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Elements of Complexity Science in the Computer-Based Assessment of Athletes' Performances

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Introduction

Beginning from the history of sports performance forecasting technology, men were always fascinated of the possible evolution of records and of the performance marginal limit.

In the past, people did not even take notice of progressive evolution. Now it is difficult not to notice it. Every adult, during his own lifetime, has been able to observe the appearance of personal computers, the Internet, and cell phones, while practically anyone who wants to do so is able to own his own automobile, and so on.

Sociologist M. Sukharev, in his work, "The Explosion of Complexity," presents the sequential steps of these changes: "There is one more pattern that is evident in societal development - the acceleration of growth of complexity with time. For tens of thousands of years tribes lived on Earth armed only with spears or bows and arrows. In several hundred years we have leapt through industrial technological civilization. It is unclear as to how many years the computer era will last but the current speed of social evolution is unprecedented."

In this article, on the basis of analysis of extensive scientific and factual materials, a hypothesis will be formulated providing answers to the noted questions and allowing predictions to be made for both the immediate future of the evolution of the sports records as well as the general direction of evolution in the far distant future.

For some, chaos and catastrophe is a science of process; a new way of thinking; a return to the study of phenomena on a human scale [4]. For others, the essence of chaos theory is the mathematical model used to formulate "strange attractors", "fractals", and "phase space." In our attempt to integrate chaos theory into the field of sport performances, both of these doctrines will be examined.

As one of the most dynamic social activities, sport aims at human being's shaping and developing. This justifies specialists' interest in periodically perform-forecasting analyses which can identify the evolution trends. We are mainly referring to the high-performance sport which has a continuously increasing social role, a phenomenon that determines some specialist to state that the acme will be followed by a crisis or an imminent decline (A. Dragnea, 1993) as it happened to Ancient Greece.

Forecasting the evolution of human development is a modality of knowledge, focused on elaborating predictions based on the development trends.

This estimation has a significant importance in solving the following issues:

- the selection and orientation of athletes who are able to achieve the peak performances during the contest event;
- to emphasize the physical and psychic training;
- to study the conditions for carrying out future sports activities;
- to determine the sports target result required for winning a competition and establish the features of sports training;
- to predict the possibility to accomplish certain sports results.

The starting point of this study was the assessment of the psycho-motor ability of junior athletes at the control test and the contest event by using the correlation methods for the continuing development of the methodology of training process.

About evaluated sportsman performances

The "model" and "modeling" notions reached deeply in the sport theory and practice. The functions (cognitional, cultivational-educational, instrumental and normative), accomplished by the models used to solve the problems of the sport theory and practice, can have various characteristics. The efficient management of the training process is coherent with using of various models.

The models used in sports are divided in two basic categories: in the first there are included the models which characterize the structure of the contest activity namely those that hint at various aspects of the sports training, the morpho-functional models, that reflect the morphological particularities of the human body, therefore assuring the reaching after the level requested by the sports performance. In the second category there are included models which reflect the continuity and the dynamics of the sports performance establishing and of the short, medium, long and very long time plane planning and the models of various training exercises with the foresight of their complexity [1].

The general models reflect the characteristic of the object or of the process, obtained based on the study of a large sportsmen batch having an exactly gender, age, weight and which practice a certain kind of sport.

The group models are made based on a study of a sportsmen ensemble (or team), being different through a specific index in the category of each kind of sport, for example: the models of the “pass in five” technical-tactical actions at hockey, the models from the contest action of the wrestler and swimming etc.

The individual models are elaborated for each sportsman in part and these are based upon the data of the long researching of the separate training of the sportsman and upon his reactions to various tasks, etc.

The sportsmen performances are evaluated through periodical tests. Based upon these tests we can draw conclusions referring to the way in which the sportsman answered to a certain training program, to the parameters which can be increased, to the accumulated tiredness level. To extrapolate these data in the sight to aim at the next evolution of the sportsman and to predict some next performances it must to find an evolution law for values controlled periodically till a certain moment. This prediction can be made for one or more tests, at the middle of the training period, so that the evolution from the second part or from the end of this period could be instituted, in order to prepare the new training program.

From the specialized literature results that the sports forecasting problems centres round the using of the various forecasting methods (extrapolation method, modeling method and examination method). The forecasting made using the extrapolation method allows to form the sports results on the hierarchical system on the basis of the study of some adequate laws from the previous period. The forecasting accuracy can be right if the forecasting period is shorter and if the data are more.

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 analyzed from a person to another), the time periods for which the approximation is made 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 which 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 (Fig. 1) [3].

