FIS2005 **http://www.mdpi.org/fis2005**

Is Information Some Kind of Data ?

M. Burgin

Department of Mathematics
University of California, Los Angeles
405 Hilgard Ave.
Los Angeles, CA 90095
URL: http://www.math.ucla.edu/~mburgin/

Abstract: The aim of this paper is to consider different approaches to information in science and philosophy, as well as to separate such concepts as genuine information, false information or misinformation, disinformation, and pseudoinformation. To understand the situation, we discuss relations between information, meaning, and data. The base of this research is the general theory of information, which is a new, encompassing other directions approach in information science. This theory is built as a system of basic ontological and axiological principles, encompassing all known theories of information. The results of this paper help to understand and explain how information functions in society.

Keywords: information, data, knowledge, misinformation, disinformation, pseudoinformation

MSC 2000: 94A15

1 Introduction

Information has become the most precious resource of society. However, there is no consensus on the meaning of the term "information," and many researchers have considered problems of information definition. A significant landmark of this advent was the *Electronic Conference on Foundations of Information Science* (FIS 2002). One of the topics that were actively discussed was the problem whether information is *any* meaningful data or meaningful data that have additional properties to be information (cf., for example, (Menant, 2002) and (Roederer, 2002)).

This discussion has three aspects that need clarification. The first one is *methodological*. It deals with the scientific base of the discussion. The second aspect is *ontological* and is related to the essence and nature of information. The third aspect is *theoretical* and is aimed at elucidation of the scope of this theory.

However, to have a valid and efficient theory of information, it is not enough to have a correct definition of information. We need properties of information and information processes. There are many directions in modern information theory that suggest their description of information and information processes. Some approaches to the concept of information are analyzed in Section 2 of this paper.

Kinds of information and their theoretical representations form an extensive diversity of phenomena, concepts, formulas, and ideas. However, it has become possible to synthesize all directions and approaches in the general theory of information, which is taken as the base for this work. Elements of this theory are presented in Section 3 of this paper.

It is necessary to remark that many arguments are presented by different researchers for impossibility to develop a unified definition of information. In particular, a persuasive argument for impossibility to give such a unified definition is given in (Capurro, Fleissner and Hofkirchner, 1999). This result and many other arguments undermine generality of conventional definitions of information and imply impossibility of a universal definition of information.

Nevertheless, a solution to this important problem is given in the general theory of information. It became possible through utilization of a new definition type. Namely, to overcome limitations of the conventional approaches and to solve the problem of information definition a parametric definition is used in the general theory of information (cf., for example, (Burgin, 2003)). Parametric systems (parametric curves, equations, functions, etc. are frequently used in mathematics and its applications. For instance, a parametric curve in a plane is defined by two functions $f(t)$ and $g(t)$, while a parametric curve in space has the following form: $(f(t), g(t), h(t))$ where parameter t takes values in some interval of real numbers.

However, as a rule, only numerical parameters are used. A more general parameter, functional, is utilized for constructing families of non-Diophantine arithmetics (Burgin, 1997; 2001).

In the case of the general theory of information, the parametric definition of information utilizes a system parameter. Namely, an infological system (see Section 3) plays role of a parameter that discerns different kinds of information, e.g., social, personal, chemical, biological, genetic, or cognitive, and combines all of the in one general concept "information".

In Section 2 of this paper, we discuss some contemporary trends in understanding information. Section 3 contains those elements of the general theory of information that are used in Section 4 to separate and determine such concepts as genuine information, false information or misinformation, disinformation, and pseudoinformation.

2 Some Trends in Understanding Information

The first, methodological issue is crucial for ability to understand the phenomenon of information. It demands to explicate the grounds for the discussion on the meaning of the term "information." Many assume that there is something that is called information and we have to disclose what it is. This is the linguistic or common sense approach, which puts names ahead of things, attributing real life phenomena to words. According to this approach, we have to find something that corresponds to the word "information."

In contrast to this, the scientific or ontological approach corresponds words to real life phenomena. According to this approach, the question is not what information is, but rather for what phenomenon it is adequate to use the name "information." To do this properly, we begin with a cluster of situations to which the word "information" is usually related. The task of science is to explain these situations, formatting, if necessary, a concept with the name "information." So, the problem is not to explain how people use this word, but to form a reasonable scientific content for it.

For example, people divided all objects that give light and are observed in the sky into three categories: the Sun, Moon, and stars. The base for such categorization was the observed size of these celestial bodies and the intensity of their light. Later, when astronomers learned more about movements of these bodies, they discovered that some of those objects that were called stars have different nature. Astronomers introduced a new category of celestial bodies, naming them planets. Much later physicists found that the Sun is also a star. However, if we only discuss how people use the words "Sun" and "star," we would never be able to know this peculiarity of the Sun.

In a similar way, now many experts call some kinds of enhanced data (meaningful or meaningful and true or meaningful and useful or organized and comprehensible etc.) by the name information. O'Brien (1995), for example, writes that terms *data* and *information* are used interchangeably, but while *data are raw material resources*, *information are data that has been transformed into a meaningful and useful context*. In (Laudon, 1996), we find a similar notion of information, which is defined as *an organized collection of data that can be understood*.

One more definition of information is presented in (Rochester, 1996). According to him, *information is an organized collection of facts and data*. Rochester develops this definition through building a hierarchy in which data are transformed into information into knowledge into wisdom. Thus, information appears as an intermediate level leading from data to knowledge.

However, information is an objective phenomenon, for which it is more productive to investigate how it exists and functions, than to deliberate on the meaning that different people assign to this word. Comprehensive analysis of the phenomenon made possible to discover that information has very different nature from data and knowledge. In contrast to this widespread opinion, the general theory of information (Burgin, 2003; 2004) suggests that *if we compare data with substance, then information relates to data (and knowledge) in the world of structures as energy relates to substance (matter) in the physical world*. This correlates with the opinion of Warner (1996) that data need to be manipulated to give information. This approach also allows one to study by exact means the problem of information representation considered by Roederer (2002).

