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Pattern recognition : origin of self-organization of material structures. The ‘indistinguishability theorem’

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1. Summary :

The question is the following : can the numerical mechanisms of the ‘pattern recognition’ lead to the creation of sensory-motor structures that would be **self-organized** as are the **living beings** that ensure in any circumstances the perennality of their structure confronted to a multiform environment that can only degrade them.

We demonstrate that the objects of the world that are perceived through measurements are physically **indistinguishable** from the point of view of any other system that may produce actions and this regardless of the properties that can be attributed to these objects. This is what we call the ‘**indistinguishability theorem**’.

Considering the ‘indistinguishability theorem’, the sensory-motor structures created by the digital mechanisms of Artificial Intelligence can only be **organized** through the *supervision* of human beings whose cognition has the physically paradoxical ability to discern objects in the world that are all fundamentally **indistinguishable**.

2. Keywords

Pattern recognition, autonomous, artificial intelligence, classification, measurement, sensory-motor, creation, self-organisation, order

3. Introduction

- Pattern recognition' is a set of techniques that aim to **identify** the forms of objects from their characteristic parameters in order to make **decisions** depending on the **categories** attributed to these forms. All **living beings** naturally possess this essential capacity **to categorize** which allows them, for example, to avoid *all ‘hot’ objects* which could destroy them, but also to move towards *any ‘cold’ object* which, hypothetically, would bring them the energy necessary for their mobility.

‘Pattern recognition’ is consequently a central issue in Artificial Intelligence and Robotics which are essentially *sensory-motor* systems composed of *sensors* and *actuators* (locomotion or gripper systems, displays) which by means of a controller are connected to each other in such a way that the actions resulting from perception of the objects with which they interact, respond adequately to the functions assigned to them. Thus, a *sensory-motor* system whose structure would be destroyed by any significant rise in temperature would have to move away from any hot object and for this very reason would have to be provided with the long-lasting function {*flee* a forest fire, a molten lava, a flaming oil slick,...}. To this end, the system controller should have the ability to create **coherent categories** of objects perceived by its *sensors*, in this case the category [*flee* from all hot objects].

It is for this last reason that the *sensory-motor* system would be **self-organized** and not simply **ordered** as are all objects in the world which result from obliged physical interactions between different elements.

- With his ‘Ugly duckling’ theorem, Satoshi Watanabe [1], [3] has shown that in the framework of ‘pattern recognition’ processes, a set of objects that are assumed to have a certain number of

properties, any two objects as distinct, equally share the same number of predicates (properties) whatever the pair of objects chosen in the set.

The response of a ‘pattern recognition’ mechanism is therefore fundamentally ambiguous, so that there is no single way to **categorize** a set of objects, unless **one gives an arbitrary preference** to a certain number of their properties. The *self-classification* of world objects is totally at random.

- In order to evaluate the relevance of the **categorizations** made by a ‘pattern recognition’ mechanism applied to sensory-motor structures provided with an Artificial Intelligence, we carry out the ‘functional analysis’ of a thermometric measuring device of familiar use, a thermostat. This thermostat is an **artifact** which is in charge of recognizing different thermal states, in this case the air temperature of the room in which it is installed, in order to adequately activate a heating or air conditioning unit for the comfort, if not the life of its user.

The functional analysis of the thermostat leads to the determination of the different possible connections between the *sensor* and the *actuators* (radiator, air conditioner) of the thermostat connections that should lead to the instantiation of the required function, i.e. the regulation of the room temperature.

Taking into account the question asked « can the numerical mechanisms of ‘pattern recognition’ lead to the creation of sensory-motor structures that would be **self-organized like living beings** », it follows that these different connections must be those that could **appear spontaneously with regard to the only physical laws**, therefore in the absence of the human beings who have created the said ‘thermostat’.

The aim in this instance is then to establish connections between the *sensor* and the *actuators* (‘radiator’ and ‘air conditioner’), which are such that : (1) the ‘radiator’ is only turned on when the environment of the thermostat is ‘cold’, (2) the ‘air conditioner’ is only turned on when the environment is ‘hot’. This is the expected operation of a thermostat that must ensure the comfort, the ‘pleasure’, if not the life of the users.

