Java Lab of the falsification of Evolution

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Abstract

A sample of Java programs has been chosen to convey a message: evolution is an amazing tool in the hands of a genius but it is pretty useless otherwise. This is, of course, a challenge for everybody in our community. Anyway, evolution is, as any other tool, of limited power. In particular, there is no scientific reason to believe that it played an important role in the origin of species. This is my report to you of what I have been making in the last 44 years. By studying it, you can get a lot of ideas to make your own report to the world. Take in mind that you enjoy an unconditional license to use every element of this site in whatever form you prefer, the present material included. Make your best to get a final product that must be fair, bold, clear for beginners but challenging for experts, robust and enticing.

Contents

1 INTRODUCTION

Java enables a thorough testing of the Evolutionary Theory because many questions can be studied in depth. So, we are looking for a natural falsification of that theory. This means that the falsification must arise from the study of evolution instead of being brought forth by ingenious tricks: we must calculate mandatory and ubiquitous predictions and compare them with observations to decide next that they are quite different. So, let us begin by noting that evolution is a methodology that we all use to solve problems of our ordinary life.

2 EVOLUTION AS AN ALGORITHM

The idea of evolution is to change things to improve quality and to enrich options by assembling patches, merging a proposal from here to a proposal from there. Let us see how this idea is transformed into a very concrete receipt or algorithm to solve problems.

2.1 Starting with common sense

We all use evolution as a tool to solve problems everywhere and every now. Two examples will suffice to show this:

Suppose we need to design a menu that shall be low in sugar. So, one can try *rice + potato*, change *potato* by *black bread* and if one has tried *pasta + rice* and also *rice + beans*, what about trying *pasta + beans*? In evolution, the first operation is called *mutation* and the second *recombination*.

Imagine now that we want to fix a craft. If we buy a new part to replace an old and defective one, we are making a mutation. But if we exchange the defective part in the damaged craft by a functioning part from another object, we are executing recombination.

In the first example, we are trying to minimize sugar excess and in the second we try to maximize functionality. We are dealing in both cases with *optimization problems*. To improve solutions we use two techniques: mutation and recombination. This is *evolution* and is what we all do everywhere and every now. With some practice one can see evolution everywhere.

It happens that this methodology can be automated and generalized as follows:

1. An *optimization target* is defined (minimize sugar excess).

2. A verbal or *genetic description* of the objects that are the subject of optimization must be given (rice, potatoes, bananas are all words that describe real objects). This step is also called *encoding*.

3. A *population* of individuals (tentative solutions) is generated by random concatenation of symbols of a given alphabet (The alphabet for a menu are the ingredients: *rice, onions, potatoes...* A tentative solution, a menu, is a string of those ingredients: *rice + peas*).

4. Individuals are *mutated* and *recombined at random* and the resultant solutions are evaluated. To evaluate a solution, that is a verbal description,

it must be decoded into an object of experimentation. The process of evaluation assigns a score or *fitness* to each solution. A common definition of the fitness function for maximizing problems assigns 0 to useless objects and 1 to perfect ones (*rise + potatoes* have a low fitness because they contain too much sugar in the form of starch. By contrast, *beans + rice* are well scored because beans are rich in proteins not in sugar).

5. Fitnesses are used to build *a new population*, say, the probability of cloning is proportional to the fitness. So, fitness incarnates the feedback we are so used to.

6. This is *done over and over*, recurrently, until an acceptable solution is achieved. Each round is called a *generation*.

This receipt is one form of defining **GA (Genetic Algorithms)** in general according to *Darwinian Evolution*. They are totally mechanistic and so they can be run by computers. Used language results from the fact that historically GAs were inspired by Genetics (things must have a verbal description) and by the Darwinian Evolutionary Theory. Real life contains variations of evolution that do not fit the automatism of Darwinism, rather some kind of guide or help is included. Example: a mother is always celebrating the deeds of her baby that he or she could span his or her mind as a source of creativity, of variation. Besides, she furnishes feedback at every moment that the baby could know how good is the performance of his or her decisions. To end this list, her nagging has as purpose to minimize the suffering of inappropriate decisions. This type of conditioning classifies better as *Lamarckian Evolution* and resultant algorithms are created by Artificial Intelligence practitioners (see vol VII, Hearts and minds).

Now, what can be achieved by Genetic Algorithms?

2.2 Direct algorithms

There are a multitude of problems that are solved right in front of own eyes by genetic algorithms. Let us call them **direct problems**. Their existence and proliferation allowed many people to imagine that evolution is the final explanation of our existence. A glorious representative of this school of thought is Richard Dawkins ([9] 1986; [10] 2006). This type of literature is very important for those persons that, like the Author, believe that if evolution explains us then God has no right to judge us. The persistence influence of Dawkins is captured here by two important and direct programs that adapt to Java two of his algorithms from the first cited work:

1. `Shakespeare4` from Vol XIV that matches a phrase.

2. `Morphs` from Vol IV that makes drawings that resembles insects and other critters.

3. To these we have added `EvolArt` from Vol IV that outputs patterns, some of which look artistic.

`Morphs` and `EvolArt` create variability, while `Shakespeare4` represents a GA: it uses mutation, recombination, assessment of solutions and reproduction recurrently to fit a target. The Reader is invited to verify on this program that direct algorithms have three properties. First: they steadily gather small change generation after generation until perfection to the full is achieved (*to gather small change* is a trademark of Dawkins that is a synonym of *gradualism*, a trademark of Darwin). Second: when problems are nested, solutions of tiny problems can be used as partial solutions of enlarged ones. Third: it is productive to select the best exponents of a generation to start a new one.

