DEFINING SITUATIONS - FUNDAMENTAL LEVEL OF PERCEPTION

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Abstract: I deal with development of general intelligent system (agent). This system should be able to examine surrounding environment and develop as effective behavior as possible. I present ideas about creating general intelligent system. Additionally, perception is examined in greater detail. A method used for differentiating sensory readings into more regions (situation) is called 'Defining Situations'. This method provides complexity reduction in incoming data. Raw continuous multi-dimension sensory readings are transformed into form of logic expressions.

Keywords: intelligence, perception, defining situations, intelligent agent.

1. INTRODUCTION

After 50 years of research in the field of Artificial Intelligence results are far behind expectations. A lot of AI technologies are going to be successfully applied in many fields of human endeavor, but despite this, AI community failed to develop anything that could demonstrate intelligence comparable to intelligence of humans.

This paper presents ideas about designing intelligent systems (agents). General issues are addressed in section 2. Section 3 proposes architecture and function of inner modules of an intelligent system. Section 4 describes process of 'Defining Situations' in greater detail. Defining Situations is part of perception machinery of the intelligent system.

2. GENERAL INTELLIGENT SYSTEM[1]

2.1. Theoretical issues

I see the cause for AI community to fail introduce real intelligent artifacts in over-focusing on separate methods and little emphasis given on creating whole working intelligent systems. No single method can be sufficient for intelligence, intelligence is very likely the product of many (tens, hundreds, thousands) methods or mechanisms, see (Minsky, 1988). Because of this we do not need complete theoretical understanding of all single AI methods and we do not need spend much time on tuning performance and precision of these methods on chosen specific problems. Instead, we need a full spectrum of methods for coping with every kind of

[1] General Intelligent System - this name is ambiguous on the purpose: "any intelligent system/entity" when speaking generally about intelligence and "intelligent system (agent) designed to work in any (new) environment" - "general" is here used to stress the aspect of intelligence - ability to adapt to new conditions.

encountered conditions and a mechanism that will select best method from this spectrum based on actual performance. Method that fit best into current conditions will then be used. Another issue here is that no intelligent system today is able to really explore its environment from scratch. No system today is able to built valid, structured, complex, usable descriptions of reality. Designers of intelligent systems provide them with pieces of knowledge that seems to be adequate for the system, but using this knowledge leads to brittle behavior. The only knowledge one can really use is the knowledge one derived from his own experience and this knowledge can be eventually completely revised when turned to be inadequate.

So, my concern is to design intelligent system that employs many methods for coping with every aspect of possible conditions[2] together with a method for choosing which method is best to employ in actual conditions, see my previous work (Beneš, 2004). Additionally, there is need for advanced filtering and data scaling methods. Performance of many algorithms drops significantly when processing large data - processing cost can be reduced by filtering out unimportant/uninteresting data. Moreover, there is always the possibility that we are processing data unnecessarily big. If we employ a method that examines more differently downscaled versions of input data we may uncover the size of data that is sufficient for our needs so we can avoid unnecessary processing in the future.

As I mentioned, intelligent system should be able to derive all its inner representations and its inner setup from its experience. Nobody (including intelligent system designer) can accurately foresee all important courses of events in complex changing domains. So, no hard-wired knowledge can ever guarantee robust behavior - sooner or later it will cause a major failure and significant drop of performance of the system unless there is the opportunity to bypass this legacy knowledge. Intelligent system must employ mechanisms for gathering significant information from surrounding environment. If the system has the opportunity to manipulate the world (environment) in the situation that already appeared it can discover specific information in these conditions or conduct experiments in this situation and recheck previously gathered information. There is significant link between behavior of the system (performed sequence of actions) and the perception of the system. The system is manipulating surrounding environment and that influences directly what is coming to sensors and more indirectly what can be percepted in general (some specific information can be revealed in some specific situation only - for example). On the other hand, past and actual information acquired by perception mechanisms is used to adjust behavior of the system to ensure as good performance as possible. It is believed that this motor-sensor-motor-sensor-motor... loop is an essential feature of intelligent systems - prerequisite for developing intelligence.

Inner modules and workings of an intelligent system should be designed to be as general as possible. It means that used methods should guarantee the system to produce rich spectrum of different behaviors. Preserving their very varying outcomes, these inner methods should be as similar to each other as possible in their structure and face they show to the rest of the system. This should guarantee easier modifying or alternating of these methods by the system itself and some degree of similarity should also make building of the model of inner processes of the system easier. This model of self is for advanced systems equally important as the model of outer world.

