Perception in Human-Computer Symbiosis

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Abstract. Today computers and more generally smart technology do not take into account the diversity of perception leading to the exclusion of the plurality of representation and decision even if such diversity may play a crucial role in human-computer interaction especially in our small world. We introduce in this paper a conceptual framework developing a bridge between set and perception theories to support computing with perceptions. In this context, human-machine interaction is not only guided by computation but it is also based on human-human interaction through machines and social networks.

Keywords: Perception · Interaction · Set · Accessibility

1 Introduction

Until now, a machine is said to be intelligent if its intelligence is similar to natural intelligence displayed by human especially when understanding language, learning, reasoning, and problem solving [11]. Alternatively, Human-Computer Symbiosis envisions a coupling of a human brain with intelligent machines allowing new type of thinking and data processing [10]. Nowadays, computers are connected to humans and play a human-like role, just think of Chatbots that conduct an on-line textual conversation with a human, humanoid robots that accompany old people, intelligent avatars used in e-commerce, etc. But, can computers have abilities of humans to live in the real world? Humans achieve their daily life's goals using their ability to think. From R. Descrates [1] until J. McCarthy [2], the recurring conclusion is that computers may outperform humans in calculus, but they would lack general reasoning abilities and have a limited relation to the world in general.

More generally, the emergence of intelligent interactive technologies will certainly have a great impact on the lifestyle in our society and this context emphasises significant challenges that lie ahead [9]. A crucial philosophical challenge is related to the significant role of the perception of physical environments in thinking. In fact, humans perceive the world through their five sense and act according to their perception which is in turn affected by their individual factors like

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education, culture, psychological peculiarities, past individual experience, etc. On the contrary, computers run programs developed by human programmers encoding problem solving algorithms and methods. Consider, for example, that the following short message is broadcasted through a social network: "The meat I eat became very expensive!". Computers use efficient linguistic tools to define its semantic by applying natural linguistic methods to induce that "meat" is a noun, "eat" and "became" are verbs, the overall sentiment of the message is negative, etc. However, what is the semantic of "the meat I eat"? The answer does not depend only on linguistic considerations, but it is also related to the sender/reader of the message. In fact, Asian people eat dogs and cats, which are domestic animals for European people that eat horse meat except English persons. Furthermore, Muslims and Jewish eat cow but not pork, whereas the cow is venerated, throughout India, as a holy animal. Finally, vegetarians do not eat meat at all. In conclusion, we are facing classes, which are not only characterized by their members but they depend on their observers.

For humans, there are a number of reasons behind such diversity, which may be the consequence of sensors used to see objects, the application of community rules and the person believes, preferences, education, values, socioeconomic status, life experiences and more generally the different egocentric particulars. However, today computers do not take into account the diversity of perception and excluding consequently the plurality of representation and decision even if such diversity may play a crucial role in human-computer interaction especially in our small world. In the context of Human-Computer Confluence [5], we introduce in this paper a conceptual framework developing a bridge between set and perception theories to support computing with perceptions [6–8].

2 Perceptions, Concepts and Sets

Epistemologists have proposed various theories of what perception is and how we perceive reality, i.e., the outside world. The three main perception schools [4] are Naïve realism, Representative realism and Idealism. The Naïve realism is an Arestotelian theory, where we directly perceive the world as it is; i.e. things are what they seem, whereas Representative realism is an indirect realist theory of perception considering that real objects are only perceived indirectly, through intermediate representations, called ideas or sense data, in our consciousness. The third school is defended by George Berkeley who is persuaded by the thought that we have direct access only to our experiences of the world, and not to the world itself: to be is to be perceived.

Humans perceive objects and concepts like Car, Children, Animals, Flower, Brid, etc., where a concept C can be defined a set of individually necessary contraints for being a C. Concepts are the basic elements of thoughts generally identified with mental representations, with abilities, or with abstract objects [12–14]. Different approaches and methods that have been developed to conceptualise and represent "concepts" [15]. Formally, a concept or a classe of physical or mental objects can be represented by a set. The characteristic (membership) function of a set X, denoted $\mathbf{1}_X$, can take on only two values 0 and 1, and consequently, $\mathbf{1}_X(x) = 1$ or 0 according as x does or does not belong to X. However, several classes of objects encountred in the real world reveal the fallacy of this assumption because such objects have not precise criteria. Hence the need to replace the boolean membership with a continum of grades of membership [16]. Using fuzzy sets, L. A. Zadeh has introduced, in his paper [17], a computational theory of perception considering that perceptions are intrinsically imprecise and stressed the need of "a methodology in which the objects of computation are perceptions - perceptions of time, distance, form, direction, color, shape, truth, likelihood, intent, and other attributes of physical and mental objects". More recently, Z. Pawlak introduces Rough sets to express vagueness based on sets boundary regions [18,19].