2.3 Lengthy algorithms

The fitness of a string in the program `Shakespeare4` measures the number of matching sites. This feedback makes it possible to gather small change, site by site. So, what must a problem have in order to be not direct, **lengthy**? All we need is to hinder gathering small change. As an example let us consider the problem in which one must guess a password. In this case, you have a perfect match else you have nothing. There is no possibility to gather small change. As we know, guessing passwords is difficult and that is why they form part of the modern industry of cyber-security. Now, to understand why, let us compare three methods to solve the password problem: by deterministic search, by randomness and by evolution.

For sake of easiness, let us suppose that the password number is binary of length n, something like 1001110. For a deterministic search, we can use a for loop. The number of trials ranges from 1 to 2^n. In average we have $\frac{2^n}{2} = 2^{n-1}$ trials. This problem is solved for binary numbers by randomness in program `RandomSearch` from Vol IV. The program is intended to show that randomness is very powerful and that actually it is almighty in a word of unlimited resources. But our world is extremely limited and here randomness gets rapidly frustrated. In fact, randomness can guess a number in the first trial but it can also fail until the end of time. That is why evolution has been sold by science as the obvious alternative to randomness, a propaganda that has been based on direct problems. Now, evolution is not better than chance to solve lengthy problems and the `Password` problem is enough to show it. Test this assertion with program `ChanceVsEvolution`.

Intrigue: Is there in biology lengthy problems? If the answer is affirmative, are they rare?

3 EVOLUTION AS A BIO REALITY

Astonishing as it might be, *GAs can be implemented with molecules.* In fact, the first artificial GA that was run on DNA was announced in 1994 (Adleman [1]. Nevertheless, GAs always have been running by nature over the DNA of every genome. Always.

Example: your black eyes are those of your maternal grandfather while your abundant blond hair is that of your maternal grandmother because the DNA of your grandfather recombined with that of your grandmother. At the same time, your bones are stronger than those of both mother and father because of a mutation in the DNA responsible for bone structuring. You resulted to be both handsome and bold and that is why you are so loved by girls.

So, what do we have here? We have here mutation and recombination along a ruthless environment that is ready to award your qualities and to chastise your defects by measures that augment else depress your reproductive potential. This is the renown biological evolution formally acknowledged by science since 1850 thanks to a field study made by Darwin in Los Galapagos Islands (Darwin, [8] 1859) plus a lead triggered by Mendel (Mendel [16] 1866) and that ended in modern Molecular Biology.

3.1 Evolution in the hands of a genius

We preach that evolution is as powerful as your imagination. So, it would be good to look at a *smart example*. The preferred one of the Author is that of the immune system to synthesize antibodies that defend us from bacteria, viruses and cancer. (NIH, [17] 2003). Antibodies have two parts, one constant, the other variable. The variable part is taken from a combinatorial basis and responds for the specificity of each antibody. The GA consist in the combinatorial basis plus the gluing procedure of the variable and constant parts. The used GA is very simple but it is startling because it is the inspiring example of the strategy of *using evolution to solve a problem one step off the solution.* Besides, the immune system uses the very modern `n-gram` technology to distinguish self from non-self (Wikipedia, [29] 2017). This technology is applied in `Program I22 English` of Vol IX to discriminate the language used to write a text, German else English.

4 EVOLUTION AS A THEORY

Evolution is strongly tied to Darwin. An important event in his life was the death of his beloved daughter Ann at age 10 (Wikipedia [30] 2017b). We adhere to the consideration that the ensued sadness impulsed him to change the faith in a God-with-us by a faith in an autonomous process dubbed natural selection that kills less fitted individuals and allows fitted to survive and reproduce. After that he published his *Origin* (Darwin, [8] l.c. 1859):

```
It is interesting to contemplate an entangled bank,
clothed with many plants of many kinds,
with birds singing on the bushes,
with various insects flitting about,
and with worms crawling through the damp earth,
and to reflect that these elaborately constructed forms,
so different from each other,
and dependent on each other in so complex a manner,
have all been produced by laws acting around us ...
Thus, from the war of nature,
from famine and death,
the most exalted object which we are capable of conceiving,
namely, the production of the higher animals,
directly follows.
There is grandeur in this view of life,
with its several powers,
having been originally breathed into a few forms or into one;
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```
and that,
whilst this planet has gone cycling on
according to the fixed law of gravity,
from so simple a beginning endless forms most beautiful
and most wonderful have been, and are being, evolved.
```

While this was written in 1859, the further development of the theory led to the postulate that there is no gap in within ordinary and living matters. So, we officially became sons and daughters of the dust of the stars. Additionally, GAs were formulated around 1950 following the model of natural evolution. Nevertheless, this was not a historical necessity because, as everyone knows by instinct, GAs derive from common sense, from ordinary life. By the same token, Darwin was not a historical necessity. In fact, *to invent the Evolutionary Theory is a must for everybody* if only we merge the following points:

1. GAs always have being running by nature around us.
2. Variants synthesized by natural GAs have different reproductive potential.
3. Our entrails are terribly similar to those of a hen.

After summing up we will exclaim: *We are here by evolution!* If besides we remember that mutation and recombination happen at random, we will reinforce the suspicion that God has nothing to do with us.

More explicitly, our *Evolutionary Theory would say*: mutation and recombination produce variants with diverse reproductive potential so, some individuals leave more spring than others while variability is being created. This process is repeated year over year and in the long run we have that from simple organisms the Earth has been filled in life with all the grandeur and richness that we see everywhere.

