The darwinian structure of the design process

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Abstract

This text is meant only to be a stimulus for the discussion to be held, in a specific panel, at *Generative Art 2001*. In the text, "provocative enough" to spur animated discussion, some very basics of *darwinism* and *genetics* are given with the only purpose of declaring a **common** "stage for the play" where everybody feels at ease. Common stage and common vocabulary if not even common language. The main thesis is very strong, therefore comments and critics are warmly encouraged. They are the selective pressure that steers the evolution of ideas. We all need them. The thesis is basically the following: *"Every creative process is a darwinian one"*. Besides, it will be shown that it is also a very peculiar one where the information and its implementation sometimes switch their role one another.[1]

1. Thesis - Think genetically

Beyond any personal religious belief or scientific theory, the vast majority of people consider any living entity being a masterpieces of "design" and an example of perfection in "engineering".

(Almost) any living being is also considered to be an example of beauty and all of them are recognized as a marvel of functionality.

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[1] No bibliography will be cited, given the type of paper, in order not to make the presentation heavy. Credits must be given to Richard Dawkins (Darwinism) and to Francisco Montero and Federico Moràn (Prebiotic Evolution). All the misinterprettions are obviously only mines.

The universally asked question is then:

> "How could all those great *things* have been done?
> (without some *separate external* entity taking care of their *design*)"

The Darwinian theory gives a complete and (nowadays) widely accepted answer to the previous question (albeit, unfortunately, the theory is *not correctly* understood by the vast majority of people yet).

I will not enter, here, into the discussion of whether the Darwinian theory is the correct answer *to the previous question* or not, just because my interest, here, is of a different nature.

The interesting question for me, here, is rather the following:

> *"can we **emulate** (at least part of) the 'creation' process for our own purposes (i.e.**design**)?"*

In order to answer to the last question it will be necessary, in the following, to challenge some common beliefs.

Before doing so it will be also necessary to observe that, while, in the biological sciences, there is the trend of using procedures (e.g. genetic *engineering*) that have ben originally developped in engineering, vice versa, in engeneering, procedures, derived from darwinian theory, are more and more accepted (e.g. *genetic* algorithms).

In *design* it may appear, at first sight, that this is not the case ***yet***. The modern process of design does not leave anything to "chance", does-it?

My main (strong) thesis to be proved, here, is then that, *looking beyond the appearances*:

> ***any** creative process is a darwinian one*
> *and*
> ***any** "rational" procedure aimed at its optimization (e.g. design)*
> *is just a different form of a process*
> *that is still and intrinsically of darwinian nature.*

2. Proof - How We can think genetically – (The darwinian theory of creativity)

In order prove my strong thesis I will go into a series of steps. The first series of steps serve the purpose of getting rid of some commonplaces and misunderstanding about the darwinian theory, then I will follow on in the real discussion.

2.1. Getting rid of Commonplaces and Misunderstanding about Darwinian Theory

2.1.1. Design versus Chance

First of all I have to solve the apparent contraddiction between *design* and *chance*. "Chance" happens to be the concept most often associated to darwinism in order to disprove it alltoghether or, at least, to rule out its applicability beyond the realm of biology.

In order to solve the said (apparent) contraddiction it is necessary to note that, at its very fundamental level, in the darwinian theory (of the emergence of complexity) there are two main concepts *mutation* and *selection*.

It is then of paramount importance to undertstand that the "core", the "holy Grail", of the darwinian theory (of the emergence of complexity) lyes in the part of theory explaining the role played by the *selection* process.

Then there is the other part: the *mutation*. It is also fundamental to note that the mutation, need **not** necessarily to be "random". The real important fact to be aware of is that the mutation-selection process is so powerful that "even" in the case in which the mutation would be "random", the selection is still powerful enough to "steer" the evolution in the "necessary" direction.

Is really unfortunate that the detractors of darwinian theory have attacked the theory from the side of the role played by *random* mutation, generating confusion among the relevant role of mutation and selection (and of the different possibilities offered by random and *non*-random mutation). I do acknowledge that, in fact, is contrary to the everyday experience that randomness *alone* can generate some form of "meaningful" result. The tricky point stay in the (italicized) word: "*alone*". I.e.:*"It takes two to Tango" : mutation and selection*.

2.1.2. Two important definitions

Phenotype: that is the body of the individual living being

Genotype: the set of all the genetic information belonging to a given individual.

2.1.3. Craftmanship, Engeneering, Design and Darwinism

At first sight one can be sceptical about the applicability of darwinian theory in order to explain also modern engeneering and design processes (and not only the emergence of primitive "stone age" craftmanship).