It is interesting that in contrast to many researchers, who assume that meaning is a necessary attribute of information, Menant writes (2002) that “it is quite natural that information and meaning are different things.” From this he derives that there is meaningful and meaningless information. At the same time, some researchers insist that the concept “meaningless information” is as meaningless as the concept “false information.” The general theory of information supports the idea of existence of meaningless information and makes it possible to develop further this concept, relating to it quantitative estimations of meaning by means of a semantic measure of information.

Many examples show that empirically it is more relevant to treat only information for a system, i.e., relative form of information. Objective information, which is independent of any receptor, is only a theoretical construct that is modeled by operators in system state spaces (Burgin, 1994).

At the same time, if we assume that some kind of meaningful data is information, then we have to admit that Menant is right, writing that the principle of genetic neutrality (GN) “supports the possibility of information without an informed subject, to adapt a Popperian phrase. Meaning is not (at least, not only) in the mind of the user.”

However, if data only contain information as a distinct essence, then it is also possible to have information without “an informed subject.” The acceptor of information may be, for instance, an artificial system such as computer. At the same time, according to the general theory of information, to speak about “objective” information without an acceptor is similar to considering "objective" molecules without matter.

Let us consider the first, methodological aspect of the problem of false information, while ontological and theoretical aspects are considered in Section 4 based on the general theory of information. For example discussing whether false information is a kind of information, some researchers give examples, such as a "false constable" or "forged banknote," to show that the concept "false information" is inconsistent. The fallacy of this argumentation is that these and other terms (constable, banknote, signature etc.) that are used to enlighten the situation with the term "information" are names of artificial objects. These names are defined while the objects they designate were created and are functioning in society. These objects together with their names depend on social agreement.

In contrast to this, information is a natural phenomenon, which exists both in nature and in society. People do build and determine information as a general phenomenon. They only generate, produce, discover, store, transform, process, collect, send, and receive multiple instances of information. People have to discover what information is as they discovered before what atoms and molecules are.

To adequately discuss a possibility of false information existence from a methodological point of view, it is necessary to take into account three important issues: multifaceted approach to reality, historical context, and personal context. Thus, we come to the following conclusion.

First, there is a *structural issue* in this problem. Namely, the dichotomic approach, which is based on classical two-valued logic and rigidly divides any set into two parts, in our case, true and false information, gives a very approximate image of reality. Much better approximation is achieved through the multifaceted approach based on multivalued logics, fuzzy reasoning, and linguistic variables.

Second, there is a *temporal issue* in this problem. Namely, the problem of false information has to be treated in the historical or, more exactly, temporal context, i.e., we must consider time as an essential parameter of the concept.

Third, there is a *personal issue* in this problem, i.e., distinction between genuine and false information often depends on the person who estimates this knowledge.

In light of the first issue of our discussion about false information, we can see that in cognitive processes, the dichotomic approach, which separates all objects into two groups, *A* and *not A*, is not efficient. Thus, if we take the term "false information", then given a statement, it is not always possible to tell if it contains genuine or false information. To show this, let us consider following statements:

1. "*Pi* is equal to 3."
2. "*Pi* is equal to 3.1."
3. "*Pi* is equal to 3.14."
4. "*Pi* is equal to 3.1415926535."
5. "*Pi* is equal to $(4/3)^2$."

According to the definition of *pi* and our contemporary knowledge that states that *pi* is a transcendent number, all these statements contain false information. In practice, they are all true but with different exactness. For example, the statement (4) is truer than the statement (1). Nevertheless, in the ancient Orient, the value of *pi* was frequently taken as 3 and people were satisfied with this value (Eves, 1983). Archimedes found that *pi* is equal to 3.14. For centuries, students and engineers used 3.14 as the value for *pi* and had good practical results. Now calculators and computers allow us to operate with much better approximations of *pi*, but nobody can give the exact decimal value of this number.

Importance of the temporal issue is demonstrated by the following example from the history of science that helps to better understand the situation with false information. Famous Greek philosophers Leucippus (fl. 445 B.C.) and Democritus (460-360 B.C.) suggested that all material bodies consist of small particles, which were called atoms. "In reality," said Democritus, "there are only atoms and the void."

We can ask the question whether this idea about atoms contains genuine or false information. From the point of view of those scientists who lived after Democritus but before the fifteenth century, it contained false information. This was grounded by the fact that those scientists were not able to look sufficiently deep into the matter to find atoms.

However, the development of scientific instruments and experimental methods made it possible to discover micro-particles such that have been and are called atoms.

Consequently, now it is a fact, which is accepted by everybody, that all material bodies consist of atoms. As a result, now people assume that the idea of Leucippus and Democritus contains genuine or true information.

This shows how people's comprehension of what is genuine information and what is false information changes with time. Lakatos (1976) and Kline (1980) give interesting examples of similar situations in the history of mathematics.

All these examples demonstrate that it is necessary to consider false information as we use negative numbers, as well as not to discard pseudoinformation as we do not reject utility of such number as 0. History of mathematics demonstrates that understanding that 0 is a number and a very important number demanded a lot of hard intellectual efforts from European mathematicians when Arab mathematicians brought to them knowledge about 0 from India.

Going to the third point of the discussion about false information related to the personal issue, let us consider other examples from the history of science as here we are studying information by scientific methods.

In his lectures on optics, Newton developed a corpuscular theory of light. According to this theory, light consists of small moving particles. Approximately at the same time, Huygens and Hook built a wave theory of light. According to their theory, light is a wave phenomenon. Thus, somebody would like to ask the question who, i.e., Newton or Huygens and Hook, gave genuine information and who gave false information. For a long time, both theories were competing. As a result, the answer to our question depended whether the respondent was an adherent of the Newton's theory or of the theory of Huygens and Hook. However, for the majority of people who lived at that time both theories provided pseudoinformation because those people did not understand physics.

A modern physicist believes that both theories contain genuine information. So, distinction between genuine and false information in some bulk of knowledge depends on the person who estimates this knowledge.

Thus, we have seen that the problem of false information is an important part of information studies and we need more developed scientific methods to treat these problems in an adequate manner.

The general theory of information makes it possible to explicate essence and meaning of genuine information, false information or misinformation, disinformation, and pseudoinformation in a consistent network of concepts that represent specific phenomena from the real world.