5 EVOLUTION AS SCIENCE

It is good to have thoughts but it is advantageous **to test ideas** if only this is possible. Now, *there are too much data supporting the Evolutionary Theory.* Let it be enough to recall that the DNA of a chimp and that of a human differ by no more than 5% (Britten [6] 2002). Now, if a lot of data supports a theory, is it correct? No, by no means. The situation is similar to a cousin that pretends to be your brother in order to share a part of your inheritance. He can bring you thousands of true facts to support his claim, family stories and partial-DNA studies included. But all we need to prove him wrong is to show that his DNA has long chunks that do not appear in that of your fathers.

By the same token, Java can help us to bring data that support the Evolutionary Theory but our great commitment is to show that Java is powerful to provide insight that allows us to see how false is that theory. Let us see.

5.1 The hand as test

The hand is so important for us that it is a natural election for a person that wants **to test evolution over a concrete and important trait**. At first sight, a hand is simple. In fact, to make one with pieces of wood and cords is a task for freshmen. Since it seems so easy, this becomes automatically a challenge for us. A portable solution is proposed in `Program M29 HandOnlyBoxess12` of Vol XIII. So, the human hand does not seem to be out of the scope of evolution that has as raw material the hand of the chimp (Young [31] 2003)). `Program M124 HandChimpHuman4` of Vol XIII proposes a cartoon of the evolutionary thinking. By the same token, *if we suppose that bones are evolvable* and if we already have a theory to explain the architecture and relative measures of the components of the hand, then evolution can fit those measures straightforwardly. This is illustrated by `Program M48 FossilRecord5` of Vol XIII. So, we ask: where is the theory? The intelligent answer is that the best theory is no theory at all because evolution is sufficient. This line of thought is exemplified as follows:

A finger with 3 phalanges and its corresponding metacarpal is similar to a tail. Thus, the simplest biological boned model of a hand is a tail that we oversimplified next to a broken line with 4 strokes. Our immediate purpose is to prove that evolution can reproduce the fact that almost all the vertebrae of the tail of a monkey have the same length. Our proof has two parts: first, we reformulate the problem as an optimization one and next we use evolution to solve it and to show that the corresponding algorithm is direct because the solution is arrived at just in front of own eyes. So, our optimization problem reads as follows: the tail must maximize the grabbing of cylindrical objects such as the arm of a tree. In a 2D cartoon, the tail must cover a circle allowing maximal grasping. Our guess is that this is accomplished when the space in within the circle and the formed quadrilateral achieves a minimum. We must observe a constraint: the number of bones is fixed.

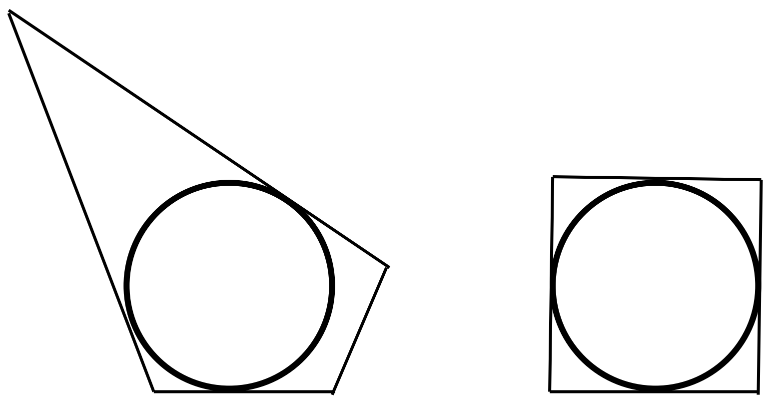

Figure 0. A tail with four bones can embrace a circle but the space in within the circle and the resultant quadrilateral might vary. Our purpose is to select the arrange with the minimal space in excess. We expect a square. Our guess is that this arrangement will favor the maximal grabbing of the circle by the tail that we idealize as a polyline with 4 strokes.

The code can be found in `program P73 EvolutionOfTail3` of Vol XV. It allows us to test our expectation. If we succeed, we have an invitation to formulate more severe tests to the belief that evolution is responsible for the approximate equality of the vertebrae of snakes, of the tail of monkeys and of the phalanges of the hand. Beware: we are assuming that bones are evolvable, i.e., that evolution can deform the shape of bones.

5.2 Evolution without purpose

When we assume that the hand has a function, we must face the accusation that we are humanizing evolution because the evolution envisaged by Darwinism has no purpose at all. What could be the meaning of such an accusation? `Program M63 FossilRecordd10` of Vol XIII might help us to understand it: some few random mutations of bones of the hand are given to operate in tandem.

We see that our machinery can produce complex structures similar to composed tails or fingers. Nevertheless, the Author considers that resulting structures naturally inspire the beholder to see potential weapons: axes, awls, hammers, and maces. Therefore, a prediction immediately springs: a trend towards sophistication of hands that are weapons by themselves must have arisen with a clear track in the fossil record. This prediction makes sense in the presence of a high doses of intelligence, both to understand that a hand can be used as a weapon and to exercise sexual selection. If intelligence is lacked, we can think of coevolution. If this is also lacked, the only thing that we can predict is too much variability. Nothing like that is found anywhere.

If coevolution of the brain and the hand is accepted, it allows us to study the possibility to consider that the hand has indeed a function for its owner and so, we can continue with the study of its evolution.

