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# CONSIDERATION ABOUT THE EVOLUTION OF PERFORMANCES IN NATURE AND TECHNOLOGY

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## Abstract

The evolution of the human performances is made through leaps, the time periods for which it is made the approximation must be longer than the time between two performance leaps of the tested sportsman, but at the same time must not include more than three evolution bearing because the prediction for a too longer time can't be made. At present the scientific world is increasingly referred to the term evolutionary singularity related to the development of our civilization. There is the idea that in the period 2030-2050 we will be approaching the maximum of scientific and technological development that is currently evolving exponentially. This exponential increasing, accelerated, will change its evolutionary slope but it's hard to believe that it will complete abruptly near a point called the Wall of Complexity.

*Keywords:* performance, evolution, technology, complexity science

## 1. Introduction

The growing faster evolution of civilization became particularly evident in modern times. Moreover, in recent years we have literally become spectators to major changes occurring during only a generation [F. Munteanu, *Introduction in Complexity Science*, online at: www.complexity.ro]. There are also significant changes taking place on the level of each area of human activity: in the early 1990's began a sharp increasing in the processes of globalization and interpenetration of economies and cultures. This manifested in the rising level of civilization and the increasing standard of living, witnessing an exponential growth of world population, energy consumption, accumulation of manufactured products and increase the level of scientific informations. To the extent that such development is linked to the cost of energy and other resources, it is clear that in time they will be exhausted or will be more difficult to be procured. On the other hand, if the evolutionary trends persist, scientists announce reaching a critical situation at the economic level but also social, with strict reference to the value system that determines human activity, biosphere's instability, the emergence of

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unstable macroeconomic environment [F. Munteanu, *Introduction in Complexity Science*].

The movement of environmental bio-components is made in large spaces, so-called ecosystems, which have a space-temporary character. Here, whatever evolution of movement over time, the rest states are very relative; the overall movement par excellence is of transitory nature, with reactions stimulated by the nature of the information received. In addition, water and air, without which there can be no life, are the main physical non-biotic components of the environment, as well as being carriers of information. The temperature of system is in constant change, the relative state of permanent regime being not only a situation of transition from one variable movement to another, depending on the complex factors involved. Therefore, a special attention should be paid to non-permanent phenomena. The thermal information propagates in different three-dimensional environments which interact, that make the effects to recover on variable distance. To this is added the fact that the diffuse propagation of information is made much slower compared to other types of phenomena. By extension, meaning that the current line (or field line) can be estimated to be the propagation line of information, then the flow represented as amount of fluid particles crossing a living section in unit time can be defined as information flow, equations of motion are equations of propagation of information, potential movements can be considered as falling within the (potential) propagation systems of information.

## 2. Elements of Complexity science applied to performance evaluation

Complexity science studies complex systems that are defined by several attributes:

- Sensitivity to initial conditions: the evolution of the system is dependent on the small inherent differences in reproduction of an experiment; small initial fluctuations can increase over time, indefinitely long. It follows the principle difficulty to reproduce an experiment and thus inability to cumulate empirical data to identify a causal link.
- Self-organization: the spontaneous ordering and not predictable phenomenon generated by interactions between quasi-identical systems that involve installing the critical state in which small disturbances can trigger major effects. It is difficult to identify a 'cause' when it shown a major change (it may be due to very small disturbance of a different nature or to essential external causes). Such a process depends on a previous generation phase, specific and non-reproducible, phase in which a system accumulates 'history' and thus are individualized. It is clear that a causal approach becomes difficult.
- A complex system is defined by its structure. Mainly not to be analysed by breaking down into parts.

From the above it follows that a classical approach is inadequate and therefore need to develop a specific methodology to address, dedicated to understanding and using of complex systems. We can say in conclusion that complexity study allows the development of new concepts, methods, models, valuation techniques and technologies being extremely useful in overcoming the limits imposed by the current paradigm [F. Munteanu, *Introduction in Complexity Science*].

Chaos theory is a research area for studying the behaviour of dynamic systems, which are sensitive to initial conditions. This sensitivity is popular called 'butterfly effect'. Small differences in initial conditions (such as those due to numerical rounding errors), lead to major differences for chaotic systems in general, impossible to predict. This happens even though these systems are deterministic, meaning that their future evolution is fully determined by their initial conditions. In other words, the deterministic nature of these systems makes not its predictable. This behaviour is known as deterministic chaos.