[2] "Coping with conditions" stands for solving problems, conducting research, balancing resources, developing new methods etc.

2.2. Intelligent agent

Intelligent systems need to be situated in their environment, see (Brooks, 1991). Idea that intelligence needs situatedness or embodiment is relatively new in the field of AI, but it has good chance to be true. Being in the environment and having bidirectional motor-sensor connection to it is essential for any kind of intelligence to emerge. Then all intelligent systems are also intelligent agents. Fig. 1 shows connection between an agent and environment it is situated in.

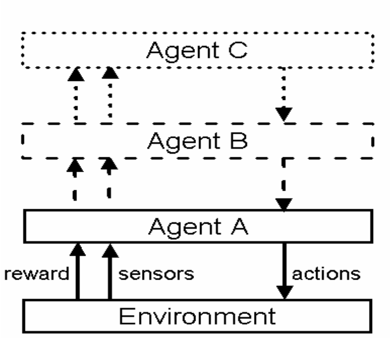

Fig. 1: Connection between agent and environment. Inner mechanisms of the agent could be seen as environment for another (copy of the) agent - this is the way how to easily create sophisticated control hierarchy.

Another often ignored aspect of intelligence is its connection to performance - success. In other words, intelligence can be directly measured in terms of success, reward, completed goals, reinforcement, fitness function. What else is intelligence if not ability that uses adaptation to new environment and insight into working of the world for performing most effective behavior? Agent has body with sensors and actuators. Special kind of sensor is received value of fitness function. This value comes from environment like sensory readings, it shows the agent how good it performs in the environment. This is the way how the designer tells the agent goals it should follow.

Virtual environments are suitable for developing intelligent agents. Development is cheap and we have complete control of it - we can arbitrarily adjust complexity; we can observe everything that is happening.

3. INTELLIGENT AGENT ARCHITECTURE

Architecture of an intelligent agent consists of 4 main parts (see Fig. 2): perception, behavior, model and deliberation. Simplest behavior is created in behavior module without using of sensory data entering perception module. More advanced behavior is using reactive principles, sequences of actions are directly triggered by detected features, events, situations. More advanced behavior uses expectations given by model and involves override of reactive behavior when needed. As we have seen before, there is tight connection between motors (actuators) and sensors. Therefore there is resemblance between behavior module and perception module.

3.1. Behavior module

One part of the behavior module is *macroact constructor*. Macroact constructor deals with building more powerful actions from the basic primitive actions performed by actuators. There are many approaches how to assemble the composite (macro)actions[3], but the main idea is that created macroacts should perform some defined more advanced task than the simpler (primitive) actions are able to accomplish.

3.2. Perception module

Situation definition is part of the perception module. Situation definition deals with creating regions in sensory state space. Division to one region (usually one) and the rest of state space is called a *situation*. Analogically to reducing complexity by construction and using of macroacts (performing of many primitive actions is masked by performing of one macroact), working with situations reduces complexity by working with situations (being / not being in defined region in sensory state space) instead of directly working with abundant raw sensory data.

3.3. Model and Deliberation

These are advanced modules. Model module creates and stores representations of performed activity; of detected features, relations and developments in environment and also representation of the agent itself in relation to outer environment is stored here. These representations are used for creating expectations and supporting behavior. Deliberation module provides high level processing. Inconsistencies in model are detected here and resolving methods are suggested; resource balancing and priority assigning (for behavior and many concurrent parallel processes in other modules) is performed here.

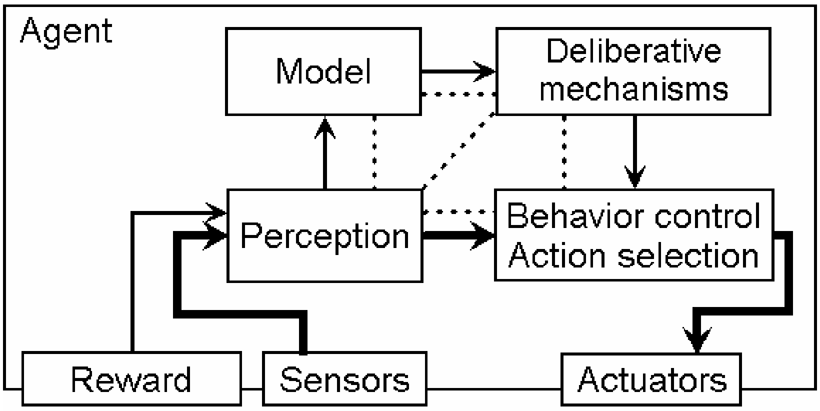

Fig. 2: Intelligent agent architecture.

