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On the 'nature' of the 'artificial'

Massimo Negrotti[1]

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Abstract
Since the work by Herbert Simon, no particular attention has been paid to the distinction between conventional technology and technology directed at the reproduction of natural instances. Nevertheless, if we had a general knowledge of the methodological aspects that any attempt to reproduce natural objects or processes unavoidably requires, then we would understand why, as a rule, no artificial device can 'converge' to its natural counterpart and why, on the contrary, the more it advances, the further away it goes from it. As a result, our efforts should be oriented to deeply investigate the artificial as it were a truly new 'nature' in itself.

Keywords Artificial · Natural · Conventional technology · Observation · Boundaries · Side-effects · Naturoids · Reproduction · Performance · Information · Transfiguration

1 Introduction

Digitization, conceived as an information based translation of phenomena, is a two phase cultural process because it involves two cultural levels: that of design and that of its final spread within society. The latter aspect is analysed much than the former because of its direct effects on human behaviour and, to some degree, on our way of looking at reality. Nevertheless, design plays a key role since designers always try to guess, on one hand, which projects are potentially achievable in exploiting current technology, and on the other, which projects final users will potentially reward. This paper will address the first issue for digitization regarding a long standing tradition that today is strongly encouraged by the advancements of digital electronics and computer science. I am referring to the very wide world of the *artificial* that is at the basis of any project in all the most advanced technologies, digitization included. In whatever field of contemporary advanced technology, be it Artificial Intelligence or domotics, bioengineering or robotics, we can ascertain that the main, tacit aim is the artificial reproduction of some human characteristic, aspect, ability or behavior. Therefore, it is clear that the outcome of any artificialization project will be successful if, and only if, it will match human perceptions, or needs, regarding the natural thing or process that the artificialization intends to reproduce. On the other hand, no artificial object or process will completely overlap its natural counterpart and, as a consequence, if the final user will accept the artificial, then he/she will also implicitly accept the features that diverge from it, resorting to some adaptation strategy or even neglecting them. In either case, users are forced to change more or less relevant traits of their behavior or of their perception of reality.

Thus, the study of the reasons that make an artificial object or process always intrinsically different from the natural object or process it comes from, holds great importance for understanding why and how its large diffusion in our society is triggering new cultural models that still are far from being understood.

2 The notion of 'naturoid'

The human desire to reproduce natural objects and processes ranges from pure dreams to actual design: from Icarus's wings to current robotics and bioengineering. I propose the concept of *naturoid* for referring to man's attempts to reproduce natural objects or processes. The development of naturoids may be viewed as a special class of technological activity, distinct from the 'conventional' technology which does not attempt to reproduce natural phenomena but creates things that do not appear in nature. The concept of naturoid

✉ Massimo Negrotti
massimo.negrotti@libero.it

[1] University of Urbino, Urbino, Italy

should be useful for a methodological research that could find out possible shared rules, potentialities and constraints characterizing every human effort to reproduce natural objects or processes.

Many designers think that the improvement of a naturoid consists in its growing overlap with the natural instance, and that the final result will be the complete reconstruction of a natural object of process, from its external aesthetics to its inner structure and working. I will try to show that a naturoid is always the result of a reduction of the complexity, due to an unavoidable multiple selection strategy of the natural object it tries to reproduce. Nevertheless, the reproduction process gives to naturoids their own complexity that only partially overlaps the natural one, resulting in a transfiguration of the natural exemplars and their performances, leading to something new. Therefore, the more the performances of contemporary naturoids improve, the more, paradoxically, they move from their natural counterparts. Thus, naturoids will increasingly affect our relationships with advanced technologies, on one side, and with nature on the other, but in ways quite beyond our current predictive capacities.

3 Artificial and conventional technology

In the recent past, the debate on the feasibility of Artificial Intelligence focused on the complex and still 'mysterious' character of intelligence and took for granted the concept of artificial, simply understood as something 'not natural' or generically 'manmade'. On the other hand, if we could have a body of general knowledge about the artificial in itself, we could deduce from it the characteristics that even AI must exhibit as a particular case of a general class. Man has generated and will generate a great variety of naturoids (from Heron's constructions to robotics, from Vaucanson's machines to medical engineering, robotics and so on). Therefore, assuming a scientific viewpoint which could enlarge Herbert Simon's seminal point on 'the science of the artificial' (Simon 1970), the main problem can be described by the following question: despite their substantial difference, is there something that any naturoid share, from the methodological point of view? In other words: is it possible to describe the general designing constraints and rules, and the unavoidable general outcomes, of any project for a naturoid?

To better circumscribe the specific subject of our study, we can start from a useful taxonomy.