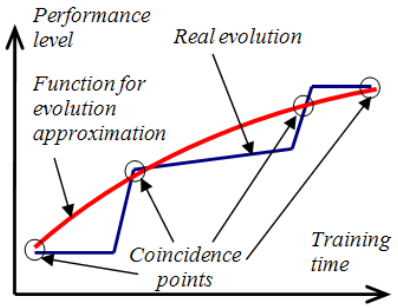

Fig. 1. Two points

Analysis of junior athletes’ performances

The basic tenet of chaos theory is that simple systems with simple laws can result in complexity [7]. Thus, all complex systems are comprised of simple laws that determine its behavior. Something is determining the behavior of the system. The challenge of the chaos scientist is to identify the simplest rules that determine the behavior. The key is to discover the equation ruling the system's behavior.

The acceleration of both biological as well as human evolution rates has long been noted. One of the founders of evolutionary paleontology, V. O. Kovalevsky, in a letter to his brother dated December 27, 1871, wrote, "The fact of acceleration of the progress of life, so to speak, is interesting; more time passed, of course, from the Laurentian to the Silurian periods than from the Silurian period to the present epoch; each subsequent major Earth period is shorter than the previous one, and in this short time, more diverse forms of life had time to come into being and become extinct than in the previous era; beginning with the Tertiary period, life has been hurtling along at full speed ".

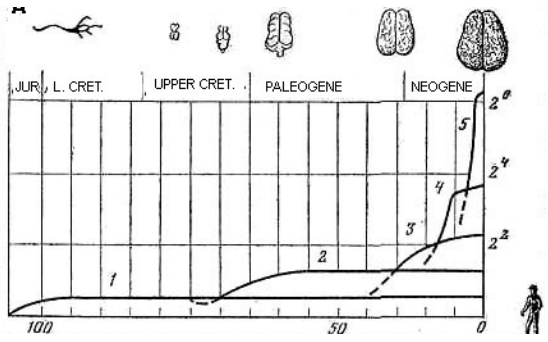

Fig. 2. Animal cephalization stage – graph evolution (*Balandin 1979*)

The frequent occurrence of both a widely known dynamic, characterized by a logistic *S-curve* (Fig. 2), as well as its combination with an "exponential decrease." But on what does it depend - in a combination or without a combination "with a decrease?" Apparently, it depends on the subject of research. That is why a "decrease" is a

special event for us. In pure processes, after the *S-curve*, there may take place not "an exponential decrease," but a decrease on a reflective expanded *S-curve*, moreover either immediately or after a very long period of time (for example, see the graph shown above of the evolution of man's intellectual capabilities during his life). In other words, these are the varying directions of independent processes [6].

The point of "singularity" is not collapse at all. This is a point on the evolution graph in which the speed of this evolution itself is at its peak. How can this be combined with peak growth rates? In the work of TRIZ expert, V.G. Sibiriakov, "Crisis Design: The Road to Success," we read: "If the system has exhausted the resources of its development, integrate it with another system which has the same principal function. And it is preferable that the second system be younger and at the first or second stage of its own evolution. Such integration produces a new system, the development resources of which are much larger than either of the original ones (by definition). It is clear that even if we just combine these two curves in a graph we will get a qualitative leap" (Fig. 3).

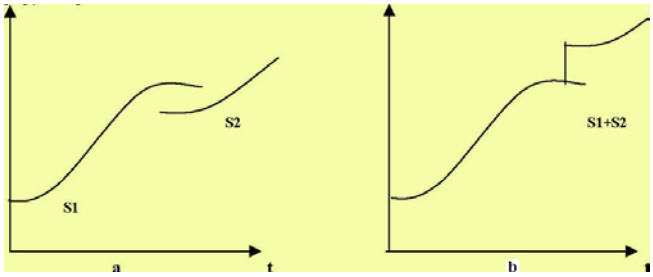

Fig. 3. Models of evolution (*A. Zharov*)

The conclusions from V.G. Gorshkov's article, "Limits of Stability of the Environment," (USSR AS Reports, 1988, volume 301, No. 4, pp. 1015-1019, pub. Nauka) are: "If today's proportion of human consumption (7%) is maintained and a halt in economic growth occurs, a complete depletion of the biosphere and deformation of the environment will occur in several hundred years. If today's economic growth rates are maintained this should take place in the latter half of the next century."

Such evolutions can be compared to the ability of enhancing the performances of a living organism once this organism joins the learning and training program as described below.

To create a model, each variable is plotted on its own dimensional space over time (known as "phase space" in chaos language). Each point in phase space represents a complete description of the system in one of its possible states [8]. By connecting the plotted points, a model or pattern of the overall behavior of the system emerges. When the pattern emerges, it is considered a strange attractor. Thus, at any moment, chaotic systems are either flowing to or temporarily maintaining an attractor state [9].

In order to assess the curve of human performances in sports, the results of the junior athletes of the C.S.S.–S.C.M. Bacau, Romania, aged 15 to 18 years and competing in the 100m race, were analyzed throughout a period of 43 months. The sports performances have a different dynamic evolution for each individual, therefore it is impossible to establish a generally available pattern. For drawing the conclusions and assessing the dynamics of performance in time, the average values of progresses for three groups of athletes (Juniors I, Juniors II and Juniors III) were analyzed (Fig. 4).

