Introduction to a Systemic Theory of Meaning

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Abstract:
Meaningful information are present everywhere in our environment, as well as within ourselves (language, signs, symbols, thoughts, ...). Theories have been proposed concerning meaning associated to language or to signs. But little has been done to address meaning as a concept, independently of the information carrying it.
We try here to fill this gap by introducing a systemic approach to a theory of meaning.
We define corresponding basic notions: meaningful information, meaning generator system, domain of efficiency of a meaning, relations with knowledge. Elementary notions of information or signal processing are used and different cases of transmission of meaning are presented. This introduction is to be continuated by applying it to the analysis of different cases of meaning that can be present in matter, life, human or machines.

Keywords:
Epistemology, meaning. Signal, information, system, constraint, generation, efficiency, knowledge. Peirce, Varela, Maturana, Sharov, Shannon, Uexkull.

1. Introduction

Information and meanings are an important part of the world surrounding us, as well as part of ourselves. It is quite obvious to consider that there are some relations between these information and these meanings.
When looking at a newspaper, we pay attention to the articles that have some meaning versus our subjects of interests. These meanings may be different from the ones that have motivated the authors of the articles.
Depending if we are on the beach or under shelter, noise from thunderstorm will generate different meanings for us.
A frog has a visual system able to see objects the size of an insect or worm, providing it moves like one. Visual information of food that is not moving will produce no meaning for a frog.
Male cicadas call female cicadas for copulation and reproduction by producing a specific sound. This sound is meaningful regarding the survival of the species.
On the same token, it is generally agreed upon that information processing machine do not take into account the meaning attached to the information they process. Because the meaning related to the information belongs to the user of the machine or to the designer, and cannot be transferred to the machine.

These few examples show that questions relative to the nature and the content of meaning related to information can come up in many circumstances of our everyday life.

Important work has been done by philosophers and scientists on questions relative to the meaning of words, sentences, language or signs.
On the side of the philosophers, Charles Sanders Peirce has elaborated at the end of the 19th century a theory of sign with categories involving meaning and representation. Peirce is considered as the source of the contemporary philosophical conception of semiotic - the science of signs - http://www.peirce.org/.
The Peircean concept of sign contains three components: The Object of thought, the Sign representing the object, the Interpretant (that provides a mental representation). The Interpretant is also a sign that can be interpreted too. And the semiotic process goes on. These three components cannot be

separated. The Peircean sign is qualified as «Triadic». The notion of meaning is sometime associated to the Interpretant in Peirce's writings.

During the 20th century, analytic philosophy, close to logic and to language, has related the meaning of a sentence to it's truth or falsehood (the Oxford Companion to Philosophy makes available information on "analytic philosophy" at: http://www.xrefer.com/entry.jsp?xrefid=551266&secid=.- , and on "meaning" at: http://www.xrefer.com/entry.jsp?xrefid=552759&secid=.-)

Regarding the activity of scientists, Claude E. Shannon has elaborated in the 1940's a way to measure the content of information in a message. But the meaning of the information was not taken into account as irrelevant to the engineering problem. A few years after, Donald MacKay proposed to look at the meaning of information as related to a target oriented communication. The positioning of the notion of meaning in the history of Information Theory is available in J. Segal PhD Thesis (in French) at: http://www.mpiwg-berlin.mpg.de/staff/segal/thesis/

More recently, A. Sharov has analyzed the problem of the sense of information with the help of biosemiotics. Two aspects of the sense of an information are introduced: the meaning and the value. Meaning being the semantic characteristic of the sense, and value being the pragmatic characteristic.
http://www.ento.vt.edu/%7Esharov/biosem/txt/biosem.html

A lot also has been written about meaningful information as feeding our motivations and our beliefs.
But not much has been done regarding the notion of meaning by itself, whatever the information associated to it or the system managing it.

It is this aspect about general linking of information to meaning we are interested in.
We believe that there can be some common ground for most types of information/meaning linking, and that this common ground can be explicited by defining a basic system managing the information and the associated meaning generation.
In order to investigate this possible common ground, we propose to use the systemic approach as it allows a generic representation of different items. Indeed, a system is defined as an ensemble of elements linked by an ensemble of relations. This definition is general, and leaves open the nature of elements constituting the system.

