Beyond Flatland?

What does semiotics add to information sciences?

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Abstract: We go back to Shannon's mathematical concept of information and suggest that, on semiotic considerations, different types of information must be distinguished of which the Shannon type covers the most simple one only. To this end we utilize the isomorphic relation between Peirce's method to systematically arrange the Boolean relations in his X-frame scheme and the arrangement of semiotical terms, indicating the different sign aspects that can be discerned in our Knowledge in Formation model. We conclude that although the 16 Boolean relations can be reduced to NAND or NOR, the semiotic terms are irreducible. We finish with the suggestion that an attempt to cover the meaning problem and the effectiveness (Weaver) problem must respect this irreducibility. The function of this paper is to raise a question, not to provide an answer.

1 INTRODUCTION

The information, computer and communication sciences mature rapidly. Turing's universal machine (Turing, 1936)[1], Shannon's method for using Boolean logic to represent circuits (Shannon, 1937) and his mathematical definition of information (Shannon, 1948) may be regarded as marking the transition from early childhood into the formal schooling phase of this living body of knowledge.[2] This phase can be characterised as focussed on getting basic skills by doing exercises of growing complexity. Shannon's mouse, created in 1950, is just one of the numerous examples. The transition from the formal schooling phase into apprenticeship may be regarded to set in as soon as the stand alone solutions fabricated are used in everyday affairs and maturity sets in when responsive systems become interrelated.

The resulting ubiquitous need of sensitivity and 'knowledge' on the side of the interpreting systems, be they human or non-human, in order to provide the right service or response, implies a growth of information in quantity and diversity. Knowledge about the integration of this diversity of information, however, did not grow accordingly. As a result we didn't come to terms with the concept of meaning. Semiotics offers the possibility to systematically take up this quest for integration without losing contact with mathematics. Our Knowledge in Formation (KiF) research program is dedicated to this goal.

[1] All three papers are retrievable, at least on 20-11-2012, from: http://history-computer.com.

[2] Of course this organic metaphor raises the question of the moment of conception. Without any wish to push the comparison too far, i.e. to suggest a direct relation between conceiving the idea to make a contraption that executes Boolean operations by means of an electrical circuit and actually making one, it is of interest to note that Peirce suggested to Marquand, his former pupil, the use of electricity, in order to improve the latter's mechanical reasoning machine, as early as 1886, as is witnessed by: "I think you might return to the problem, especially as it is by no means hopeless to expect to make a machine for really very difficult mathematical problems. But you would have to proceed step by step. I think electricity would be the best thing to rely on." In his letter to Marquand Peirce provided drawings of circuits for 'and' and 'or', cf. p. 422 (Peirce, 1993). Subsequently Peirce wrote more extensively on logical machines (Peirce, 1887) and Marquand produced a circuit diagram for an electromagnetic logical machine around 1890, cf. http://history-computer.com.

Below, after some scant words on the history of the concept of information (2), we will indicate Shannon's model of communication: we only need the general scheme since we accept, but do not need the contents of his theory in this paper (2.1). In the subsequent paragraphs (2.2.x) we shortly present Peirce's work on the 16 Boolean relations in his X-frame notation, provide a semiotic interpretation of X-frame and spend some words on the difference between full Boolean logic (logica docens) and naive logic (logica utens).

In section 3 we will show which sign aspects in Peircean semiotics are involved in Shannon's concept of information.

2 APPROACHES TO THE CONCEPT OF INFORMATION

The concept of information can be traced back to ancient Greece. At the basis of all shades of meaning, that developed during the ages, lies the idea of a form into which matter is moulded. From here the notion of information goes in two directions. On the one hand there is an epistemological line of thought in which the intellect knows the object by grasping its form. This may be termed the referential meaning of information. On the other hand there is an educational line of thought in which the transfer of knowledge predominates. This may be termed the communicational meaning of information.

