DATA VERSUS INFORMATION

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(In order of appearance in the text)

***Abstract**: From its very beginnings in early 90's as an informal endeavor promoted by Michael Conrad and Pedro C. Marijuán, the FIS initiative (Foundations of Information Science) has been an attempt to rescue the information concept out from its classical controversies and use it as a central scientific tool, so as to serve as a basis for a new, fundamental disciplinary development – Information Science [Marijuán, 2017]. The FIS discussion list has been an essential instrument to keep alive the Foundations of Information Science initiative [FIS List, 2017]. This paper presents a part of a concrete discussion about interconnections between concepts "Data" and "Information" which became a step to more clear definitions of both concepts.*

***Keywords**: Foundation of Information Science, FIS, Data, Information.*
***ITHEA Keywords**: A.1 Introductory and Survey.*

Introduction

There is a naïve and widespread opinion that new machines, mechanisms, and devices appear from out of nowhere. In the beginning, there is nothing — then a great inventor comes along and develops a completely finished something. The Goddess Athena, if we can trust the ancient myth, appeared in the same way. A powerful axe stroke split Zeus' skull and an unharmed Athena stepped out in full armament. There she stood, with spear and shield, before the surprised eyes of the Olympian Gods [Altshuller, 1999].

Machines, however, do not appear from inside the head of an inventor completely "armed." Instead, they are born weak; slowly gaining strength by absorbing many inventions [Altshuller, 1999].

The same we may say for new theories. Step by step and due the great effort of many scientists, it is possible to invent and to propose the new knowledge.

From its very beginnings in early 90's as an informal endeavor promoted by Michael Conrad and Pedro C. Marijuán, the FIS initiative (Foundations of Information Science) has been an attempt to rescue the information concept out from its classical controversies and use it as a central scientific tool, so as to serve as a basis for a new, fundamental disciplinary development – Information Science [Marijuán, 2017]. The FIS discussion list has been an essential instrument to keep alive the Foundations of Information Science initiative [FIS List, 2017].

At FIS, rather than the discussion of a single particularized concept, information becomes the intellectual adventure of developing a "vertical" or "trans-disciplinary" science connecting the different threads and scales of informational processes, which demands both a unifying and a multi-perspective approach. Above all, the solution of the numerous conundrums and conceptual puzzles around information becomes the patient task of a community of scholars, in which the ideas and speculations of each individual thinker can be shared and experienced upon by the other colleagues, so that a sort of "group mind" develops (paraphrasing L. Hyde, 1979): one that is capable of cognitive tasks beyond the power of any single person [Marijuán, 2017].

This paper presents how productive the FIS discussions are on the example of a concrete discussion about interconnections between the concepts "Data" and "Information", which became a step to more clear definitions of the both concepts. The discussion was provided via FIS List from September 15 till October 08, 2017. In this paper we extract only the posts concerned with the topic above. Several posts are not included in the text below due to lack of permission from their authors. Nevertheless, they had been fruitful and maybe seen in the FIS List archive [FIS Archives, 2017].

The paper is organized as follows: the next four sections present main ideas of the participants in discussion organized in four groups "Thesis" - "Antithesis" - "Discussion" - "Synthesis". Finally, conclusion and further work sections are given. The body of the paper is given as a dialogue between FIS members. Participant name is indicated for each contribution. Corresponding links to FIS List Archive where the posts are saved are given. All the text with no author indicated (out of the tables) is written by Krassimir Markov.

Thesis

Krassimir Markov (http://listas.unizar.es/pipermail/fis/2017-September/001496.html):

The information is a kind of material reflection and could not be separated from the matter.

Of course, if one believes in God, it could ...

Information is a state of matter which may be recognized by the (live) subject.

Christophe Menant (http://listas.unizar.es/pipermail/fis/2017-September/001538.html):

We can all agree that perspectives on information depend on the context. Physics, mathematics, thermodynamics, biology, psychology, philosophy, AI, ...

But these many contexts have a common backbone: They are part of the evolution of our universe and of its understanding, part of its increasing complexity from the Big Bang to us humans.

And taking evolution as a reading grid allows beginning with the simple.

We care about information ONLY because it can be meaningful. Take away the concept of meaning; the one of information has no reason of existing.

