THE INFORMATION

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Abstract: The current formal as well as not formal definitions of the concept "Information" are presented in the paper.

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1. Introduction

The fundamental notion of the General Information Theory is the concept "Information". All other concepts are defined based on this definition. The first not formal definition of the concept of Information was published in [Markov, 1988]. The main philosophical explanations were published in [Markov et al, 1993]. The first variant of the formal definitions were introduced in [Markov et al, 2003]. This work refines the philosophical basis and represents the more precise variant of the formal definition of the concept "information".

1.1. 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;
- establishing of the 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.

1.2. 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 realisation 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 realised 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 organisation 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 low levels of the structure of the entity. Such kind of entities has relatively free sub-entities with own behaviour 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.

1.3. Information

The reflection could not be detected by the entity that contains it. This is dialectical behaviour of the reflection - it is only an internal change caused by the interaction.

During as well as after the interaction between two entities, they may interact with other entities from the environment. If any third entity contains reflections of given entity received by 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

then the third entity became as an external relationship between entities and their reflections - it became as *“reflection evidence”*.

We may say that the *reflection* of the first entity in the second one is “***information”*** for the first entity if there is corresponded reflection evidence.

The generalisation of this idea leads to assertion that *every reflection can be considered as information, if there is corresponding reflection evidence.*

2. Formal Definitions

2.1. Entity

Definition 1. The entity A is the couple $A=(E_A,R_A)$ where:

E_A is a collection of sub-sets of a set M_A;

$R_A=\{r_i|i\in I,\ I \text{ is a set}\}$ is a nonempty set of relations in E_A, i.e.

$r_i\subset E_A\times E_A=\{(X,Y)|X,Y\in E_A\}$ is a relation and $\check{r}_i=r_i\cup\{(X,Y)|(Y,X)\in r_i)\}$, $\forall i\in I$;

and:

1. $\varnothing\in E_A$;
2. $M_A=\cup X,\ X\in E_A$;
3. $\forall r\in R_A$ and $\forall X,Y\in E_A \Rightarrow ((\exists(X,Y)\in\check{r})$ or

$$(\exists Z_1,..,Z_p\in E_A,\ Z_k\neq\varnothing, k=1,..,p : (X,Z_1)\in\check{r},(Z_1,Z_2)\in\check{r},\dots,(Z_p,Y)\in\check{r}) \ \blacksquare$$

The condition 3 means that E_A is internally connected in respect to every relation $r\in R_A$.

M_A is called **forming set** of A. The intersection ρ_A of all relations in R_A is called **forming relation** of A, i.e. $\rho_A=\rho(A)=\cap r_i,\ i\in I,\ r_i\in R_A$.

When **relationship** (X,Y) belongs to the relation r we will denote by $(X\to Y)_r$.

Every element X can be considered as an entity (E_X,R_X), for which $M_X=\{X\}$, $E_X=\{\varnothing,M_X\}$ and $R_X=\{\rho\}$, where $\rho=\{(\varnothing\to M_X)\}$. Because of this, the elements of every forming set M can be assumed as entities.

Definition 2. Let $A=(E_A,R_A)$ is an entity. B is a **sub-entity** of A if $B=(E_B,R_B)$, where $M_B\subset M_A$, $\forall X\in E_B\ \exists Y\in E_A$: $X\subset Y$ and $\forall r_B\in R_B\ \exists r_A\in R_A: r_B\subset r_A$ ■

2.2. Impact and Reflection

Definition 3. Let $A = (E_A,R_A)$ and $B = (E_B,R_B)$, $A\neq B$ and $f\in R_A$.

A **direct impact** ψ of A on B concerning the relation f is a nonempty subset of $E_{A\times}E_B$ such that

$\psi=\psi_f=(A\to B)_\psi\subset E_{A\times}E_B=\{(X,Y)|X\in E_A,Y\in E_B\}$, $\psi_f\neq\varnothing$

for which:

if X_i, $X_j\in E_A$ and $Y_k,Y_l\in E_B$, such that $(X_i\to X_j)_f$, $(X_i,Y_k)\in\psi_f$, $(X_j,Y_l)\in\psi_f$

then exists $g\in R_B:(Y_k\to Y_l)_g$ ■

If $(X,Y)\in\psi_f$ we will denote $(X\to Y)_\psi$.

Let remember that $\varnothing\in E_A$ as well as $\varnothing\in E_B$. This means that for every $f\in R_A$ and $g\in R_B$ there exists zero direct impact $o_f=(A\to B)_o=\{(\varnothing,\varnothing)\}$.

Definition 4. Let $A=(E_A,R_A)$ and $B=(E_B,R_B)$ and $\psi_f=(A\to B)_\psi$ is an direct impact of A on B.

A **reflection** of A into B realised by the direct impact ψ is the couple

$F_\psi=F=(E_F,R_F)$ for which $E_F=\{Y\in E_B|\exists X\in E_A:(X,Y)\in(A\to B)_\psi\}$ and $R_F=\{r_\psi\}$,

$r_\psi=r_{\psi,f}=\{(Y_1,Y_2)|\exists X_1,X_2\in E_A:(X_1\to X_2)_f;\ (X_1\to Y_1)_\psi;\ (X_2\to Y_2)_\psi\}$ ■

$r_{\psi,f}$ is a reflection of the relationship f by direct impact ψ.