The systemic approach will allow us to introduce the definitions and properties that characterize a meaningful information generator system without any prejudgement on the nature of the elements constituting the system, and so cover most of the cases of meaning associated to information. This will make available the basis of a theory of meaning that should allow us to later interpret and explain in a new way a number of facts observed in the domain of matter, life, mankind and machines.

The paper is organized as follows:
The next paragraph (**Information and Meaning. Meaningful Information Generator System**) will begin by asking what is really covered by the word "meaning". After having analyzed the definition of the word and evidenced it's limitations, we will propose a new definition based on a systemic approach. We will also define a Meaning Generator System.
Then we will spend some time defining the vocabulary we are using (**Definitions**).
Following paragraph (**Transmission and Efficiency of a Meaning**) will display the specificity related to the transmission of a meaningful information.
The next paragraph (**Information, Meaning, Knowledge**) will introduce relations between knowledge and meaning in this systemic approach of meaning.
Last paragraph (**Conclusion and Continuation**) will summarize the elements introduced and propose further developments.

2. Information and Meaning. Meaningful Information Generator System

The word "meaning" can be used in many different ways. Let's begin by analyzing what is generally put under this word. Dictionaries link the word "meaning" to a performance of human mind. In " Le Vocabulaire technique et critique de la philosophie" (A. Lalande), one can find for the word "meaning": "Function of signs. What a sign represents, sense of a word, of a sentence, etc." The same dictionary gives for the word "sense": "what "means to say", what communicates to the mind a word, a sentence or any other sign playing a similar role".
So, in it's common acceptance, the notion of meaning is linked to information processed by human. And this linkage to human has some heavy consequences on our understanding of the notion of meaning. More precisely, we think that the linkage of the notion of meaning to the performances of human attaches implicitly the understanding of meaning to the understanding of human mind. In fact, any information processed by man implies the involvement of human mind (intelligence, reason, emotions, thoughts, common sense, ...). So the notion of meaning is linked to the characteristics and performances of human mind. And this linkage, even if it is implicit, has important consequences on the understanding of the notion of meaning. This because we do not really know what human mind is.

Human mind is something mysterious. At current level of the development of science, the nature of mind is still to be discovered. Studies on mind are however numerous and diverse (philosophy, neurology, artificial intelligence, psychology, science of knowledge/cognisciences, ...). The results achieved so far by these many fields of research are alas far from delivering an acceptable understanding of the nature of mind. The nature of mind is currently out of the field of scientific knowledge.
So one of the reasons making difficult the study of the notion of meaning is that it is closely related to the domain of human mind which is unknown.
If we want to proceed ahead with the hope of reaching some understanding of “meaning” on a general basis, we must look at the possibility of modelizing it in a domain less complex and better known than the domain of human.
In this context, we feel that the domain of non human living elements is interesting as a starting point.

It is what we are going to do in this paper: disconnect the notion of meaning from human and come down the ladder of complexity by linking this notion of meaning to information as processed by non human living elements. As the nature of life is better understood by science than the nature of human, we can legitimately hope that an analysis of the notion of meaning for non human elements will be more productive than the same analysis done for human. It will provide more factual elements, more acceptable on a scientific base.
A simple and well chosen example of behavior of a non human living element should allow us to introduce the notion of generation of meaningful information by a systemic approach.

But disconnecting "meaning" from human at this stage should not be looked at as putting "meaning" apart from human in our approach. Such a disconnection is a temporary one. Once a modelization established using other grounds, we will have to work (beyond this paper) on applying it to human and analyze how the meaning generation system can be used in that case.

To implement our approach, we must choose a living creature that is far enough from man in terms of performances. In order to satisfy this criteria, we will choose a unicellular animal, the paramecium.
A paramecium is a unicellular animal that is able to move in water. The simplicity of this organism makes us sure about its limited performances as compared to human.
A paramecium has no mind to which could be communicated "a word, a sentence or any other sign playing a similar role". The characteristics of the paramecium that we are going to take into account are the ones shared with all living organisms: satisfy it's vital constraints. Which means the ability to subsist as an individual in the surroundings, and subsist as a species (participate to the reproduction of the species members).
We are going to take as a starting point a simple behavior of this little animal in order to introduce a definition of meaning that will be generalized up to a system. To this end, we will choose a behavior of the paramecium that can be understood as a processing of information generating some meaning.

