General Information Theory

THEORY OF INFOS

Krassimir Markov, Krassimira Ivanova, Ilia Mitov

Abstract: Theory of Infos is a part of the General Information Theory. Main features of the Theory of Infos are outlined in the paper. Further investigation is discussed.

Keywords: General Information Theory, Theory of Infos.

ACM Classification Keywords: A.1 Introductory and survey

Introduction

The genesis of the concept of Infos started from the understanding that the concept "Information Subject" is perceived as human characteristic. It is clear that in the nature there exist many creatures which may be classified to this category. To exclude the misunderstandings we decide to introduce new word to denote all possessors of the characteristics of the Information Subject.

This word is "*Infos*".

There exist several common theoretical information paradigms in the Information Sciences. May be, the most popular is the approach based on the generalization of the Shannon's Information Theory [Shannon, 1949], [Lu, 1999]. Another approach is the attempt to be synthesized in a common structure the existing mathematical theories, which are applicable for explanation of the information phenomena [Cooman et al, 1995].

Besides of this, we need to point the diligence of the many researchers to give formal or not formal definitions of the concept "information". Unfortunately, although they are quite attractive in some cases, these definitions did not bring to any serious theoretical results [Abdeev, 1994], [Bangov, 1995], [Markov P., 2002], [Tomov, 1991], [Elstner, 1993].

The development of the General Information Theory (GIT) had started in the period 1977-1980. The first publication, which represents some elements of GIT, was published in 1984 [Markov, 1984]. In 1988, the not formal definition of the concept of Information was published in [Markov, 1988]. It became as a fundamental definition for the GIT [Markov et al, 1993], [Markov et al, 2003a]. The translation of the philosophical theory into the formal one is a good approach for verification of the scientific ideas [Markov et al, 2003b], [Markov et al, 2004].

The General Information Theory is based only on primary consideration of the world as variety of entities, which are formed by relationships between entities that form lower levels. The fundamental notion of the GIT is the concept "Information". All other concepts are defined based on this definition.

The GIT is build by three specialized theories:

- Theory of Information,
- Theory of Infos,
- Theory of Inforaction.

This article presents the main features of the Theory of Infos.

Entity

In our examination, we consider *the real world* as a space of *entities.* The entities are built by other entities, connected with *relationships*. The entities and relationships between them form the internal *structure* of the entity they build. To create the entity of a certain structural level of the world, it is necessary to have:

- the entities of the lower structural level;
- established forming relationship.

The entity can dialectically be considered as a relationship between its entities of all internal structural levels.

The forming relationship has a representative significance for the entity. The destruction of this essential relationship causes its disintegration. The establishment of forming relationship between already existing entities has a determine significance for the emerging of the new entity.

The forming relationship is the reason for *the emergence* of individual properties, which distinguish the new entity from the forming ones. *The relationships form and present the entity.*

Impact, Interaction, Reflection

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. In some cases the opposite impact may not exist, but, in general, the contact may be considered as two mutually opposite impacts which occur in the same time.

The set of contacts between entities forms their ***interaction***. The interaction is a specific ***interactive relationship*** between entities which take part in it.

The contacts of the given structural level are processes of interaction of the entities on the lower levels.

During the establishing of the contact, the impact of an entity changes temporally or permanently the internal structure of the impacted entity. In other words, the realization of the relationships between entities changes, temporary or permanently, their internal structure at one or at few levels.

The internal change in the entity, which is due to impact of the other entity we denote with the notion "***direct reflection***".

Every entity has its own level of sensibility. This means that the internal changes occur when the external influence is over the boundary of the sensibility of the entity.

The ***"reflection impulse"*** for given entity is the amount of the external influence needed for transition from one state to the reflection one.

The entities of the world interact continuously. 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.

The chain of the transitive reflections is not limited. In general, the concept “transitive impact” (respectively “transitive reflection”) of the first entity on the third entity through the second one will denote every chain of impacts (reflections) which start from first entity and ends in the third entity, and include the second entity in any internal place of the chain.

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***. The internal self-reflection is possible only for very high levels of organization of the entities, i.e. for entities with very large and complicated structure. The self-reflection (self-change) of the entity leads to the creating of new relationships and corresponding entities in it.

Of course, the internal self-reflection is a result of the interaction provided between entities in the lower levels of the structure of the entity. Such kind of entities has relatively free sub-entities with own behavior in the frame of self-preservation of the whole entity. As a result of the self-reflection, some relationships and corresponding sub-entities are created or changed in the entity.

The combination of the internal and external self-reflection is possible.

Finally let remark that the reflection could not be detected by the entity that contains it. This is dialectical behavior of the reflection - it is only an internal change caused by the interaction.