And our great discussions would just not exist. .... Now,

Evolution + Meaning => Evolution of meaning.

As already highlighted this looks to me as important in principles of IS [Menant, 2011, 2017].

The evolution of the universe is a great subject where the big questions are with the transitions:

energy => matter => life => self-consciousness => ...

And I feel that one way to address these transitions is with local constraints as sources of meaning generation.

Krassimir Markov (http://listas.unizar.es/pipermail/fis/2017-September/001539.html):

I agree with idea of meaning. The only what I would to add is the next:

There are two types of reflections:

1. Reflections without meaning called DATA;
2. Reflections with meaning called INFORMATION.

Antithesis

Christophe Menant (http://listas.unizar.es/pipermail/fis/2017-September/001541.html):

However, I'm not sure that "meaning" is enough to separate information from data. A basic flow of bits can be considered as meaningless data. But the same flow can give a meaningful sentence once correctly demodulated.

I would say that:

1) The meaning of a signal does not exist per se. It is agent dependent.

- A signal can be meaningful information created by an agent (human voice, ant pheromone).

- A signal can be meaningless (thunderstorm noise).

- A meaning can be generated by an agent receiving the signal (interpretation/meaning generation).

2) A given signal can generate different meanings when received by different agents (a thunderstorm noise generates different meanings for someone walking on the beach or for a person in a house).

3) The domain of efficiency of the meaning should be taken into account (human beings, ant-hill).

Regarding your positioning of data, I'm not sure to understand your "reflections without meaning".

Could you tell a bit more?

Discussion

Stanley N Salthe (private letter):

The simple answer to your question about data is to note the word's derivation from Latin Datum, which can be compared with Factum.

Yixin Zhong (http://listas.unizar.es/pipermail/fis/2017-October/001547.html):

The discussion on the concept of information is really fundamental and is the central issue to the foundation of information science.

But, may I remind that there are two categories of the concept of information. One is the concept of object information and the other is the concept of perceived information. They are different from, but

also related to, each other.

The object information presented by an object is referred as the state of the object and the pattern with which its state varies. It has nothing to do with the subject and is therefore also termed ontological information.

The perceived information that the subject has about the object is the form, meaning, and utility of the object, all of which are perceived by the subject from the object information. The form, meaning, and utility are respectively termed as syntactic, semantic, and pragmatic information.

When talking about "information", you must be clearly aware of which category of the concept you are really mentioning to. Do not make confusion between the two categories of the concept of information.

When talking about the object information, there is only the state/pattern of the object and has no meaning. Only when talking about the perceived information, there will then be the form, meaning, and utility in it.

The data is the carrier, or expression, of the perceived information. So, data is merely the syntactic information, not the semantic information (meaning), and of course not the perceived information as whole.

What we call the "information" is often referred to the meaning of the information that is the semantic information, instead on the information in the sense of Shannon Information.

For more detail please see my paper [Zhong, 2017].

Yixin Zhong (http://listas.unizar.es/pipermail/fis/2017-October/001567.html):

It is not difficult to accept that there are two concepts of information, related and also different to each other. The first one is the information presented by the objects existing in environment before the subject's perceiving and the second one is the information perceived and understood by the subject. The first one can be termed the object information and the second one the perceived information. The latter is perceived by the subject from the former.

The object information is just the object's "state of the object and the pattern with which the state varies". No meaning and no utility at the stage.

The perceived information is the information, perceive by the subject from the object information. So, it should have the form component of the object (syntactic information), the meaning component of the object (semantic information), and the utility component of the object with respect to the subject's goal (pragmatic information). Only at this stage, the "meaning" comes out.

Karl Javorszky (http://listas.unizar.es/pipermail/fis/2017-October/001546.html):

Data is that what we see by using the eyes. Information is that what we do not see by using the eyes, but we see by using the brain; because it is the background to that what we see by using the eyes.

Data are the foreground, the text, which are put into a context by the information, which is the background. The "context" component shows the equivalent alternatives to the data object. This we find by using the commutative symbols which generate. The formal definition of the term "information" is as follows:

Let $x = a_i$ => This is a statement, no information contained.

