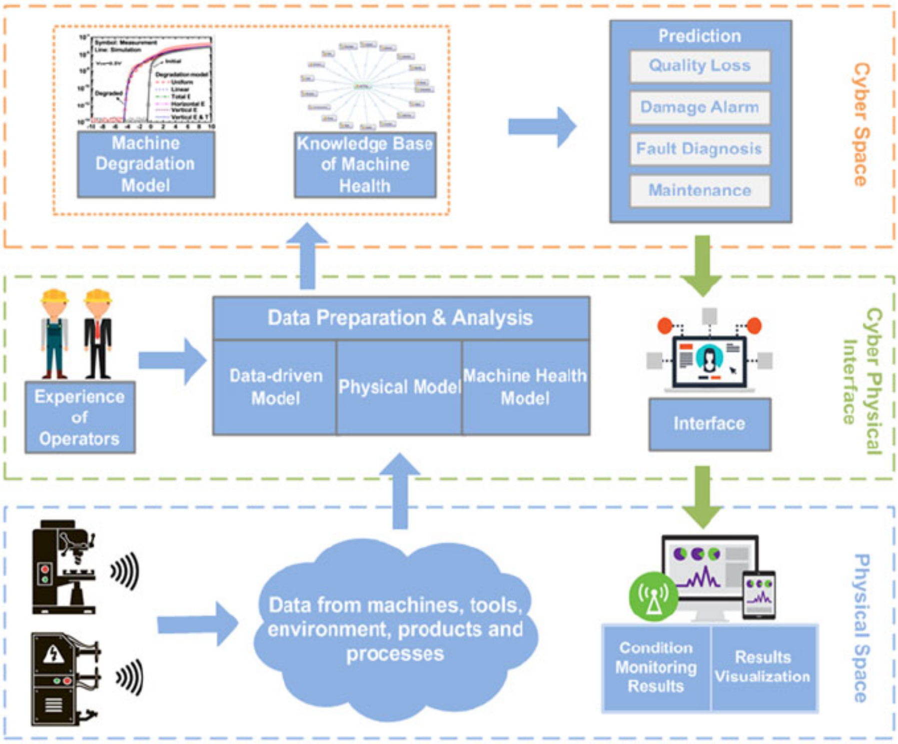

Fig. 3. The proposed framework for an intelligent condition monitoring system based on a cyber-physical approach

Other members of WG5.4 have been working on cognitive vision systems due to their potential to revolutionize human life as they are designed to work under complex scenes, adapting to a range of unforeseen situations, changing accordingly to new scenarios and exhibiting prospective behaviour. The combination of these properties aims to mimic human capabilities and create more intelligent and efficient environments. Contextual information plays an important role when the objective is to reason such as humans do, as it can make the difference between achieving a weak, generalized set of outputs and a clear, target and confident understanding of a given situation. Nevertheless, dealing with contextual information remains a challenge in cognitive systems applications due to the complexity of reasoning about it in real-time in a flexible but yet efficient way. The authors of [Sil20] propose an enrichment of a cognitive system with contextual information coming from different sensors and the use of stream reasoning to integrate/process all these data in real-time and provide a better understanding of the situation in analysis, therefore improving decision-making (Figure 4).

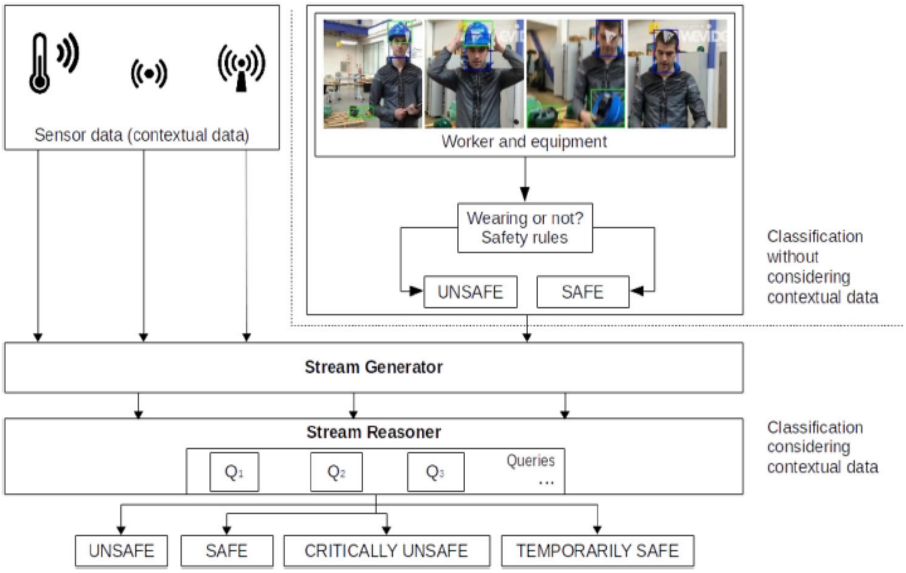

Fig. 4. Framework for enriching a cognitive system with contextual information coming from different sensors processed by stream reasoners