3 Elements of the General Theory of Information

The base of the general theory of information is a system of principles. Here we need only some of them. A reader can find other principles of the general theory of information in (Burgin, 2001; 2003)

Ontological Principle O1. *It is necessary to separate information in general from information (or a portion of information) for a system **R**.* In other words*, empirically, it is possible to speak only about information (or a portion of information) for a system.*

Why it is so important? The reason is that all conventional theories of information assume that information exists as something absolute, like time in the Newtonian dynamics. Consequently, it is presupposed that this absolute information may be measured, used, and transmitted. In some abstract sense it is true, but on practice, or as scientists say, empirically, this is not so.

Definition 1. The system ***R*** with respect to which some information ***I*** is considered is called the *receiver* of the information ***I***.

Such a receiver can be a person, community, animal, computer, database and so on.

The Ontological Principle O1 correlates with the idea of Roederer (2002) that interaction plays very important role for information. In other words, there exists no information without interaction of the carrier of information with the receiver of information. However, it is possible to speak of information not only when we have both a sender and a recipient because the recipient can extract information from a carrier when the carrier does not send it. So, the classical *communication triad* (1) is not necessary for existence of information.

$$\textbf{Sender} \xrightarrow{\textbf{\textit{Information}}} \textbf{Receiver} \tag{1}$$

The intrinsic necessary structure is the *input information triad* (2).

$$\textbf{Carrier} \xrightarrow{\textbf{\textit{Information}}} \textbf{Receiver} \tag{2}$$

The triad (2) is complemented by the *output information triad* (3).

$$\textbf{Sender} \xrightarrow{\textbf{\textit{Information}}} \textbf{Carrier} \tag{3}$$

Together the output and input information triads form the communication triad as their sequential composition.

Besides, even if information gives some image of a pattern from a sender, this correspondence is not necessarily one-to-one.

Thus, the first principle explicates an important property if information, but says nothing what information is. This is done by the second principle that exists in two forms.

Ontological Principle O2. *In a broad sense, information* ***I*** *for a system* ***R*** *is any essence that causes changes in the system* ***R****.*

This principle has several consequences. First, it demonstrates that information is closely related to transformation. Namely, it means that information and transformation are functionally similar because they both cause changes in a system. At the same time, they are different because information is a cause of a change, while transformation is the change itself.

Second, the Ontological Principle O2 explains *why* information influences society and individuals all the time and why this influence grows with the development of society. Namely, reception of information implies transformation. In this sense, information is similar to energy. Moreover, according to the Principle O2, energy is a kind of information in a broad sense. This well correlates with the Carl Friedrich von Weizsäcker's idea (cf., for example, (Flükiger, 1995)) that *energy might in the end turn out to be information*. At the same time, the von Weizsäcker's conjecture explains the exact correspondence between a characteristic of thermal energy such as the thermodynamic entropy given by the Boltzmann-Gibbs formula $S = k\cdot\ln P$ and a characteristic of information such as the quantity of information given by a similar Hartley-Shannon formula $I = K\cdot\ln N$.

Third, the Ontological Principle O2 makes it possible to separate different kinds of information. For instance, any person, as well as any computer, has many kinds of memory. It is even supposed that each part of the brain has several types of memory agencies that work in somewhat different ways, to suit particular purposes (Minsky, 1986). It is possible to consider each of these memory agencies as a separate system and to study differences between information that changes each type of memory. This would help to understand the interplay between stability and flexibility of mind, in general, and memory, in particular.

It is true, to be sure, that an adequate theory, whether of information or anything else, must be in significant accord with our common ways of thinking and talking about what the theory is about. Else there is a danger that theory is not about what it purports to be about. But, on the other hand, it is wrong to expect that any adequate and reasonably comprehensive theory will be congruent in every respect with common ways of thinking and speaking about its subject, just because those ways are not themselves usually consistent or even entirely clear. To achieve higher consistency, we introduce information in the strict sense. This concept is based on the concept of an infological subsystem of a system.

Definition 2. A subsystem IF(***R***) of the system ***R*** is called an *infological system* of ***R*** if IF(***R***) stores infological elements.

There is no exact definition of infological elements although there are various entities that are infological elements as they allow one to build conventional theories of information. For instance, knowledge, data, images, ideas, fancies, abstractions, beliefs, and similar objects are standard examples of infological elements. If we consider only knowledge and data, then the infological system is the *system of knowledge* of a given system ***R***. Such a system of knowledge is called a *thesaurus* in cybernetics.

It is natural to suppose that infological elements are different kinds of structures (Burgin, 1997).

The situation with infological elements looks similar to the situation in contemporary physics where physicists do not give a definition of matter but explain how matter is built and what elements of matter are. As such elements on the lowest level of the hierarchy, physicists take subatomic particles, physical fields, atoms, molecules and so on.

Imprecision in the definition of an infological system has its advantages. For instance, having a complex system ***R***, it is possible to determine different infological systems in it. This results in different kinds of information for this system. For instance, in (Burgin, 2001) three types of information are separated: cognitive, emotional, and effective information.

In some sense, an infological system plays the role of a free parameter in the definition of information (cf. the Ontological Principle O2a). Additional conditions on infological elements imply a more restricted concept of information.

When ***R*** is a material system, its infological subsystem IF(***R***) consists of three components:

- a material component, which is a system of physical objects;
- a functional structure realized by the material component;
- the system of infological elements.

For example, the material component of the infological subsystem of a human being is her/his brain or its part that is called memory. What is commonly called memory is not a single, simple system. It is an extraordinarily complex system of diverse components and processes. Memory of a person has three, or perhaps even more, distinct components (Minsky, 1986). The most important and best documented by scientific research are sensory information storage (SIS), short-term memory (STM), and long-term memory (LTM). Memory researchers do not employ uniform terminology. Sensory information storage is also known as sensory register, sensory store, and eidetic and echoic memory. Short- and long-term memories are also referred to as primary and secondary memory. Each component of memory differs with respect to function, the form of information held, the length of time information is retained, and the amount of information-handling capacity. Memory researchers also posit the existence of an interpretive mechanism and an overall memory monitor or control mechanism that guides interaction among various elements of the memory system.

