Intelligent Manufacturing Systems

# THE INTELLIGENT PRINCIPLE OF VIRTUAL LABORATORIES FOR COMPUTER AIDED DESIGN OF SMART SENSOR SYSTEMS

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***Abstract**: A distinguish principle for Virtual Laboratories for Computer Aided Design of Smart Sensor Systems (VLCAD-SSS) is proposed. This is the "intelligence" of the VLCAD-SSS. This principle is based on the investigation in the area of the General Information Theory (GIT) and especially of the Theory of Infos, which is a part of GIT. The understanding the VLCAD-SSS as intelligent system gives possibility to develop appropriate functions and models.*

***Keywords**: Virtual Laboratories for Computer Aided Design; Smart Sensor Systems; Intelligence; Intelligent Systems.*

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## Introduction

The concept of Virtual Laboratories (VL) originates and is based on the idea for remote access to some resources via world computer net. In the beginning VL are aimed to support educational process and were called Remote Laboratories (RL). Traditionally, Remote Laboratories have been focused on specific solutions for specific problems. We can find a wide range of RL in the literature [Gravier et al, 2008], assisting very different types of subjects (electronics, robotics, optics, fluids mechanics...), but commonly bound to a restricted set of requirements. Little attention has been paid on working on a scalable, maintainable, secure, open architecture that addresses the requirements of a wide set of experiments, and that could be open enough to support or adapt itself to new experiments. [García-Zubia et al, 2008].

[Gravier et al, 2008] present wide literature review and expose four major issues for the leverage of remote laboratories. These are reusability, interoperability, collaborativeness and convergence with Learning Management Systems. Those functionalities are pieces of a large picture, but they can be handled independently. Future research directions are merely called to address some of these issues. [Gravier et al, 2008] see in each of these paths a serious possibility to blow away a lot of problems of remote laboratories, thereby providing a richer learning experience to the students, but also to the teacher.

The indecently of the used learning theory (constructivism or behaviorism) the Remote Laboratories are aimed to support reproduction of the knowledge. A widespread learning theory today is constructivism, which emerged from cognitive science. Constructivism is usually opposed to behaviorism [Jonassen and Wang, 1993]. Behaviorism focuses passive transfer of knowledge between teachers and learners, trying to interpret knowledge acquisition as a settlement of a permanent change in learner's behavior, face to a given problem. On the opposite, constructivism try to make students learn from their own observations, using discussions with the teacher but also with their peers (sometimes referred as social-constructivism).

The support of knowledge discovery needs different tools and approaches. This scientific area is well known as Computer Aided Design [Farin et al, 2002]. The complexity of the problems to be solved causes emerging the Virtual Laboratories for Computer Aided Design (VLCAD) [Palagin et al, 2007]. Special types of VLCAD are the Virtual Laboratories for Computer Aided Design of Smart Sensor Systems (VLCAD-SSS) [Palagin et al, 2009]. Due to very specific creative area of design of the smart sensor systems, the software support needs to be "intelligent". In other words, the methods and instruments of the Artificial Intelligence need to be implemented in VLCAD-SSS. The goal of this paper is to outline this very important principle for VLCAD-SSS.

In the next section we discuss the main characteristics of the concept "intelligence". Section three describes the VLCAD-SSS as an intelligent system. Last section concludes.

## The intelligence

About the intelligence, Schlesinger and Hlavach wrote "You and we altogether should not see such a great nonsense in that one can learn about something, which has never been observed. The entire intellectual activity of individuals, as well as that of large human communities, has for long been turned to those parameters which are inaccessible to safe observation. We will not be speaking about such grandiose parameters as good and evil. We will choose something much simpler at first glance, for example the temperature of a body, which is regarded as an average rate of motion of the body's molecules.

The path leading to knowledge about directly unobservable phenomena is nothing else than an analysis of parameters which can be observed, and a search for a mechanism (model) explaining the relations between the parameters. This means an effort of exploring the relations between the observed parameters and the impossibility to explain them in another way (or more simply) than as an existence of a certain unobservable factor that affects all the visible parameters and thus is the cause of their mutual dependence. Recall astronomers who have been predicting a still unobservable planet by encountering discrepancies in observations from assumed elliptical orbits of observable planets since Kepler laws have been known. Such an approach is a normal procedure for analyzing unknown phenomena. The capability of doing such exploring has since long ago been considered to be a measure of intelligence." [Schlesinger and Hlavach, 2002], p.262.