5.3 Adding realism

The human hand is a marvel that is more clever than complex (BBC, [4] 2014)) hence, we have plenty of suspicions that evolution is not its explanation. Now, this assertion is produced by an instinctive reaction. Our directive is that **instinct, common sense, and religious beliefs must provide the fuel for hard work that shall be addressed to output objective material**. So, let us continue in the quest for clear-cut falsifications of the Evolutionary Theory. In this regard, let us pay attention to a simple trait that differentiates human and chimp hands.

Human beings can write but chimps not. That is due to the fact that we have some muscles associated to the thumb that the chimp lacks. In principle, four muscles are necessary and sufficient to write: one that pulls towards the left, other to the right, a third towards the front and the last towards the rear. Now, chimps can take hold of arms of trees much as we, although their muscles of their thumbs are weaker. So, the chimp has two of the four muscles that would be needed to write, one that pulls towards the front and the other towards the rear. The hand of the chimp lacks two additional muscles to move the thumb to the left and to the right. Curiously enough, anatomists speak of three additional muscles instead of two (Young [31], l.c. 2003). Those muscles are: flexor pollicis longus muscle (Wikipedia [26], 2016a), the deep head of the flexor pollicis brevis (Wikipedia [27], 2016b) and the first volar or palmar interosseous muscle (Wikipedia [28], 2016c). The Author does not understand the role of that redundancy: if more than two extra muscles would be desired, four or eight would be a better figure. In general, it seems to me that our Community will need some 30 years of hard and wise work to mature its understanding of the hand. The procedure is to formulate hypotheses that could be calculated with Java. Example:

Duplication of fingers is a common mutation and so, most people know that there are persons with six fingers in their hands whose neural connections work perfectly but without independence. The author has no idea about the rate of duplication of separate muscles but no theory can convince him that such separate events cannot exist. Therefore, we will rely on the possibility of duplication of muscles together with a change in their insertion points. So, our stand reads as follows:

Dogma: Muscles can be duplicated and their insertion points can migrate. Moreover, all these changes happen at random.

Null Hypothesis: Random mutations that cause duplication of muscles and migration of their insertion points are the sufficient cause of the appearing of the human hand beginning from the hand of the chimp or of some related common ancestor. Natural selection of mutants for the sophistication of functions - throwing, clubbing, manufacturing and dexter use of tools- filtered mutants to end with the type of hand we enjoy now.

To fulfill our sacred duty of studying these null hypothesis has been found to be extremely complicated. Our glory is just to exhibit a demo that simulates random duplications and relocations of muscles. This is shown by `Program MuscleMutation3Portable2` that is a simplified version of program `P83 MuscleMutation3` of Vol XV. By looking at the demo, one tends to believe that if the human hand were the result of the evolution of the chimp, then too many malfunctional hands also should have appeared. Nevertheless, to make this observation into a mandatory prediction for fossils, we need as yet to determine whether or not the ensuing problem of selecting perfection is direct else lengthy. **This is an open task**.

This case of the hand shows that **to calculate specific predictions of the Evolutionary Theory** is an important part of our duty. But we can also **reason at a general level thanks to abstraction** that results from capturing specific properties that presumably dominate the scene in question. A proposal for our case follows.

5.4 The fundamental test

The exceeding perfection of life that goes on top of its overwhelming complexity constitutes **the fundamental test** that everyone has the duty to present to the Evolutionary Theory. In fact, the path to perfection is paved with suffering. Or, objectively, perfection is preceded by too many, myriads of non functional products that are followed by mediocre improvements that are ensued by imperfect and then by almost perfect solutions. Is that backed by every sort of malformations and malfunctions as in the fossil record as in living populations as in our own bodies?

The wrong answer is affirmative and is defended as follows: unicellular microorganisms were the first to appear. Then, a nucleus with membrane augmented complexity. Next, simple multicellular organism were formed. These were followed by fishes, reptiles, mammals, hominids and at last by man. This answer is wrong because a bacterium is a cell as perfect as anyone in my body. More to the point and according to science, bacteria have been tested during more than 600 million years but my cells during 4 millions only.

Now, let us notice that most babies along every species are living marvels. In the light of their perfection and complexity, this amounts to a severe falsification of the Evolutionary Theory. Now, can we dress our ideas in objective results? Yes, we can: the first step along the path from subjectivity to objectivity is to formulate models because they are precisely defined and so, can be studied and criticized by everybody. Let us look at 2 of them.

5.5 A parable of complexity

Below we will present an official model of complexity that might look too weird. So, let us present a very simple model that at last conveys the very same message than the official one. It is so simple that its general behavior can be calculated right in the head. Let us see.

Our first model of complexity was to guess a number: this model says simply that one can achieve any design by randomness and/or evolution but that we would need eventually too much time to see it, might be more than the age of the Universe. Many items of our bodies do not fit this model: we can suffer too much damage and nevertheless we can survive. We need a model that is compatible with both complexity and partial but not mortal damage. Our proposal is to consider the model problem of guessing an ordered set of k numbers of increasing length, say, 9, 14, 326, 5738, ... For this problem one gets a point if one guesses a number. So, the fitness function would take values on the set 1/k, 2/k, ..., k/k. This model predicts that functionality must grow in leaps from almost nothing to perfection but with long periods of ecstasy in within that are the longer the larger are the numbers to be guessed. Functionality is expected here to grow with great laziness from incipient functions to mediocre performance to almost perfection to perfection -if only time is unbounded. This model classifies as a parable because it is too subjective, i.e., it is not an abstraction of concrete facts of biology. What else do we have?

5.6 An official model of complexity

Let us depart from **an abstraction of biological function**. To fix ideas let us consider a biochemical function of the enzyme Hexokinase that catalyzes the reaction

α-D-Glucose + ATP $\rightarrow$ Glucose-6-phosphate (G6P) + ADP.