3 Accessible Sets and Computing with Perceptions

At the present time, we are living in a small world allowing persons to share information and experiences even if they have different perceptions of the world. Consequently, in addition to data and knowledge, the perception will play an increasingly important role in our modern life. In fact, machines have to processes data broadcasted from different regions of the world and have to behave in a personalized way [20]. during the interaction with persons that perceive the world differently.

Let U be the universe of objects, I the set of observers, and (U, I) is the perception space. Each observer $i \in I$ has his own perception function $f_i : \mathcal{P}(U) \rightarrow \mathcal{P}(U)$, where $\mathcal{P}(U)$ is the power set of U and $f_i(X)$ is the perception of $X \in \mathcal{P}(U)$ by the observer i.

Definition 1 (Ternary relation $\in_i$). *Given a perception space (U, I), an element $x \in U$ is perceived, by the observer i, to be a member of the set $X \in \mathcal{P}(U)$, denoted $x \in_i X$, where*

$$x \in_i X \Leftrightarrow x \in f_i(X) . \tag{1}$$

Definition 2 (Accessible set). *Given a perception space (U, I), a set $X \in \mathcal{P}(U)$ is said accessible, in the perception space (U, I), if and only if,*

$$f_i(X) = X \tag{2}$$

holds for each observer $i \in I$.

Perception functions are defined according to the three main perception schools developed in epistemology [4], which are Naïve realism, Representative realism and Idealism.

Following an algebraic approach, we have defined three main classes of perception functions denoted NR, RR and I, which correspond respectively to the main perception schools, i.e., Naïve Realism (NR), Representative Realism (RR) and Idealism (I). These classes cover the pessimestic, optimistic, doubtful and ignorant perceptions.

Unlike elementary perceptions, shared perceptions are alternative representations of a set X taking into account its perception by different observers.

Definition 3 (Minimal shared perception). *binarytreeNode Let U be the universe of objects, $X \subset U$, I the index set of observers, f_i the elementary perception of the observer i and $\mathbb{Q}_I(X) = (f_i(X))_{i \in I}$ is the perception of X. The set of minimal shared perception of X, denoted $\widehat{\mathbb{Q}}_I(X)$, is defined as follows :*

$$\widehat{X} \in \widehat{\mathbb{Q}}_I(X) \Leftrightarrow (\forall i \in I, \widehat{X} \cap f_i(X) \neq \emptyset) \wedge (\forall Y \subset \widehat{X}, \exists i \in I, Y \cap f_i(X) = \emptyset) \ . \quad (3)$$

Definition 4 (Space of consistent shared perceptions). *the space of consistent shared perceptions considering the set of observers I, is the sub-lattice defined by the interval $[\cap\{Y \in \widehat{\mathbb{Q}}_I(X)\}, \cup\{Y \in \widehat{\mathbb{Q}}_I(X)\}]$*

Algorithm 1. CSPS Algorithm

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1: Input: The perception of X, i.e., Q_I(X) = (f_i(X))_{i∈I}
2: Onput: The consistent shared perception space, i.e, (CSPS, ⪯)
3: Initialized parameters: CSPS = {f_i(X) : i ∈ I}
4: repeat
5:    CSPSold = CSPS
6:    A = {X ∪ Y : X, Y ∈ CSPS}
7:    B = {X ∩ Y : X, Y ∈ CSPS}
8:    CSPS = CSPS ∪ A ∪ B
9: until Convergence: CSPS = CSPSold
Ensure: the Consistent Shared Perception Space (CSPS, ⪯).
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How to compute these shared perceptions space? To answer this question we represent the perception of a set X by the hypergraph $\mathcal{H}_I(X)$=($\mathcal{V}_I(X)$, $\mathcal{E}_I(X)$), where the set of its nodes is $\mathcal{V}_I(X) = \cup_{i \in I}\{f_i(X)\}$ and $\mathcal{E}_I(X) = \{f_i(X) : i \in I\}$ is the set of its hyperedges.