4. DEFINING SITUATIONS

4.1. Situation as sensory state space split

In this section I am going to present the mechanism of defining situation. New term *situation* is coined here as a (sensory) state space partition into (certain interesting) region(s) and the rest of the state space. So, *situation* is a very abstract notion that is incorporating all kinds of sensory experiences of an agent and is consistent with the common notion of occurring or appearing of things, objects, conditions or features.

[3] Macroactions are new actions composed of (primitive) actions.

What is perceived by the agent depends on actions performed by this agent and by the shape of fitness function this agent receives. Perception mechanisms of an intelligent system/agent are permanently adjusted to detect and process interesting sensory inputs. Interesting means useful. Attention for data that can not be used by the system to maintain or raise the level of effectivity is falling - these data are ignored or filtered out.

Situation definition is a mechanism that tries to find useful partitions of sensory state space. This partition can be derivated directly from the values of fitness function - a region will be demarcated in sensory data space where value of fitness function is high. High fitness function value region and its complement form together a new situation. Another option is situation defined on the basis of properties of available (macro)actions. Situation is defined as the partition between areas where certain action performs well and poor. In similar way, situation can be based on distinguishing between different effects of certain action or between areas where certain action can and can not be performed.

There are more ways how a situation can be defined: clustering; examples + their vicinity; neural networks; rules. Using clustering techniques, the system can demarcate regions in sensory state space where frequency of observed cases is above some threshold. This can be used to find regions where something usually happens. Arised clusters are typically not centroids - that's why I am developing new method for graph clustering based on Delaunay triangulation. Graph clustering methods are able to find arbitrarily shaped high case frequency areas. Another possibility is to define a situation by the distance to some examples or prototypes. Neural networks can be also trained to recognize a region in state space. Situation can be defined using logical rules incorporating limits for values from sensors. These rules can also include references to other situations.

4.2. Process of defining situations

Intelligent agent appears in new environment. It has no knowledge previously gained in other environments. Let's investigate agent's cognition. See (Marjanović, 2003).

In first part of cognition process our agent is acting without any use of perception. Sensory readings are recorded, but they have no influence on created behavior at this point. The agent is performing random actions. This allows investigation of action effects and at the same time portion of sensory state space is explored. Among collected statistical material, there is also a record of values of fitness function. Still without use of sensors, using records of performed actions and respective values of fitness function, the agent develops as effective behavior as possible. In theory, this behavior is robust because no matter what happens in the environment, our agent maintains as high fitness function value as possible. The agent tries to find answers on following questions:

a) WHERE are high fitness function regions?
b) WHAT fitness function depends on?
c) WHERE are WHAT (macro)acts good?
d) HOW the world works?

Question a) asks where are favorable places in sensory state space. These places can be captured using situation definition process using sensory reading and fitness function values. In complex domains there are usually no such places because fitness function value (reward) depends on the right sequences of events, instead of simply depending on a region in sensory state space.

Question b). The agent traces governable features of environment the fitness function depends on. Acquired knowledge can be used for developing more effective behaviors.

Question c). The agent needs to discover effect of actions and develop more sophisticated usable macroactions. Defined situations and their combinations[4] partition sensory state space into many areas. This partition is strongly influenced by available actions. When appropriate actions are developed and appropriate situations are defined, the agent can develop highly effective behavior conditioned by actual situation.
Question d). The agent tries to capture relations among situations, events, objects and self in the world.

There are many parallel processes that are working to find answers to mentioned questions. Some of them are building macroactions, others are grouping similar actions and filtering out bad ones. There are processes that are reducing dimensionality and finding parts of incoming sensory data that are likely to display some interesting relations, see (Cohen, *et al.*, 1997). Processes that demarcate regions for new situations and processes that are re-checking new knowledge in other possible conditions.

5. SUMMARY

I presented my reason why AI failed to bring really intelligent systems. Ideas about general intelligent system were presented - many similar methods are needed together with method that will evaluate their effectivity and choose the best method in actual conditions. Architecture for intelligent agent was sketched. Two modules are fundamental for developing basic reactive behaviors - perception module and behavior module. Part of perception module is machinery for defining situations. Definition of situations is a way to differentiate things (objects, features, events, states) in raw incoming sensory data. Intelligent agent uses this mechanism to recognize best conditions for executing respective actions.

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[4] Combination of situations is a situation as well.