Artificial Intelligence From Perception To Reasoning (A Value_System-Based Architecture)

Bogdan Enciu

Research Institute for Informatics
8-10 Averescu Avenue,
71316 Bucharest
ROMANIA
enciu@std.ici.ro / enciu@risc.ici.ro

"Knowledge can be communicated,
but not wisdom."
Herman Hesse (Siddhartha)

Abstract: This paper tries to emphasize some critical problems which appear in the main approaches of AI related to the development of advanced intelligent systems. The basis of the reasoning process is knowledge acquisition by learning, as an expression of the perception. The capability of perception is considered of being of the same importance as the reasoning for intelligent systems, especially for those that directly perform in the environment at whose events have to act in real time to reach the proposed goal. But also a reference system is needed the system activity to run in accordance with it. The aim of the proposed value_system-based architecture is that systems accomplish reflex-like actions as well as actions triggered by decision processes.

Keywords: perception, reasoning, assessment, value_system, real-time

1. A Critical Survey Over Traditional "Intelligent" Systems

The possibility of simulating intelligent behavior by computer seemed for some obviously. John McCarthy, as promoter of artificial intelligence, sustained that any aspect of learning or any other feature of the human intelligence can be described with enough accuracy such that a machine can simulate it.

However, the attempt to create intelligent machines, which would react in a way similar to the human being, was naturally confronted with the need for understanding the complex functions of knowledge (as a result of the interaction with the surrounding world) such as perception, language or reasoning.

A challenge was in the physical symbol system hypothesis launched by Allen Newell and Herbert Simon, who consider that a system has an intelligent behavior if and only if it is a physical symbol system.

For the systems developed under this paradigm, the way of solving problems derives from the predefined knowledge base. That knowledge is used in a rational sense to reach a "goal" (as a final goal we can consider the autonomous "performance" in the surrounding world and the Turing test passing [Luger, Stubblefield, 93]). This knowledge base is constituted by the experts of a domain with the help of knowledge engineers. The solutions provided by these systems can be compared with those of the philosophers who believe in the existence of a previous life. The solving of a problem can be considered as a recall of the experience from that previous existence. As it is assumed that these systems have had a complete knowledge base just from the beginning, we can conclude that all features of the system and all the symbols can be seen as "genetically" predefined. It seems that it would be impossible for the human being to transmit through genetic code the amount of knowledge acquired in a lifetime (in the case we accept the idea according to which, among others, this would be the role of the information "carriers"). One hypothesis that seems more natural is that genetically we are being transmitted codified algorithms by means of which we "build up" symbolic structures. Consequently, the symbolic paradigm still has to explain how knowledge can be acquired in time.

A possible answer to this problem could be that traditional symbolic systems can also "learn". Learning denotes changes in the system, which enable the system to do the same task more efficiently and more rapidly [Simon, 84]. In this paradigm learning is defined in such a way that it improves the search in the knowledge base rather than extends it. Efforts were made to improve the way of representing knowledge, especially "uncertain" knowledge (through probabilistic models, certainty factors, "fuzzy" sets). However, it is hard to explain, using this paradigm, how in living life, while developing one can reach some stages of knowledge and then surpass these, in the sense of transcending. Obviously, for such systems additional interventions from outside would be expected.

The learning aspects are related to the impossibility of maintaining a complicated symbolic model while it is acting on the environment in real-time. As the model extends, due to the (probably exponential) prolongation of the time needed to update that model, the system will not be able to act because of getting busy to maintain the model. One can sustain that it is a technology problem, to be solved by increasing the computing power of the system. The problem is in principle related to the impossibility of representing the aspects of a real changing universe using symbolic methods. If something changes in the real world, the system would be constrained to decide on what needs be changed in its own representation of the world.

Another aspect concerns the establishing of meaning in symbolic representations. In symbolic systems, the meaning of symbols results from the way they are connected to other symbols and the way they are processed. Thus, the explanation of the knowledge process is also related to the transformation of sensorial states into symbolic representations, and to the way that makes the connection between the real world and the internal model. In designing a system, obviously, it is assumed that sensors will "translate" correctly the events from the real world and, so, these events get properly "associated" with their internal symbol representations.