*Are engeneering and **design** really darwinian processes?*

This is a very crucial question.

On the other hand it is commonly accepted that the process of ***trial and error***, *albeit in it crudest form a very inefficient one,* is at the base of most invention processes (and in its form of experimental method at the base of scientific empirical research). After all, what is engeneering if not a process aimed at the minimization of the number of trials ad the consequent (possible) errors?

We are very proud of our *engeneering* procedures as very efficent ways of finding solutions to our needs, so are we about our *design* science as a creative process.

I will not go here into all the possible *distinguo* among *engineering* and *design*. Let me just say that those differences do exist, and are important ones, nevertheless they are not relevant at the present level of the discussion about the nature of the creative process. Anyhow I will try to focus my discussion on *design* rather than on *engineering*.

Once we have accepted the idea that the *trial and error* can be at least **one <u>possible</u> mode** of creation, the next critical question to answer is the following: "Are there any *other* modes for creation?". Before saying "yes of course there are"[2], some further considerations are needed.

At this point of the discussion I have to say that I do agree that my proposition is provocative enough, after all, nobody makes many bridges and try them until they find the one that will not break down! Do they? You may still concede that whereas this could have been true in pre-history this is not certainly the case in our space age.

2.1.4. The common cultural background or: "breaking down complexity"

Why we 'need' to break down complexity?

The answer most commonly given to the previous question is the following:

by means of breaking down complexity we are creating "more manageable pieces".

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[2] On the basis of the extraordinary advances of engineering and design, both of which appear to be all but only trial and error processes.

My answer, which is a different one, and which includes the previous as a particular case, comes out looking at the problem from a different perspective.

In my view, we break down complexity
in order to obtain what can be regarded as a
"rough genome" of the process.

But in doing so we rather play Frankenstein. The reason why we are able to re-arrange our 'limbs of thougt' and still obtain a living entity[3], is that in the realm of ideas the basic entity, the *idea*, may act both as a *genotype* and as a *phenotype* **albeit <u>not</u> at the same time**.

After all, one may note, in the pre-biotic era, in the so called "primordial soup" the self replicating entities (most likely strands of RNA, at least from a certain point on) used to make copies of *just themselves* without encoding into anything non self replicable (like, on the contrary, RNA does in todays most forms of life, encoding proteins). There was no distinction between *genotype* and *phenoype*, there were simply self replicating entities replicating just themselves.

Now, here, there is, in my view, a more subtle distinction that has been somehow overlooked up to now[4].

It is fundamentally different ***the case in which:***
a) *the replicating entity consists of <u>only</u> a genotype (e.g. primordial RNA);*
and the one in which:
b) *an entity acts both*
as <u>genotype</u> (when playing the ***mother's*** *role)*
and as a <u>phenotype</u> (when playing the ***daughter's*** *role).*

In the second case, that I will call the ***<u>binary mode</u>***[5], it is fundamental that the making of the

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[3] Contrary to the Shelley's fiction novel, transplants in the real world are generally rejected while natural sexuated reproduction includes a blending of genomes that still leads to a 'readable' genome that can be implemented via embryogenesis into a living entity. In the last years we learned how to 'edit' genomes without sexuated reproduction and still coming out with a living entity.

[4] Also all the **<u>other</u>** observations were necessary in order to make my discourse intelligible *to <u>non</u> biologists*, but most biologists should, of course, already know. This one constitutes a challenge even for the biologists.

[5] As opposed to the *<u>standard</u> mode* where p. and g. are <u>non</u> interchangeable.

daughter from the mother's information is mediated by a *true (higly non linear) embryogenesis*[6].

In other words, a simple *translitteration* is not sufficient (that is, a simple substitution of each element of the mother with other elements, following a given set of rules). It is, on the contrary, necessary a process of *growth*, that is:

*there must be the emergence of a **structure***.

2.1.5. Self replication against 'hosted' (viral) replication

We are used to think that **self**-replication is one of the charachteristics of life, if not **the** charachteristic. It is sufficient to consider the case of viruses (there are a few others though) in order to understand that the **self**-replication is not a necessary condition for a process to be governed by darwinian laws of evolution via mutation-copying-implementation-selection cycles. Replication is of course necessary but can be 'hosted' somewere outside the entity to be reproduced. We are free ***not*** to call those processes '*life'*, if we like, but still those processes can be described using darwinian 'dynamics'.

It is also important to know that **by definition** the *mutation-copying* part of the cycle regards the **genotype** whereas the *selection* part regards the **phenotype** (by definition selection acts on the phenotype not on the genotype). The *implementation* being any 'mapping' between genotype and phenotype.

