Proceeding Paper

Using Peircean Semiotics as the Grounding of Cognition †

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Abstract: This is a work in progress that aims to study Semiotic Theory as the grounding to support the development of new models of mind. These models can be used to construct artificial intelligent agents to deal with several tasks in the real world. The introduction presents a specific scope of cognition that takes perception and action as two connected moments bound together by signs. Some key concepts related to Peircean categories and sign typology are presented, and they are used to demonstrate their connections to the three instances of the world of ideas: World of Sense, World of Things, and World of Categories. Sensors/Actuators are considered as the unique interface with the properties of the world (signals). They are the basic artificial devices in the process of sign representation that lead semiosis toward more developed signs and, consequently, more complex ideas. Finally, artificial cognition must allow agents to act in the world, and it occurs by means of the sign interpretant, mostly by the energetic interpretant.

Keywords: Peircean semiotics; knowledge representation; cognitive systems

1. Introduction

Cognition can be defined as the process that occurs inside the mind, using sensors to collect data from the world, transforming these data into knowledge, and, based on this knowledge and the agent’s internal goals, generating a sequence of actions that affects the world back through the agent’s actuators. The mechanisms of cognition are the main interest of Cognitive Science, an interdisciplinary field that connects some intertwined disciplines, such as Philosophy of Mind, Artificial Intelligence, Neurosciences, Psychology, Linguistics, and Social Science. Cognitive Science seeks to generate theoretical and practical models trying to reproduce possible ways in which cognition might happen inside actual minds. In the context of Artificial Intelligence, cognitive models can be used to create artificial agents to perform several tasks in many computational fields, from robotics to network computing, from natural speech recognition to computer vision, etc. The scope of cognition proposed in this work is represented by Figure 1 and considers perception and action strongly connected parts of the whole process, a tendency introduced by the Embodied Situated Cognition movement [1]. Following some past insights [2,3], we postulate here that the study of this connection can be addressed with the support of the General Theory of Signs of the American philosopher Charles Sanders Peirce (1839–1914). His doctrine of signs, or semiotics [4], considers that “the entire universe—not merely the universe of existents, but all that wider universe, embracing the universe of existents as a part, the universe which we are all accustomed to refer to as “the truth”—that all this universe is perfused with signs, if it is not composed exclusively of signs” (CP 5.448).1 In addition, Nöth [5] (p. 41) points out that Peirce’s theory of signs is the axiom that cognition, thought, and even men are semiotic in their essence. It is also important to note that, for Peirce, thought and mind are not exclusively human attributes and must not be confounded with consciousness. For him, there is mind wherever there is representation, and wherever
there are regularities there is rationality, which does not presuppose consciousness but incorporated knowledge [6].

**Figure 1.** The scope of cognition.

### 2. Peircean Semiotics

The special theory of knowledge investigates the most elementary elements used to make sense of the world, resulting in an ontology constructed upon a system of categories to describe reality. There are three great systems of categories in the history of philosophy. The first one, proposed by Aristotle and based on language, took the classes of words as the most basic elements to categorize all things perceived in reality, leading to ten possible categories: substance, quantity, quality, relatives, somewhere, sometime, being in a position, having, acting, being acted upon [7]. The second one was developed by Kant and was based on how things appear to the mind (phenomenon); it considers that no one has access to the “things in itself”. Kant’s categorical conceptualism establishes a total of twelve categories—divided into four groups—that allow all human judgement: Quantity (Unity, Plurality, and Totality), Quality (Reality, Negation, and Limitation), Relation (Inherence and Subsistence, Causality and Dependence, and Community), and Modality (Possibility, Existence, and Necessity) [8]. The third great system of categories was proposed by Peirce, now using as a categorizing principle the connectivity between ideas. Similar to Kant, he based his thoughts on a phenomenological approach, but he achieved an even more radical result with only three essential categories related to the semiotic process (semiosis), in which all phenomena could be divided. They are Firstness, Secondness, and Thirdness [9] (p. 7). Firstness is “the mode of being of that which is such as it is, positively and without reference to anything else”; Secondness is “the mode of being of that which is such as it is, with respect to a second but regardless of any third”, i.e., a category for ideas that can only make sense while relating to another idea; and Thirdness is “the mode of being of that which is such as it is, in bringing a second and third into relation to each other” (CP 8.328), i.e., a category for ideas that are the own relation between two other ideas or, in other words, when the own relation of two other ideas becomes an idea.