Let $x = a_i$ and $i \in \{1,2,...,n\}$ => This statement contains the information $i \notin \{n+1, n+2,...\}$

The approach we are proposing roots in numeric facts and is discussed in [Javorszky, 2014]. Permutations consist of cycles. The enumeration of elements within cycles creates symbols that are both sequential and commutative at the same time.

By using the concepts presented in [Javorszky, 2013], www.oeis.org, and in the FIS chat room, one can understand the 4 variants of logical symbols that can be on 3 places in one triplet, as basic building words of a logical language.

Alex Hankey M.A. (http://listas.unizar.es/pipermail/fis/2017-October/001549.html):

This is a titbit in support of Krassimir Markov.

There was a very interesting paper by Freeman Dyson in about 1970, about which he gave a Colloquium at the MIT Department of Physics which I attended.

Dyson had analyzed data taken from higher nuclear energy levels in particular bands far above the ground state - probably using the Mossbauer effect if I remember rightly, because it has a very high resolution.

Dyson's question was simple: Does the data contain any useful information?

His analysis was that the eigenvalues represented by this selection of data were no different from those of matrix with Random Entries.

The data were equivalent to a set of random numbers.

Dyson therefore concluded that, "The Data Contained No Useful Information' for the purpose of understanding the nuclear physics involved".

Loet Leydesdorff (http://listas.unizar.es/pipermail/fis/2017-October/001552.html; http://listas.unizar.es/pipermail/fis/2017-October/001559.html) :

The search for an intuitive definition of information has led to unclear definitions. In a recent book, [Hidalgo, 2015, at p. 165], for example, has defined "information" with reference "to the order embodied in codified sequences, such as those found in music or DNA, while *knowledge and knowhow* refer to the ability of a system to process information." However, codified knowledge can be abstract and—like music—does not have to be "embodied" (e.g., [Cowan et al, 2000]).

Beyond Hidalgo's position, [Floridi, 2010, p. 21] proposed "a general definition of information" according to which "the well-formed data are *meaningful*" (italics of the author). [Luhmann, 1995, p. 67] posits that "all information has meaning." In his opinion, information should therefore be considered as a selection mechanism. [Kauffman et al., 2008, at p. 28] added to the confusion by defining information as "natural selection."

Against these attempts to bring information and meaning under a single denominator--and to identify variation with selection--I argue for a dualistic perspective (as did Prof. Zhong in a previous email). Information and meaning should not be confounded. Meaning is generated from redundancies ([Bateson, 1972, p. 420]; [Weaver, 1949]) see [Leydesdorff, 2012, Leydesdorff et al., 2017].

Guy A Hoelzer (http://listas.unizar.es/pipermail/fis/2017-October/001553.html; http://listas.unizar.es/pipermail/fis/2017-October/001555.html) :

If you start by explicitly stating that you are using the semantic notion of information at the start, I would agree whole heartedly with your post.

I claim that physical information is general, while semantic information is merely a subset of physical information. Semantic information is composed of kinds of physical contrasts to which symbolic meaning has been attached. Meaningfulness cannot exist in the absence of physical contrast, but physical information can exist independently of sensation, perception, cognition, and contextual theory.

Jose Javier Blanco Rivero (http://listas.unizar.es/pipermail/fis/2017-October/001554.html):

What if, in order to understand information and its relationship with data and meaning, we distinguish the kind of system we are talking about in each case?

We may distinguish systems by their type of operation and the form of their self-organization. There are living systems, mind systems, social systems and artificial systems.

What information is depends on the type of system we are talking about.

Maybe distinguishing between information and meaning in living systems and artificial systems might not make much sense, but it is crucial for social systems. Bits of information codify possibilities of experience and action (following somewhat loosely Luhmanns social systems theory) and meaning crystallizes when a possibility is fulfilled for a particular subsystem (interaction systems, organizations...).

The role of language in social systems is another reason to distinguish information from meaning.

In artificial systems it might make sense to distinguish between data and information, being data everything a computer needs to make a calculations and information the results of those calculations that enable it to do more calculations or to render an output of whatever kind.

So what is information at some stage of the process becomes data on other.

It is obvious that all of these systems operate closely intertwined. They couple and decouple, retaining their specificity.