By comparing the different connections that are exhaustively identified by means of the ‘functional analysis’, with those set up by technicians in charge of making thermostats, we discover that there are connections [*sensor-actuators*] that have been intentionally forgotten by these technicians because they are, antinomic to the function of thermal regulation expected.

Satosi Watanabe evokes this problematic in connection with his Ugly duckling theorem [1], [3] by talking about utilitarian « extra-logical » [2], [3] ‘weighting factors’ which apply to predicates relating to the description of objects in the process of classification. While noting that these ‘weighting factors’ cannot logically originate in empirical data that are classified for the ‘pleasure’ of human beings.

- From the ‘functional analysis’ of a thermostat, a sensory-motor system, we show that not only the **classifications** that can be applied on a set of objects with specific properties are totally arbitrary as demonstrated by Satosi Watanabe with his ‘Ugly duckling’ theorem [1], [3], but that even more the objects of the world that we perceive by means of measurements are physically **indistinguishable** from the point of view of any **actuator** whatever the properties attributed to these objects. In short, this is what we will call the **‘indistinguishability theorem’**.

4. Experimental device

A thermostat (see Fig. 1) is made up of the following elements : a *sensor* (a thermometer), *actuators* that turn on a ‘radiator **R**’ and an ‘air conditioner **C**’, *physical links* (not shown on the diagram below) between the *sensor* and the *actuators* . The environment of the thermostat is assumed to be only ‘hot’ or ‘cold’.

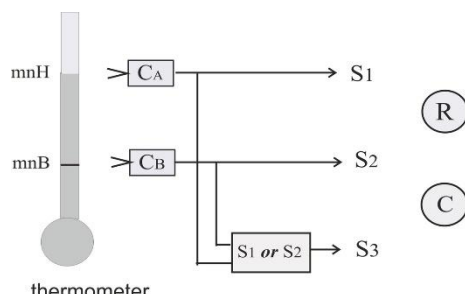


Fig. 1. Thermometric device

Two photocells **CA** and **CB** – only sensitive to the specific shape of the mercury meniscus in the capillary tube – are positioned at two points **mnH** and **mnB** of the capillary which correspond to the two possible extreme positions reached by the meniscus depending on whether the thermostat environment is ‘hot’ or ‘cold’.

When the thermostat environment is ‘hot’ and the measurement is complete (the mercury column is stabilized) only the **CA** photocell is activated because the mercury column is in the high position **mnH**, i.e. an output signal **S1 = 1**, with **S2 = 0** (the **CB** photocell is not activated). For a ‘cold’ environment, only the **CB** cell is activated because the mercury column is in the low position **mnB**, i.e. an output signal **S2 = 1**, with **S1 = 0** (the **CA** photocell is not activated).

The states of the outputs **S1** and **S2** (**0** or **1**) of the **CA** and **CB** photocells are therefore the images of the thermal states in which the so-called ‘hot’ and ‘cold’ environments are found.

Since the outputs **S1** and **S2** of the sensor can take the values **1** or **0**, it follows that there are logically $(2^2)^2 = 16$ possible operating combinations of these two outputs, that is :

0, S1, S2, S1 and S2, (S1 and ¬S2), (¬S1 and S2), (¬S1 and ¬S2), (S1 or-exclusive S2), (¬S1 or-exclusive S2), (¬S1), (¬S2), (S1 or S2), (S1 or ¬S2), (¬S1 or S2), (¬S1 or ¬S2), E.