The reflection F_ψ will be assumed as a sub-entity of B.

2.3. Transitive Impact and Transitive Reflection

Definition 5. Let:

$A=(E_A,R_A)$, $B=(E_B,R_B)$, $C=(E_C,R_C)$;

$f\in R_A$, $g\in R_B$;

$\varphi_f=(A\to B)_\varphi$ is a direct impact of A on B concerning the relation f;

$\psi_g=(B\to C)_\psi$ is a direct impact of B on C concerning the relation g.

We will say that the direct impacts φ_f and ψ_g can be composed if the reflection of the relationship f by direct impact φ is a subset of g, i.e. $r_{\varphi,f}\subset g$.

Definition 6. If φ_f and ψ_g can be composed than the couple $\{\varphi_f,\psi_g\}$ is a **transitive impact**

$$\xi=\xi_f=\psi_g\circ\varphi_f = (A\to B\to C)_\xi \text{ of } A \text{ on } C \text{ through } B \ ■$$

It is clear, that every transitive impact is a chain of at least two composed direct impacts. In general, this chain can contain more than two composed direct and/or transitive impacts. Such chain is transitive impact, too.

Definition 7. Let $A=(E_A,R_A)$, $B=(E_B,R_B)$, $C=(E_C,R_C)$.

Let $\xi=\{\varphi_f,\psi_g\}=\xi_{f,g}=(A\to B\to C)_\xi$ is transitive impact of A on C through B.

The **transitive reflection** of A into C through B realised by the impact ξ is the couple $G_\xi = G = (E_G, R_G)$ for which

$E_G = \{Z \in E_C | \exists X \in E_A$ and $\exists Y \in E_B : (X,Y) \in (A \to B)_\varphi$ and $(Y,Z) \in (B \to C)_\psi\}$ and

$R_G = \{r_\xi\}$,

$r_\xi = r_{\xi,f} = \{(Z_1, Z_2) | \exists X_1, X_2 \in E_A :$

$$(X_1 \to X_2)_f;\ (X_1 \to Y_1)_\varphi;\ (X_2 \to Y_2)_\varphi;\ (Y_1 \to Z_1)_\psi;\ (Y_2 \to Z_2)_\psi\} \ \blacksquare$$

If A and C are equal than:

- the transitive impact ξ will be called **self-impact**;
- the transitive reflection $G_\xi = G = (E_G, R_G)$ for transitive self-impact $\xi(A \to B \to A)$ will be called **self-reflection**.

2.4. Interaction and Interactive Reflections

Let denote by Ω_{AB} the set of all direct or transitive impacts of A on B.

Definition 8. Let $A = (E_A, R_A)$ and $B = (E_B, R_B)$. An **interaction** between A and B is a set $\Delta_{AB} = \{\Delta_i \mid \Delta_i \in \Omega_{AB} \cup \Omega_{BA},\ i = 1,..,h\ \}$ ■

Definition 9. Let:

$A = (E_A, R_A)$ and $B = (E_B, R_B)$;

$\Delta = \Delta_{AB} = \{\Delta_i \mid i = 1,..,h\}$ is an interaction between A and B;

$F_{\Delta i} = F_i = (E_{Fi}, R_{Fi})$ is reflection realised by the impact Δ_i;

An **interactive reflection** V_{AB} between A and B realised by the interaction Δ_{AB} is the set of all reflections $F_{\Delta i}$; i.e. $V_{AB} = \{F_{\Delta i} | i = 1,..,h\}$ ■

The self-interaction Δ_{AA} is the interaction from A to A where all impacts are self-impacts. In such case the corresponding interactive reflection is called interactive self-reflection.

2.5. Information

Definition 10. Let:

$A = (E_A, R_A)$ and $B = (E_B, R_B)$;

τ is an impact of A on B, i.e. $\tau = (A \to B)_\tau$. , $\tau \in \Omega_{AB}$;

$\exists$ entity $C = (E_C, R_C) : C \neq A,\ C \neq B$;

$\exists\ \psi = (B \to C)_\psi$ which can be composed with $\tau = (A \to B)_\tau$;

$\exists$ transitive impact $\xi = \{\tau, \psi\} = (A \to B \to C)_\xi$;

$\exists$ impact $\varphi = (A \to C)_\varphi$; , $\varphi \in \Omega_{AC}$ and $\varphi \neq \xi$;

F_φ is a reflection of the impact φ and F_ξ is a reflection of the impact ξ.

F_τ is **information** for A in B if $\exists r \in R_C : (F_\varphi \to F_\xi)_r$ ■

The entity A is called **source**, the entity B is called **recipient**. The relation $r \in R_C$ for which $(F_\varphi \to F_\xi)_r$ is called **reflection evidence** and the entity C is called **information evidence**.

If V_{AB} is an interactive reflection of between entities A and B, and entity C contains reflection evidences for all reflections of V_{AB} than C is called **information witness**.

Every reflection may be considered as information iff there is corresponded information evidence or information witness.

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, if a reflection evidence exists then 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 that "*the information is reflected relationship".*

Conclusion

The translation of the philosophical theory into the formal one is a good approach for verification of the scientific ideas. The concept “Information” of the GIT was presented formally in this paper. The definition given above is a first step for building the formal part of the GIT. Together with the philosophical explanations, it gives us a useful tool for investigation of the information phenomena in the real world.

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