The corresponding functional structure is her/his mind in the case when the material component is the brain. In the case of memory, we take the system of knowledge as the corresponding functional component. Infological elements in this case will be units of knowledge of the individual.

Another example of an infological system is the memory of a computer. Such a memory is a place in which data and programs are stored. It is also a complex system of diverse components and processes. Memory of a computer includes such three components as the random access memory (RAM), read-only memory (ROM), and secondary storage. While RAM forgets everything whenever the computer is turned off and ROM cannot learn anything new, secondary storage devices allow the computer to record information for as long period of time as we want and change it whenever we want. Now three kinds of such devices are utilized: magnetic tapes and corresponding drives, magnetic disks and corresponding drives, and optical disks and corresponding drives.

Ontological Principle O2a. *Information in the strict sense or, simply, information for a system **R**, is everything that changes the infological system* IF(***R***) *of the system **R**.*

This implies that for a complex system there are different kinds of information. Each type of the infological system determines a specific kind of information. For example, information that causes changes in the system of knowledge is called cognitive information. Existing approaches to information theory and problems with understanding information as natural, social, and technological phenomenon resulted in a current situation when researchers consider only cognitive information.

The Ontological Principle O2a implies that information is not of the same kind as knowledge and data, which are structures (Burgin, 1997). Actually, if we take that *matter* is the name for all substances as opposed to *energy* and the *vacuum*, we have the relation that is represented by the following diagram.

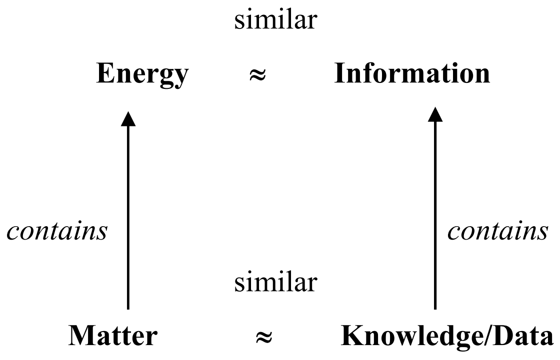

Figure 1. Information/Energy Diagram

In other words, ***information is related to knowledge and data as energy is related to matter.***

Here it is necessary to remark that many people think and write that there is no distinction between matter and energy. They base their belief on the famous formula from the relativistic physics

$$E = mC^2 \qquad (1)$$

However, this belief is only a misconception because the letter m in (1) does not stand for matter, as well as the letter E in (1) does not stand for energy. Here m means "mass" and E means the quantity of energy. "Mass" is only one of the characteristics or measures of material objects. What concerns the symbol E in (1), it is necessary to make a distinction between energy as a natural phenomenon and energy as some physical quantity. The latter is a measure of the former. It is natural to call this quantity by the name "the quantity of energy." However, traditionally it is also called energy. There are other measures of energy. For instance, entropy is another measure of thermal energy. Indeed, the thermodynamic entropy S, often simply called the entropy in the context of thermodynamics, is usually interpreted as a measure of the amount of energy in a physical system that cannot be used to do work (cf., for example, (Wikipedia)).

Thus, formula (1) gives a relation between two measures of two distinct natural phenomena. Namely, this formula estimates how much energy is stored in matter.

The reasoning that formula (1) means absence of distinction between energy and matter is similar to the following argumentation. Let M be a man, T be a tree, and $h(x)$ denotes the height of x. Then some can (incorrectly) say that the formula $h(\mathrm{M}) = h(\mathrm{T})$ means that there is no distinction between M and T. Although this fallacy is more evident than the fallacy of equating energy and matter, both fallacies have the same nature.

It is important to understand that saying or writing that matter contains energy or knowledge contains information is not the same as saying that a bottle contains water. The meaning of the expression "knowledge contains information" is similar to the meaning of expressions "the brain contains knowledge" or "a person has knowledge." In other words, it is possible to extract energy from matter, as well as it is possible to extract information from knowledge. In some cases, such extraction goes on automatically (on the unconscious level). It gives an illusion that information comes itself into a system.

Distinction between knowledge and cognitive information has important implications for education. For instance, transaction of information (for example, in a teaching process) does not give knowledge itself. It only causes such changes that may result in the growth of knowledge.

This correlates with the approaches of Dretske (1981) and MacKay (1969), who declare that information increases knowledge and knowledge is considered as a completed act of information.

However, the general theory of information differs from Dretske's and MacKay's conceptions of information because the general theory of information demonstrates that information transaction may result not only in the growth of knowledge but also in the decrease of knowledge (Burgin, 1994).

Any system can have an infological subsystem. Consequently, in contrast to the opinion of some researchers, information is important both for the biotic and abiotic worlds. Information enters non-living physical world even without living beings.

At the same time, Roederer defines information as *the agent that mediates the correspondence between features or patterns in the source system A and changes in the structure of the recipient B*. This definition strongly correlates with the definition from the Ontological Principle O2a. Taking such infological system as genetic memory, we come to the concept of biomolecular information considered by Roederer (2002).

Menant (2002) bases his approach to the meaning of information on the assumption that information is a basic phenomenon in our world. Different kinds of information and infological systems induce existence of different types of meaning in the sense of Menant. It is possible to consider meaning for a given infological system. This results in emergence of an individual meaning when a person receives some information. For instance, a mathematical theorem has different meaning for a student, professional mathematician, and engineer.

Although meaning, as we have seen, is not an inherent attribute of information, many observations show that meaning is closely connected to information that is received, searched for, disseminated, and processed by people. To explain this peculiarity, it is possible to suggest the Filtering Hypothesis based on main assumptions of the general theory of information. First, meaning in a general understanding is connected only to cognitive information. Second, to answer the question why a message/text that has no meaning for an individual *A* has no information for this individual, we have to assume that, according to the general theory of information, a message has information for *A* if and only if it changes the knowledge system of *A*.

The human mind does not accept everything that comes from senses. It has filters. One of such filters tests communication for meaning and rejects meaningless messages. Thus, meaningless messages cannot change the knowledge system of the individual *A* and consequently, have no information for this individual. Thus, we come to the following conclusion.