At the same time, the manipulation of the symbol asks for the existence of an internal "processing" mechanism that can involve many resources and a lot of time. The idea of "splitting" complex symbolic structures into some simple ones and even of replacing the "atomic" ones by machines, was suggested [Dennett, 78].

Another aspect consists in the relation between designer/modeler, expert system/robot and world/environment. In the case of expert systems design, the knowledge engineer plays the part of an observer of the human expert behavior for problem-solving and, subsequently, he describes this behavior in symbolic terms [Hart, 92]. That means the definition of the knowledge aspects from a domain, considered as the basis for system building. Consequently, the knowledge engineer analyses and models the domain from the real world with the help of the human expert. That signifies that the categories, the objects and the symbols are those of the knowledge engineer and they are not based on the system experience, but on the experience of the engineer. Additionally, this way of knowing the domain is a static one and it "seizes" the experience of the expert and the engineer at that time moment.

These aspects generate other problems. The world is dynamic, permanently changing, that means "static knowledge" will always become unsuitable in a certain moment, so the system will not be adaptable. If a situation is encountered which cannot be taken up properly by the implemented domain model, the behavior of the system will be inadequate. Even if the system can learn, the primitives (i.e. the object and event classes that can be represented by the system) will remain the same. If a failure free interaction of the system with the environment is compulsory, then the system would have to be capable of continuously adapting to changes.

Given that the symbols that form the world model for the system are not based on the system experience, the system will not be capable to make the connection with the external world as an expression of the "perception" of its own sensors. This raises a special problem for the autonomous robots that have to interact with the environment without human intervention.

The aspects related to the contact with the surrounding world seem to have been approached more successfully by the connectionist models. These were worked out in trials of brain-like modeling, obviously influenced by biological aspects. For the moment they are considered only as a new "computational scheme" [Kröse, Smagt, 93]. Some of these models, that have in view only the parallel distributed processing, cannot be considered for developing a new paradigm. Neural networks are already "classical" but they solve problems at the level of phenomena "perception" and a primary "action" to these rather than at the level of "reasoning" on these. The networks are trained through a "reaction" to strengthen or weaken some connections depending on a correct or, respectively, incorrect response. If the problem belongs to pattern recognition, the network has all the chance to learn to "recognize" well a big enough number of patterns. But if, for example, the problem involves the learning of word streams, correctly or incorrectly from a grammar point of view, then the things are complicated due to the reduced capacity of "stimulating" the network. Learning implies just this internal reaction mechanism at a certain response. In case of performing in the real world this reaction does not exist anymore under the form of the acceptance or nonacceptance of a response either correct or incorrect (the instructor does not exist any longer).

One of the interesting approaches to the autonomous systems is the reinforcement learning technique. The networks lacking assistance can obtain only from outside a "reaction" of approval or disapproval of their response in the form of the consequences that succeed the response.

While in a symbol based system the symbols can be used partially or totally by their combining and recombining in different ways, a neural network can be used only as a whole that cannot be "split" into components. The "constituent parts" of a network can be considered, eventually, as the states of that network. The states can be local (for example, in a network they can identify a unit or a local group of units that become active at a certain "stimulus") or distributed (that affect the whole network and can be detected through a "pattern" of activity and connections). In either situation it is not clear how to find a symbolic structure in the network states [Harnad, 97].

If a system, based on a neural network, "sees", for instance, a human being, when referring to his height the system will respond with "tall" or "short" according to the assessment of height expressed by the person who assisted the learning of that network. If the network learns unsupervised, the appreciation will be done based on whether the system has reached a goal depending on the height of the human being whom it interacts with (if a short human being could lead towards the reaching of the goal and the goal cannot be reached, then the system will assess that the human being is "tall") and, certainly, different goals could lead to different assessments.

With a symbolic system, the capability of assessing height is fully assigned to the designer who is forced to "supply" the system with an assessment criterion, a reference value/range. The assignment of this criterion is an open problem [Flondor, 97]. Consequently, the representation, which determines the response function, is "connected" to the outside world only in the reference frame of the designer.