So, the function of this enzyme is to activate glucose that it could participate in exo-energetic reactions. Without this step there is no energy for many forms of life. We can use the language of mathematical functions to encode this biochemical function: to the input (alpha-D-Glucose , ATP) associate (Glucose-6-phosphate, ADP) but leave intact the rest of the world, Or, to any other input associates the same input. This last statement says that this enzyme is highly selective and so enables the on-demand formation of specific biochemical pathways.

From this we learn that biological function can be encoded in the language of mathematical functions and that every functional design in as elaboration of a generic proposition: do this (activate the glucose) but not that (activate or change anyhow something else). Let us notice that to the question Did you do this? one can answer yes else no, true else false. So, the phrase 'The Hexokinase catalyzes a phosphorylation reaction' is true, while 'The Hexokinase can phosphorylate fatty acids' is false. In general, any expression that can be classified as true or false given a reference set is called a **proposition**. True and false also are denoted T and F and as 1 and 0. These are appropriate to describe concrete events of nature.

One can generate **formulas** or compound propositions beginning from elementary propositions or variables or from other formulas by the use of logical operators:

- The NOT or negation operator: which takes one proposition p and produces the proposition denoted $NOT(p)$ or $\sim p$ that is false whenever p is true and is true whenever p is false.
- The AND operator takes two propositions p and q and produces a third one, noted $AND(p, q)$ or $p \wedge q$ that is true if and only if both of p **and** q are true.
- The OR operator takes two formulas p and q and produces a third one, denoted $OR(p, q)$ or $p \vee q$ that is true if one of p **or** q is true and false if both are false.

One can see that with the set of operators $\{NOT, AND, OR\}$ one has more than enough to generate all possible operators that take one, two or any number of inputs to produce one compound proposition. For that reason, we restrict ourselves to these operators.

Every proposition encloses a mathematical function that is per se a full description of the possibilities and restrictions in regard with design of useful crafts. Example: $p \wedge (q \vee (\sim r)) = AND(p, OR(q, NOT(r)))$ associates true to (true, true, *) that means p is true, q is true, r could be true or false. It also associates true to (T, *, F). It associates False to (F, *,*). We have calculated the output for all 8 possible inputs.

In general, we say that a proposition is **satisfiable** when we can show a truth assignment to its variables that makes the proposition true. We also say that the truth assignment satisfies the proposition or the formula. So, $p \wedge (q \vee (\sim r))$ is satisfiable - take (T,T,T). By contrast, $(r \wedge (\sim r)) = AND(r, NOT(r))$ is not because it is a contradiction, it always outputs F. A contradiction might represent do-undo cycles that so abundantly happen in nature. Example: a world to be ecological in the long range needs to undo everything that it does.

Anyway, the do and undo functions are separated in most cases as in time as in space and executed by possibly unrelated actors. That is why we center our attention over satisfiable propositions that represent doing, creating, designing. So, we define:

SAT or the satisfiability problem of mathematical logic consists in studying the assignment of truth values to the variables of a proposition with the purpose of making it true. SAT proposes a question in regard with a given proposition: Does this proposition is satisfiable? To answer YES you must show a satisfying assignment otherwise you must prove that all assignments evaluate to false.

We can perceive the power of SAT to capture complexity if we embed it into real life. To that aim, let us imagine that the chief declares that there is a bonus in big money if all persons fulfill their tasks as scheduled. Tasks are realizable but these demand effort and concentration. If the team consists of one or two persons, we have no problem. But if the team consists of three persons or more, the chief cannot deny that he is trying to win a lot of money at zero cost by manipulating the people with a void promise. If we reformulate this example for a group of 7 persons as a proposition, we get $p \wedge q \wedge r \wedge s \wedge t \wedge u \wedge v$, which is exactly equal to guessing the binary number 1111111. Now, to match by a deterministic algorithm a binary number with n figures one needs 2^n trials in the worst case. This is an exponential function that overgrows very rapidly. Say, $2^{300} > 10^{80}$ which is the number of atoms in the universe (Villanueva, [23] 2015). That is why both problems, guessing a number and SAT, are lengthy.

SAT is a mine of experimental possibilities. One is related to **conjunctive normal forms**, which are expressions of the form

$$(\sim p \vee q \vee \sim r) \wedge (\sim p \vee q \vee \sim r)$$

This formula has 2 **clauses** on 3 **variables**. The clauses are $(\sim p \vee q \vee \sim r)$ and $(\sim p \vee q \vee \sim r)$ and the variables are p, q, r. Conjunctive normal forms have satisfiable exponents, such as $p \wedge q$ which is true for the TT evaluation. And also have not satisfiable members such as $p \wedge \sim p$, which is a contradiction. Now, we can read the overall structure of these forms: the ANDS, that join clauses, represent restrictions: do this and that and that. You are not allowed to do whatever comes to the mind. But the clauses contain diverse options. This means that conjunctive normal forms represent as restrictions as complementary optional choices.

What do we lost if we restrict ourselves to the study of conjunctive normal forms? We consider that we lost not too much. Our reasoning goes as follows: the formula $p \wedge q \wedge r \wedge s \wedge t \wedge u \wedge v$ belongs in the class of conjunctive normal forms. Moreover, it is exactly equal to guessing the binary number 1111111, which is a lengthy problem. On the other side, the formula with just one clause and too many variables, like $p \vee q \vee r \vee s \vee t \vee u \vee v$ is almost a tautology because it gets true for all assignments except one: FFFFFFF. This means that conjunctive normal forms expand the world of complexity almost completely.