Chaotic behaviour can be observed in many natural systems such as weather predictions. The explanation of such behaviour can be found by analyzing a mathematical chaotic model, or by analysis techniques such as Poincaré maps.

A typical application is in Ecology and biological population prediction. The equation would be simple if population increases indefinitely, but predators and limiting food sources make this equation to be complicated. The simplest equation, that takes into account this, is:

$$X^* = k \cdot X\,(1 - X) \tag{1}$$

In this equation, $X$ is the current level of population (a number between 0 and 1) where 1 is the maximum possible population and 0 represents extinction of that population, $X^*$ is the population in next year, $k$ is the rate of growth. The question is how this parameter affects the equation? The answer is clearly that a high rate of growth means that the population will decrease if the current level is high. Same discuss developments in an individual sport performance. If growth rate is a low value the development, which falls initially on a curve, undergoes a bifurcation when the growth rate passes a certain value. Each of the two bifurcations divide themselves for a certain level of the parameter analyzed so the number of development opportunities increases. Bifurcations occur increasingly more often until chaos. Over a certain growth rate is impossible to predict the behaviour of the equation. However, at a careful analysis, one can see white bands. Looking more closely at these bands we see little windows of order.

Feigenbaum assessed the rate of occurrence of bifurcations. He found that they occur at a constant rate, calculated as 4.669 [1]. In other words, he discovered the exact scale at which the self-similarity occurs. The same scaling factor was found in other situations, so the whole class of mathematical functions behaved similarly predictable. This universality would help the analysis of other chaotic equations.

## 3. Modelling the evolution of athletes performance during the training periods

It is known that the leading ambassadors of Romania abroad are athletes who achieve outstanding performance in most sport areas. These performances are due to an outstanding work in training hours under the supervision of top class coaches. However, most people working in high performance sport area raise the question of equipping the training spaces with testing and working technique in line with the pursued objectives in the physical training of that sport.

As in any field, also in sports there is a need of introducing new techniques, computerized, on testing and controlling the work activities of athletes. This paper is a correlation between areas of interest that intersect in that it opens horizons of research for specialists in sports through studies and researches of engineers in the field of computers and instrumentation.

The developed systems lead to carry out research on the development of systems that are based on virtual instrumentation, systems using acquisition boards for signals from sensors, transducers and digital video cameras, and to develop powerful software that should provide the necessary resolution of optimal determinations of the monitored parameters. The study of technical possibilities to achieve the proposed equipment is completed with software allowing optimal extraction of information about the fairness of movements made by the athletes. Along with problems to be solved, the equipment allows new perspectives in research in sport.

At present, a particularly importance in athletes' training for performance is the aspect of analysis and synthesis, evaluating a variety of factors that directly or indirectly affect the sportive training process at different training stages.

In this context scientific research grants a possibility to obtain objective information from the application of different tests that determine the level of somatic, functional, psycho-motive, psychological, etc. development.

Forecasting the evolution of human development is a way of knowledge, directed to the formulation of future prediction based on analysis of its development trends [2]. This estimation has a special significance and requires solving the following problems:

- selection and orientation of athletes capable of achieving the highest performance in the contest;
- highlighting the physical and mental preparation;
- study the conditions for conducting future competitive activities;
- determination of the satisfactory sporting result for victory and the establishment of the training features;
- forecasting the possibility to obtain sporting results.

Most mathematical models that have registered the progress athletes training require a quantification of the evolution of performances in as many terms. The collective goal is to identify the full scope of parameters to be taken

into account in an athlete's performance evaluation, and also the mathematical methods that can be used to model the relationship between training and performance.

Athletes are evaluated periodically in terms of results achieved in sport in which they evolve, but such methods fail to fully express the level of training. The literature recommends psychological and physiological testing, but not determining the impact that these results have on the full training of the athlete and the influence of these performances in the future evolution in a training program.