Robert K. Logan (http://listas.unizar.es/pipermail/fis/2017-October/001570.html):

So now for my definition of information as can be found in the book [Logan, 2014]:

- *Data* are the pure and simple facts without any particular structure or organization, the basic atoms of information,
- *Information* is structured data, which adds meaning to the data and gives it context and significance,
- *Knowledge* is the ability to use information strategically to achieve one's objectives, and
- *Wisdom* is the capacity to choose objectives consistent with one's values and within a larger social context."

Stanley N Salthe (http://listas.unizar.es/pipermail/fis/2017-October/001572.html) :

In subsumption hierarchy format [Salthe, 2012] :

{facts {data --> information {knowledge {understanding }}}}

Synthesis

Krassimir Markov (http://listas.unizar.es/pipermail/fis/2017-October/001585.html):

I agree with all above! What is missing? Why we could not come to common understanding if practically we all talk about the same phenomenon and share the same idea?

We all agree that there exist two dualistic forms of information ("what is information at some stage of the process becomes data on other"):

- *External information for the agent* (Informational entity, interpreter, human brain, etc.) called "object information" ("data, information without meaning, what we see by using the eyes; physical information; "given" or "revealed" by God; pure and simple facts without any particular structure or organization, the basic atoms of information!");
- *Internal information for the agent* (interpreter, human brain, etc.) called "perceived information" ("syntactic information + semantic information + pragmatic information; seen by using the brain; semantic information; structured data, which adds meaning to the data and gives it context and significance!").

What we have is the equation: *"Internal information"* =

= *"external information reflected by the agent"* + *"subjective for the agent meaning (or semantic)"*.

But, the internal information for one agent is external for all others and has no meaning (semantic) for them until they reflect it anyway (via some secondary reflections created in the environment by the first agent) and add a new meaning.

This way we have seen that the meaning (semantic) is separated from the external and internal information and exist only in a special case. I.e. we have the same phenomenon in both cases plus some agent depended reaction - adding the meaning ("semantic; structured data, which adds meaning to the data and gives it context and significance").

Finally, the problem with naming the pointed phenomenon has risen. I prefer to call it a "reflection" because of way it is generated - by reflection from the environment via all possible sensors of the agent.

Now, it is not good for me (Occam's razor!) to use name "information" for all the cases pointed above (External information and Internal information). I prefer to use concept "information" only in the second case - Internal information. For the first case (External information) I prefer to use concept "Data".

So, we come to what I had written:

Data = Reflection;

Information = Reflection + Meaning

Further work

Sungchul Ji (http://listas.unizar.es/pipermail/fis/2017-October/001589.html):

Recent discussion on *information* on this list reminds me of one of the main principles of signs advanced by Ferdinand de Saussure (1859-1913) -- *the arbitrariness of linguistic signs.* In contrast, Peirce (1839-1914), a chemist-turned-logician-philosopher, seems to have succeeded in capturing the universal features of all signs, however fleeting, both linguistic and otherwise.

The power and utility of the Peircean definition of signs can be illustrated by applying his triadic definition of signs to the term, 'information', viewed as a sign (having an arbitrary meaning, according to Saussure). My impression is that all the varied definitions of information discussed on this list (which supports the Saussre's principle of the arbitrariness of signs) can be organized using the ITR (Irreducible Triadic Relation) diagram embodying the Peircean principle of semiotics. This is done in Figure 1 below, using the definition of 'information' that Professor Zhong recently provided as an example. As you can see, the ITR template has 6 place-holders, 3 nodes and 3 arrows, which can be populated by more than one set of concepts or terms, as long as the terms or concepts are consistent with one another and obeys well-established laws of physics and logic.