Conjunctive normal forms are important for us because they allow a more gradualistic fitness than SAT:

We redefine the fitness of a valuation as the number of clauses in the proposition that are satisfied by the valuation. For instance, if we have the proposition $(p \vee q) \wedge (\sim p \vee q)$, the fitness of the valuation TF, true for p and false for q, is 1 because with that valuation, the clause $(p \vee q)$ gets true while $(\sim p \vee q)$ is false. In the SAT semantics, the fitness should had been 0 because the whole proposition gets false with the given valuation. This new fitness induces the following optimization problem:

Max-K-SAT=Maximum K-satisfiability is the problem whose goal is to find an assignment that maximizes the number of satisfied clauses for a given conjunctive normal formula over N variables, where each clause contains at most K variables and each chosen variable can be negated. We see that a proposition is satisfiable if and only if Max-K-SAT ends with a valuation that satisfies all clauses, i.e. if the maximal fitness in the population is equal to the number of clauses in the proposition. So, Max-K-SAT extends SAT. But we have a gradualistic extension because the fitness can effectively take on intermediate values that lie in within the extreme ones. So, evolution is expected to outperform randomness when it is given the task to solve MaxKSAT problems. This means that the fitness function must increase after the initial generation that is synthesized by randomness. But, how much? With Program MaxKSATvsEvo one can test the following assertions:

- Randomness is very good to produce mediocre solutions. These appear in the first generation.
- Evolution is good to improve the mark of randomness.
- When the ratio of variables per clause is small the problem is lengthy for evolution because it becomes similar to matching the binary number TTT...T and progress comes in laps that are interspaced by ever longer periods of ecstasy. Otherwise the proposition is satisfiable and the problem is direct for evolution.

6 CONUNDRUMS

Have you saw a kid trying to use a hammer to intake water? Probably not. It seems that we learn very early in life that **no tool is good for everything**. This is another fold of complexity. Let us see now that evolution, being a real tool and not magical, has conundrums of primordial biological importance that it cannot solve. Else, cosmological time is needed to go beyond poor and mediocre solutions.

6.1 Evolution vs evolution

Let us study the following problem in which we cause **a head to head collision of evolution as a tool, an algorithm, and evolution as a theory** that says that the tool is almighty in the world of problems.

We depart from a tree T, calculate a distance matrix among its leaves M and use evolution to restore the tree T from the matrix M. The distance in a tree from one leaf to another is defined as the minimum distance along all paths that connect the two leaves.

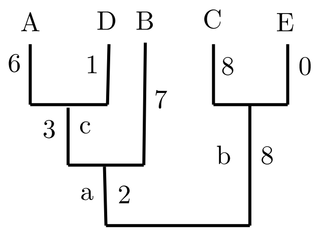

Figure 1. This tree shows that leave A is more related to D than to E. In fact, the distance from A to D is 7 while that of D to E is 19.

This problem is given to evolution in **Program K65 EvolFull10** from Vol XI. Our results are impressive: the Evolutionary Algorithm can solve the problem for 3 and 4 leaves but fails from 5 on. Now, why is this problem so difficult for evolution? Let us propose an explanation that goes along the previous graphic:

Depicted tree conveys information about the distances in within every pair of leaves, data that can be consigned in a matrix:

	A	B	C	D	E
A	0.0	16.0	27.0	7.0	19.0
B	16.0	0.0	25.0	11.0	17.0
C	27.0	25.0	0.0	22.0	8.0
D	7.0	11.0	22.0	0.0	14.0
E	19.0	17.0	8.0	14.0	0.0

Let us suppose now that the problem is to find the tree whose distance matrix is

`Target distance matrix`

	A	B	C	D	E
A	0.0	16.0	27.0	7.0	19.0
B	16.0	0.0	25.0	11.0	17.0
C	27.0	25.0	0.0	22.0	10.0
D	7.0	11.0	22.0	0.0	14.0
E	19.0	17.0	10.0	14.0	0.0

We see that we must match the values of all links of a tree. So, this problem is similar to that of guessing a number and so, we expect a lengthy problem. Some lengthy problems allow to gather change through the generations. But proposed program shows that when the number of leaves is greater than 5 the algorithm does not converge to the targeted tree and matrix. Why?

Let us suppose that we departed from the target matrix cited above and that we have arrived to the depicted tree of the figure with its corresponding matrix. If we compare the two matrices, we see that they differ by just one entry, the distance in within C and E. By looking at the depicted tree, one might naively think that the obvious solution is to change the length of the link to C from 8 to 10. This will indeed remedy the problem with the distance between C and E. But the price we must pay is that all other distances will change. Say, the distance between A and C will change from 27 to 29. And so on: every distance will suffer a change. This implies that every single change, tiny as it could be, will cause the error to increase.

So, the difficulty of posed problem is due to the fact that every change has side effects all around. This allows us to formulate a warning: one usually teaches that an optimization problem generates a landscape with peaks and valleys much as a landscape in our planet. But we see that the landscape associated with this problem is not constant. Rather it changes over every step much as it happens with a person that has to walk a slack high-wire.

The common sense example of this conundrum is the battle against death. It admits no treatment because of the negative side effects created by remedies and no-remedies alike. The same situation is found in genetics and carries the name of **pleitropy** and happens when one gene affects many traits. In our example of the tree, a gene is represented by the value of a link in the tree and the traits are the distances among leaves. Pleitropy was known to doctors since long ago because when one pleitropic gene fails a lot of problems arise as in the Marfan Syndrome (The Marfan Foundation, [15] 2014). The anti-evolutionary role of pleitropy is mathematically well established (Waxman and Peck, [24] 1998).