The history of technology shows two universal, different and parallel lines of design: a conventional technology, aimed at inventing objects that do not appear in nature, and a technology of naturoids, which aims at designing objects inspired by nature.

Nevertheless, it is important to consider that an autonomous technology of naturoids does not exist, in the sense that we lack a specific technology intrinsically destined to reproduce nature. Thus, the technology of naturoids is nothing but a reorientation of the conventional one. As we will see, this fact has relevant consequences on the character of any naturoid, and, even more so, on their evolution. The arrow in the Fig. 1 indicates that the development of a naturoid, or its improvement, is strictly dependent upon the technological knowledge available, its concepts and tools. At the end, we can say that naturoids are 'alternate realizations' (Rosen 1993) of natural objects or processes that are rebuilt thanks to the, as it were, 'plasticity' of conventional technology. There is no university currently offering courses at a School of Artificial Technology—apart from some specific courses of study in Artificial Intelligence and other courses in very specific areas—just because naturoids are usually designed by conventional engineers and in fields very far each other. On the other hand, if we could gain reliable and general methodological knowledge on the design of any kind of naturoid, then we could imagine courses on this topic as a basis for training of engineers of a new kind.

4 A three-step hypothesis

From a methodological point of view, the hypothesis we present here says that anyone who wishes to reproduce artificially something that is natural, has to make three unavoidable selections:

- An observation level (OL).
- An exemplar (EX).
- An essential performance (EP).

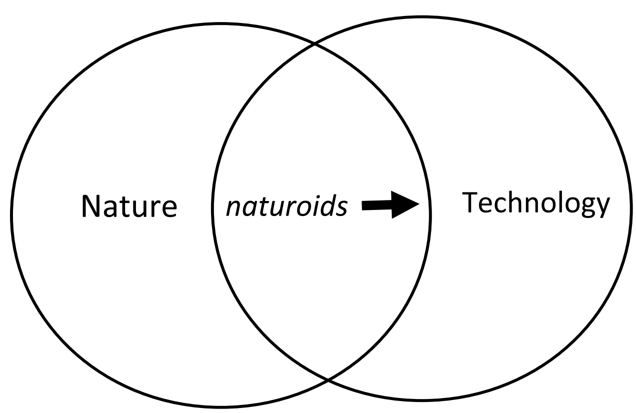

Fig. 1 The arrow indicates that the reproduction of natural exemplars can only rely on conventional technology, and in this way, inheriting all its properties, not only the ones needed to reproduce natural objects or processes

These three selections work as a funnel, as the selection of the EX depends upon the selection of an OL and the selection of an EP depends on the selection of an EX.

5 The observation level

It is clear that, to build a model of something, and then to reproduce that something, one must be able to observe it (directly or indirectly) in nature. This point underlines that any given natural object or process can be observed, and then described, from several, alternative OLs. This concept has some similarity with the levels of analysis or description levels adopted in some studies of complexity (Oppenheim and Putnam 1958). It is also can allude to the *observational perspectives* of C. Morris's 'objective relativism' (Morris 1948) but in a more empirical version.

We may describe a natural object or a process placing us at more than one observational level of course, but we can adopt only one level per unit of time. The empirical sciences, ever growing in number, constitute a sort of institutionalization of separate observational levels. For instance, a flower may be observed from a physiological, mechanical, biochemical, electrical, relational, or even architectural or aesthetical OL but no synthetic definition can be proposed for defining a flower simultaneously from all the known OLs. This explains why, when a scientific problem is very complex, a true struggle usually emerges for establishing the most relevant OL, the 'father', so to say, of all the other OLs. As a rule, both in daily life and in the scientific world, any description of an object lets us clearly understand what OL was selected, knowingly or unknowingly, as dominant. Sciences are the best example of this fact because they very often struggle for establish which of them should have the last word.

When we try to set up a multiple-OL description, it usually happens that (a) one OL prevails over others, or (b) we simply collect separate descriptions, or (c) we end up building a new OL. The third case, when it is successful, is that of so-called interdisciplinary research. Think of biophysics. Certainly, it is not the mere 'sum' of biology and physics, nor can it be taken as a new way of unifying the sciences following the efforts of the Vienna Circle. Furthermore, nobody will expect fundamental advancements in biology or physics from biophysics. Rather, it works on its own specific and new observation area, with its own problems, theories, techniques, lexicon and literature. Clearly, it becomes a truly new OL.

Concluding this section, we can say that the selection of any OL allows some empirical data to enter the description model, while unavoidably leaving others out of it because they can only be observable by changing the OL. Thus, any model, despite its incompleteness, should not be taken as a trivial '*part*' of the natural phenomenon, but as its 'profile', that is to say the phenomenon regarded from a selected OL.