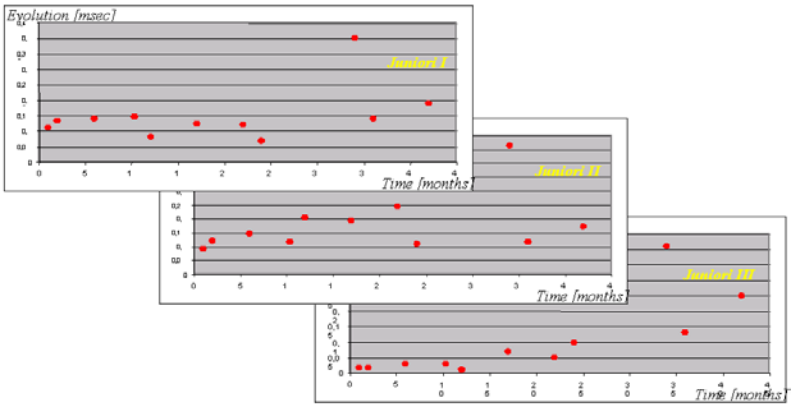

Fig. 4. Graphic representations of evolution for each group of athletes

From the graphic representations in Fig. 4, it can be noticed the quite similar answer of the athletes at the imposed training program. An interpolation of results obtained by the Junior III athletes is represented in Fig. 5. The graphic approximations present an interpolation by means of spline functions of the intermediary results registered for this athlete sample (blue curve), and an approximation curve from which the annual breaks of the training cycle were eliminated (green curve).

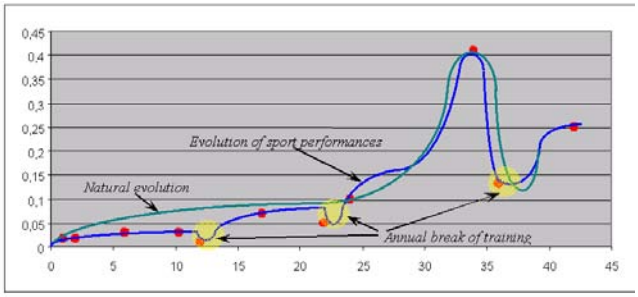

Fig. 5. Approximation of athletes' evolution throughout the training period

Conclusions

The evolution of sports performances was assessed by means of a graph in analogy to the phase space in which the progress achieved by each athlete between two consecutive control tests is depicted. The graphic representation reveals the dynamics of performances which doesn't have a constant and linear evolution but an evolution in leaps with oscillatory and various values.

As far as the evolution of results is concerned, the major leap is achieved during the 3rd year of training. This could be the reason for establishing a two-year training period for each category of junior athletes. Even if there are significant individual differences between them, each junior athlete accomplishes this important performance leap during the 3rd year of training. The progress certifies that the training program was tailored to each athlete's needs. It is recommended to identify a training program able to lead to this major leap as soon as possible, thus the athlete to establish sports records in his or her category.

The curve of evolution for the high-performance athletes and the leaps in living organisms' evolution (Fig. 2) are very alike but on a different time scale. The pattern of characteristics respects the particularities of chaos theory and catastrophe theory of Complexity Science, a fact which leads to the idea that it is possible to forecast the sports results for a certain athlete if his or her training program matches the psychomotor performances of an individual.

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 understanding 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 behavior.

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Г. Рата, Е. Рата, М. Р. Милици. Компьютерная оценка состояния здоровья атлетов в сложнейших ситуациях // Электроника и электротехника. – Каунас: Технология, 2010. – № 1(97). – С. 73–76.

На основе экспериментальных исследований предложены гипотезы о состоянии спортсменов. Это позволяет определить критические состояния, когда нагрузка происходит скачкообразно. Установлено, что осуществлять прогноз после трех скачкообразных состояний невозможно. Ил. 5, библ. 9 (на английском языке; рефераты на английском, русском и литовском яз.).

G. Rata, E. Rata, M. R. Milici. Atletų būklės kompiuterinio vertinimo mokslinis sudėtingumas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 1(97). – P. 73–76.

Nustatyta, kad, remiantis moksline literatūra ir gautais eksperimentais, bus galimybė suformuoti hipotezes, leidžiančias atsakyti į žinomus klausimus, bei prognozuoti būsimas būklės tendencijas. Žinant, jog žmogaus būklė kinta šuoliais, siekiama, kad šių šuolių trukmė būtų ilgesnė nei laiko skirtumas tarp testuojamų sportininkų šuolių. Daugiau nei trijų būklės šuolių prognozuoti neįmanoma. Il. 5, bibl. 9 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).