2. A Value_system-based Architecture

Intelligent systems that directly get in touch with the world (that is continuously changing, partially unknown and unpredictable) should real-time react to changes. This architecture attempts to solve the problem of reflex-like actions (as a response to external stimuli) as well as the problem of decision-making based on advanced knowledge. The design and implementation of such architecture cannot be done in a symbolic or connectionist manner exclusively.

In the symbolic approach, the system design provides the system with models of the environment it will perform in. These models form the necessary base for internal process planning for each system. The processes are used to decide in particular actions. However, the plan-oriented systems will rapidly enter combinatorial problems because of the many alternatives which have to be considered, given the unpredictability of the surrounding environment. As the environment is only partially known, a complete model is impossible to build. Even if only partial models are developed, maintaining the updating models needs a lot of resources and computing power. On the other hand, there could be no need (less wish) for developing "complete" or very detailed models, because only a limited zone and events from the environment in which the system performs, are relevant to its actions. What is relevant could be determined just from the interaction with the situations created in the environment and not exclusively through elaborate models. Actually, the environment itself contains the knowledge which the system needs for reaching its goals. In this sense, a system must have the capability first to "perceive" correctly the events from outside and then to "reason" on them.

The structure of the proposed architecture is determined by AI techniques (neural networks, fuzzy logic, inferential mechanisms) as well as by response time aspects. At the level of perception the approach based on neural networks will dominate whilst the level of reasoning and representation of advanced knowledge will be of symbolic nature. The levels of the architecture are relatively independent of each other.

As a rule, the actions are based on a value system. This is met there where the capability of event differentiation is obvious. It should be noticed that, in practice, the human expert's behavior, the result of his interaction with the problem domain and with the problem, can show identical actions even in different situations or different actions in similar situations. For a system, its "behavior" would be the result of the interaction with the environment. The problem of qualitative (not only quantitative) differentiation of events could be decisive in the extraction of relevant information and in actions for attaining the proposed goal. This way one may consider that perception could have some flexibility in order to be able to "serve" the internal learning processes. Human being reasons using concepts. Obviously, the concepts that the human being learns are influenced by his perception but the learned concepts can also determine changes to the perceptual "representations".

In the author's opinion, for an intelligent system the way of acting on the events cannot be dissociated from the existence of a mechanism establishing priorities. Such mechanism implies a "value_system" and an evaluator. The value_system will be anytime modifiable, depending on events as well as on the goals of the intelligent system. The same applies to the knowledge base. The internal processes of the evaluator will establish the significance of events as well as the way of action depending on them.

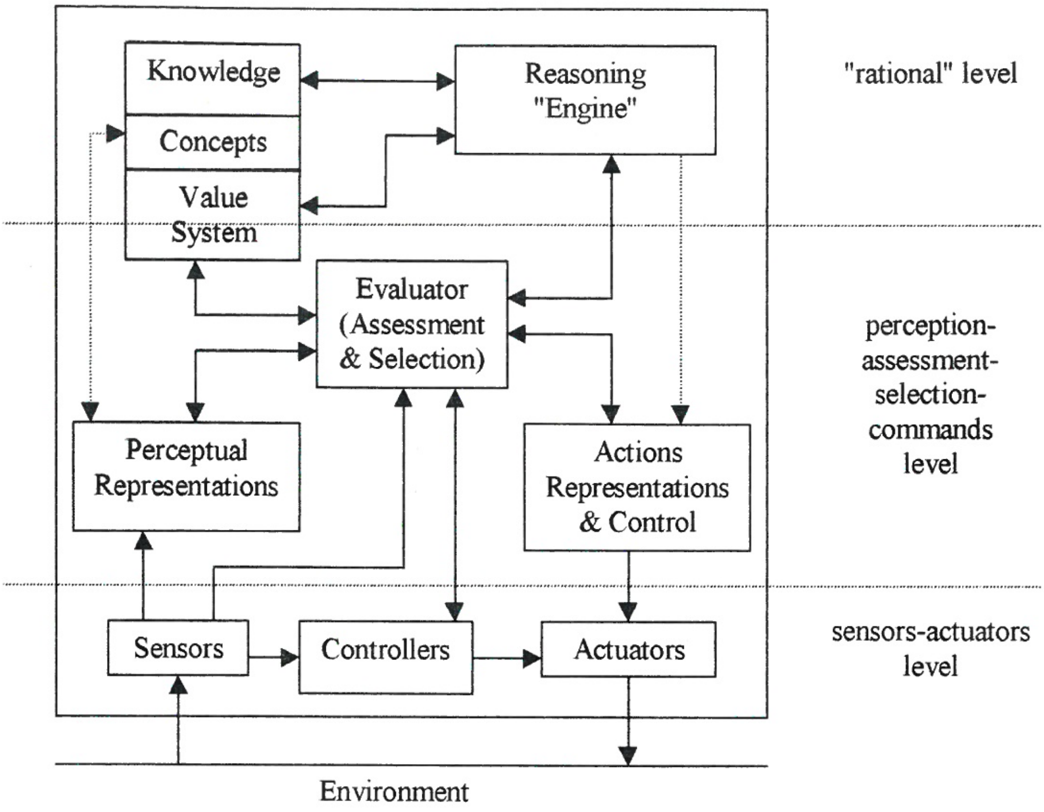
The image of the architecture might not clearly outline the connection levels of the system components. Thus, objects, events, states, properties can be represented at different levels (perceptual, conceptual, knowledge, actions) and the representation of each element can have correspondence at different levels.