With the following notations :

- $\neg S_i = \textit{non-S}_i$
- $\textit{or-exclusive} = (S_1 \textit{ and } \neg S_2) \textit{ or } (\neg S_1 \textit{ and } S_2)$
- $\neg(\textit{or-exclusive}) = (S_1 \textit{ or } S_2) \textit{ and } (\neg S_1 \textit{ or } \neg S_2)$

In the Euler-Venn diagram (see Fig. 2), the 16 **operative** combinations of the outputs **S1** and **S2** correspond to the 16 possible unions (**1 to 1, 2 to 2, 3 to 3, 4 to 4**) of the domains **e1, e2, e3, e4** resulting from the atomic domains **S1** and **S2** :

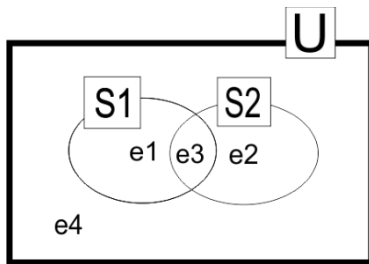


Fig. 2. Euler-Venn diagram

Since the mercury meniscus of the thermometer cannot be in both the high (**mnH**) and low (**mnB**) positions in the capillary tube, the outputs **S1** and **S2** can never be simultaneously activated, that is : **S1 = ¬S2** and **S2 = ¬S1**. As a result, the 16 **operating** combinations of the sensor outputs **S1** and **S2** are reduced to the following 4 **operating** outputs : **0, S1, S2, S3 = {S1 or S2}**.

The universe **U** of the Euler-Venn diagram being thus divided in 2 *adjacent* domains **S1** and **S2**, the domain **e3** is void so that the combinations of the two outputs **S1** and **S2** are well reduce to the only 4 following outputs :

0, S1, S2, S3 = {S1 or S2}.

To finalize the implementation of the thermostat, it remains for the technician to connect the three outputs **S1, S2, S3** of the thermometric *sensor* to the input of the *actuators* so that: (1) the ‘radiator **R**’ is only turned on when the environment of the thermostat is ‘cold’, (2) the ‘air conditioner **C**’ is only turned on when the environment is ‘hot’.

● Experimental protocol

The experimental protocol to be used by the technician is as follows (to simplify the description of the experimental sequence, the 'hot' and 'cold' environments of the thermostat are replaced by 'hot' and 'cold' objects respectively placed in front of the thermometer bulb) :

1. The technician first places a 'hot' object in front of the thermometer and then connects the outputs **S1, S2, S3** that are activated ($S_i = 1$) to 'air conditioner **C**', as specified.
2. The technician then places a 'cold' object in front of the thermometer and connects the activated ($S_i = 1$) outputs **S1, S2, S3** to the 'radiator', as specified.

● Setting up {sensor-actuator} connections

To carry out in an *exhaustive* way – as Nature would spontaneously do in the lack of any human being – the connections between the outputs **S1, S2, S3** which are activated ($S_i = 1$) and the *actuators*, the technician will build the Universe of all possible solutions, that is to say the implementation of 4 – and only 4 – setups in which only the connections between the 3 outputs **S1, S2, S3** of the thermometric *sensor* and the two *actuators* will be changed, that is :

Setup 1 :

- 1.1 Presentation of the 'hot' object. Output **S1** (activated) is connected to 'air conditioner **C**'.
- 1.2 Presentation of the 'cold' object Output **S2** (activated) is connected to 'radiator **R**'.

Setup 2 :

- 2.1 Presentation of the 'hot' object Output **S1** (activated) is connected to 'air conditioner **C**'
- 2.2 Presentation of the 'cold' object Output **S3** (activated) is connected to 'radiator **R**'.

Setup 3 :

- 3.1 Presentation of the 'hot' object. Output **S3** (activated) is connected to 'air conditioner **C**'.
- 3.2 Presentation of the 'cold' object. Output **S2** (activated) is connected to 'radiator **R**'

Setup 4 :

- 4.1 Presentation of the 'hot' object. Output **S3** (activated) is connected to 'air conditioner **C**'.
- 4.2 Presentation of the 'cold' object. Output **S3** (activated) is connected to 'radiator **R**'.

● Acceptance test

It then remains to verified whether the thermostat which has been thus 'naturally' prepared by implementing 4 different set-ups in order to eliminate any arbitrary choice by the technician fulfills the objective that has been set : (1) the 'radiator **R**' is only turned on when the environment of the thermostat is 'cold', (2) the 'air conditioner **C**' is only turned on when the environment is 'hot'.