Many experiences have been implemented with paramecia. For instance, it has been shown experimentally that a drop of acid in the water at the vicinity of a paramecium will make it move away, looking for a location containing less acid.
This reaction of the paramecium is understood by noticing that acid water is a hostile environment for paramecia. This reaction of a paramecium moving away from a hostile environment allows us to introduce the notion of meaning for a non human living entity. The acid environment represents for the paramecium an information that will participate to some generation of meaning within the paramecium. A meaning that "has sense of", that "wants to say": "the environment is becoming hostile versus the satisfaction of vital constraints".
And this meaning is going to trigger in the paramecium an action aimed at putting it at distance from the acid environment.
So we can say that the paramecium has created internally a meaning related to the acidity of it's environment, in connection with the satisfaction of its vital constraints.
More precisely, this example brings up several characteristics relative to the notion of meaning we are trying to conceptualize. Let's formulate these characteristics in order to bring up a "systemic aspect", more general than the living element we have taken as example. These characteristics are five in number and are explicited hereunder (the characteristics relative to the living element taken as example are in parenthesis).

1) A meaning (the environment is becoming hostile versus the satisfaction of vital constraints) is associated with an information (level of acidity in water) incident on a system capable of processing the information (the paramecium).

2) A meaning is generated because the information processing system possesses a constraint linked to its nature (vital constraints that are to be satisfied in order to maintain a living nature).

3) A meaning is generated because a received incident information (level of acid in water) has a connection with the constraint of the system (too much acid in the water impacts the satisfaction of the vital constraints of the paramecium).

4) A meaning is a meaningful information relatively to the constraint of the system (information meaning that the environment becomes locally hostile versus the satisfaction of the vital constraints).

5) The meaningful information is going to participate to the determination of an action that the system is to implement (move towards a less acid location) in order to satisfy it's constraint (satisfy it's vital constraint).

These five characteristics bring us to propose a definition of meaning in the framework of a relation between an incident information and an information processing system submitted to a constraint.

A meaning *is a meaningful information that is created by a system submitted to a constraint when it receives an external information that has a connection with the constraint. The meaning is formed of the connection existing between the received information and the constraint of the system. The function of the meaningful information is to participate to the determination of an action that will be implemented in order to satisfy the constraint of the system.*

Figure 1 summarizes the relations that have been introduced between incident information, information processing system, constraint, meaningful information and action determination.

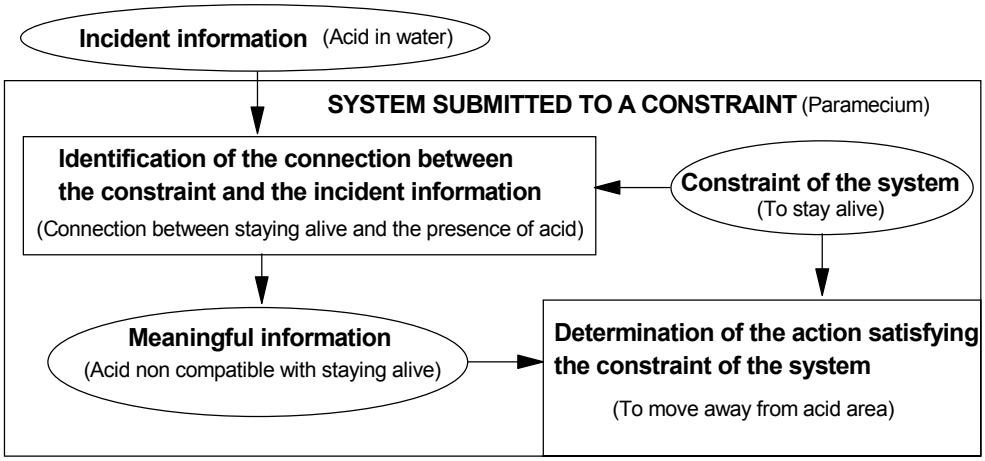

Fig 1 CREATION OF A MEANINGFUL INFORMATION

In the following text, we will use indifferently the expressions "meaning" or "meaningful information".

