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Using plausible reasoning in model construction

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Abstract: Present work is compose from two parts, the first consist on a phenomenological analyze of Artificial Intelligence collocation. The results of this analyze consist on seven questions. In the second part of the paper we tray to answer to the first two of this questions. This is the opportunity to present the plausible reasoning theory and to solve an example with this theory

1 Introduction

After a briefly introduction, many scientific works on Artificial Intelligence (AI) [1,2,3], focus on describing fuzzy logic, neural networks, etc. We think that it is also important to reveal (here in a phenomenological way) what we aspect from the science which is named Artificial Intelligent. Usually the first step of such analyses is to find the appropriate questions which will make deeper the phenomenon understanding. The results of the phenomenological researches on artificial intelligent (AI) syntagma (collocation) are questions which allowed the possibility to deep the understanding of the AI and which can drive to intelligent product construction. The second part of the present paper intend to answer to the first questions: *Are they known theories that have as object the human knowledge?* and *How can we use them in order to develop a human knowledge model?*. One possible answer could be "The Laplace model of commune sense". The named model is based on reverend Thomas Bayesian and Laplace results and was developed in [4].

The backgrounds of the present work are E.T Jayne's probability theory [4] where the rules of the mentioned model are presented and also the related works of Cox and E.T. Jayne. We will mention also the work of E. Yudkowsky [5] where an epistemology based on Thomas Bayesian result is presented and also J. Pearl work on causal reasoning [5]. The bridge between the Bayesian plausible reasoning and mobile robots has been inspired by the work of C. Pradalier, where the navigation of a mobile robot is controlled using Bayesian's filters [5].

Our intention is to transform the rules of "Laplace model of commune sense" into axioms, and to present some theoretical results which are obtained from these axioms. These examples are resumed to the Bayesian theorem and Bayesian filter.

In the end we will present an example which is connected to the mobile robots locomotion. This will give the possibility to analyze results of the plausible reasoning theory.

2. The phenomenological analyses of AI syntagma

2.1 Definition of AI

The Artificial Intelligence is a syntagma composed by two terms (intelligence and artificial) that through their nature generate an interior stress, because the term of intelligence is in the ontic acceptation bound by the human or at the most by the living

being and the *artificial* attribute comes to underline the fact that we have in mind a human creation or more precisely a product achieved by the human being. In this way the Artificial Intelligence becomes a human product that imitates the intelligence features (human, eventually naturals). We must recognize that from a psychological point of view this comment amplifies the mentioned stress. In our word the intelligence has become a fetish and has generated, in this way, a psychological complex. We will remember that all the people wish to prove intelligence even many of them don't know exactly what the intelligence is. Because of that behavior we accept hardly that intelligence can be associated with an object.

After all this considerations if we have accepted that AI is a product that copies the human intelligence than we have to understand what means *intelligence* and what means *to copy*.

The intelligence

The intelligence is defined in several ways, from this richness we will start with the following work definition: *The intelligence is the capacity of understanding the experience and the capacity to take benefit from this understanding*.

The enunciated definition articulate causally two attributes: the experience understanding and the benefit of this understanding. If we focus at the *experience understanding* we will discover that is a tautological expression, because the experience assumes a certain understanding. For example, the experience in the Kantian sense it is more then a sensations assembly, including a certain base of knowledge.

Because of this reason will replace the *experience understanding* through a term more comprehensive that transform the work definition in: *The Intelligence is the capacity of knowledge and the capacity to take benefit from this understanding.*

If we wish to analyze now what *take benefit* means, we have to admit that this collocation assumes ethical approaches. Because in this moment we intend to avoid such ethical approaches we will reduce the significations of the benefit and will replace this expression with: *the facility of knowledge accessing* (inclusive the ones that mention the possibility of benefit).

In this way the work definition has become: *the intelligence is the knowledge capacity and the facility of access these knowledge*. According to this definition an intelligent human being is the one that can know easily and can use this knowledge (fruitfully).

The imitation

We will return at the *artificial* term content in the AI syntagma. We intend to copy the intelligence features of the human being and for that is important to understand what means *to copy* .To copy in an ontic sense is the operation in which the original is transposed with approximation into a product. Then, when I copy, I don't claim to perform an identical one but only to transpose certain features that I consider to be essentials. I'll give up, in this way, at all that seems to be accidental and I will perform a representation accepted by the original object concept.

To imitate is an activity that it's bounding by the knowledge because I don't imitate the object himself but I copy my knowledge regarding this object. Furthermore, when I imitate I decide that certain notions are important and other don't, and these decisions are based on my knowledge.