Filtering Hypothesis. Meaning plays the role of a test criterion for information acceptance by an individual. Consequently, a message without meaning gives no information for this individual.

The same is true for social information where meaning also plays the role of a test criterion for an information filter. However, either it is irrelevant to expand this connection between information and meaning beyond personal and social information or it is necessary to extend the notion of meaning so as to grasp other kinds of information.

This brings us to the problem of information representation considered by Roederer (2002) and other researchers. An exact meaning of the term "information representation" can be deduced from the Principle O3.

Let ***I*** be some portion of information for a system ***R***.

Ontological Principle O3. *There is always some carrier* ***C*** *of the information* ***I****.*

For instance, people get information from books, magazines, TV and radio sets, computers, and from other people. To store information people use their brains, paper, tapes, and computer disks.

Existence of a definite carrier for information allows one to speak about this carrier as a *representation of information*. According to the Principle O2, information is the same if it causes the same changes in a given infological system. Thus, the same information can be represented in different carriers, e.g., by different texts, or even by carriers of different nature, e.g., there cases when it is possible to convey the same information by an oral message, written or printed text, and picture.

Carriers of information belong to three classes: material, mental, and structural. For example, let us consider a book. It is a physical carrier of information. However, it contains information only because some meaningful text is printed in it. Without this text it would not be a book. The text is the structural carrier of information in the book. Besides, the text is understood if it represents some knowledge and/or other structures from the cognitive infological system. This knowledge and other corresponding structures form the mental carrier of information in the book.

Two of the three types of information carriers are related to elements of the basic triplet (triad) of Jumarie (1986): the system *S* that is the *material medium* where information is physically defined; the *universe of discourse U* where information is semasiologically defined; and the *observer R* who considers *S* and *U* in his own subjective framework. The system *S* that is the material medium where information is physically defined corresponds to the physical carrier of information. The universe of discourse *U* where information is semasiologically defined corresponds to the structural carrier of information. The observer *R* who considers *S* and *U* in his own subjective framework corresponds to the mental carrier of information.

For adherents of the materialistic approach Principle O3 must be changed to a stronger version:

Ontological Principle OM3. *There is some substance/substratum* ***C*** *that contains information* ***I.***

This substance ***C*** is called the *physical carrier* of ***I***.

The first three ontological principles ((O1)-(O3) or (O1)-(OM3)) imply that information connects the carrier ***C*** with the system ***R*** and is a component of the following triple structure

$$(\boldsymbol{C}, \boldsymbol{I}, \boldsymbol{R}) \qquad (4)$$

As a rule, there is some channel through which information comes from ***C*** to ***R***. For example, The carrier ***C*** of ***I*** is a piece of paper and ***R*** is a person reading the text written on ***C***. Then the corresponding channel is the space between the paper and the eyes of the person.

The structure (4), as well as structures (1) – (3), is a special case of the following more general structure that is called a named set or a fundamental triad (Burgin, 1997).

According to the ontological principles, information causes changes. Consequently, it is natural to assume that measure of information is determined by the results that are caused by reception of the corresponding portion of information. It is formulated in the first principle.

Axiological Principle A1. *A measure of information* ***I*** *for a system* ***R*** *is some measure of changes caused by* ***I*** *in* ***R*** (*for information in the strict sense, in the chosen infological system* IF(***R***)) .

This principle implies that a unique measure of information exists only for oversimplified system. Any complex system **R** with a developed infological subsystem IF(***R***) has many parameters that may be changed. So, complex systems demand many different measures of information in order to reflect the full variety of system properties, as well as of conditions in which these systems function. Uncertainty elimination (which is measured by the Shannon's quantity of information) is only one of possible changes, which are useful to measure information.

4 Types of Information

Utilizing the concept of an information measure and applying some types of such measures, we can give exact definitions of genuine information, false information or misinformation, disinformation, and pseudoinformation. There are two classes of approaches to such constructions: relativistic and universal. The latter is subdivided into object-dependent and attitude-dependent approaches. At first, we consider a relativistic approach to this problem.

Let us consider such infological system as thesaurus or knowledge system ***T*** and fix some numerical measure *m* of information, which reflects changes of ***T***. Taking ***T*** as the infological system restricts our study to cognitive information, for which distinctions between genuine information, misinformation, disinformation, and pseudoinformation are more natural.

Definition 3. A portion of information ***I*** is called *genuine information relative to the measure m* if $m(\boldsymbol{I}) > 0$.

To have genuine information relevant to usual understanding, we take such measure as correctness of knowledge or such measure as validity of knowledge. However, it is necessary to understand that the truth of knowledge and the validity of it its acquisition are not always the same. For instance (Suber, 2000), the truth of knowledge represented by propositions and the validity of reasoning are distinct, while there are relations between them. This relationship is not entirely straightforward. It is impossible to say that truth and validity, in this sense, are utterly independent because the impossibility of "case zero" (a valid argument with true premises and false conclusion) shows that one combination of truth-values is an absolute bar to validity. When an argument has true premises and a false conclusion, it *must* be invalid. In fact, this is how we define invalidity.

Definition 4. A portion of information ***I*** is called *false information* or *misinformation* (*misleading information*) *relative to the measure m* if $m(\boldsymbol{I}) < 0$.

Thus, we have misinformation when its acceptance makes our knowledge less correct. For example, let us consider people who lived in ancient Greece and accepted ideas of Leucippus and Democritus that all material bodies consist of atoms. Then they read Aristotle's physics that eliminated the idea of atoms. Because we now know that the idea of atoms is true, Aristotle's physics decreased true knowledge about such an aspect of the world as the existence of atoms and thus, gave false information about atoms.

We can ask the question whether this idea contains genuine or false information. From the point of view of those scientists who lived after Democritus but before the fifteenth century, it contained false information. This was grounded by the fact that those scientists were not able to go sufficiently deep into the matter to find atoms.

We see that false information is also information because it has a definite impact on the infological system. Only this impact is negative.

It is interesting that there is no direct correlation between false information and meaningless information. Bloch in his book "Apology of History" (1961) gives examples when false information was meaningful for people, while genuine information was meaningless for them.