Information

The real world contains unlimited number of entities. When an entity contacts another, there exists a great possibility to join third entity in this process. It is clear; the third entity may contact and reflect each of others as well as the process of realization of the interaction between them — the process of realization of the contact is a specific (temporal) forming relationship between entities and during the process of establishing the contact the entities form new (temporal) entity which in the same moment may be reflected by the third entity. 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.***

In this special case, when there exist the triple

"(source, recipient: evidence)",

the reflection of the first entity in the second is called ***information*** in the second for the first entity.

Let point one very important case of the real world - simultaneous contacts of the three entities. Every one of them may be source, recipient and evidence in the same time. There exist six cases which represent the simultaneous contacts of three entities. Therefore, the entities A, B and C may be in the next six reflection relations: (A, B: C); (B, C: A); (C, A: B); (A, C: B); (C, B: A); (B, A: C).

All reflection relations are equivalent from point of view of the interrelations between reflection source, reflection recipient and reflection evidence. Because of this we will discuss only the case (A, B: C).

For practical needs, it is more convenient to follow the next consideration.

The reflection in the recipient represents both the relationships and the sub-entities of the source. From other point of view, the relationships build up and present the entities. Because of this, the reflected relationships are the essence of the reflection. In other words, iff there exist reflection evidence than the reflection of the forming relationship may be considered as "information" for reflected entity. Therefore, in the sense that the evidence exists to point what relationship (between what entities) is reflected and where it is done, we may say

"The information is reflected relationship".

So, the *reflection* of the first entity in the second one is "***information"*** for the first entity if there is corresponded *reflection evidence*. The generalization of this idea leads to assertion that ***every reflection can be considered as information, iff there exists corresponding reflection evidence.***

Activity and Information Expectation

Every forming relationship as well as every relationship unites the entities and this way it satisfies some theirs possibilities for building the relationship by establishing the contact. In other words, for creating the forming relationship we need:

- entities, from which the new entity is able to built;
- 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:

1. all possibilities of the entities for establishing the contact are satisfied by such possibilities of other entities;
2. 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. From point of view of the entity, the interaction may be external or internal.

During the interaction given entity may be destroyed partially or entirely and only several but not all parts of the destroyed entity may be integrated in the new entity. This means that there exist both constructive and destructive processes in the process of interaction between entities. The determination of the type of the interaction depends on the point of view of given entity. The interaction dialectically contains constructive and destructive sub-processes.

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 theirs a posterior internal integration in the new structures;
- the external influence on the environment.

The internal changes may lead to removing of some sub-entities if they have no possibilities for integration with the others, i.e. if they have no free valences to be resolved in the process of integration.

The external influence is the most important. 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 Information Witness

Let remember the special case from above 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).

In this case 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.

In addition, if during establishing the information relationship ***i*** = (source, recipient: evidence) in the reflection evidence is generated information expectation (activity) it is called ***"information witness"***.

As the information witness is more complex entity so the information relationship may be more complex. In addition, let remark that the complex reflection is time-depended process. In other hand, the memory and actual context determine the result of the complex reflection.

The Information is a Model

As Marx Wartofsky remarks, the concept "model" has been used for denotation of the very large class of phenomena: mechanical, theoretical, linguistic, etc. constructions. He gave a good definition of the model relation and made clear the main characteristics of the model [Wartofsky, 1979]. This definition is as follow:

The model relation is triple M:

$$M: (S, x, y)$$

where "S" is subject for whom "x" represents "y". In other words only in this relation and only for the subject "S" the entity "x" is a model of the entity "y".

As we point above, the interaction between two entities is a specific theirs relationship. If there exist information witness (W) of the interaction between two entities as well as of the existence of the information about the first entity in the second entity, W became as subject for whom the information in the second entity represents the first one. In other words, there exists relation

$$M: (W_{BA}, I_{BA}, A),$$

where "A" and "B" are entities, and the W_{BA} is the information witness, which proofs that the assertion "$I_{BA} \subset B$ is information in B for A" is true.

In the relation (W_{BA}, I_{BA}, A) the information I_{BA} is a model of A.

The Information Model

The entities of the world interact continuously in the time. It is possible, after any interaction one another may be realized. 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. The chain of the transitive reflections is not limited.

Let A, B and C are entities; A and B interact and after that B interacts with C. If there exist the relations:

- M_{BA}: (W_{BA}, I_{BA}, A), where W_{BA} is the information witness, which proofs that the assertion "$I_{BA} \subset B$ is information in B for A" is true,
- M_{CB}: (W_{CB}, I_{CB}, B), where W_{CB} is the information witness, which proofs that the assertion "$I_{CB} \subset C$ is information in C for B" is true,

and if $M_{C(B)A}$: ($W_{C(B)A}$, $I_{C(B)A}$, A), where $W_{C(B)A}$ is the information witness, which proofs that the assertion "$I_{C(B)A} \subset C$ is information in C for information in B for A" is true.