6.2 Evolution vs complexity

We have introduced two methods to create complexity: adding requirement over requirement, modeled by SAT, and to use pleitropy to entangle functions. We have argued that these methods are a terrible burden. But we also have seen that evolution is powerful. What could be the net effect of these two factors operating together over fossils? If we play with both factors shoulder to shoulder, complexity and evolution, we shall predict a huge amount of fossils amidst a lazy trend to increasing complexity. This is so self evident that it becomes a challenge for us. So, we have prepared a Java simulation in which worms must crawl up the screen. Initially they have just some few links but successful worms get enlarged by one link. This captures the power of evolution to increase complexity. At the same time, a synchronized work of all links is necessary to crawl up so, this problem is like guessing a number and therefore it is lengthy. Moreover, we have a process of fossilization that runs in background. Fossils can be studied a posteriori in order to answer a question: What is the proportion of perfect fossils that climb the screen to that of imperfect ones that do not? The code can be seen in `Program L112 WormsRandJFXa10` of Vol XII.

We must recognize now that **a model is no more than an idea**. But **science compares ideas with facts of nature**. So, let us work out some possible realizations of pleitropy in biology.

6.3 Living fossils

`Program N28 DisfiguredSphere2` of Vol 14 shows that mutation can erode shape immediately: not in vain the left and right sides of our bodies are always different. So, how is it that we human beings are all so similar one to another along history and continents? How is that possible? Our idea is to involve pleitropy as follows:

Shape in biology must be a natural byproduct of programmed reproduction, differentiation and death of cells. Now, the reproduction of cells is described by a tree: the mother cell is the root and its descendants form the arms of the tree. Let us assume that cell reproduction is equivalent to cell splitting so, our trees are binary. This representation of temporal events depicts a mother cell that disappears to give rise to two daughters. But if we pay attention to space events, a cell can give rise to many children that fill surrounding space. In space representation, reproduction would be best depicted by a tree with various children. The number of children may be supposed to be self regulated to fill in vacua.

On the other hand, our previous example of pleitropy resulted from the problem of fitting a tree to a distance matrix. Let us apply the very same model to ontogeny: the tree is given by cellular reproduction and the overall fitness function that depends on many interconnected traits is the shape itself that is possibly determined by the cellular interactions with the rest of the body.

To test the idea that this setting is a realization of pleitropy and that therefore it is a conundrum for evolution, we propose the following simulation: evolution is given the task of fitting a cube of size l by a tree. This must fill the interior of the cube as well as its boundary points for integer values. This simulates the ontogeny of a bone. Evolution does it directly for $l = 1$. For $l = 2$ evolution also succeeds although sometimes fails to do it immediately. Incredibly, evolution succeeds for $l = 3$. `Program N114 TreeToShapes17` of Vol XIV shows us that a perfect fitting is too ambitions for $l > 3$ so, one posits as task to fit a fraction of points, say 0.7. This is easy for evolution. But perfection is outside its scope: evolution cannot navigate freely in the space of trees that fit into a cube of side 4 or larger. This is our answer to the question: are bones evolvable?

Thus, pleiotropy is all pervading along biological shape if only shapes have some selective value. Now, we give a very high selective meaning to wings, the hands of birds, and so, we are happy when we see how they land. Nevertheless, we deny an important selective meaning to the shape of the human hand. Now, by looking at own hands, how perfect they are, one feels that our explanation is partial and that something else must exists.

6.3.1 The genetic code

A **living fossil** is the name given to a species that lives amidst us and whose first specimen appeared millions years ago (Waggoner, [25], 2013; Brasier et al, [5], 2006; Casane, Laurenti, [7], 2013). The most strange of all living fossils is **the genetic code**. In fact, the genetic code is at the bottom of everything that means life so, it is is used and reused everywhere and every now. As a consequence, it enjoys the highest possible degree of pleiotropy. So, our bet shall be that there is no variability of the genetic code. Nevertheless, this is blatantly false: the mitochondria and nuclei of human cells have different genetic codes (Elzanowski et al, [11] 2016) and various simulation studies show us that it is worth considering the idea that observed variants of the genetic code appeared by evolution (Ofria, [18] 1999). This is a fascinating theme for research that cannot be treated in isolation.

6.3.2 Enzymes and monomorphism

We abstracted SAT from the study of functions and we found it to generate as lengthy as direct problems. Nevertheless, SAT is simple per se: in the space of truth assignments one tries to answer the question: does a system that is described by a given formula have at least one useful property for design? So, our next step is to consider the evolution of functions inside a binary description (no generality lost). In this case, we are investigating the bounds of evolution in the space of formulae, which are filled in pleitropy because the same variables operate over possibly many clauses to build together a function. Now, formulae might represent mathematical functions that express both possibilities and restrictions for design. So, evolutionary implications are expected. Anyway, to sustain our claims we always need **systems that use and reuse the same set of interacting units to build great functional projects**. Biochemistry offers us the right example:

The epitome of function in biochemistry is given by enzymes. Pleitropy arises as follows: all enzymes have the same recurrent set of building blocks that are called amino-acids, around 20. Enzymes are encoded by DNA so, they are linear structures of, say, 100 amino-acids long. Thanks to molecular interactions with water and among amino-acids themselves, the linear polypeptides bend into spatial structures forming, say, globules. The enzymatic activity depends on this 3D structure and it is sensible to any tiny change. In fact, that instability allows the immense diversity of catalyzed reactions by enzymes, their highly selective power and also the control of their activity by ligands that may interact with the globule through, say, van der Waals forces (RCSBProteinDataBank [20] 2013; Freer [12] 2011).