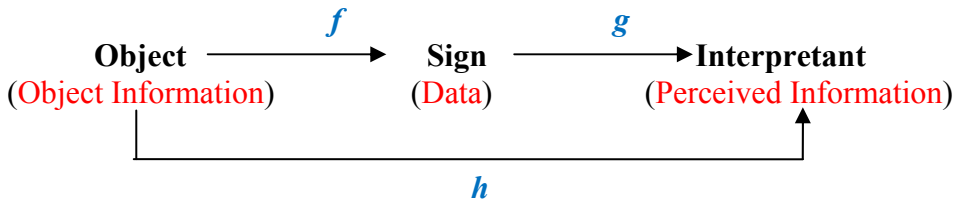

Figure 1. A suggested definition of 'information' based on the triadic definition of the sign proposed by Peirce (1839-1914). The symbol, A --- > B, reads as "A determines B', 'A leads to B', ' A is presupposed by B', 'B is supervened on A' (http://www.iep.utm.edu/superven), etc.

f = natural process (or *information production*)

g = mental process or computing (or *information interpretation*)

h = correspondence (or *information flow*)

Object = Something referred to by a sign (or intrinsic information*)

Sign = Something that stands to someone for something other than itself in some context. Also called 'representamen' (or referential information*)

Interpretant = The effect a sign has on the mind (or state) of the interpreter (human or non-human) (or normative information*)

*) These terms discussed by T. Deacon on FIS list [Deacon, 2017] are added in proof to indicate that they are another example of the irreducible triadic relation (ITR) of Peirce.

Mark Johnson (http://listas.unizar.es/pipermail/fis/2017-October/001591.html):

Which "information paradigm" is not a discourse framed by the education system? The value of the discussion about information - circular though it appears to be - is that we float between discourses. This is strength. But it is also the reason why we might feel we're not getting anywhere!

A perspective shift can help of the kind that Gregory Bateson once talked about. When we look at a hand, do we see five fingers or four spaces? Discourses are a bit like fingers, aren't they?

Christophe Menant (http://listas.unizar.es/pipermail/fis/2017-October/001599.html):

We should indeed be careful not to focus too much on language because 'meaning' is not limited to human communication. And also because starting at basic life level allows addressing 'meaning' without the burden of complex performances like self-consciousness or free will. (The existing bias on language may come from analytic philosophy initially dealing with human performances).

Interestingly, a quite similar comment may apply to continental philosophy where the 'aboutness' of a mental state was invented for human consciousness. And this is of some importance for us because "intentionality" is close to "meaning". Happily enough "bio-intentionality" is slowly becoming an acceptable entity [Menant, 2015]. Regarding Peirce, I'm a bit careful about using the triadic approach in FIS because non human life was not a key subject for him and also because the Interpreter which creates the meaning of the sign (the Interpretant) does not seem that much explicit or detailed.

Krassimir Markov (http://listas.unizar.es/pipermail/fis/2017-October/001592.html):

I agree with your considerations!

Let me remark that the General Information Theory [Markov et al. 2007] is much more than a single concept. What is important now is to finish this step and after that to continue with the next. It may be just the idea about meaning.

What we have till now is the understanding that the information is some more than data.

In other words:

d = r ;

i = r + e

where:

d => data;

i => information;

r = > reflection;

e => something ***Else***, internal for the subject (interpreter, etc.).

And at the end, the same, but very important form:

i = d + e

Conclusion

Yixin Zhong (http://listas.unizar.es/pipermail/fis/2017-October/001588.html):

The proposed formulas in summary are good. May I mention that the following formulas will be more precise:

Object Info = External info = Syntactic info = Data

Perceived info = Internal info = Syntactic info + Semantic info + Pragmatic info

In other words, data is also a kind of information - called syntactic information, the information without meaning and utility associated. And therefore we have a uniform concept of information.

David Kirkland (http://listas.unizar.es/pipermail/fis/2017-October/001597.html):

Data (that which is given) is objective: the combination of discrete entities or disturbances (energy bundles, photons, sounds, numbers, letters etc) ....

and...

Information (that which is created) is subjective: 'collated or interpreted data' dependent upon, and possibly existing uniquely in, the eye/mind of each beholder. (your Else)

Gordana Dodig-Crnkovic

Let me start with a meta comment: I find the idea of publishing FIS exchanges very good and hope that it will attract attention of the wider readership and inspire colleagues to join the list.

My next comment is about the function of "data". Sociologists collect "data" about social phenomena, and those "data" are not in the form of pixels, counts, signals or symbols. Sociologists treat interviews, video-recordings, and any other type of empirical evidence as "data". It is input that informs their explanatory framework that is on a higher level of abstraction than constructions of theories in fundamental sciences.