After that, to imitate means the approach of a certain technology. The technology assumes the knowledge of some procedures, the existence of some tools and objects

(materials) where I will implement my copy. So in the knowledge process imitation I must identify all these elements.

Therefore we can conclude that when we mention the AI syntagma we refer at the copy of our knowledge about knowledge and about the access of this knowledge.

2.2 Opinions about knowledge

The above analyze has underlined our capacity to know about knowledge process. We must mention from the beginning that the human knowledge sources are of various forms: mythical, religious, artistically, scientifically etc. and we must specify our position regarding this problem. Therefore bellow when we mention the cognition about knowledge we will understand the scientifically cognition of the human knowledge in her generality. Now it is natural to analyze what we understand through scientific cognition. The subject vastness and the space allowed to this article will be balanced trough the *opinion* term used in the following description. Also we will formulate certain opinions on the subject:

- Scientific knowledge divide the reality in quasi independent domains (the systematic vision);
- For a certain domain it's start from a minimum number of fundamental troughs. When this principles are proposed we desire that they are independent and in minimum number. The principles are carried out inductively, this process is induced by the experience and are after that adjusted through the theory results that they generate;
- Based on the principles, through deductions, theories are constructed. A theory represent the knowledge that can explain the phenomena from a certain domain of the reality;
- Based on a certain theory, a particular phenomenon is represented through the model. The model is a peculiar knowledge assembly, obtained by approximation process, that aspire to become operational;
- Scientific knowledge must be validated continuously by the experiment;
- It has as aim the a priori knowledge, more precisely we wish to know how will ensuing the phenomena before the experimentation (*voire pour prevoire*).

Conclusively the scientific knowledge has as operational element the model. The model is defined as being an approximation of the phenomenon which is constructed starting from a theory by elude the *non important* from the *important* of the phenomenon. This process (the separation in important and non important) is a subjective decision (depend on the subject – human – that know), but we have the hope that the experiment will infirm the bed decisions. We have mentioned that the model is operational this means that the model can be used directly for obtaining the mentioned purpose: the a priori knowledge.

We can describe the phenomenon of model using in two ways: first if the model is simple we can use it directly (mental experiment), but if the model is too complicated to be used directly we must use technologies in order to obtain results. This technology contain methods (mostly mathematical), tools (mostly computers) and support objects (paper, computer screen, etc.). We name this operation as simulation.

It is important to approach the fact that when we imitate, we will not imitate the subject himself or the phenomena but the imagined model.

2.3 Results of phenomenological analysis

If we will resume the previous results we can say that when we mention the AI syntagma we aspect to find a science which contain the technology to copy the model's of human knowledge and the access to this knowledge. In order to construct such models this science must be linked to cognition theories.

Starting from these conclusions we can find now the appropriate questions which allow the possibility to deep the understanding of the AI and which drive to intelligent product construction.

1. Are they known theories that have as object the human knowledge?
2. How can we use them in order to develop a human knowlege model?
3. How can we simulate this model and how can we improve it?
4. What is the technology – the methods and the tools – which can be used in order to copy the model?
5. What are the properties of the object that can be transformed in intelligent object?
6. How can we experiment the intelligent object?
7. What are the ethical aspects of the intelligent object construction?

3 The theory of plausible reasoning

The secound part of the present paper intend to answer to the first questions: *Are they known theories that have as object the human knowledge?* and *How can we use them in order to develop a human knowledge model?*. One possible answer could be "The Laplace model of commune sense" [2].

The axioms:

1. The representation of degree of plausibility is given by the plausibility function:

$$p:\Phi \to [0 \quad 1];\ \ p(A \mid X) = y \tag{1}$$

where:

Θ is a set of sentences

$p(A \mid X)$ is a continuous and monotonic function which associates a particularly degree of trough for the sentence A in the condition that sentence X is true;

2. The consistence of the commune sense requires the following property for the function *p*

$$p(AB \mid X) = p(A \mid X)\,p(B \mid AX) \tag{2}$$

$$p(A \mid X) + p(\neg A \mid B) = 1 \tag{3}$$

$$p(A + B \mid X) = p(A \mid X) + p(B \mid X) - p(AB \mid X) \tag{4}$$

$$p(A_i \mid X) = \frac{1}{n} \qquad i = 1...n \tag{5}$$

where $\{A_i\}|_{i=1...n}$ is a complete set of mutual excusive sentence

Some comments are necessaries:

- by consistence we mean:
  - every possible way of reasoning a sentence must lead to the same result;
  - the equivalent sentences have an equal degree of plausibility;
- in order to obtain the degree of plausibility for a sentence we must take into account all the evidence available;
  - $p(AB \mid X)$ means the plausibility of sentence A **and** B in the condition that sentence X is true;
  - $\neg A$ means **non A;**
  - $p(A+B \mid X)$ means the plausibility of sentence A **or** B in the condition that sentence X is true;

The theoretical results:

Analyzing the mentioned axioms theoretical results can be deduced. From the beginning we will mention that because the probability function has the same properties (1…5) it can be accepted that the plausibility function is synonymous with the probability function. This is the only reasons that theoretical results from probability theory can be transferred to the theory of plausible reasoning.
It is obvious that we do not intend to present exhaustive theoretical results. We will resume presenting the Bayesian theorem which can easily deduced from (1).