Definition 5. A portion of information ***I*** is called *pseudoinformation relative to the measure m* if $m(\boldsymbol{I}) = 0$.

This concept shows the advantage of the relativistic approach. Really, the unit of information I can be pseudoinformation with respect to one measure, making no changes in the infological system IF(R)of a system R according to this measure, and it can be a genuine information, which results in a lot of changes of IF(R) with respect to another measure.

For example, in some database D that is considered as an infological system, we have a description d of some person A. Then information I comes, telling us that d is a description not of A, but of another person K. Then with respect to such measure m as the volume of data, nothing changes in D and I is pseudoinformation as the number of bytes in D stays the same. But because the previous attribution of d to A was incorrect and the new attribution of d to K is correct, I is true or genuine information with respect to such measure as correctness.

Moreover, false information with respect to one measure can be true information with respect to another measure. For example, let us consider some statement X made by a person A. It can be true with respect to what A thinks, but it can be false with respect to the real situation.

Definition 6. A portion of information $\boldsymbol{I}$ is called *disinformation relative to the measure m* if it is intended misinformation relative to the measure m.

However, the relativistic approach is too general because not all measures m reflect such property as truthfulness. For example, we can take such measure m that measures the changes in the volume of the system of knowledge $\boldsymbol{T}$: in bytes, kilobytes, and gigabytes for computer thesaurus or in number of books and journals for library thesaurus. This measure has nothing to with the truthfulness of information that is contained in computer files or in books.

Thus, to get more exact representation of the convenient meaning of the term “true information,” we take a measure tr of truthfulness of knowledge in the system $\boldsymbol{T}$. Utilizing such a measure, we develop the universal approach.

At first, we introduce $tr(T, D)$ as a function of two variables where the range of the variable T is a set of different knowledge systems and the range of the variable D is a set of different object domains. It is supposed that each element or system of knowledge refers to some object domain because knowledge is always knowledge about something (Burgin, 2004).

To distinct knowledge from beliefs and fantasy, we need some criteria. There are two types of such criteria: *object-dependent* and *attitude-dependent*. According to the first approach, we have the following definitions.

Definition 7. *General knowledge **T*** about an object F has the structure represented by the diagram (5) and high level of validation.

$$\begin{tikzcd} W \arrow[r, "g"] & L \\ U \arrow[u, "t"] \arrow[r, "f"'] & C \arrow[u, "p"'] \end{tikzcd} \qquad (5)$$

We assume that in this diagram there are:

1) some class U containing the object F;
2) an intrinsic property that is represented by an abstract property T = (U, t, W) with the scale W, which is defined for objects from U;
3) some class C, which includes a name «F» of the object F;
4) an ascribed property that is represented by an abstract property P = (C, p, L) with the scale W (Burgin, 1990), which is defined for names from C;
5) the correspondence *f* relates each object H from U to its name (system of names or more generally, conceptual image (Burgin and Gorsky, 1991) «H» from C;

and

6) the correspondence *g* relates values of the property T to values of the property P. In other words, *g* relates values of the intrinsic property to values of the ascribed property. For example, when we consider a property of people such as height (the intrinsic property), in weighting any thing, we can get only an approximate value of the real height, or height with some precision (the ascribed property).

There are different systems of validation: science, for which the main validation technique is experiment; mathematics, which is based on logic with its deduction and induction; religion with its postulates and creeds; history, which is based on historical documents and archeological discoveries. Each system of validation implies a corresponding validation function *tr*(***T***, *F*) that gives a quantitative or a qualitative estimate of the truthfulness of knowledge ***T*** about the object *F*. It is possible to take some unification of all values *tr*(***T***, *F*) ranging over all objects *F* to which knowledge ***T*** can be related. This allows us to obtain a truthfulness function *tr*(***T***, *F*) for systems of knowledge. In general, such unification of values *tr*(***T***, *F*) is performed by some integral operation in the sense of (Burgin and Karasik, 1976). Examples of such operations that are relevant to the problem of information truthfulness estimation are:

1) taking the average value;
2) taking the minimal value;
3) taking the maximal value.

Let us consider some measures of correctness.

Example 1. One of the most popular measure *tr*(***T***, *D*) of correctness is correlation between the experimental data related to an object domain *D* and data related to *D* that are stored in the knowledge system ***T***.

Correlation *r* is a bivariate measure of association (strength) of the relationship between two sets of corresponded data. It varies from 0 (no relationship or random relationship) to 1 (perfect relationship) or from -1 (perfect negative relationship) to 1 (perfect positive relationship). It is usually reported in terms of its square (r^2), interpreted as percent of variance explained. For instance, if r^2 is 0.1, then the independent variable is said to explain 10% of the variance in the dependent data.

The measure of correlation introduced by Pearson is given by the formulas:

$\Sigma\, (x_i - \bar{x})((y_i - \bar{y}) > 0$ is + correlation;

$\Sigma\, (x_i - \bar{x})((y_i - \bar{y}) < 0$ is - correlation;

$\Sigma\, (x_i - \bar{x})((y_i - \bar{y}) = 0$ is 0 correlation.

The *correlation coefficient* is a measure of linear correlation and is given by the formula:

$$r = \frac{\Sigma\, (x_i - \bar{x})((y_i - \bar{y})}{\sqrt{\Sigma\, (x_i - \bar{x})^2\, \Sigma\, ((y_i - \bar{y})^2}}$$

Beside correlation *r*, which is the most common type of correlation measure, other types of correlation measures are used to handle different characteristics of data. For example, measures of association are used for nominal and ordinal data.

Example 2. It is possible to take as a measure *tr*(***T***, *D*) of correctness validity of stored in the system knowledge ***T*** about the object domain *D*. There are different types of validity. For example, researchers have introduced four types of validity for experimental knowledge: conclusion, internal, construct, and external validity. They build on one another, and each type addresses a specific methodological question.

According to the *attitude-dependent approach*, we have the following definitions.

Definition 8. *General knowledge* ***T*** about an object F for a system *R* is the entity that has the structure represented by the diagram (5) that is estimated (believed) by the system *R* to represent with high extent of confidence true relations.