There are research collectives that apply the systems theory to analyse the responses to physical training. The athlete's strain-impulse response involves a specific training program management characterized by an excessive number of performance tests. Another preoccupation consists in using of artificial neural networks that allow a more precise description of the nonlinear evolution of the training process. And they are limited by the large number of data sets needed to achieve the desired mathematical model. Some of these methods cannot provide useful information on the relationship between training and performance. A number of alternative mathematical approaches, such as variance analysis and methods of chaos theory, may be viable alternatives of athletes' development modelling.

For the scientific validity of the topic, the authors considered necessary to study literature dealing with this topic. There were found a whole series of bibliographical sources, of the authors from country and abroad (treated, dictionaries, lectures, monographs, bulletins of Romanian Federation of Athletics, Romanian Federation of Swimming, Romanian Federation of Volleyball, magazine articles of pedagogy, textbooks, etc.). Many of these papers were presented as translations in the documentary sector of Research Centre for Physical Education and Sports in Bucharest. The studied authors have treated in their papers and study how to test the somatic, functional, psycho-motive, psychological capacity.

Currently, the problems regarding the sporting training cannot be achieved without the application of different modern technologies, which provide the possibility to obtain the most objective and useful information on structuring and improving the training process. Information technology for evaluation must be based on precise mathematical models. At present, there are possibilities to apply the computing technique to manage the whole process of training and testing of athletes of different age groups. The feature of a test set out by definition is that it has to behave a certain technique for success or failure evaluation, in the aim to let the numerical notation of success.

Today models are widely used for solving problems of theory and practice of sport. Effective management of the training process is possible only with the use of mathematical models of increasingly complex [http://fan.lib.ru/z/zharow_a/2050buduschee.shtml]. The models used in sports are divided into two basic categories: models that characterize the subject in competitive activities and those used in various periods of sports training (e.g.

morpho-functional models reflecting the morphological features of the human body). A separate category is that in which are included the models that reflect the continuity and dynamic of sports performance in short, medium, long and very long term. General models reflect the feature of the object or process and have on base the study of a large group of athletes grouped by sex, age, and weight and practice a particular sport.

Group models are based on a study of the whole (or team), being different depending on the sport. Individual models are developed for each sport in hand, and are based on data from the entire period of individual training of the athlete and its reactions to different applications [http://fan.lib.ru/z/zharow_a/2050buduschee.shtml].

Athlete's performances are measured by periodic tests. Based on these tests, we can draw conclusions on how the player responded to a specific training program, to the preparation process parameters that can be amplified, to the level of accumulated fatigue. To extrapolate these data for monitoring the future progress of the athlete and to anticipate some aspects of its preparation, must find a law of development, therefore a mathematical function for extrapolation of data. This forecast may be for one or more tests, in the midst of training, that to allow drawing conclusions on the effectiveness of the program used by that time, so that the evolution in the second half or the end of this period to provide the results expected or maximum possible.

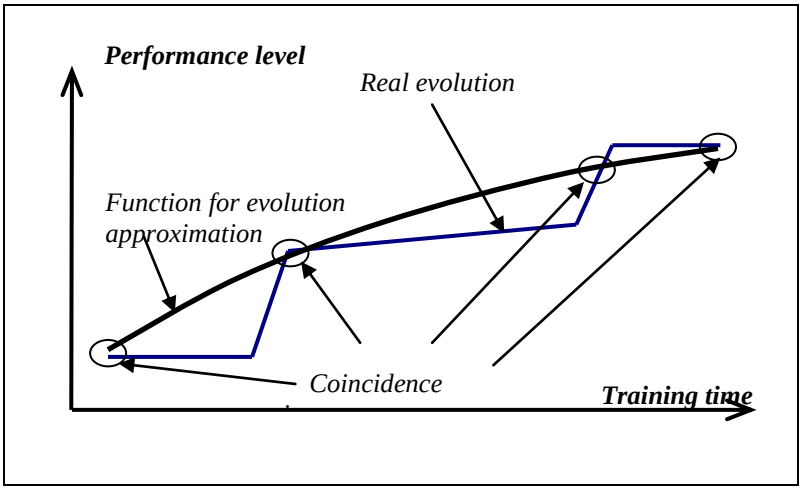


**Figure 1.** The evolution of the human performances.

Knowing that the evolution of the human performances is made through leaps (discontinuous functions, with variable level thresholds that appear at different moments of time for the same sportsman and with variation difficult to analyse from a person to another), the time periods for which it is made the approximation must be longer than the time between two performance leaps of the tested sportsman, but at the same time must not include more than three evolution bearing because the prediction for a too longer time can't be made.