In both strains of thought the idea of a measure for information did develop. Peirce took the muddy end of the stick when he tried to provide a measure for the concept of information within the referential tradition. Shannon's successful mathematical approach to information clearly belongs to the second, communication oriented tradition. Since we think it is best to append on Shannon in our attempt to get a hold on the meaning problem, here we omit a treatment of Peirce's measure for information.

2.1 Shannon's model of communication

At the start of his 1948 paper Shannon states the problem for which he provides his solution:

> The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point (Shannon, 1948).

Immediately after, he distinguishes his approach from the referential tradition:

> Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. (Shannon, 1948)

This in order to be able to schematize the essence of the communication system he deals with:

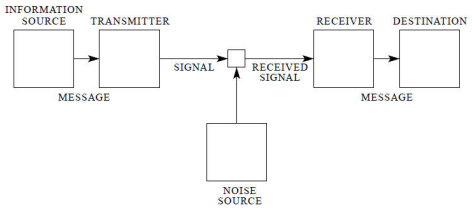

Figure 1: Shannon's model of communication systems

Since we accept Shannon's analysis of what happens in the channel –i.e. a transmitter transforms the message into a signal, suited for the kind of channel utilized, that is send through the channel to the receiver, which in its turn transforms the signal into a message, by an inverse procedure– our interest goes solely to the information source and the destination.

The information source produces messages, the destination is the person (or thing) for whom the message is intended, according to Shannon. We take this to mean that, in symmetric communication, at both sides of the channel there is an agent capable of producing and interpreting messages. It is important to realize that neither the genesis and purpose of the message to be send, nor the interpretation of the message is covered by the mathematical theory of communication. It is only the efficient and accurate transfer of the message between two interpreting systems that is covered.

Shannon acknowledged this when he stated that the meaning problem is irrelevant for his engineering problem. But this, of course, does not mean that it is, in principle, hopeless to get an engineering hold on the process of interpretation. Weaver clearly was of this opinion when he suggested stochastic means to approach at least part of the meaning problem:

> The idea of utilizing the powerful body of theory concerning Markoff processes seems particularly promising for semantic studies, since this theory is specifically adapted to handle one of the most

significant but difficult aspects of meaning, namely the influence of context (Weaver, 1998).

Besides that, he decomposed the meaning problem into three levels at which the engineer will meet problems. Alongside problems at the technical level, there are semantic problems and effectiveness problems.[3]

Stamper extended the amount of levels from three to six, cf. (Liu, 2000). Van Breemen suggested a coordination of the levels distinguished by Stamper with the semiotic KiF processing model (Van Breemen, 2010), which originally was developed by Farkas and Sarbo (Farkas, 2000). In section 3, we will show that it is possible to identify in KiF the interpretation aspects that are involved in Shannon's mathematical model of communication.

2.2 Peirce

Ch.S. Peirce (1839-1914) was an extremely versatile thinker. For our present purposes only parts of his work on logic (2.2.1) and semiotics (2.2.2) are of importance. In section 2.2.3 we will pay attention to the distinction Peirce made between a *logica utens* and a *logica docens* in order to clarify the difference between naive (inborn) logic that is used in our KiF approach and Boolean logic. This positions our work with regard to the logical tradition and is meant to prevent the reader to conclude that an equivalence relation exists between both logics.

2.2.1 The Booleans and X-frame notation

Usually the development of the truth tables is dated 1912 and attributed to Russel and Wittgenstein. Anellis discovered that Peirce did much work on the truth tables since 1893. In the course of this work, Peirce saw himself confronted with the need to find a notation for the 16 Boolean connectives on two variables in a systematic way. This led to the manuscript *A Proposed Logical Notation(Notation)*, ca. 1903 unpublished, in which Peirce, inspired by the square of oppositions 'explored the relation between the relations between two terms or propositions' (Anellis, 2011). Clark made an extensive study of the manuscript. The treatment below is based on (Clark, 1997). Our aim is not to promote the actual arrangement of the connectives, we only want to utilize the idea behind the set up, i.e. the idea that ideally in our intellectual endeavour we progress from doubt to belief or logically from potential contradiction to trivial tautology.