The above definition of "meaning" calls for the following precision and complements:

- The meaningful information is an information generated by the system submitted to a constraint. It is not the incident information, which is only a contributor to the meaningful information generation.

- An information that has not been produced by a system submitted to a constraint is meaningless.

- A meaningful information is meaningful relatively to the constraint of a system, and only relatively to that constraint. Calling S the constraint of the system, we will write "meaningful (S) information" or "meaning (S)" the meaning relative to the constraint S. (if several connections exist between the constraint and the incident information, we can list the meanings: S1, S2, ..).

- The action that will be implemented to satisfy the constraint can be internal to the system or be external and involve other systems. A meaning can be transmitted from one system to another.

- A meaningful information is generated by an ensemble containing:
. A system submitted to a constraint and able to receive an incident information.
. An information incident on the system.
. An information processing element, internal to the system and capable of identifying a connection between the received information and the constraint.

We name "***meaningful information generator system"*** *(or* ***"meaning generator system" - MGS -)*** such an ensemble. A meaningful information cannot appear or exist spontaneously, with no cause. Every meaning has an origin which is the MGS that has produced it.

The components of this meaningful information generator system are drawn on Figure 2.

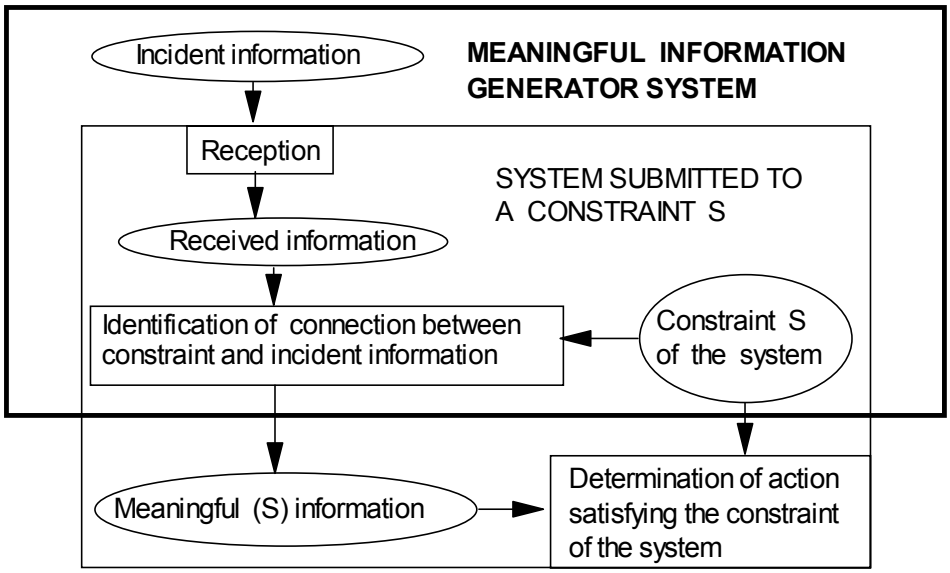

Fig 2 MEANINGFUL INFORMATION GENERATOR SYSTEM

The systemic definition of meaning proposed here above has been built up with an example coming from the non human living world that has been generalized and formalized into a system. This approach is distinct from the Peircean theory of sign (although some elements may be looked at as functionally close):

- Peirce's theory is a theory of sign, and the present paper is centered on meaning. With Peirce, when meaning is explicitly taken into account, it is relatively to the Interpretant. In the present paper, meaning is presented explicitly as a meaningful information. Meaning is defined as the result of a defined information processing done by a system submitted to a constraint.
- The Peircean presentations of sign are done relatively to human (the Interpretant is a human mind, with some indication towards non human minds). As based on mankind, the Peircean theory is rich, powerful and complex. Our introduction of meaning in the present paper is done relatively to an information processing system, with no reference to human for purpose of generality regarding the nature of the information processing system. Such a starting point is much more simple. It is to be progressively widened by analyzing the different constraints that are to be associated with material systems, living systems and human ones.
- The element of this paper that could be related with the Peircean theory of sign is the Meaning Generator System. This MGS can be compared to a simplified version of the Peircean Interpretant.