Because the evolution step functions cannot be approximated it is tried the approximation used continuous functions that coincide with the evolution functions at the edges of the approximation interval and in another maximum two points chosen into this interval (Figure 1) [3].

The challenge of scientists in terms of complex systems is to find the simplest equation describing the system behaviour. The evolution of biological systems is a non-exponential if one analyzes the evolution of alive until this moment. The same law seems to govern also the human performance and thus of the athletes. But graph evolution cannot increase exponentially tending to infinite. It is characterized by an inflection point that gives for function the shape.

A slower growth after one point of inflection (singularity) is a period of stagnation, marked by coercions and conflict situations but indicating the proximity of a time that switches suddenly the system to another evolutionary level. The 'singularity' point does not mark the involution or stagnation in all respects. It is only the point where the speed of evolution is at its peak and will decline gradually in the next period. V.G. Sibiriakov said: „If the system has exhausted its resources for evolution, it will turn into another system which has the same primary function. It is expected that this new system to be the first or second stage of its evolution." [http://www.trizdiol.ru/subPage/ru/Library/] Such a transformation produces a new system, which has more development resources than the original system.

When referring to developments in contemporary human society consumption we find a complete exhaustion of the biosphere within the next few years [2]. Calculations indicate the coming out of this moment after a maximum of 20 years. However, little can happen. Such evolutions can be compared also with the ability to increase performance of a living organism when it enters learning or training program as will be seen below.

A.D. Panov did some research on accelerated development rates. To understand the processes taking place he uses the concept of attractor, which is defined as the trajectory in the space of states of a system around which all real trajectories are located and often coincide [http://fan.lib.ru/z/zharow_a/2050buduschee.shtml]. A history attractor is a model around which the actual trajectory points fluctuate. It can be said, that all previous history of human performance follows an attractor characterized by a similar self-acceleration regardless of historical periods. Thus, on a states graph, the evolution can be described by the equation:

$$t_n = t^* - T / a \cdot n \qquad (2)$$

in which $a > 1$ is the coefficient of historical time acceleration, which shows the reducing of the duration at each subsequent period, compared with the previous period. $T$ is the duration of whole time interval, $n$ is the number of the period evaluated, and $t^*$ is a given point in time that can be called the singularity moment. It is easy to see that if n approaches infinity, the sequence $t_n$ is arbitrarily close to the point of singularity $t^*$, without overcoming it. The intervals between crises, around singularity points, tend to zero while their

density is infinite. So, close to the point of singularity, the system is characterized by increased instability, marked by crises and periods of change, tending to an evolution of different type. It is the time when an athlete must change to a higher category, to address differently the training program, changing the quantity into quality at physical, motivation and also intellectual level. It is important to note that passage through the point of singularity does not mean an imminent disaster for an individual but a significant evolution.

Natural evolution is an initial exponential stage but that cannot go on indefinitely. After an initial part with exponential evolution occurs an inflection point that gives to evolution graph an aspect similar to letter *S* – typical sequence of system evolution according to its age. The graph aspect is still clearly influenced by environmental features and evaluated performance (Figure 2).