Proposition 1 (Minimal shared perception). *Let $X \subset U$ a set of objects, I a finite subset of $\mathbb{N}$ and $F = \{f_i : i \in I\}$ a set of observers. The perception function of X, i.e. $\mathbb{Q}_I(X)$ is represented by the hypergraph $\mathcal{H}_I(X)$=($\mathcal{V}_I(X)$, $\mathcal{E}_I(X)$), than the set of its minimal transverses, denoted $MinTr(\mathcal{H}_I(X)$, corresponds to the set of minimal shared perception: $\widehat{\mathbb{Q}}_I(X) = MinTr(\mathcal{H}_I(X))$.*

4 The Wedding Dress Problem

Consider a girl who is getting married, how she can choose her wedding dress? Instead of using e-commerce search engines, we propose an application based on perceptions of her friends in social media like Facebook or Instagram. Here are the main steps of the process: (1) The girl chooses dresses for which she is hesitant, (2) She share these selected dresses on the wall of her social media, (3) Her friends select the ones they prefer and return their feedback (perceptions), (4) the shared perceptions is than computed, (5) the girl browses and filters dresses in the space $CSPS$ and (6) return back to (2) except if the girl considers it remains only few dresses. After that, she has to decide considering different criteria like the price, delivery of the dress, etc. In this problem, the human-machine interaction is not guided by an optimization algorithm, but humans exchange their perceptions in an iterative process, whereas computers compute the space of shared perceptions. In the following section we illustrate this processing using an example:

- (1) At the begining, the girl who is getting married selects a list of wedding dresses she is interested, and she is hesitant. Let us assume for example that this list is represented by the set

$$X = \{1, 5, 6, 7, 10, 11, 12, 13, 17, 21, 24, 26, 28, 31, 101, 102, 103\}$$

- (2) Next, she share these selected dresses on the wall of her social media like Facebook considering
- (3) Her friends select the ones they prefer and return their feedback (perceptions). For example, consider that her five friends A, B, C, D and E return the following answers:
  - $A = \{12, 21, 24\}$
  - $B = \{1, 10, 13, 21, 31\}$
  - $C = \{6, 10, 17\}$
  - $D = \{1, 7, 21, 26, 31, 101, 102\}$
  - $E = \{10, 6, 7, 11, 1, 5, 28, 103\}$
- (4) Next, we the shared perceptions are computing leading a set containing 70 minimal shared perceptions $Bd_*(X)$ that includes for example the flowing sets $\{1021\}, \{621\}, \{1012101\}, \{11217\}, \{1112131726\}, \{512131726\}, ...\}$.
- (5) The algorithm CSPS is than applied using is applied $Bd_*(X)$ to define the consistent shared perception space $(CSPS, \preceq)$.
- (6) the girl who is getting married browse the $CSPS$ space, filters the differents results and than the process returnback to the step (2) except if the girl considers that they remain only few dresses.

This example shows that the perception of the concept "Best Weeding Dress" is plural and diverse. The search task can not be resolved only using the classical human-machine interaction supported by search engine and e-business systems, but this interaction is guided by the perception of friends, the computation of the space CSPS and the intraction Human-Human, which are of prime importance.

Please note that the accessibility notion is related to the perception and can best be summarized as follows: *to be accessible is to be perceived*, which is weaker than the Berkeley's idealism, i.e *to be is to be perceived*, see [3] for more details on the work of George Berkeley.

5 Conclusion

In this paper we propose a conceptual set framework based on a perception theory where the main question about the role of perception of the world in human-machine interaction. Humans may have different perceptions of the world, whereas computers have only descriptions which are more syntactic than semantic. We introduce a new line of research that make a bridge between perception and set theories is introduced, i.e accessible sets, where the accessibility is related to the perception and can be summarized as follows "to be accessible is to be perceived". This perception is more weak than Berkeley's idealism, where objects are nothing more than our experiences of them, i.e. "to be is to be perceived". Finally, our proposal can also be seen as an attempt to define a computational theory of perceptions which can be used as a basis for integrating the diversity of perceptions in human-machine interactions.

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