What constitutes "data" and information depends on the role of this input for the receiver. It agrees with the view of Jose Javier Blanco Rivero who argues:

"So what is information at some stage of the process becomes data on other. It is obvious that all of these systems operate closely intertwined. They couple and decouple, retaining their specificity."

Karl Javorszky focus on context of application, when he argues that general formula such as $\boldsymbol{x = a_i}$ contains no information, while the statement $\boldsymbol{x = a_i}$ with $\boldsymbol{i} \in \{1,2,...,n\}$ contains information because it limits $\boldsymbol{i}$ to certain range of values.

The above argument refers to an agent who intends to act upon information provided by the first statement, and the action is possible when in general formula concrete data are substituted.

In other words, as Freeman Dyson said:

"The data contained no useful information for the purpose of understanding the nuclear physics involved" as quoted by Alex Hankey (Emphasis added)

Information **for the purpose** is different from **the information that describes an object** (which Algorithmic information theory of Solomonoff and Chaitin provide in the form of shortest program needed to describe/generate data structure).

Information is relational. **It is agent-dependent** and when it is "objective", it is inter-subjective in a strict and well-controlled way. It is important to elucidate how "objectivity" is construed in sciences. One important aspect that is left outside this discussion is information dynamics: how the process from "objective" to meaningful information unfolds in the world, see [Dodig-Crnkovic, 2012].

David Kirkland's makes short summary: *"Data (that which is given) is objective. Information (that which is created) is subjective."*

It should be read in the light of the above characterization of "objectivity". Characterizing information as "subjective" refers to the cognitive process of data transformation and integration in a cognizing agent. That subjective information is then checked with other agents in order to reach inter-subjective validation of information. For non-human agents acting on misinformation eliminates an organism, so there is a tendency, favorable for survival, of using correct information.

In his post (http://listas.unizar.es/pipermail/fis/2017-October/001566.html, not included in this paper) Lars-Göran Johansson adviced: "We can proceed with scientific research, using any information concept we think useful, without assuming it refers to anything." is applicable as long as we are not forced to communicate between disparate scientific frameworks that all use concept of information and define it in different ways. However today we are learning from other research fields – we want to incorporate mathematical theory, computing, physics, biology, neuroscience and cognitive science, networks, ecology and philosophy – this situation is visible from FIS discussions – and all of them use the concept "information" but in different ways. What we are searching is to build connections, translations, bridges, we want to know how "information" processed in the neuron is different from the information processed in a bacterium is different from information communicated via computers with or without people in the loop.

In his post, Terrence W. Deacon [Deacon, 2017] addresses the problem of multiplicity of concepts of information and calls for more careful study of context: "try to agree about **which different uses of the information concept are appropriate for which contexts.**" This implies to search for explication of underlying assumptions for different concepts of information as they are used in different contexts. One step in this direction is an attempt to make information taxonomy [Burgin and Dodig-Crnkovic, 2017]

Majority of discussions still presuppose that when we say "information" we think of human communication. See e.g. the Oxford dictionary definition of information: https://en.oxforddictionaries.com/definition/information .

It does not mention information in the rest of the natural world such as bacterial or plant communication via "chemical languages".

Finally, this article presents both the discussion about data vs. information as well as the existence of variety of different concepts of information and touches upon the notion of "meaning" and relationship between "objective" information in the world or information carrier and subjective/intersubjective information in cognizing agents (that in principle can be any leaving organism even though discussion still centers on humans).

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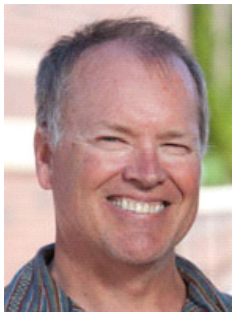

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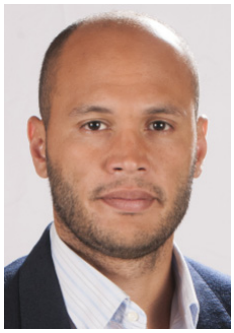

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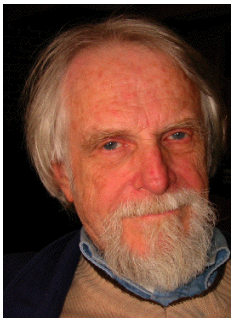

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