In such case, from point of view of the $W_{C(B)A}$ the information $I_{C(B)A}$ is a model of A. In other hand, because of transitive reflection, $I_{C(B)A}$ is created as reflection of the I_{BA} but not directly of A.

This means that $I_{C(B)A}$ is a model of the information in B for A.

In other words the $I_{C(B)A}$ is an ***information model*** in C for A.

The collecting of information models for given entity in one resulting entity may exist as a result of the process of interaction between entities. Such process is in the base of the ***Information modeling***.

If an information model IM contains information for (reflected from) the two source information models IM_1 and IM_2 than the source information models are "***similar***" in the sense of the model IM.

The similarity of the information models causes the establishing the relation of aggregation between them.

The relation of similarity aggregates the similar models in new ***internally determined information model*** in the memory of the information witness.

The aggregation may cause the generating the new information activity, which may be resolved not only in the environment around the information witness. The possibility of self-reflection may cause the generating the new information models in his memory without any external influence and so on.

This process of aggregation and generation of new models is not limited.

The (information) models internally generated via self-reflection are called "***mental (information) models***" of the information witness.

Resolving the Information Expectation

Because of the existing of the information expectation, i.e. the existing of the secondary information activity, the Information Witness "expects" to combine the information valences with any others.

The combining the valences of the information expectation with some others is called ***resolving the information expectation***.

Let "n" is the number of free valences in an information expectation. After the contact some of them are combined as well as the others are not. The new valences, which are generated by the contact, do not belong to the information expectation before contact. They may form new information expectation but the basis for our reasoning will be the starting information expectation.

The normalized by "*n*" number *D'* of the not combined valences is called ***degree of discrepancy*** (D) of the incoming reflection to the information expectation, i.e.

$$D = \frac{D'}{n}$$

The normalized by "*n*" number *C*' of the combined valences is called ***degree of combining*** (C) of the incoming reflection to the information expectation, i.e.

$$C = \frac{C'}{n}$$

There exists the equation: $C + D = 1$.

From point of view of given expectation for contact the number of free valences is fixed. After the contact, as a result of reflection, some of the free valences of the entity may be combined with any new (internal or external) valences. Of course, new free valences may occur. The number "*n*" varies in the process of interaction. Every contact may change it.

The more valences of the information expectation have been resolved, the more qualitative is the incoming information and vice versa.

The difference A between normalized number C of resolved valences and normalized number D of not resolved valences of the information expectation is called *adequacy of the reflection to the information expectation*, i.e.

$$A = C - D$$

It is easy to see that the values of adequacy A are in the interval [-1,1].

The Infos

The resolving of the information activity is *a goal* of the information witness.

This goal may be achieved by the establishment and providing (information) contacts and interaction.

The entity, which has possibility for:

- *(primary) activity* for external interaction;
- *information reflection and information memory*, i.e. possibility for collecting the information;
- *information self-reflection*, i.e. possibility for generating "secondary information";
- *information expectation* i.e. the (secondary) information activity for internal or external contact
- *information modeling and resolving the information expectation*

is called *Infos*.

Conclusion

What gives us the concept “Infos”?

At the fist place, this is the common approach for investigating the natural and artificial information agents.

In other hand, this is the set of common characteristics which are basic for all entities, which we may classify to the category of the Infos.

And, at the end, this is a common philosophical basis for understanding the information subjects.

The development of the General Information Theory should not become by the single creative impulse. For a long period, the constructive activity of the many researchers is needed for establishing the new common paradigm.

We all need free scientific look at things, which will permit us to build the general theory without partiality, and aberrations taking in account all information paradigms already created and adopted.

Our main goal is to provoke the scientists to continue the research in this important area and to make the next step.

The concept "Infos" is basic for the General Information Theory [Markov et al. 2003a]. Its definition is only the starting point for further investigations and building the *Infos Theory*.

The variety of types of Infoses in the real world needs to be investigated and classified in the future research. At the first step, we may propose that may be at least two main types of Infoses exist:

- *infogens* - the natural creatures;
- *infotrons* - the artificial creatures.

Also, the Infos Theory needs to give answers to many other very important questions, such as:

- What is the nature of the activity of the Infos?
- What is the difference between the living level of the Infos and the non-living one?
- Is it true that the boundary between non-living and living entities is self-reflection and internal activity for satisfying the secondary (information) possibilities for internal or external contact?

Etc.

It is impossible to answer to all questions in a single article. We may make only the next little step.

This was the aim of the present paper.