For instance, Bertrand Russell (1926) uses an attitude-dependent approach in his definition of knowledge, which he begins with consideration of beliefs.

Belief relations in a system are estimated by belief and plausibility measures (cf. Klir and Wang, 1993) or by extended belief measures that are introduced below. It makes possible to take some belief or plausibility measure as a measure *tr*(*T*, *D*) of truthfulness of knowledge in the system ***T***.

A belief measure is a kind of fuzzy measures.

Let *X* be a set of elements and **P**(*X*) be a set of subsets from *X*.

Definition 9. A *fuzzy measure* g on *X* is a mapping g: $\mathbf{P}(X) \rightarrow [0,1]$ from crisp subsets of X into the unit interval, having the properties:

(1) $g(\varnothing)=0$;

(2) $g(X)=1$;

(3) If $A \subseteq B$, then $g(A) \leq g(B)$.

It is possible to interpret the value g(A) as the degree of available evidence or our belief that a given element of *X* belongs to the subset A.

Important type of fuzzy measures is the set of all belief measures.

Definition 10. A *belief measure* in X is a partial function Bel: $\mathbf{P}(X) \to [0,1]$ that is defined on a subset $\boldsymbol{A}$ from $\mathbf{P}(X)$ and satisfies the following axioms:

(Be1) $\varnothing, X \in \boldsymbol{A}$, $Bel(\varnothing) = 0$, and $Bel(X) = 1$.

(Be2) For any system $\{ A_i ; i = 1, 2, \dots , n \}$ of sets from $\boldsymbol{A}$ and any n from $\boldsymbol{N}$,

$$Bel(A_1\cup \dots \cup A_i) \geq \Sigma_{i=1}^{n} Bel(A_i) - \Sigma_{i<j} Bel(A_i \cap A_j) + \dots + (-1)^{n+1} Bel(A_1\cap \dots \cap A_i)$$

For each set A $\in \mathbf{P}(X)$, Bel(A) is usually interpreted as the degree of belief (based on available evidence) that a given element of X belongs to the set A.

Related to belief measures are plausibility measures.

Definition 2.14. A *plausibility measure* in X is a partial function Pl: $\mathbf{P}(X) \to [0,1]$ that is defined on a subset $\boldsymbol{A}$ from $\mathbf{P}(X)$ and satisfies the following axioms [3, 27]:

(Pl1) $\varnothing, X \in \boldsymbol{A}$, $Pl(\varnothing) = 0$, and $Pl(X) = 1$.

(Pl2) For any system $\{ A_i ; i = 1, 2, \dots , n \}$ of sets from $\boldsymbol{A}$ and any n from $\boldsymbol{N}$,

$$Pl(A_1\cap \dots \cap A_i) \leq \Sigma_{i=1}^{n} Pl(A_i) - \Sigma_{i<j} Pl(A_i \cup A_j) + \dots + (-1)^{n+1} Pl(A_1\cup \dots \cup A_i))$$

Belief measure and plausibility are *dual measures* as for any belief measure $Bel(A)$, $Pl(A) = \overline{1} - Bel(A)$ is a plausibility measure and for any plausibility measure $Pl(A)$, $Bel(A) = \overline{1} - Pl(A)$ is a belief measure.

When the axiom (Be2) for belief measures is replaced with a stronger axiom

$$\mathrm{Bel}(A\cup B)=\mathrm{Bel}(A)+\mathrm{Bel}(B) \text{ whenever } A\cap B = \varnothing,$$

we obtain a special type of belief measures, the classical probability measures (sometimes also referred to as Bayesian belief measures).

A belief system, either of an individual or of a community, contains not only beliefs, but also disbelief. To represent this peculiarity, we use extended belief measures.

Definition 12. An *extended belief measure* is a function Bel: P(X) $\to$ [-1,1] that satisfies the same axioms as belief measures.

Remark 1. It is possible to represent an extended belief measure by an intuitionistic fuzzy set (Atanasov, 1999).

The measure $tr(T, D)$ of correctness validity allows us to define truthfulness for information. If we have a thesaurus $\boldsymbol{T}$ and a unit of information I, then the truthfulness of I about an object domain D is given by the formula

$$tr(I, D) = tr(I(\boldsymbol{T}), D) - tr(\boldsymbol{T}, D)$$

Here $I(\boldsymbol{T})$ is the thesaurus $\boldsymbol{T}$ after it receives/processes information I. The difference shows the impact of I on $\boldsymbol{T}$.

Definition 13. The function $tr(I, D)$ is called a measure of *object related truthfulness* or simply, *correctness* of information.

Example 3. System related truthfulness is useful for estimating statements of witnesses. In this case, the measure of inconsistency $ncons(\boldsymbol{T}_A, \boldsymbol{T}_B)$ between $\boldsymbol{T}_A$ and $\boldsymbol{T}_B$ is equal to the largest number of contradicting pairs (p_A , p_B) of simple statements p_A from $\boldsymbol{T}_A$ and p_B from $\boldsymbol{T}_B$ when p_A and p_B are related to the same object or event. The measure of inconsistency $ncons(\boldsymbol{T}_A, \boldsymbol{T}_B)$ between $\boldsymbol{T}_A$ and $\boldsymbol{T}_B$ determines several measures of consistency $cons(\boldsymbol{T}_A, \boldsymbol{T}_B)$ between $\boldsymbol{T}_A$ and $\boldsymbol{T}_B$. One of such measures of consistency $cons(\boldsymbol{T}_A, \boldsymbol{T}_B)$ between $\boldsymbol{T}_A$ and $\boldsymbol{T}_B$ is defined by the formula

$$cons(\boldsymbol{T}_A, \boldsymbol{T}_B) = 1/(1 + ncons(\boldsymbol{T}_A, \boldsymbol{T}_B)) \qquad (6)$$

It is possible to normalize the measure of inconsistency $ncons(\boldsymbol{T}_A, \boldsymbol{T}_B)$, defining $ncons_{\mathrm{N}} (\boldsymbol{T}_A, \boldsymbol{T}_B)$ as the largest ratio of the number of contradicting pairs (p_A , p_B) and number of all pairs (p_A , p_B) of simple statements p_A from $\boldsymbol{T}_A$ and p_B from $\boldsymbol{T}_B$ when p_A and p_B are related to the same object or event. This measure generates the corresponding normalized consistency measure $cons_{\mathrm{N}} (\boldsymbol{T}_A, \boldsymbol{T}_B)$ by the formula (6). Another normalized consistency measure $cons_{\mathrm{N}} (\boldsymbol{T}_A, \boldsymbol{T}_B)$ is defined by the formula (7).

$$cons(\boldsymbol{T}_A, \boldsymbol{T}_B) = 1 - ncons(\boldsymbol{T}_A, \boldsymbol{T}_B) \qquad (7)$$

Taking some object domain $\boldsymbol{D}$ and tr as the measure m in Definitions 3-6, we obtain unconditional concepts of true and false information.