The degree of trough for sentence A in condition of O, is proportionally with the sentence A degree of trough and sentence O in condition of A degree of trough, and inverse proportional with the degree of trough of sentence O

$$p(A \mid O) = p(A)\frac{p(O \mid A)}{p(O)} \tag{6}$$

In order to converge to the model construction we will link this theoretical result to the Bayesian filter [6]:

A Bayesian filter allows to estimate the state X_t for a Markovian system in condition of knowing the observation $Z_1,..Z_t$. In order to solve this problem several steps are necessary:

- variable definition:
  $\{X_i\}_{0\le i\le t}$ the system states; $\{Z_i\}_{0\le i\le t}$ observations;
- decomposition

$$p(X_0 ... X_t, Z_0 ... Z_t) = \prod_{i=0}^{t} p(X_i \mid X_{i-1}) p(Z_i \mid X_i) \tag{7}$$

- initial knowledge:
  - the initial state distribution;

$$p(X_0) \tag{8}$$

  - the transition **model** from state i-1 to state i

$$p(X_i \mid X_{i-1}) \tag{9}$$

- the sensor **model**;

$$p(Z_i \mid X_i) \tag{10}$$

- the question

$$p(X_t \mid Z_t ... Z_0) \tag{11}$$

4. A case study

In order to exemplify the mentioned theoretical results we will consider the case of a mobile robot which modifies his state (position) and - from time to time- make observations (measure his position), see figure 1.

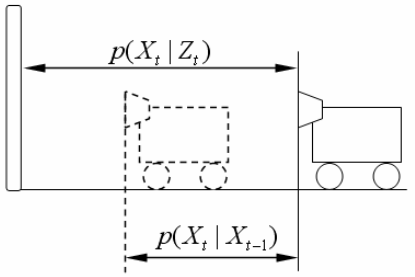

Figure 1. The mobile robot

According to the Bayesian filter definition, in order to answer to question (10) preliminary models are needed. For the transition model (7) we have proposed the normalized distribution (12)

$$p(X_i \mid X_{i-1}) = \frac{\exp\left(\frac{(X_i - (X_{i-1} + 0.5))^2}{2 \cdot 0.5^2}\right)}{\sum_{X_i} \exp\left(\frac{(X_i - (X_{i-1} + 0.5))^2}{2 \cdot 0.5^2}\right)} \tag{12}$$

For the sensor model (8) we have proposed the normalized distribution (13)

$$p(Z_i \mid X_i) = \frac{\exp\left(\frac{(Z_i - (X_i + 0.5))^2}{2 \cdot (1 + 0.1Z_i)^2}\right)}{\sum_{Z_i} \exp\left(\frac{(Z_i - (X_i + 0.5))^2}{2 \cdot (1 + 0.1Z_i)^2}\right)} \tag{13}$$

For the initial position we have use the distribution (14), see figure 1.

$$p(X_0) = \frac{\exp\left(\frac{(X_0)^2}{2 \cdot 0.5^2}\right)}{\sum_{X_0} \exp\left(\frac{(X_0)^2}{2 \cdot 0.5^2}\right)} \tag{14}$$

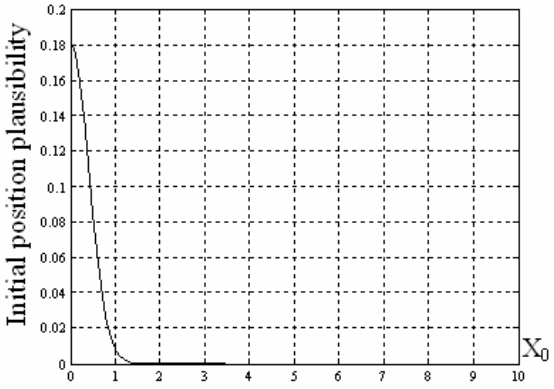

Figure 1. The initial state

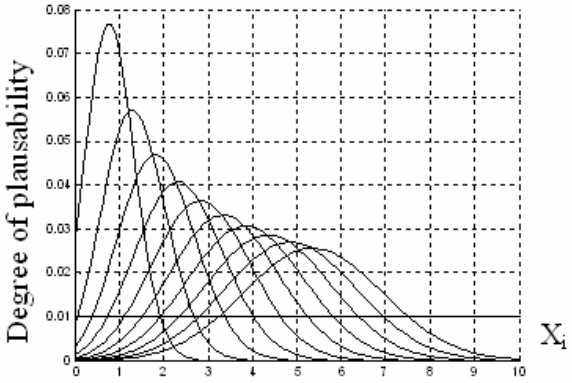

Figure 2. Transition without observation

Using these models we have imagined and simulate the following situations:

1. The robot has several state transition and no observations are made during this transitions. This situation is computed with equation (15).

$$P(X_i) = \frac{\sum_{X_{i-1}} P(X_{i-1}) P(X_i \mid X_{i-1})}{\sum_{X_i} \sum_{X_{i-1}} P(X_{i-1}) P(X_i \mid X_{i-1})} \tag{15}$$

   Simulation results are presented in figure 2. If we analyze this result the main conclusion is that even the translation value - according to (11) – remains constant, the degree of plausibility has decreased continuously from translation to translation. This means that the degree of trust decrees continuously.
2. The robot performs several observations – without performing any transition. This situation is computed with equation (16)

$$P(X_i) = \frac{\sum_{Z_i} P(X_i) P(Z_i \mid X_i)}{\sum_{X_i} \sum_{Z_i} P(X_i) P(Z_i \mid X_i)} \tag{16}$$

   From figure 3 and 4 where we have presented the results of this simulation we can see that the degree of plausibility increases continuously and converges to value 1 (absolute trust).

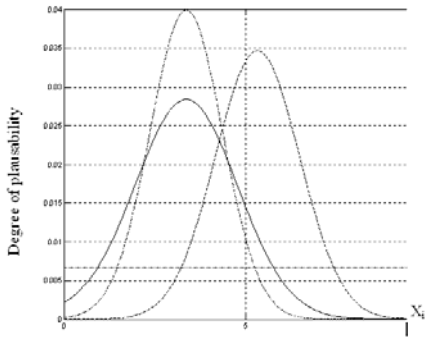

Figure 3. Two observation (.-.- and ---) which starts from the same state (-)

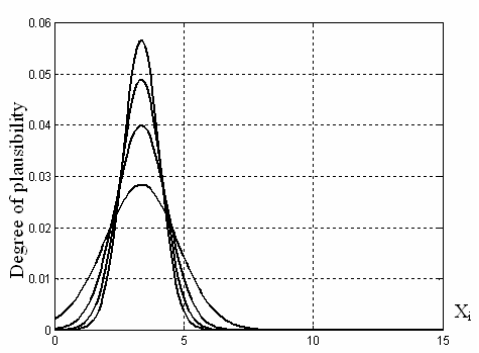

Figure 4. Increasing the plausibility by several observations

3. The robot performs transitions and after each transition performs observations. We have presented in figure 5 two situations. The first involves two observations after each transition, and the second only one observation after each transition. It can be observed that the first strategy increases the degree of plausibility for the current state of the robot.

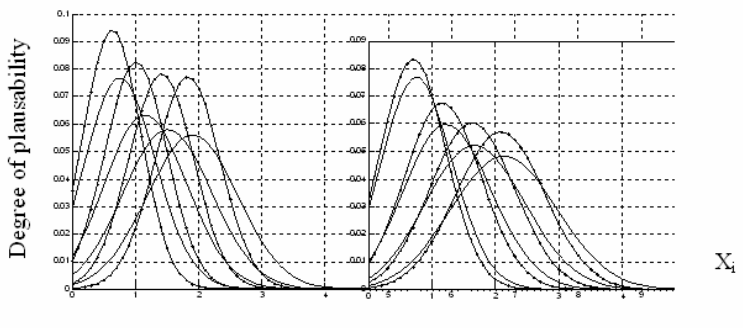

Figure 5
Transitions (-) followed by two or one observations (-.-)

5. Conclusions

Present paper consist from two parts. In the first a phenomenological analize of AI colocation is performed. The result of this analyze are seven question which intend to deep the understanding of AI. In the second part we tray to answer to the first two questions by presenting the plausible reasoning theory. This theory is proposed in [4], but we have structured it from a new point of view which corresponds to the description from the previous analysis. We consider that the main advantage of this theory consist in fact that it allows epistemological model which contains both inductive and deductive process. The presented example underlines this aspect. Increasing the plausibility of a sentence by performing observation means to perform the induction. We will underline also two aspects which have been obtained from simulation. We will mention firstly the diminution of the trust, during repeated use of a theoretical model and secondly the possibility to increase the plausibility by performing observations.

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