So, do enzymes have the imprinting of pleitropy? Yes, it is called **monomorphism** and means that a given enzyme has no variability. Additionally, many cases are known of **conserved sequences** that are the very same through various species (UCBase, [22], 2013). But evolution is powerful enough to deeply surprise us: not all enzymes are monomorphic (Ridley, [21] 2004). Moreover, it seems that observed variants in **polymorphic loci** have almost the same functional performance. This was first observed by Motto Kimura in 1968, who was able to use this finding to formulate and calculate his *Neutral Theory* according to which *molecular evolution is mostly restricted to equivalent replacements over the background of sampling effects* (Allen Chen's Coral group, [2] 2000?).

Our words seem to imply that our war against pleitropy is a priori lost. That is not the case. Rather, we propose the following slogan: **to use evolution in design one must invent important problems that are one step off the solution**. This is actually possible and directed evolution is a fundamental method of modern enzyme design (Packer et al, [19] 2015). Now, what is the meaning of our slogan in this specific situation? It means to slightly deform an enzyme to catalyze a slightly different reaction that does not happen in nature.

6.4 GP (Genetic Programming): bugs over bugs.

DNA conveys various types of information. One of them consists in verbal receipts to build polypeptides, say, proteins. If we say algorithms instead of verbal receipts, we are saying that **the genome is software**. If we add that GAs can be implemented over DNA and that nature always have being playing with them to finely tune a species to its environment and to synthesize antibodies, we are saying that **evolution is a natural software developer**. The Evolutionary Theory now reads: *evolution is the software developer that is responsible for the software that enlivens all living beings.* So, this theory **predicts** that **evolution shall be useful to develop software**. **This prediction is true**. In fact, all human developers run in their minds a sort of evolutionary algorithm to develop software: from a possible humble beginning more functional complexity is added, tested, corrected and so on. The automation of this program is known as GP (Genetic Programming) which has produced fruits since long ago (Koza [14] 2007).

In its turn, Java has provided a solution that solves the problem once and for all: it comes with a method to convert a string into Java code that can be compiled and run. This is shown by Program R9 RuntimeCompilerExample of Vol XVII version 2. If you can do this, all you need to make GP is to evolve the encoding string to fit into your needs. Java provides various possibilities for GP including Clojure that is a language of the Java clan and that seems to be very appropriate for GP. So, we give for verified the mandatory prediction of the Evolutionary Theory that the evolutionary algorithm shall be useful to develop software.

On the other hand, **the huge variability, extreme complexity and exceeding perfection of living forms demand from GP to produce high quality software of whatever complexity and for whatever function**. This is a mandatory prediction. Thanks to Java it is testable. And what did happen? After too much work to get started, **one cannot see anything like that**. Instead the situation is similar to that found in the Antarctic: amidst the most severe cool, there are various research stations where you can find shelter, food, company, instrumentation and hard work. Very hard work. Likewise, we can enjoy today a relatively easy world in Java GP due to the efforts of many pioneers. So, GP is for people that love harsh adventures and that have too much knowledge and wisdom to fabricate tiny but important projects worth a PhD dissertation. Anyway, be ready to use supercomputing. In this regard, we can now assert that if the Evolutionary Theory is true then natural evolution has supercomputing powers (Gibney, [13] 2017). To be honest, its powers must be super-super computing. If someone thinks like this, let him or her play with `Program Q100 BinaryAdder3LH3` of Vol XVI that faces to a very simple problem: can evolution design a binary adder using evolutionary native operations?

Are you thinking that GP is too esoteric? Not really: since you use evolution to develop software, **your programs must be evolvable**, i.e., used style must facilitate evolution to higher functionality. Now, one can classify own style very easily by answering a simple question: can you understand your programs instantaneously when you come on Mondays to continue work? How difficult is to get close to this! But we have no other choice. Thus, make up your mind and be brave because you are not alone! Many people use to struggle with evolvability and have shared their experiences so, one have a lot to learn from them (Biel, [3] 2017).

Now, GP is a terrible, clear cut and immediate falsification of the Evolutionary Theory. In fact, software is built over use and reuse of the very same interacting elements to conform a great functional unit. So, slightly complex software must be pervaded in pleitropy. Explicitly:

The closest reality to every developer is that **there is no software without bugs whose correction creates more bugs**. Since GP is less efficient than human developers, it must produce still more bugs. This is actually so: a bug is just a proposal that does not match the target. And GP burns bugs might be for hours, days, and months to solve extremely simple problems. Now, nature runs GP on the DNA of living beings. This GP to be responsible for the existence of species must be accompanied with tons of bugs in the form of malfunctions and malformations as in the fossil record as in extant populations as in our own bodies. Nothing like that is found. End.

7 CONCLUSION

The excel quality of life is built over items that fulfill many requirements and whose parts interact to conform great functional units. We cannot exclude the possibility that evolution could make some great deeds in its battle against the arising complexity. But we can retro-predict with absolute certainty that if evolution were the cause of our existence, then the tracks of the ensuing evolutionary activity would be abundantly seen as in the fossil record as in extant populations as in our own bodies in the form of thousands of malformations and malfunctions. The reason is that the predicted type of evolution towards perfection, if any, should have gone in leaps with interspaced long periods of ecstasy. Nothing like that is seen. This is a clear-cut falsification of the Evolutionary Theory. But on the other hand, evolution is an ordinary tool to solve problems. The geniality, as shown by the immune system, is to invent clever problems one step off the solution and give them to evolution.

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