Definition 14. A portion of information $\boldsymbol{I}$ is called *true* or *correct information* about $\boldsymbol{D}$ if $tr(\boldsymbol{I}, \boldsymbol{D}) > 0$.

Definition 15. A portion of information $\boldsymbol{I}$ is called *false information* or *misinformation* (*misleading information*) about $\boldsymbol{D}$ if $tr(\boldsymbol{I}, \boldsymbol{D}) < 0$.

It is possible to measure truthfulness of knowledge not with respect to an object domain, but with respect to another thesaurus. For example, one person A gives some information I to another person B. Then it is viable to measure truthfulness of I with respect to A or more exactly, to the system of knowledge $\boldsymbol{T}_A$ of A.

To achieve this goal, we use some measure $cor(T, D)$ of correlation or consistency between knowledge systems T and D. Let $\boldsymbol{T}_A$ be the system of knowledge of A and $\boldsymbol{T}_B$ be the system of knowledge of B.

Definition 16. The function $cor(I, \boldsymbol{T}_A) = cor(I(\boldsymbol{T}_B), \boldsymbol{T}_A) - cor(\boldsymbol{T}_B, \boldsymbol{T}_A)$ is called a measure of *system related truthfulness* or simply, *genuineness* of information.

Example 4. Object related truthfulness works when the real situation is known. However, it is impossible to compare knowledge directly with a real system. So, in reality, we always compare different systems of knowledge. However, one system of knowledge can be closer to reality than another system of knowledge. In this case, we can assume that the corresponding truthfulness is object related (at least, to some extent).

This assumption is used as the main principle of science: it is presupposed that correct experiment gives true knowledge about reality and to find correctness of a model or theory, we need to compare the model or theory with experimental data.

Such an approach to knowledge is developed in the externalist theories of knowledge (Pollock and Cruz, 1999).

Example 5. Let us consider the system $\boldsymbol{T}_A$ of knowledge of a person A. The system $\boldsymbol{T}_{SA}$ is generated from all (some) statements of A. Then the value of the function $tr(\boldsymbol{T}_{SA}, \boldsymbol{T}_A)$ reflects sincerity of A, while the value of the function $tr(\boldsymbol{T}_{SA}, \boldsymbol{T}_A)$ reflects sincerity of information I given by A.

Definition 17. A portion of information $\boldsymbol{I}$ is called *true* or *genuine information* about $\boldsymbol{D}$ if $cor(I, \boldsymbol{T}_A) > 0$.

Definition 18. A portion of information $\boldsymbol{I}$ is called *false* or *misleading information* with respect to the measure m if $cor(I, \boldsymbol{T}_A) < 0$.

Remark 2. It is possible to use not only zero, but some other number $a \neq 0$ as a threshold that separates correct and false information.

Remark 3. It is possible to consider more than two gradations or classes of information. For example, we can separate such classes as highly correct/true, sufficiently correct/true, weakly correct/true, weakly false, and highly false information.

Remark 4. It is possible to treat truthfulness as a linguistic variable (Zadeh, 1973).

Considering different types of information that are produced and utilized by people, it is promising to take into account intentions. This separates disinformation from other types of information.

Definition 19. A portion of information $\boldsymbol{I}$ is called *objective disinformation* if it is intended misinformation relative to the measure $tr(\boldsymbol{I}, \boldsymbol{D})$ where $\boldsymbol{D}$ is some object domain.

There are different levels of disinformation: personal, group, and social.

Definition 20. A portion of information $\boldsymbol{I}$ is called *personal* (*group, social*) *disinformation* if it is intended misinformation relative to the measure $cor(I, \boldsymbol{T}_A)$ ($cor(I, \boldsymbol{T}_G)$ or $cor(I, \boldsymbol{T}_S)$, correspondingly) where A is some person (G is some group and S is some society, correspondingly) and $\boldsymbol{T}_A$ is the system of knowledge of A (G or S, correspondingly).

This shows that not all kinds of misinformation are disinformation. In addition, it gives us a criterion to discern these kinds of information. In some cases, such distinction is very important, for example, in scientific research or in politics.

5 Conclusion

It is demonstrated how the general theory of information explains relations between meaning and information, making possible to understand such phenomena as genuine information, false information, disinformation, and pseudoinformation. Types of information that are separated in this paper help us to understand and explain how information functions in society, as well as what are properties of information that is produced, extracted, transmitted, stored and processed by people.

In addition, the general theory of information solves the controversy whether information exists only in society or there is information in nature and artifacts. In reality, according to ontological principles the answer to this question depends entirely on our choice of a class of infological systems and carriers of information. If we consider only such infological systems as human brains, then we come to the situation where information is only what people accept on their mental level. At the same time, if we assume that possible carriers and infological systems are results of human activity (such as different databases) and existence (such as intelligence and memory of society), then it is possible to consider only information in society. However, if there are no restrictions on infological systems, we come to the conclusion that information exists everywhere.

To conclude, it is necessary to remark that people in general and contemporary researchers, in particular, consider only cognitive information. At the same time, the general theory of information made possible the discovery of other types of information: emotional and effective (Burgin, 2001).

All these advantages of the general theory of information open new perspectives for the further research. For instance, it becomes possible to study properties of genuine information, false information, disinformation, and pseudoinformation by theoretical tools.

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