Using his categorization principle, Peirce then derives that Firstness is related to the ideas of simple potentiality, possibility, and independence, feelings not yet converted to reflection, just a glimpse of the reality in the state of pure indetermination, all ideas that are absolutely independent of further ideas to subsist; Secondness relates to the experience in space-time, to action, to the experiential reality, to a fact, to the perceptible consistency without purpose or judgement, because all these ideas require a relation to other ideas, in order to be conceived—any point in space or time requires a connection to another point in space or time in order to be space or time, any action requires an actor, a fact requires an existence where the fact materializes, a consistency requires a reference to what it is consistent to; and Thirdness, corresponding to mediation, to law or habit, to continuity, to purpose and judgement, to thought and representation, because all these ideas are in themselves relations between other ideas: mediation is the relation between two other things, a law puts under relation all its possible instances, a habit is nothing more than a
learned law, continuity is the principle of recursive mediation between two others, purpose is a glimpse of the future mediating the flow of past to present. Regarding thought and representation, Peirce derives an ingenious explanation for these concepts of Thirdness by introducing his notion of a sign: “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. The triadic relation is genuine, that is, its three members are bound together in a way that does not consist in any set of dyadic relations.”

3. The Three Worlds of Ideas

If categories are sets of the most elementary concepts, or ideas, that appear in one’s mind, semiosis is the process that links such ideas in order to form more complex concepts. In addition, signs are the elements that encode ideas within the mind. The ideas can be of different types, expressing different aspects of reality, and such aspects can be connected to the three Peircean categories. The aspects of possibilities (World of Possibilities), such as imaginations, speculations, hypothesis, plans for the future, exploration of scenarios, etc., are in the domain of the Firstness and describe reality by means of qualities or properties; the aspects of the actuality or existence (World of Existence) are things that are really happening or really happened and stand in the domain of the Secondness, describing reality by means of things or existents; and, finally, the aspects of the laws (World of Laws), such as categories, types, habits of behavior, patterns, learning algorithms, etc., are in the domain of the Thirdness and describe reality by means of the categories of things and the regularities found in the world (see Figure 2a). In this scenario, an agent that deals with all these aspects of a certain environment is immersed into three different instances of the world of ideas: The World of Senses, the World of Things, and the World of Categories. As the interface between agent and environment is provided solely by its sensors, the agent has direct access only to the World of Senses, that is, to the properties captured and measured by the sensors, which are translated to the agent’s mind as Qualisigns, the most basic class of signs among Peircean typology. Thus, the World of Things and the World of Categories can only be presumed (see Figure 2b).

![Figure 2](image-url)

Figure 2. (a) Aspects of reality and its worlds; (b) instances of the World of Ideas.

After accessing the properties of the world through its sensors, the agent immerses into the semiotic processes that it can handle. Note that not all properties of the world nor all ranges of these properties can be captured, but just a fraction of them. Furthermore, each artificial agent must be programmed in such a way that the semiosis can flow, in order to establish knowledge and also to use it. Semiosis promotes the growth of signs, first from Qualisigns towards Sinsigns related to the World of Things and then from Sinsigns towards Legisigns related to the World of Categories. These dynamics make the system deal
with increasingly developed signs, of which the most developed of them is the Argument Symbolic Legisign or simply the Argument.