6 The exemplar

The EX is the natural object or process which one chooses as the target of one's attempt at reproduction. Any reproduction project usually takes the name from the EX it places at its core (for instance, 'project for an artificial heart'). This is due to the fact that, especially after the rise of rationalism, we all view the world as a collection of things that can be isolated from one another, named, measured, classified, etc. But, in selecting the natural object we wish to reproduce, the isolation becomes a sort of ever-arbitrary 'uprooting' of it from its context. When we *define* an EX, we refer to the Latin meaning of this term because *definire* means exactly 'to fix the boundaries'. Therefore, the main problem here is that of the boundaries we decide to set to build a model that could be, on one side, a satisfactory description of the natural thing, and, on the other, a manageable model by means of current conventional technology. While the former issue regards the scientific advancement, the latter clearly depends upon the features of the available technological tools. Actually, any project of reproduction of an EX could be intended as a 'technology driven' model.

Anyway, setting the features and the boundaries of the EX is a process that, first of all, strictly depends upon the OL we have selected, and, of course, upon the amount of accurate scientific knowledge we have at our disposal. Clearly, if we neglect or ignore some key part or component of the natural object, the resulting naturoid will exhibit features completely or partially different from those of the natural EX.

If we take into account the case of biology, we discover that almost all components of a living system (organs, glands, vessels, etc.) are linked to one another. Therefore, it is not surprising that, historically, the experiments, for instance, on thyroidectomy were misinterpreted due to a wrong setting of the borders of the involved organic object that induced scientists to remove the parathyroid (Hamdy 2002).

The same possible mistakes may occur describing, and then trying to reproduce biological systems that live symbiotically with others, or others that survive only in some special environments. The case of the brain and of its dependency on the many and heterogeneous inputs it receives, is one of the most complex examples, of course.

7 The essential performance

While the EX refers to the structure of a natural object, the EP refers to the function, behaviour or appearance of the EX that one considers as the *main* one. In other terms, the

EP is the performance that best describes the 'essence' of an EX according to the current knowledge. In some way, the EP is the feature without which the EX, according to our view, would lose its core nature. Thus, examples of EPs are the pumping action of the heart, the filtering action of the liver, the intelligence as a problem-solving capacity of the brain, the detection of obstacles by a biological ultrasound sensor, the appearance of rocks in a landscape, or the sound of a violin.

The selection and then the definition of an EP depends on the definition of the EX, and therefore on the selected OL. If a model neglected a component of the EX, then its performance would obviously disappear and, as a consequence, it would lose the possibility of being a candidate for playing an essential role.

In the selection of the EP, the problem is that different observers or scientists, who might place themselves at different OLs, might indicate different performances of any EX. In other words, each 'school of thought' has at its core their own idea of what has to be considered as essential in an EX and this fact can considerably affect a project in any field; in Artificial Intelligence as in related sub-fields, digitization included, in prosthetics as in robotics, and so on. By the way, we must here emphasize the difference between an EP included in the design of a naturoid and what happens in a simple automatic device, because an automatic device points directly at the EP—for example, opening a door, adjusting the temperature—neglecting the way a human being would do it.

The key role of the OL in isolating the EX from it context, is having the EP as its main feature, and this is clearly shown in the history of automata which have been dominated by mechanical, hydraulic or electrical 'visions' of human functions and performances. And it happens today, too, because any project for a naturoid cannot but assign to some particular performance the role, so to say, of 'master', leaving to the others—if considered in the model—a secondary role of 'slaves'. For instance, it is useless to underline that in the current technology of robots, the notion of 'information' and of 'information processor' is, de facto, dominant thanks to the advancements of computer science and of the information technology it is based on.

In any case, it should be underlined that designers are almost always aware of the presence of more than one EP in any natural object or process. Therefore, they sometimes try to set up models in which the EP is put in relation with other known performances to approximate the natural EX in a more realistic way. Nevertheless, the reproduction of the interrelation among many performances raises the problem of governing the cross-talk among heterogeneous subsystems that may speak, so to say, different languages, for instance chemical, bio-chemical, electrical, mechanical often mixed together.

How this happens in nature, particularly in biology, is often unknown and, therefore, trying to reproduce the interaction among sub-systems adopting a specific language may introduce in the model of a naturoid further differences regarding the EX and its EP. In the end, this problem is similar to that of simultaneously considering more than one OL, and leads to the same drastic consequences.