1. The technician presents a 'hot' object in front of the thermometer, hence the activation states $S_1=1, S_2=0, S_3=1$ of the thermometric sensor outputs. The technician then transfer successively the activation state of the outputs **S1, S2, S3** of the thermometric sensor in the 4 specified setups and he notes :

Setup 1 → 'air conditioner **C**' is on

Setup 2 → 'radiator **R**' and 'air conditioner **C**' are simultaneously in operation.

Setup3 → 'air conditioner **C**' is on

Setup4 → 'radiator **R**' and 'air conditioner **C**' are simultaneously in operation.

2. The technician presents a 'cold' object in front of the thermometer, hence the activation states $S_1=0, S_2=1, S_3=1$ of the thermometric sensor outputs. The technician then transfer successively the activation state of the outputs **S1, S2, S3** of the thermometric sensor in the 4 specified setups and he notes :

Setup 1 → 'air conditioner **C**' is on

Setup 2 → 'air conditioner **C**' is on

Setup 3 → 'radiator **R**' and 'air conditioner **C**' are simultaneously in operation.

Setup 4 → 'radiator **R**' and 'air conditioner **C**' are simultaneously in operation.

● Assessment of the experiment :

1. With the presentation of the 'hot' object :

Setups 1 et 3 → 'air conditioner **C**' is turned on **2** times

Setups 2 et 4 → 'air conditioner **C**' and 'radiator **R**' are simultaneously switched on **2** times

2. With the presentation of the 'cold object' :

Setups 1 et 2 → 'radiator **R**' is turned on **2** times.

Setups 3 et 4 → 'air conditioner **C**' and 'radiator **R**' are simultaneously switched on **2** times

The 'objects' (or 'environments') qualified as 'hot' and 'cold' are at the same time *different* because 'air conditioner **C**' as well as 'radiator **R**' are separately switched on twice in the 4 set-ups, but also *identical* because 'air conditioner **C**' as well as 'radiator **R**' are simultaneously switched on twice in the 4 set-ups. These 'objects' are therefore statistically *indistinguishable* in terms of the actions they can cause.

5. Conclusion

● Objects of the world that are actualized by means of measurements are physically *indistinguishable* from the point of view of any *actuator*. This is what we have called the '**indistinguishability theorem**' that applies to objects that have any number of properties.

The fundamental **indistinguishability** of the objects of the world prohibiting logically the creation of coherent categories which found any process of **self-organization**, the techniques of the 'pattern recognition' which aim at identifying the forms of objects starting from their characteristic parameters, cannot thus be at the origin of sensory-motor structures which would be **self-organized** like the **living beings**.

As such, Artificial Intelligence is not a process of imitating human intelligence. It only generates solutions that are physically **indistinguishable** by any other system and can therefore only produce **random actions** that are logically antinomic to any **self-organization** which found the living.

Artificial Intelligence mechanisms are thus nothing more than highly efficient computing devices necessarily **supervised** by living beings. The solutions they generate in response to the information transmitted to them are all fundamentally *indistinguishable* while waiting for human beings to classify them into **coherent categories of actions** that respond to their questioning. The 'computational theory of cognition' is therefore formally unfounded.

● Since there are living beings on Earth that are naturally **self-organized** physico-chemical structures as well as the tools they create like thermostats, it is that these living beings must be provided with '**weighting factors**' that apply both to the interactions that develop in their own structure and to the connections relative to the tools they have built like the thermostat. The essential virtue of this '**weighting factors**' being to make physically **distinguishable** the objects of the world with which these systems interact, a process which founds the very existence of these **living beings** and the **artifacts** they have designed :

If the technician who implements the thermostatic device described above (Fig. 1), applies for his enjoyment the '**weighting factor**' {1,1,0} to the natural outputs **S1**, **S2**, **S3** of the sensor, then only the two operative outputs **S1** and **S2** remain. Therefore, the universe of all possible connections between the sensor and the actuators is reduced to the following two assemblies :

- The activated output **S1** is connected to the 'air conditioner **C**' (when the 'hot' object is presented to the thermometer).
- The activated output **S2** is connected to the 'radiator **R**' (when the 'cold' object is presented to the thermometer).