The reality cannot be given in one definition. There exist many definitions of the concept "**intelligence".** For instance, a definition given from practical point of view is given in [Fritz, 1997]: the "intelligence is the ability to reach ones objectives. A system is more intelligent if it reaches its objectives faster and easier. This includes the ability to **learn** to do this. The intelligence of a system is a property of its mind. The mind is the functioning of its brain. An **intelligent system** is a system that has its own main objective, as well as senses and actuators. To reach its objective it chooses an action based on its experiences. It can learn by generalizing the experiences it has stored in its memories. Examples of intelligent systems are persons, higher animals, robots, extraterrestrials, a business, a nation. An **artificial intelligent system** is a computer program. We can say that it is like the proverbial black box; it has inputs and **learns** which outputs get the most approval by human beings. It stores experiences in its memory, generalizes them, and thus can deal with new circumstances (new inputs)".

The philosophical and practical points of view are two sides of the same idea. Nevertheless, from these definitions it is not clear what the main characteristics of the intelligence are. We need definition that is more detailed and in the same time to be universal to cover natural and artificial intelligence. The correct understanding of the concept of intelligence gives possibility to organize the process of design in proper way. This needs to be one of the main features of VLCAD-SSS.

The application of intellectual methods of information processing in smart sensors systems' problems/tasks is conditioned at least by three groups of factors.

- First, this information is complicated: it comes from various sources, in a considerable volume and irregularly, it has various nature, ranges and units of measurements.
- Second, data that is being collected relates to the significantly important areas of implementing the smart sensors systems – monitoring the quality of water and air, danger of fires and level of ground waters, weather and climatic anomalies, sharp dangerous situations and "creeping" accidents, etc.
- Third, processing of this information in general requires application of such operations, as estimation, comparison, analysis, classification etc.

All this area, i.e. the specified information, its collection and processing, its analysis and decision-making, management and taking actions, control and estimation of results – all this is in general poorly structured, has more likely qualitative rather than quantitative nature and therefore is insufficiently formalized, and is beyond usual methods of representation and computer processing.

Within the last decades and especially due to the introduction of personal computers, researches and application results of new methods of work with complicated information in difficult conditions were started in a variety of areas (management, economics, business, computer science, etc.). They have got the name of intellectual methods, and it is not always a metaphor.

We may define the intelligence as "ability to think abstractly", as "ability to operate effectively in the present conditions", "ability to react correctly to certain problems", "ability to study", "ability to receive knowledge from experience", "skill to get the abilities that lead to desirable results", "ability to adaptation", etc.

In Webster dictionary, the dictionary of authority, there is the following interesting definition: intelligence is an ability to be taught (to be learned) or to achieve the comprehension due to experience. Another definition from the same source is to have a ready and quick apprehension.

In Oxford dictionary of current English (ed. A. Hornby) which is an excellent source, the following definitions (besides others) are presented: intellectual – having or showing good reasoning power; intelligence – the power of perceiving, learning, understanding and knowing.

We will consider the methods of information processing as intellectual which are as a rule referred to rational activity particularly. These are functions in which comparison, estimation, generalization, systematization, aggregation and decision-making are realized – in difficult conditions, when there is a lack of information, time etc.

In general, the definitions of the intelligence are covered by next definition [Mitov et al, 2010], which follows from the General Information Theory [Markov et al, 2006] and especially from the Theory of Infos [Markov et al, 2009].

***The intelligence is synergetic combination of:***

- **(primary) activity for external interaction**. This characteristic is basic for all open systems. Activity for external interaction means possibility to reflect the influences from environment and to realize impact on the environment. For instance, in Walter Fritz' definition [Fritz, 1997] these are "senses" and "actuators";
- **information reflection and information memory**, i.e. possibility for collecting the information. It is clear; memory is basic characteristic of intelligence for "the ability to **learn"**;
- **information self-reflection**, i.e. possibility for generating "secondary information". The generalization (creating abstractions) is well known characteristic of intelligence. Sometimes, we concentrate our investigations only to this very important possibility, which is a base for learning and recognition. The same is pointed for the intelligent system: "To reach its objective it chooses an action based on its experiences. It can learn by generalizing the experiences it has stored in its memories";
- **information expectation** i.e. the (secondary) information activity for internal or external contact. This characteristic means that the prognostic knowledge needs to be generated in advance and during the interaction with the environment the received information is collected and compared with one generated

in advance. This not exists in usual definitions but it is the foundation-stone for definition of the concept "intelligence";

- **resolving the information expectation**. This corresponds to that the "intelligence is the ability to reach ones objectives". The target is a model of a future state (of the system) which needs to be achieved and corresponding to it prognostic knowledge needs to be "resolved" by incoming information.

In summary, ***the intelligence is creating and resolving the information expectation*** [Mitov et al, 2010].