While referring to more specific publications on naturoids presented at the end of this paper, it could be useful to draw attention to two quotations that clarify the above considerations. The first refers to Jacques de Vaucanson's attempt, in the XVIII century, to reproduce mechanically the digestion of a duck, when he defined the essential performance he wanted to privilege as follows: "I do not claim that this should be perfect digestion, able to generate bloody and nutritional particles to allow the survival of the animal. I only claim to imitate the mechanics of this action in three points: in the swallowing of the wheat; in soaking, cooking or dissolving it; in allowing its going out forcing it to visibly change its stuff" (Vaucanson 1738; seen in Losano 1990). The second concerns the initial stages of the project for an artificial retina when the authors, Mahowald and Mead say: "In building a silicon retina, our purpose was not to reproduce the human retina to the last detail, but to get a simplified version of it which contains the minimum necessary structure required to accomplish the biological function". (Mahowald and Mead 1991).

8 Reproduction and transfiguration

To improve the efficiency and effectiveness of a naturoid, designers usually end up adding new components to the model—coming from conventional technology, of course,—even if they do not have any known correspondence with the structure of the EX. This often happens in robotics, but also in pharmacology, medical engineering, Artificial Intelligence and other fields. This fact implies a growing own complexity of the naturoid that does not overlap the complexity of the natural EX. Rather, the EP will be surrounded by a growing context of devices and modules whose 'nature' and performance should improve the naturoid to perform like the EX does. However, at the same time, they increase the structural dissimilarity of the naturoid from the EX. This means, paradoxically, that the more a naturoid exhibits an EP similar to the human one, or more advanced or refined, the more its 'nature' will be further from the natural EX.

Furthermore, any naturoid project triggers a sort of inheritance principle of the materials adopted, which are obviously different from those that nature adopts. Their interaction, along with the features of the added devices mentioned above, increases the probability that sudden events and side effects only randomly overlap natural phenomena. If this holds true, then in facing naturoids human beings find themselves in a particular paradoxical situation, since they can take advantage from an improving EP if, and only if, they also accept to deal with a growingly different 'species' along with its related requirements and expected or unexpected behaviour.

9 The case of AI and robotics

All the selections we have seen also apply to the reproduction of human intelligence or human behaviour, of course. For instance, it is very difficult to establish the boundaries of any 'module' of brain activity and to identify their essential performance. This problem also arises in regard to the interaction among multiple modules, or sub-systems, of the brain activity. Since the brain works as a whole and all its sub-systems cooperate in some way, it makes no sense to reproduce one of them as a stand-alone naturoid, because its working in the EX is characterized by a continuous cross talk with all the others: memory is linked to perception, perception to emotion, emotion to sensation and so on. As a stand-alone system, an artificial device (naturoid), can be more effective than its natural counterpart in some very finite areas, but it is precisely this difference that testifies to its artificiality. This becomes even more evident when trying to connect two or more artificial modules without knowing the 'language' adopted by the natural EX.

Actually, we should underline the fact that all AI and robotics projects rely on an information-based modelling of the human brain/mind; but information, in terms of bits and bytes, is not the 'material' the brain adopts in its working. The brain works (as do muscles, nerves, glands, etc.) by means of the interchange of chemical or electrochemical signals that in many cases involve the whole body. Information is surely very useful to describe EXs and EPs, but this does not mean that the described system works on the basis of it. An example to illustrate this is a likeable dispute between two scientists. One of them, Michael Tabor, of the University of Arizona, Tucson, supported the idea that it is mathematically possible to describe the twining of tendrils (as spirals of bacterium or telephone cables). Neil Mendelson, of the same university, observed that, to reproduce them however, it would be strategic "…to describe exactly what happens to fibres in the real world" (Tabor 1999). Human performances, and many other natural phenomena, can sometimes be usefully simulated and even enhanced by information processes. But it is precisely the increase in performance that places an AI-based device in a world apart, boosted on one side and impoverished on the other, that is to say, transfigured, as happens for all naturoids.

10 Conclusion: the two faces of the artificial

The theory we have sketched here has sought to clarify two distinct aspects. One, it analyzes the general process of designing a naturoid, showing that this implies an unavoidable set of methodological selections. These selections will be reflected in the resulting model, and then in the actual naturoid, in terms of intrinsic and extrinsic dissimilarities as compared to the EX and to its EP. Two, the discussion underlines that naturoids, due to their own complexity and heterogeneous features, tend to set up an 'apart reality' only partially overlapping the natural one.

The usefulness of several naturoids in some cases is accompanied by problems for humans—just think about the trouble that comes from almost all prosthetic devices—but, generally speaking, humans are pushed to adapt themselves, more or less consciously, to the dissimilarities in exchange for their benefit and, therefore, they enter the outfit of our daily or professional life. This implies a growing latent divergence that will challenge human nature, pushing it to biological and cultural limits, maybe waiting for possible feedbacks.

Case studies, including communication and music, can be found in:

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