The MGS can be used a priori for any system submitted to a constraint.
The MGS introduced here is simple because it's function is to generate a meaningful information with one incident information and one constraint.
Real life cases are more complex. Meaning generation may involves several incident information and different constraints, and is often associated with other functions like representation, memory, action implementation. There are even some cases, like human, where the constraints are not all clearly understood.
We make the hypothesis that the MGS can be used as a basic and general element.

3. Definitions.

To allow clear development of our systemic approach, we need to specify the content of the vocabulary we are using.

First, information exists only as carried by a signal. Information does not exist per se. We call ***signal*** any variation of energy (ex: sound vibration - noise, voice -, electromagnetic field change - light, radio -, chemical diffusion - odor -, presence of an element - ink, protein -...). The origin of the signal is the transmitter which is the source of the energy variation.
Then, by associating an information to a signal, we define an ***information*** as being the content of the energy variations within the signal (ex: Amplitude and modulation of a vibration, variation of chemical concentration at a given point, ink density, molecules in the protein,...).

It is to be noted here that a signal is not a priori permanent. The variation of energy that has produced the signal can have a limited duration of existence (thunder produced during a thunderstorm has a limited duration). But the signal will propagate, and so will continue to exist, even if the energy variation that has produced it does not exist any more (Three km away, the noise of thunder can be heard 10 seconds after its creation, which is terminated). By the same way, a meaningful information that has been produced by a system will continue to exist even if the system that has originated it does not exist any more. The meaningful information exists with the signal that carries it, and this even if the system that has created the meaningful information has disappeared. A meaning (S) stays meaningful in the absence of S.

We deal with the couple formed by the signal and the information carried by the signal. When reading the word "information", one should understand "information carried by the signal"

A ***receiver*** is an element capable of extracting an information from an incident signal (ex: hearing, sight, sensitivity to a chemical/physical element, ...) and transferring it on another signal.

Regarding ***processing of information***, it covers all types of actions applied to information (creation, modification, storage, integration in a signal, extraction from a signal, comparison with other signals, transformation, ...)

Regarding the ***constraint of a system***, we regroup under this term the ensemble of automatism, rules, laws and finalities that the system must respect to satisfy its nature. For example, as summarized above, the constraints of a living system are to survive and to reproduce itself (vital constraints). If the living element is not able to survive, it will die and loose it's nature of living element. If the living element is not capable of reproducing itself, it's nature as a species will disappear.

This "constraint of the system" is an elements that will need significant development in the continuation of this paper. Our example with the paramecium's vital constraint corresponds to a simple case. But for other systems, the constraints may be more complex. They may for instance evolve depending upon memorized experiences, or be modified by other information. But they still functionally keep their role as constraints in the MGS.
As an example, it is clear that the constraints for human are significantly more complex that the constraints for animal life (among other things, because of reflected consciousness performances and associated free will). We will have to identify, with needed precision and detail, the constraints associated to the system for each system taken into account.

Finally, the word "***connection***" used in the expression "connection between incident information and constraint" is to be understood as "all the relations that can exist".

4. Transmission and Efficiency of a Meaning

We have seen above that a meaningful information can be transmitted to other systems. But a transmitter and a receiver can be submitted to different constraints. And a new and different meaning may appear in the receiver.

To take these different cases into account, we introduce the notions of “efficiency of a meaning”. It will characterize the possibility for a meaningful information to participate to the determination of an action.

The animal world offers many examples of transmission and reception of meaningful information. As seen above, male cicadas call female cicadas for copulation and reproduction by producing a specific sound. This sound is meaningful regarding the survival of the cicada species. But other systems present in the surroundings can have different constraints. If a “cicada eater” can hear the sound produced by a male cicada, he will find it and eat it. So a given information can generate different meanings depending upon the constraints of the receivers.
This is why we need to introduce the notion of “efficiency of a meaning”.

