

The "Intelligence"

Krassimir Markov

markov@foibg.com

Abstract: *A definition of the concept "intelligence" is introduced in this text. The basic concept "information expectation" is discussed as foundation-stone for definition of the concept "intelligence". It is shown that the intelligence is creating and resolving the information expectation.*

Keywords: *Intelligence, Information Expectation, General Information Theory*

Introduction

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)".

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.

From other point of view, we may say that the "intelligent systems" may be studied in accordance with theirs genesis – natural or artificial. The growth of natural information technologies permits to find new theoretical decisions and corresponded realizations influenced by the investigations of natural information phenomena and especially of the models of the information processes in the brain.

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.

Theoretical background

To discover the essence of the concept "intelligence" we need to remember some of the main concepts of the General Information Theory (GIT) [Markov et al, 2007]. It is built by three specialized theories (1) Theory of Information, (2) Theory of Infos and (3) Theory of Inforaction.

In the General Information Theory *the real world* is considered as a space of *entities*. The entities are built by other entities, connected with *relationships*. Building the relationship between the entities is a result of the **contact** among them. During the contact, one entity **impacts** on the other entity and vice versa. The set of contacts between entities forms their **interaction**.

The internal change in the entity, which is due to impact of the other entity we denote with the notion "**direct reflection**". It is possible, after one interaction may be realized another. In this case, the changes received by any entity, during the first interaction, may be reflected by the new entity. This means the **secondary (transitive external) reflection** exists.

One special case is the **external transitive self-reflection** where the entity reflects its own relationships as a secondary reflection during any external interaction. Some entities have an opportunity of **internal self-reflection**.

When an entity contacts another, there exists a great possibility to join third entity in this process. So, the third entity may reflect any vestiges of this interaction from both first and second entities. In the special case when the third entity contains reflections of the first entity received by both two different ways:

1. by transitive impact of the first entity on the third one through the second entity,
2. by impact of the first entity on the third one which is different from the transitive one, i.e. it can be direct impact or transitive impact through another entity (-ies),

then the third entity became as an external relationship between first entity and its reflection in the second entity – it became as "**reflection evidence**" of this relationship. The first entity is called **reflection source**; the second entity is called **reflection recipient**; and the third entity is called **reflection evidence**.

The reflection of the source in the recipient is "information" for the source if there is corresponded reflection evidence.

*The **information** is the triple (**source, recipient: evidence**).*

What is important in this definition is that information is a kind of reflection but not every reflection is information. Information is a subclass of the class of reflections.

Every forming relationship as well as every relationship unites the entities and this way it satisfies some their possibilities for building the relationship by establishing the contact. In other words, for creating the forming relationship we need: (1) entities, from which the new entity is able to build; (2) possibilities of the entities for establishing the contact by satisfying of which the forming relationship may be originated.

The forming relationship is the aggregate of the satisfied possibilities for establishing the contact. It is clear that after establishing the relationship we may have any of two cases:

- all possibilities of the entities for establishing the contact are satisfied by such possibilities of other entities;
- there are any free possibilities after finishing the establishment of the new relationship - on the low levels of the entity or, if it is a new entity, on the level of the whole entity. Disintegration of the whole entity or any its part may generate any possibilities too.

In the second case, the entity has any "**free valences**", which needs to be satisfied by corresponded contacts with other entities. We may say the entity has **activity** generated by the free possibilities for establishing the contacts with the entities from the environment.

The process of interaction is satisfying the possibilities for contact of the entities.

If the entity is a complex, it is possible for it to have an opportunity of self-reflection. In such case, it is able to reflect any reflection, which has been already reflected in it. In this case, because of the new internal changes (self-reflection) the entity may obtain any new "**secondary activity**".

The secondary activity is closely connected to the structural level of the entity, which correspond to the level of the self-reflection. This way the secondary activity may be satisfied by internal or external entity from point of view of the given entity. In other words, the **resolving** of the secondary activity may be **internal** or **external**.

During the establishment of the information relationship it is possible to be generated any secondary free activity (possibilities on the low levels of the entity or on the level of the whole entity) which needs to be satisfied by corresponded contacts with other entities. The secondary activity generated by the information relationship is called "**information activity**".

On given level of complexity of the entities a new quality becomes – the existence of self-reflection and internal activity based on the main possibilities for contact of the sub-entities as well as based on the new (secondary) possibilities created after internal self-reflection. The internal activity may be resolved by:

- the internal changes which lead to partial internal disintegration of the sub-entities and their a posterior internal integration in the new structures;
- the external influence on the environment.

The impact on the entities around the entity is the way to resolve its activity. The destroying of the external entities and including the appropriate theirs parts in itself is the main means to exist and satisfy the free valences.

One special kind of activity is the information one. We assume that the secondary activity needs to be resolved by relevant to the information valences corresponded opposite (information) valences which need to be of the same genesis, i.e. generated by any information relationship. So, not every entity may be used for resolving the secondary activity. This way, the entity expects a special kind of (information) contacts and (information) interaction for resolving the information activity. Because of this the information activity is called ***"information expectation"***.

The entity "expects" to combine the information valences with any others because of the information expectation, i.e. the existing secondary information activity. The combining the valences of the information expectation with some others is called ***resolving the information expectation***. The resolving of the information activity is a ***target*** which may be achieved by the establishment and providing (information) contacts and interaction.

Definition of the concept "intelligence"

Now we are ready to introduce the definition of the intelligence [Mitov et al, 2010], which follows from the General Information Theory [Markov et al, 2007] and especially from the Theory of Infos [Markov et al, 2009].

The intelligence is a 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 correspond 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].

Conclusion and future work

In this text we presented a definition of the concept “intelligence” as a common approach for investigating the natural and artificial intelligent agents. It is clear; the reality is more complex than one definition. Fortunately, there exists good theoretical ground, especially in the areas of pattern recognition and data mining as well as the decision making, which may be used as basis for further research. Possible extensions of this work may be investigation of:

- the partial resolving of the information expectation when it is needed to decide which cases are good to be chosen as reached target;
- the statistically generated information expectation which is based on self-reflection and generalization.

Presented understanding of intelligence is important for realizations of the intelligent computer systems. The core element of such systems needs to be possibility

for creating the information expectation as well as the one for resolving it. The variety of real implementations causes corresponded diversity in the software but the common principles will exist in all systems. Summarizing, the artificial system is intelligent if it has:

1. Activity for external interaction;
2. Information reflection and information memory;
3. Possibility for generalization (creating abstractions);
4. Information expectation;
5. Resolving the information expectation.

At the end, let point five main problems of the science “Artificial Intelligence” – to develop more and more “smart”:

1. senses and actuators - to realize external interaction;
2. memory structures - to learn;
3. generalization algorithms - to make abstractions;
4. prognostic knowledge generation - to create information expectation;
5. resolving the information expectation - to reach objectives.

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