In figure 2 the four possible states of things are given. In figure 3 the 16 relations are distributed over the 4 corners of the 4 quadrants according to a system.

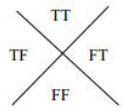

Figure 2: The truth values of two interrelated terms are given in four quadrants in X-frame.

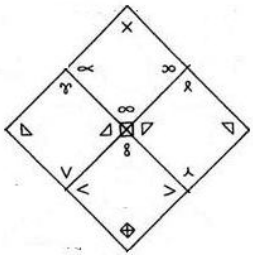

Figure 3: The X-frame. The symbols for the Boolean connectives are put in the 16 corners.

At the bottom of the bottom square we find the sign for a contradiction (an occasion for doubt). At the top of the top square we find the sign for a tautology (an occasion for belief). In this manner 'each of the 16 possible assertions may be represented", cf. (Clark, 1997).

X-frame is not meant as a process description, but it gives all possible different logical relations in a dependency structure. However, if we suppose that an interpreting system in a given state of information (variable A) and an incoming sign as an effect (variable B) can be logically related to each other in 16 different ways, ways that somehow *progress* from potential absurdity to trivial tautology, at the most the 4 compartments indicate where an interpretation process fails, if it fails. For instance failure in passing FT means that the actual effect is not-T (it is not interpreted as true), TF that the state is not-T, etc.

Consider the following example. You see a shade on a panel of your kitchen, it looks like velvet and you think "What the heck is a string of velvet doing

[3] That the technical problem is involved in the meaning and effectiveness problems is clearly stated by Weaver: Thus the theory of Level A is, at least to a significant degree, also a theory of levels B and C. I hope that the succeeding parts of this memorandum will illuminate and justify these last remarks (Weaver, 1949).

there?" You walk towards the panel and notice that a spoon above the panel is throwing a soft reflection. You remove the spoon and the doubt is turned into belief. In this example the general impression of the kitchen is your state on which a puzzling effect, the shadow, appears. You get stuck in your interpretation process, retrace the process, start with doubting the least familiar part of the experience, which in this case is the effect (FT quadrant). Since the tripartite relation between the state (TF, general impression of the kitchen, yet without clear understanding of the effect), the effect (FT, the velvet impression, without knowing the involved state) and the knowledge present in the interpreting system, do not lead to an interpreted state - effect relation (TT, state and effect are interpreted), the interpreting system tries to find a solution and is able to reconsider the relations in the FT quadrant, i.e. by supposing that the shadow of a spoon is responsible for the experience. By removing the spoon, the hypotheses is turned into a probable explanation. On the next occasion a habit exists in the memory of the interpreting system, the shadow is recognized as due to a reflection, the gate is open and no doubt arises.[4]

Notice that in the example the final stage is not a tautology, it is the unification of a state relation with an effect relation, depending on what is present in the memory of an interpreting system. Thus a difference is established between probable knowledge, depending on the knowledge present in the given interpretation system and the tautologies of logic and mathematics, that in principle must be independent of the specific experience of any given interpreter.

2.2.2 A semiotic interpretation of X-frame

In figure 4 the KiF processing model is presented, for a detailed treatment the reader is referred to (Sarbo, 2011). Here a very superficial treatment must suffice. The only precautionary remarks we wish to make are:

(1) that the model regarded as a procedural description of interpretation processes only covers what is habitually known, it does not cover learning,
(2) that the model regarded as a semiotic description of interpretation processes is suitable for a top down as well as for a bottom up interpretation,
(3) that, at the instant an impression occurs in our mind, that mind virtually is in a state, which with the impression as an effect interacts.