The adaptability to the environment must be considered through the increase of the "attention" given to important features of the environment is. Consequently, the value_system is based on priorities established by the evaluator or by the reasoning engine from "experience". The evaluator can sort and assess events. The evaluator is able to "categorize" in time only events relevant to the system activity, by learning, subsequent to repeated action of the system. According to the nature of the event, the evaluator can "alert" the rational level if the event demands a complex processing which accesses the advanced knowledge of the system, and inhibit an action at sensors-actuators level. The process of reasoning can be interrupted when an event comes up which makes action (i.e. for the "survival" of the system) be imminent. The result of every action will be assessed. This may bring about changes in the value_system and, sometimes, even in the knowledge base. Also, the reasoning processes can determine changes in the knowledge base and the value_ system.

The "reciprocal" relation between the perceptual representation and the concepts points out the capacity of perception of being flexible. The stimuli, for the moment undistinguished, can become perceptible distinctively. Following the assessment and reasoning, actions triggered by processes which initially called for detection of more informational elements from the environment, can be accomplished through the detection of a single element representing a more complex structure. This means the acting speed should go up.

If there is a need for action strategy the system will make use of the reasoning engine in order to make decisions. The mechanism is inference-like.

By building in the evaluator and the value_system, the intention has been not to create a "supervisor" of the system but to "organise" as good as possible the system actions, priority resting with the action to critical events. The capability of the value_system to be modified will in a way enhance "liberty" to the intelligent system and improve the system behavior. This is not too far from the idea that systems can set out their own goals!



The value_system-based architecture

It is the approaches based on neurological and psychological grounds, attempting to explain the brain functions and the knowledge processes, which are the future of the system performing autonomously in different environments or trying to pass the Turing test.

REFERENCES

DENNETT, D., **BRAINSTORMS: Philosophical Essays on Mind and Psychology**, MIT PRESS, Cambridge, MA, USA, 1978.

FLONDOR, P., **Presentation At the "Fuzzy Sets" Seminar**, Research Institute for Informatics, Bucharest. 1997.

HARNAD, S., **Pylyshyn's Critique of Neural Nets,** http: //cogsci.soton.ac.uk /...../ 0115.html. 1997.

HART, A., **Knowledge Acquisition for Expert Systems**, MCGRAW-HILL, INC. 1992.

KRÖSE, B. and SMAGT, P., **An Introduction To Neural Networks**, A Course Delivered at the University of Amsterdam, 1993.

LUGER, G. and STUBBLEFIELD, W., **Artificial Intelligence**, THE BENJAMIN/ CUMMINGS PUBLISHING COMPANY, INC., 1993.

SIMON, H., **Why Should Machines Learn?** in R.S. Michalski, J.G. Carbonell and T. M. Mitchel (Eds.) Machine Learning, SPRINGER-VERLAG, 1983.