3.4. AI-based semi-automated Invention & assisted brainstorming

AI-based computer tools within the context of invention raise another axis of research which is more methodological and practical. In this research, one of the WG5.4 teams wonders about the systematization of the inventive process and in particular to what extent certain stages can pass from man to machine, including in the formulation and resolution phases.

Some authors argue that a possible intermediate path lies in reversing the classical process of constructing a problem graph to go step by step in 4 steps towards a list of solution concepts [Mas20].

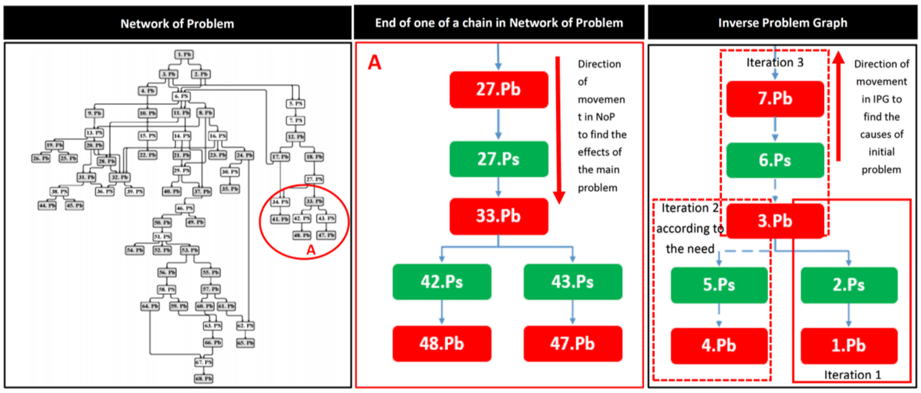

Fig. 5. Network of Problem and its difference with Inverse Problem Graph

This approach aims to get straight to the point of the problem to the contradiction by feeding on real-time information from semantic extractions from current scientific texts.

In this research, the authors start from the fact that the minimum necessary in the analysis of a problem requires at least one partial solution and two antagonistic problems. This subset must be qualified by one parameter of action and two parameters of evaluation to clarify the contradiction underlying this portion of the graph within a larger problem. From a contradiction to the inventory of the elements of information likely to solve it also implies a large part of automation and exploration of knowledge bases artificially exploited to provoke the creative act. If the solution concept is distant from the expected objective, it is a direct return to a new exercise of formulation-contradiction-resolution which is proposed and so on until the objective is reached. Through this approach, the team tends towards a high level of assistance to the inventive act, making it much faster without sacrificing the inventive relevance of the results.

4. Conclusions

As evoked in the introduction, the new developments in artificial intelligence and the 4.0 paradigm push the WG5.4 to reconsider the research lines and the perimeter where these new directions need to take place. Following this idea, collaborations with other WG in TC5 or with other TCs need to be developed. In particular, natural synergies with other groups of TC5 appear, mainly with *WG5.1 Global product development for the whole life-cycle*, *WG5.7 Advances in production management systems* and *WG5.11 Computers and environment*, because these groups work closely to the new topics that emerged in WG5.4.

But, if we analyse in detail the research works that are the main focus of WG 5.4 today, it is clear that natural synergies appear also with TC12 Artificial Intelligence. The topics addressed by its workgroups (knowledge representation, reasoning and management, machine learning and data mining, collective and computational intelligence) are the ones that appear in the new research lines of WG5.4, as analysed in section 3.

In the years to come, we intend to change the life cycle of our group. Our intentions clearly raise the question of a name change, the expression Computer Aided Innovation seems to be beyond our possibilities, on the other hand, we feel much closer to inventive activity than to the entire continuum that separates an initial problem situation from a market success. One of our past publications talked about the innovation pipeline, and it is quite true that only a very broad multidisciplinary scientific activity could address such a field in its entirety. In view of the size of our group and the scientific fields covered by our members. It is therefore more than a contribution to the upstream inventive phases of the innovation pipeline that needs to be discussed, with particular attention to the role played by the combination of information sciences and engineering sciences in formalizing inventive activities.

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