We have seen above that a meaningful information keeps it's meaningful characteristic even if the system that has generated it disappears. In other words, a meaningful (S) information remains meaningful in a location where the constraint S does not exist. But it is obvious that no action aimed at the satisfaction of the constraint S can take place in a location where the constraint S does not exist (the paramecium cannot try to move from a place where it is not). In other words, the meaning (S) will be able to participate to the determination of an action only in the locations where the constraint S exist.

We define the ***efficiency of a meaning*** as being the aptitude of the meaningful information to participate to the determination of an action aimed at the satisfaction of the constraint of the system. We will note "**efficiency (S)**" the efficiency of a meaning relatively to the constraint of the system S.

We correspondingly define the "***domain of efficiency of a meaning***" as being the domain where the meaningful information is capable to participate to the determination of an action aimed at satisfying the constraint of the system. The domain of efficiency (S) is the location where the constraint S of the system is existing. In other words, the meaningful (S) information is efficient (S) in the domain of efficiency (S).
Outside of it's domain of efficiency, the meaningful information will still be meaningful but this meaning will not be usable for determining an action related to the satisfaction of the system's constraint. The information is meaningful but the meaning is not efficient.

These notions relative to the efficiency of a meaning can be summarized as follows:
A meaningful information produced by a transmitter system in which exists a constraint (T) will be meaningful (T) and efficient (T) in the transmitter. Out of this domain of efficiency (T), the transmitted information is meaningful (T) and non efficient (T). If this information is received by a receiver in which exists a constraint (R) having a connection with the received information, then the receiver will generate an information that will be meaningful (R) and efficient (R) in the receiver. R can be identical to T. In that last case, the receiver belongs to the domain of efficiency (T).
(This is the case of the male cicada transmitting a meaningful (T) information. The female cicada is part of the domain of efficiency (T), but the cicada eater is not. The cicada eater has a different constraint)

5 Information, Meaning, Knowledge

Information and meaning have obvious relations with knowledge: what is known is made of information. And the information is known because it has some meaning for the knower.
The definitions of knowledge are various. (http://www.humanlinks.com/wwwboard/topic3/messages/2.htm).
Among the possibilities, some seems to fit with the generality of a systemic background:
“knowledge is organized information applicable to problem solving".

Our definition of meaning contains terms that echo this definition of knowledge: "information created by a system", "is to participate to the determination of an action". These expressions show that the

notions of meaning and knowledge are close. Both correspond to specific information which has been created/organized, and both exist for specific action/problem solving.

Moreover, looking at the nature of both notions can also bring up some interesting tunings.
The nature of knowledge is generally positioned on an epistemology spectrum between two distinct positions: knowledge as a true image of the outside world - objectivist position -, or knowledge as a specific build up of reality by the knowing element - constructivist position -.
(http://www.stemnet.nf.ca/~elmurphy/emurphy/cle2.html)

The constructivist position is more recent than the objectivist one and has several important developments. As an example, F. Varela and H. Maturana have build up the "autopoietic" approach and the "enaction" paradigm that describe how the outside world can be better taken into account by a system as a construction that will serve ad hoc behaviors, rather than as a representation of an existing environment. (http://www.informatik.umu.se/~rwhit/AT.html#Tutorial)

The approach on meaning introduced here with the MGS is on the constructivist side: the meaning is built up by the system from it's constraint, which is internal to the system.
Possible addition of some non mandatory functions like memory, representation or simulation will not significantly modify the constructivist positioning of our approach.

6 Conclusion and Continuation

In this introduction to a systemic theory of meaning, we have built up definitions and properties for:
- a meaningful information
- a meaning generator system (MGS)
- the domain of efficiency of a meaning

We have also presented the relations between meaning and knowledge.

A possible continuation to this introduction could be:
a) Characterize the domains where we want to apply this systemic approach: matter, life, mankind and machines. These domains have appeared one after the other during the course of evolution. We would analyze their chaining to make available a track where could be utilized the notions introduced here.
b) Application of the systemic approach of meaning to these four domains of evolution.
An identification of the corresponding constraints with their chaining through evolution would be a guide line. As an example, the constraints of human could be analyzed as an evolution of the constraints of life. Such an evolutionist approach could bring some new elements relatively to the constraints of human as we know them today (pleasure, reality, ego, id, superego, ...).

More information on these points can be found at: http://www.theory-meaning.fr.st/