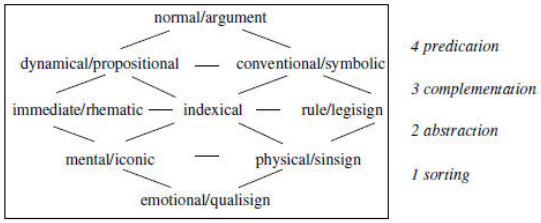

Figure 4: The semiotic KiF processing model with the technical semiotic terms pertaining to the sign aspects on the right of the slash and the terms pertaining to the process that interprets sign types on the left. At the right of the box the four different phases that can be discerned are given.

We suppose a message and start the analysis with our field of perception, the unsorted collection of qualisigns. In the *sorting* phase we single out the message in our field of perception, but only as a form (iconic) and as being present now (sinsign).

In the *abstraction* phase, all interpretational possibilities, offered by the present form, are made virtually present (rhematic), and, if the impression is somehow familiar, which is only one of the interpretational possibilities, the form is recognized (legisign).

In the *complementation* phase the memory is addressed (cf. indexical) by the rhematic form and, if this form is familiar, also by the recognized form. Through the familiar form a concept is retrieved (cf. symbolic), let's say the concept 'duck'. On the propositional side, out of all virtual interpretational possibilities, one is chosen that is deemed adequate for the state the interpreting system is in. When in a restaurant, it is the noun phrase 'eatable animal', when in a Hooligan brawl, it will more likely be the verb phrase 'evade'.

If both lines lead to a unifiable result, the *predication* phase sets in and the habit of response, that is associated with this result, is triggered. A top chef in the bird section, with some spicy off duty habits and a tribal attitude, may, when the noun and the verb meanings collide, experience a halting interpretational process. Is this the case then the next state of *this* interpreting system will be puzzlement

[4] To our great surprise we recently found, in organization theory, a model that is isomorphic with the X-frame model. It is the Cynefin framework of (Snowden and Kurtz 2003). He distinguishes 5 domains: Chaos (FF), Simple (FT), Complex (TF), Complicated (TT) and Disorder. Disorder is located in the center, see (Snowden, 2007)

concerning which situation 'duck' was meant for. An effect will be looked for that decides the case.

In the isomorphic X-frame model, the chef is stuck in the TT compartment, the implication and converse implication prove not unifiable. He could as well got stuck in the FT compartment, for instance, when indeed he was in a Hooligan fight, couldn't reduce the surrounding noise and had to shout: What? But in this case an event, included in the interpretational possibilities of the rhematic position in the TF compartment, such as, for instance, the sudden appearance of a fist in his field of vision, could help him over his acoustic problems. If all these options fail, the chef got stuck in the disorder in the indexical position and is destined to end up in the chaos of the FF compartment, with a blue eye.

2.2.3 Naive and Boolean Logic

Peirce makes a distinction between an utens and a docens of logic and mathematics. The logica utens is operative when, in daily circumstances, we uncritically apply our inborn capacity for logic. The logica docens is active when we critically apply our school logic to a case at hand. The utens relates to the docens as the analytical mechanics resident in the billiard player's nerves, relate to knowledge of these mechanics, cf. (Peirce, 1931-1935).

The naive logical processing scheme developed by Farkas and Sarbo provides an answer to the question whether the distinction between an utens and a docens extends to the logical operations themselves. Their answer is affirmative.

A major difference between naive and Boolean logic is that the first can be interpreted as a procedure –a series of operations on collections of qualia– and the second, as an algebra with operations on sets. As a consequence the collections of qualia appear in naïve logic as state and effect, while they are abstracted in Boolean logic as logical variables.

There are also other, less important differences between the two systems. One of them is the possibility in Boolean logic to have any number of variables and logical operations in a single expression. This is opposed to the limitations of `naive' logic, which is a procedure only capable of establishing relations between two variables at a time and a realization of operations in an order that is dictated by the order of sign interactions in the processing schema. Another one is the different interpretation of logical values (true/false), as a representation of the status of cognitive processing (`naive' logic) and as a logical constant (Boolean logic). This may explain the different way in which X-frame and KiF distribute the connectives in the diamond. A complete treatment of naive logic can be found in (Sarbo, 2011).