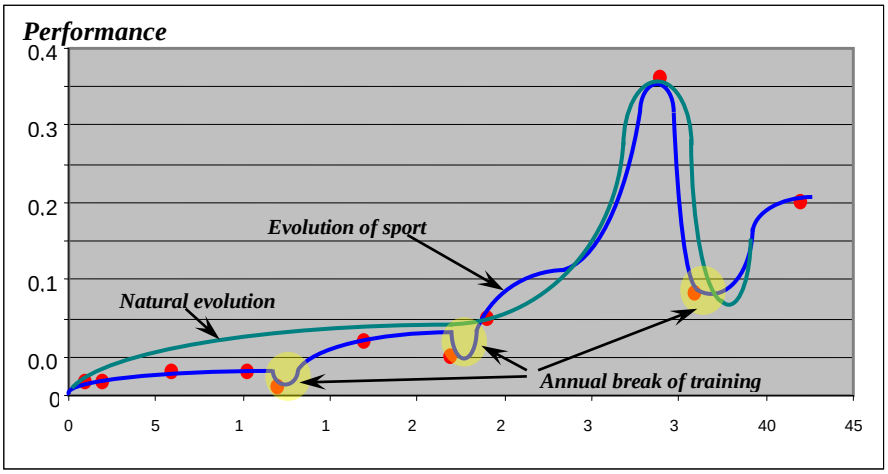


**Figure 2.** Approximation of the athletes evolution.

Raymond Pearl (1879 - 1940) developed mathematical tools of qualitative analysis for evolution processes over time of a complex system (biological). No real system is able to grow exponentially because there will be a moment characterized by its depletion. For example, the evolution of performance could increase exponentially only a certain period of time after the law:

$$dN = r \cdot N \cdot dt \;\; = N_0 \cdot e \cdot r \cdot t \qquad (3)$$

where $N_0$ is the initial performance, $r$ is the proportionality exponent and $t$ is time, which passed from the initial time.

Then, the evolution equation will take the form:

$$dN = r \cdot N \cdot [1 - (N/k)] \cdot dt \quad \text{or} \quad N = k / (1 + e - k \cdot r \cdot t) \qquad (4)$$

When $N$ is much smaller than $k$, the term $N/k$ can be neglected and obtain the relation (1). However, when $N$ approaches the peak value ($k$), the term $N/k$ tends to 1 and consequently the variation of $N$ ($dN$) tends to zero, so the value is stabilized around that value corresponding to the value $k$. Curve characterized by this equation, and the equation itself has many names: curve *S*, saturation curve, logistic equation, Verhulst-Pearl curve, Volterra equation. In addition, there is the

possibility that a system is maintained at a stable level and then to self-destruct. The only question is when will happens it: immediately or after a period of time exceeding significantly the evolution duration. The second alternative is possible if there are no solutions that offer new choice and structures. Therefore, in preparing athletes, quality jumps or changes may occur that would place the individual on the other levels of performance. Generally, these jumps must occur during the period between the training cycles.

Psychological training of the young athlete should ensure a balance between depth understanding of their problems and a sentiment of empathy towards the weak and disadvantaged. The athletes are mostly psychological influenced in competition. The social systems of moral education must have a component oriented on knowledge, on the formation of appropriate responses (logic and intuition) and to be able to relate to certain events and facts to keep unaltered mood. There are also quality transitions during which structural units return, in a new level, superior to the existing one.

## 4. Conclusions

At present the scientific world is increasingly referred to the term evolutionary singularity related to the development of our civilization. There is the idea that in the period 2030-2050 we will be approaching the maximum of scientific and technological development that is currently evolving exponentially. This exponential increasing, accelerated, will change its evolutionary slope but it's hard to believe that it will complete abruptly near a point called the Wall of Complexity.

To predict performance in competitive sports the results of subsequent evaluations during training period are used. Based on this analysis, starting from the potential possibilities of athletes, tests planning is done. It is interesting to analyse how these results of periodical verification are correlated with the competition results on the basic test.

The evolution of sports performances was evaluated using a graph designed like a phase space in which is represented the progress of each athlete in a period between two successive tests. In such a representation one will not notice a constant linear dynamics performance, but a oscillating one in different level jumps.

The chaos theory perspective would also allow sport scientists to return to the study of phenomena on a human scale by providing researchers a macroscopic approach to understand complex systems. Individual parts of a system would no longer have to be studied in isolation because the chaos method of discovery is capable of measuring and plotting an unlimited number of variables over time. Perhaps this approach will help us better understand complex sport behaviour [2].

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## References

[1] M. Lyubich, Annals of Mathematics, **149** (1999) 319–420.
[2] G. Rata, E. Rata and M.R. Milici, Electronica ir Electrotechnika. T115 (Medicine Technology), **1** (2010) 73-76.
[3] D.L. Milici, *Computerized System for Testing and Formation the Speed of Backward Push of Sportsmen*, Proc. 13th International Symposium on Measurements for Research and Industry Applications, International Measurement Confederation IMEKO TC4, Athens, 2004, 673–677.