Bibliography

[Abdeev,1994] R.F.Abdeev. The Philosophy of the Information Civilization. Moscow, VLADOS, 1994. (in Russian)

[Bangov, 1995] I.Bangov. A Graph-Topological Model of Information. Int. J. Information Theories and Applications, 1995, v.3, n.6, pp.3-9.

[Burgin, 1997] M.S.Burgin. General Information Theory. http://www.math.ucla.edu/~mburgin/res/compsc/Site3GTI.htm

[Burgin, Markov, 1991] M.Burgin, Kr.Markov. Formal Definition of the Concept Materialization. Mathematics and Mathematical Education, BAS, Sofia, 1991, pp.175-179.

[Cooman et al, 1995] G.de Cooman, D.Ruan, E.Kerre, Eds. Foundations and Applications of Possibility Theory. World Scientific, Singapore, 1995.

[Elstner, 1993] D.Elstner. About Duality of the Information and Organization. Int. J. Information Theories and Applications, 1993, v.1, n.1, pp. 3-5. (in Russian)

[Gladun, 1994] V.P. Gladun. Processes of New Knowledge Formation. Pedagog 6, Sofia, 1994 (in Russian).

[Glushkov, 1986] V.M.Glushkov. Epistemological Nature of the Information Modeling. In: V.M.Glushkov. Cybernetics, Questions and Answers, (in Russian), Moscow, Science, 1986, pp. 33-41.

[Lu, 1999] C.-G.Lu. A Generalisation of Shannon's Information Theory. Int. J. of General Systems, 28:(6), 1999, pp.453-490.

[Markov, 1984] Kr. Markov. A Multi-domain Access Method. Proc. of Int. Conf. "Computer Based Scientific Research". Plovdiv, 1984. pp. 558-563.

[Markov, 1988] Kr.Markov. From the Past to the Future of Definition of the Concept of Information. Proceedings "Programming '88", BAS, Varna 1988, p.150. (In Bulgarian).

[Markov et al, 1993] Kr.Markov, Kr.Ivanova, I.Mitov. Basic Concepts of a General Information Theory. IJ Information Theories and Applications. FOI ITHEA, Sofia, 1993, Vol.1, No.10, pp.3-10

[Markov et al, 2003a] Kr.Markov, Kr.Ivanova, I.Mitov. General Information Theory. Basic Formulations. FOI-Commerce, Sofia, 2003.

[Markov et al, 2003b] K. Markov, K. Ivanova, I. Mitov, E. Velikova-Bandova. The Information. IJ Information Theories and Applications, FOI ITHEA, Sofia, 2003, Vol.10, No.1, pp.5-9.

[Markov et al, 2004] K. Markov, K. Ivanova, I. Mitov, E. Velikova-Bandova. Formal Definition of the Concept “INFOS”. Proceedings of the Second International Conference “Information Research, Applications and Education” i.TECH 2004, Varna, Bulgaria. Sofia, FOI-Commerce, 2004, pp. 71-74. Int. Journal “Information Theories and Applications”, 2004, Vol.11, No.1, pp.16-19

[Markov P., 2002] P.Markov. Think with Your Mind. Markov College. Sofia, 2002. (in Bulgarian)

[Pavlov, 1987] T.Pavlov. Collection of Selected Works, Vol. II. Theory of Reverberation. Science and Art, Sofia, 1987. (in Bulgarian).

[Rosenblueth, Wiener, 1945] A.Rosenblueth, N.Wiener. Role of Models in Science. Philosophy of Science, Vol.12, No.4, 1945.

[Shannon, 1949] C.E.Shannon. The Mathematical Theory of Communication. In: The Mathematical Theory of Communication. Ed. C.E.Shannon and W.Weaver. University of Illinois Press, Urbana, 1949.

[Tomov, 1991] K.Tomov. The Resomal-Isomorphic Principle. Arges, Sofia, 1991. (in Bulgarian)

[Wartofsky, 1979] M.W.Wartofsky. Models. Representation and the Scientific Understanding. D.Reidel Publishing Company, Dordrecht: Holland /Boston: USA, London: England/, 1979.

[Popper, 1968] K.R.Popper. Conjectures and Refutations: The Growth of Scientific Knowledge. Harper & Row, Publishers, New York and Evanston. 1968.

Authors' Information

Krassimir Markov - Institute of Mathematics and Informatics, BAS, Acad.G.Bonthev St., bl.8, Sofia-1113, Bulgaria; markov@foibg.com

Krassimira Ivanova - Institute of Mathematics and Informatics, BAS, Acad.G.Bonthev St., bl.8, Sofia-1113, Bulgaria, e-mail: ivanova@foibg.com

Ilia Mitov - Institute of Information Theories and Applications FOI ITHEA, P.O.Box: 775, Sofia-1090, Bulgaria; e-mail: mitov@foibg.com