4. Sensors as Sources of Iconic Information

Sensing devices are key elements of artificial cognition to access the World of Senses. They allow artificial agents to get direct access to their environment by capturing the signals from the world. There are three essential sensing aspects in the process of conveying signals to signs: 1. Transduction relates to the capacity to transform certain physical property of the world into another specific property that the artificial system can deal with; 2. Intensity is a number that correlates the different relative levels of manifestation of some property in the world with the level of the transduced signal in the artificial system; 3. Position/Orientation embodies the momentary source of signals in space and time. When these signals are encoded in the interpreter’s mind, we say that it generates ideas, and the primary ideas are encoded as Qualisigns. From then on, semiosis is sparked, promoting the growth of signs towards more developed Sinsigns (concerning presumed existents) and Legisigns (concerning necessities or laws), which leads to the construction of knowledge (see Figure 3a, the whole process, and Figure 3b, examples of signs according to the proposed representation).

Figure 3. (a) The process of signal transduction and its sign representation in the interpreter’s mind; (b) examples of signs according to the proposed representation. Note that dashed white circles stand for possibility, white circles stand for actuality, and black circles stand for regularity (law).

Considering the sign in relation to its object, a sign can be an icon, an index, or a symbol, the most basic of them being the icon that has some sort of similarity or analogy to its object. Icons, in turn, can be divided into pure icons (Qualisigns) and hypoicons (Rhematic Iconic Sinsigns and Rhematic Iconic Legisigns), and there are three types of them according to the mode of Firstness that they participate in: Images (First Firstness) that present in themselves the same properties as their objects; Diagrams (Second Firstness) that show in their parts the same state of affairs as the parts of their objects; and Metaphors (Third Firstness) that hold in themselves another kind of parallelism, e.g., some sort of analogy to their objects (CP 2.277). In this context, sensors can be understood as metaphors of the property they measure, by sharing with them the same numerical intensity as these properties, i.e., they are in a relation of analogy to them. Besides that, the information regarding the sensor position and orientation provides the required data for being the substrate that turns these signals into a sign, becoming knowledge for the agent.

5. The Interpretants and Action

Acquiring knowledge is important to artificial agents because it allows them to act in their environment in an effective way. In semiotics, action relates to the interpretants. As pointed out by Short [10] (pp. 214–240), Peirce, in his mature writings, considered that
despite a sign requiring an interpretant, it can be a mere possibility in place of being always an actuality. This leads to the idea of an interpretable sign instead of an interpreted sign, which means that not all semiosis implies a never-ending interpretation process but can lead to a feeling or to an action. These kinds of degenerated interpretations might lead to a different interpretant classification: an Emotional Interpretant is a feeling, an Energetic Interpretant is an action, and a Logic Interpretant is a new sign (genuine interpretant). Then, it is postulated here that the path from knowledge to action takes place when the interpretant of the sign is an energetic interpretant, which leads to three types of actions: Random Actions used during exploratory behaviors (Firstness); Reactive Actions directly generated by a particular set of stimuli (Secondness); and Goal-based Actions, when a future state the agent is supposed to reach (goal) and a representation of a set of possible actions (plan) should lead the agent from its current state to the desired goal state. In this sense, agent behavior is understood as the composed sequences of these three types of actions.

6. Conclusions

The General Theory of Signs developed by Charles Sanders Peirce provides an extensive set of concepts for grounding cognition into a solid philosophical theory. In the field of Artificial Intelligence, these concepts can lead to many insights, which might be useful to the construction of artificial intelligent agents. The Peircean typology of signs, which extends far beyond standard approaches to purely symbolic Artificial Intelligence and also to more recent approaches trying to fill the symbolic/numeric gap, such as, e.g., neural networks, which can provide a substrate to the development of many research fields, such as robotics, network computing, visual computation, and more. This work demonstrates that symbols can be grounded on indexes (using attention mechanisms) and icons (creating mental simulations), which creates the opportunity for artificial agents to have a full understanding of natural language sentences and other types of communication. This work aimed to provide an introduction to Peircean semiotics and its use in Cognitive Science in order to develop new models of minds. Considering the richness of the General Theory of Signs, we presented here just a glimpse of the innovative possibilities of cognitive models to be constructed and tested. This is just the beginning.

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