The last is a very important point. If we allow that also non **self**-reproducing entities can evolve (by means of mutation-copying-implementation-selection cycles) an entire new universe of phenomena can be modeled as a darwinian process.

2.2. Proving the thesis – Recognizing the (hidden) Darwinian nature of the design process

2.2.1. The drawing as a genome

Instead of using the term *idea,* from now on, I will use here the term **descriptor**[7] since the term *idea* has a semantic domain that is too vast, having been widely used in so many different contexts and times. Quite obviously what described above using the term *idea* still holds.

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[6] Otherwise it will be simply case a).

[7] I could have used also the term **model** which is less ambiguous of the term idea but still carryes some ambiguities due to its wide usage.

In design, as in many aspects of everyday life, we are able to manipulate both physical objects and their abstractions. Probably not all the abstractions can be **descriptors,** or, at least, not all the abstraction can be **good** descriptors. And, for sure, not all the abstraction are descriptors good for design.

A drawing can be a descriptor of a given object and insofar is an abstraction of it.

Now, what is the purpose in manipulating abstractions instead of their relevant objects?

It all depends on the type of abstractions. I will discuss here only the case of descriptors.

The descriptor is a genotype that can be interpreted in order to implement a physical object. It can be operating in binary mode or standard mode

I will discuss here only the case of physical tangible object but the theory is general and can be extended to the case of intangible entities and processes. Intangible objects and processes are still phenotypes obtained by means of interpretation of a suitable genotype that I have called here a **descriptor**.

2.2.2. The hidden genotype and the manifest phenotype

The *selection* process is the part of my thesis that is less likely to be challenged because we may easily accept the fact that in the *design* process we *do* make choices, don't we? As already said, by definition, the selection acts on phenotypes, that, in the case of design, are our artifacts, tangible objects (but, as said before, they can be also processes), usually prototypes of all sorts. We make prototypes in order to have *the* object for a selection.

In selecting a phenotype (e.g. a given prototype) we implicityly select also the relevant genotype.

Usually we select a population of phenotypes rather than a single phenotype (for reasons that I will clarify in a moment). I will not go too much into this though, because in biology is still an open question if the evolution applies to the genome, the idividual or the group. In fact Darwin wrote about the evolution of species not of individuals. At this level of the discussion we may leave this part of discussion out.

We (usually) select a population istead of a single individual for several reasons. Among them there are the following that, in my view, are the most relevant for the present discussion:

1. Selecting a population implies selecting a set of genotypes wich parallelizes the process, speeding it up
2. The possibility of mutation are greater acting on a variety on genomes instead of only one.
3. Crossover (mixing) of genomes is possible

Since we do not (usually) act (for what I have said before) *directly* on the genotype we are *unaware* that we are acting on the genotype as well, when dealing with the phenotype. In both 'real', 'wet' biology and in this discussion

> *we are normally unaware of the underlying genotype*
> *that, nevertheless, do exists, regardless of our awareness about it*
> *(as it existed the law of universal gravitation before Newton formalized it).*

2.2.3. Binary Mode and its role in Design

As we have seen, a *descriptor* in *binary mode* can be both a genotype and a phenotype until it finally encodes in the physical **final**[8] object.

Before this last encoding, the descriptor goes under several cycles of mutation-copy (as genotype) and selection (as phenotype). Hence, switching from phenotype to genotype, the descriptor goes again into mutation-copy and so on.

The difference between evolution under **standard (darwinian) mode** and **binary mode** can be clarified by the following example.

You have an idea then you **schetch** it. In doing so you map your genotype idea into the phenotype **schetch**.

Now you face two possible modalities of going on. (And you usually use both).

- "Standard Mode" – **Mutate** (slightly) the idea (genotype) and encode it in one or more schetches (phenotypes). **Select** the schetches (phenotype) that you prefer, implicitly selecting the idea (genotype) behind it. And so on until satisfied.
- "Binary Mode" – as in the previous case except that once you have your schetch (phenotype) you treat it as it were a moldable, parametric, modular genotype and not a rigid "cooked" phenotype

Now you can **select** the variations you need. You need for what purpose? In order to **select** you inescapably need to implement your genotype into some phenotype before actually making any **selection**. You can, vice versa, further en-code it in a more structured "blue print" or "project" or prototype.

3. Conclusions

After this, very brief, travel into the realm of the **"Darwinian Theory of Creativity".** I am far from sure to have convinced anyone that the creativity ***is*** governed by darwinian principles. My scope is of a more modest nature: "I wish that there could be a discussion on wether **modelling** the creativity in a darwinian way we can improve our design science and capabilities".

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[8] As we will see in the following the physical *prototype* is still a *descriptor*