In accordance with the imposed specification : the 'air conditioner **C**' is thus only switched on when the environment is 'hot', and the 'radiator' only switched on when the environment is 'cold'.

Due to the preparation of the technician with his '**weighting factor**' {1,1,0}, the fundamentally inoperative natural thermostat thus becomes a fully operational thermostat because it is suitable for the permanence of life.

The ‘**weighting factors**’ that all humans are naturally equipped with, that Satoshi Watanabe qualifies as « extra-logical » [2], [3] because it cannot derive from a strictly logical process, would be according to him the product of ‘extra-logical’ probabilistic **processes of evolution** that would have naturally created decisional mechanisms suitable to the emergence and perpetuation of life. This would explain why there are factual ‘classifications’ of objects that living beings have always created to ensure their well-being, if not their life. According to the said ‘**indistinguishability theorem**’, let’s show that this assumption about the probabilistic origin of the ‘**weighting factors**’ is not logically founded :

– As a physical process which would be the *probabilistic* product of evolution, this ‘**weighting factor**’ could be defined by complementary dual attributes such as ‘**F**’ and ‘**non-F**’ like the descriptors ‘hot’ and ‘cold’ (with ‘cold’ \equiv ‘non-hot’) related to the quantity ‘temperature’. In order for this ‘**factor**’ which would be derived from natural evolution to be operative with respect to a technical device such like the thermostat, that implies that there would be a causal link between the said ‘**factor**’ object with its specific properties ‘**F**’ and ‘**non-F**’ and the connections of the thermostat which would have to be weighted.

However, in view of the **indistinguishability theorem**, the ‘**F**’ and ‘**non-F**’ values of the ‘**weighting factor**’ would be strictly *indistinguishable* from the point of view of the connections that would have to be weighted.

As such, the ‘weighting factor’ that would have to be applied to the connections associated to the outputs **S1**, **S2** and **S3** of the thermostat in order for it to play the expected role of regulating the temperature of a room, could therefore only be distributed **randomly** and therefore operationally **inoperative**. The hypothesis concerning the nature of the ‘weighting factors’ as a technical objects which would result from the mechanisms of the ‘natural selection’ is thus unfounded.

- The ‘Deep learning’, a form of Artificial Intelligence that relies on a very large number of artificial (or *formal*) neurons distributed in multiple layers (up to a few hundred layers), is a significant example of a digital automatism whose only property is to be extraordinarily efficient in terms of computational speed and manifold correlations between objects that are subjected to its analysis.

After a long ‘unsupervised’ learning phase during which an operator **blindly** presents to the input ‘retina’ of the ‘Deep learning’ machine a large number of images including all kinds of objects – like cats – the operator tests this machine by placing a real cat in front of its input ‘retina’. The operator then says to observe that among the **N** neurons of the machine, only the neuron **Nc** is *activated*, and to conclude that the machine has **self-discovered** the {cat} concept [4]. But this conclusion is logically unfounded :

The different states of activation or non-activation of the **N** output neurons of the ‘Deep learning’ machine are from the point of view of any third system – **other than a living being** – strictly **indistinguishable** like the ‘hot’ and ‘cold’ states of the objects placed in front of the thermal sensor of a ‘natural’ thermostat – **not prepared** by a technician. So that the activation states of the output neurons of the ‘Deep learning’ machine cannot be the source of **coherent actions** like those generated by a thermostat **prepared** by a technician by means to the ‘**weighting factors**’ with which it is naturally provided with.

It is this ‘**weighting factor**’ possessed by all human beings, and in particular the operator in charge of the machine, that leads this operator to associate at the level of his language the presence of a living cat that he observes – an animal of which he has a precise utilitarian knowledge dating from his childhood – with the only activated output **Nc** of the machine.

It is the human operator who in this case has created the concept {cat} and not the ‘Deep learning’ machine which would have **self-discovered** a new concept.

6. Références

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