3 PEIRCE, KIF AND SHANNON

Marty records 76 definitions of the sign that are formulated by Peirce in the course of his career.[5] A suitable definition for our present purposes is the following:[6]

> A Sign, or Representamen, is a First which stands in such a genuine triadic relation to a Second, called its Object, as to be capable of determining a Third, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object [...]. (Peirce 1931-1935)

First, Second and Third refer to the categories Peirce distinguishes. They respectively stand for monadic (sign in regarded in itself), dyadic (sign regarded in relation to its object) and triadic (the sign regarded as standing in a relation to its object by an interpreting thought) relations. The lower categories are involved in the higher, but not the other way around.

Peirce's categories can be applied recursively in order to yield the sign aspects that belong to each of the main categorical sign distinctions, (i.j) indicates one of the 3 possible categories (i) and one of its 3 sub categories (j), cf. figure 4. Thus arise, Qualisign (monadic,1.1), Sinsign (dyadic,1.2) and Legisign (triadic,1.3); Iconic (2.1), Indexical (2.2) and Symbolic (2.3); and Rhematic (3.1), Propositional (3.2) and Argumentative (3.3).

The KiF arrangement of semiotic terms results from the assumption that the highest sign type, the argument, represents a complete cycle of sign action. But, since the lower categories are involved in the higher, in the execution of an argument or a process of interpretation, all sign aspects must be involved. From this it follows that we claim to provide a semiotic analysis of logical arguments. For a full treatment of the semiotic interpretation of the KiF model see (Sarbo, 2011).

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[5] http://www.cspeirce.com/rsources/76defs/76defs.htm for R. Marty's listing of the definitions.

[6] It would have been better if Peirce had written, as he did elsewhere: "to assume the same or a more informed relation".

Let's assume that the information source and the destination in Shannon's schema consist of interpreting systems that process information according to KiF, see figure 5.

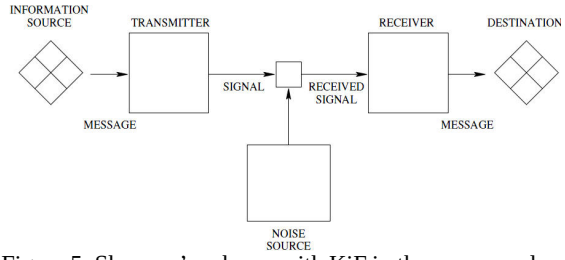

Figure 5: Shannon's schema with KiF in the source and destination positions.

A comparison of Peirce's incomplete sign definition above with Shannon's statement of his communication problem learns that, besides a difference in viewpoint, the main difference resides in the use of terms. Whereas Peirce writes about a sign that raises an interpretant sign standing in the same relation to its object as the original sign, Shannon writes about a message reproduced as exactly as possible. This enables the question which part of the KiF interpretation process is at stake in the communication of a message when we disregard the meaning problem and disregard the technical problem.[7]

At the very least, the sign regarded as an object that functions as a familiar sign, is needed. But, if a sign is a legisign (type), then the instance (sinsign) has a form (iconic) in which qualities (qualisign) are involved. Although, all interpretative possibilities, which inhere in the rheme position, may be considered to be existent, for any given interpreter, the interpretative possibilities a sign actually offers are dependent on the interaction between a sign and a given interpreting system. So, in essence, the iconic, the sinsign, and the involved qualisigns, are those that must be communicated. All the other sign aspects belong to the meaning problem. Semiotics offers a structured way to approach this problem.

Shannon's concept of information is restricted to information as data, which is a potential for interpretation. Peirce has shown that this potential can be developed to nine perspectives on the input. From a logical stance these perspectives can be associated with Boolean relations. In other words, in interpretation we look at the input from all possible logical perspectives. We suggest that KiF offers a schema that enables us to deal with the meaning and effectiveness problems in a systematic way.

[7] A semiotic treatment of the technical problem would be in need of the complete KiF process in order to cover the coding and decoding of the message.

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