## VLCAD-SSS as intelligent system

Creating of Virtual Laboratory for Computer Aided Design of Smart Sensor Systems (VLCAD-SSS) is very important scientific-technical problem. Based on received experience and wide analysis of world literature [Palagin et al, 2009] separate out the next main principles of VLCAD-SSS:

1. ***VLCAD-SSS is man-machine system***. All design systems, which had been developed and will be developed, are computer-aided, and designer is the main part of these systems. Human in such systems has to solve tasks, which cannot be well defined, and problem, which human by using own heuristic abilities may solve better and more effective than computer. Close interaction between human and computer during the design process is one of principles of development and exploitation of any CAD systems for computer device designing.

2. ***VLCAD-SSS is hierarchical system***, which use comprehensive approach to automation of all design levels. The level hierarchy is presented in the system structure as hierarchy of subsystems.

3. ***VLCAD-SSS is a set of informational-concerted subsystems***. This principle refers not only to connections between large subsystems, but to connections between separate parts of subsystems. Informational compliance means, that almost all possible sequences of design tasks are served by informational-concerted programs. One program is informational-concerted if all data in this program are part of numeric arrays and do not need transformations during sending from it to another program and inversely. So, the results of one program can be incoming data for another program.

4. ***VLCAD-SSS is an open system***, which are permanently expanding. Permanent progress of technology, designed objects, computer technology and computational mathematics lead to appearance of new, more perfect mathematical models and programs, which replace old analogs. VLCAD-SSS has to be open system and be able to use new methods and tools.

5. ***VLCAD-SSS is specialized system with maximum using of unified units***. Requirements of high efficiency and universality for any system are, as a rule, conflicting or competitive. It is reasonable to develop VLCAD-SSS on the base of unified parts. Necessary condition of unification is searching of common principles in the modeling, analysis and synthesis of technical objects.

Now we are able to add a new principle:

6. ***VLCAD-SSS is an intelligent system***. This means that VLCAD-SSS has to cover all given above characteristics of the intelligent systems:

- **VLCAD-SSS (primary) activity for external interaction**. This follows from principle 4 - VLCAD-SSS is an open system and it is clear, the activity for external interaction means possibility to reflect the influences from environment and to realize impact on the environment. VLCAD-SSS needs to have "senses" and "actuators" which may be of different types starting from trivial computer keyboard and screen;
- **VLCAD-SSS information reflection and VLCAD-SSS information memory**, i.e. the possibility for collecting the information. Memory is basic characteristic of intelligence for “the ability to **learn”.** VLCAD-SSS is based on special kind of multi-dimensional memory organization [Markov, 2004], which gives new possibilities to support computer intelligent processes;

- **VLCAD-SSS information self-reflection**, i.e. possibility for generating "secondary information". The VLCAD-SSS needs to be able to find regularities in the stored data to have possibility to classify the received information in proper classes and to prepare basis for further decision making;
- **VLCAD-SSS information expectation** i.e. the (secondary) information activity for internal or external contact. During the information interaction with the end user, the VLCAD-SSS needs to be able to use the regularities in the data found during self-reflection. It is important to discover regularities in the incoming data to have possibility to classify the received information in proper classes and to prepare basis for further decision making. The prognostic knowledge is generated in advance and during the interaction with the environment the received information is collected and compared with one generated in advance;
- **VLCAD-SSS resolving the information expectation**. VLCAD-SSS needs to create appropriate targets as models of the future states of the creating systems which need to be achieved and corresponding to it prognostic knowledge to be "resolved" by incoming information. The manual and/or automatic experiments with the generated models have to be achieved and corresponding to it prognostic knowledge needs to be "resolved" by incoming resulting information.

## Conclusions

A distinguish principle for Virtual Laboratories for Computer Aided Design of Smart Sensor Systems (VLCAD-SSS) was proposed. This is the “intelligence” of the VLCAD-SSS. This principle is based on the investigation in the area of the General Information Theory (GIT) [Markov et al, 2006] and especially of the Theory of Infos [Markov et al, 2009], which is a part of GIT. The understanding the VLCAD-SSS as intelligent system gives possibility to develop appropriate functions and models.

The principle of intelligence pointed above is a basis for further work. The provided corresponded prototype realization and experiments with an intelligent machine learning system called PaGaNe [Mitov et al, 2009] shows good results to be implemented in the VLCAD-SSS. The intelligence of VLCAD-SSS may be realized using intelligent system PaGaNe because it is based on the same advanced multi-dimensional model of memory organization [Markov, 2004] which is proposed for VLCAD-SSS [Palagin et al, 2009].

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