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DEVELOPMENT OF COMPUTER TECHNOLOGY AND CLASSICAL SCIENCES

Igor Andrianov, Jan Awrejcewicz

Summary. Some problems caused by a sudden development of computer technology on the classical sciences are discussed.

1. Introduction

"The purpose of computing is insight, not numbers" - this idea given by R. Hamming (1975-1998), the author of the famous book "Numerical methods for scientists and engineers", has motivated us to write this contribution.

Such phrases as "Nowadays computers expand very widely human being's possibilities", "Computers are needed but they cannot fully substitute human behaviour", and so on, are well known, many times repeated in numerous journals and books. However, this issue becomes more complicated if somebody tries to read more carefully papers by J. Guckenheimer, M. Gromov, I. Elishakoff and others. We are going to present our point of view on the subject of computers versus the traditional analytical approach on the basis of the cited scientists opinions as well as our own understanding.

2. Critical voices

A social response to an process is characterized by three steps: unlimited optimism, a reaction showing strong criticism with an emphasis on disadvantages, and, finally, a partial inclusion of a new process in a cultural paradigm.

It seems that an influence of computers on our life is still in the initial phase. However, the number of books, papers, talks, TV programme, etc. devoted to advertising the power of computers is extremely high. Let us focus on this problem for a moment.

First of all, we feel that serious estimation of limits of computer oriented science is needed. A belief in unlimited possibilities of computers leads to manipulation and control of the social behaviour of a human being. Real complex processes like a climate change caused by a thermal effect or a nuclear war, or a state of economy depend on extremely high numbers of parameters. Very often a priori model of the process is not known but it depends on the chosen parameters. For instance, according to one group of researchers, a thermal effect leads to a temperature decrease on the Earth, whereas another group predicts its increase. Simulation models also lead to prediction of the duration time of a nuclear winter either within tens (or hundreds) of years or within weeks (or months). Both groups accuse each other of a change of initial data or an improper choice of essential parameters, and so on. Recently, it has been shown that the prediction of the Stock Exchange behaviour by means of computer modelling is impossible.

A dangerous illusion is introduced when one assumes that an accuracy can be improved by increasing the number of parameters, which are sometimes not easy to define or the price of their estimation is high. Computer algorithms should be stable (and they should not depend on small changes of initial data) against unknown parameter changes, but one can observe a lack of the corresponding theories in this field.

3. Psychological problems

Development of high technology results in decreasing prices of computers and simultaneously in increasing their computational abilities. For a researcher a devil's temptation occurs: verify again and build the more adequate models with the use of more advanced hardware and software. By the way, the more complex the computations are the more difficult their verification is.

According to Hamming, a good theoretical researcher should estimate a result a priori and should behave rather in a sceptic way as far as the obtained results are concerned. A problem occurs not due to potential wrong results introduced by the subroutines used, but due to a formulation of the problem and due to the fact that the expectations are different. This observation corresponds with the paradoxal phrase of Hamming "...It is better to solve a problem properly formulated in an improper way than to solve an improperly formulated problem using a proper way".

"No time for thinking - we should jump" - this phrase is very often used in our life, substituting an idea by an activity.

Furthermore, even if a problem is properly stated, one should recognise advantages as well as disadvantages of the numerical algorithms used. "By including the exacting algorithms to the libraries of programs, we formulate standard approaches which can easily lead to ignoration of numerical analysis" (J. Guckenheimer). An increase of the number of subroutines and program packages developed on the basis of different principles results in an increase of probability of omitting the existence of their limitations and principal systematical errors.

Finally, the following psychological problem appears. Large computer projects (demographic, genetic, synergetic, climate modelling, etc.) need extreme efforts due to identification, unification, verification of the number of parameters, reverification and so on. It means that a share of uncreative activities is also extremely high. An individual influence of a researcher becomes washed out. A similar problem occurs in physics (addressed, for instance, by A. Semenov) but here the problem refers to thousands of researchers instead of hundreds involved in the above mentioned field of searching new particles in physics.

4. Honesty - the best policy

It is rather evident that authors of computer programs use mathematics.

"Stupidity dressed in a mathematical uniform does not look as stupidity" warned known mathematician L. Schwartz. "An experience of collaboration with physicians and biologists shows that a new mathematics is needed which does not exist up till now" (I. Gelfand). "During collaboration with representatives of other fields of science a key effort should be focused on showing the possibilities of mathematics" (N. Wiener). It is clear that for computer science oriented researchers it is rather difficult to be totally honest: grants and funds as well as the advertisements are needed. A compromise between honesty of a researcher and the battle for money should be achieved.

It seems that in published papers stronger emphasis should be put on a choice of parameter sets and the rules for negligibility of other parameters should be exhibited (if there is a lack of such rules, it should be clearly stated). The alternative approaches and results should also be added. We follow the way of thinking of C. A. Dana: "Fight for your convictions, but remember that they do not include the whole truth and the only truth".

5. "That what is fully under control is never real. That what is real is never controlled in full"

The phrase given in the subtitle belongs to V. V. Nabokov and it serves as a helping tool in the dispute "can a machine think"?[1]. While solving complex problems one needs to avoid the problems with a dimension and indeterminity of the boundaries. The last evidence is, as it has been proved recently, of a principal character. Unpredictibility of behaviour of even simple non-linear systems gives rather a hopeless prognosis for a long time climate and economy behaviour prediction [2, 3]. In other words, a fully rational description of our world is impossible. As it has been mentioned by Z. Freud "A property of a scientific way of thinking is characterized by satisfaction of only approaching the truth and by prolongation of the creative work without waiting for the final confirmations". It can be said that in science islands of rational approaches and theories are linked by irrational bridges of dazzles. Optimists believe that the described situation can be modelled by relative simple non-linear systems, but it is rather far from truth [4].

6. Virtual world

The world of computer models belongs to the world of new reality. Already V. V. Nalimov warned that scientific literature can be overwhelmed by works whose "scientific" contribution is related to the use of powerful computers and algorithms.

A speed of computations does not play a role of limitation, but the problems with organization of the memory, the errors estimation related to identification, and (perhaps the most important) a choice of profitable information drawn from extremely large sets of data play the key role. The situation is similar to that of the status of experimental and theoretical physics: a specialist of computer information analysis (further referred to as an analyst) should translate the simulation results into a language of human oriented science (Figs. 1, 2).

Let us briefly remind a history of the Internet. The encyklopedia "Britannica" serves as the best source of information. The fundamental goal of an analyst working in a virtual world is the same as in the real one: "The main goal of science is oriented on generalization of the maximal possible number of empirical facts by the use of logical deduction in the frame of the lowest number of hypotheses and axioms" (A. Einstein). A search for symmetry and regularity (or evident unsymmetries and irregularities) plays the key role for any researcher.

Here is an important place for asymptotical methods, based on decreasing dimensions and decompositions, multiple scale analysis, and homogenizations [4]. In addition, an analyst and an specialist in computer models should closely cooperate. An advantage of computer models lies in a possibility of quick verification of hypotheses, detaching small (large) parameters, estimation of stability of different characteristics, etc. A role of an analyst is to formulate important and properly

stated questions as well adequate conclusions on the basis of the obtained results. As modern physics shows, it is extremely difficult to find one researcher exhibiting knowledge of both experimental and theoretical physics.

Of course, the connections between the world of computer modelling, the world of human science and the real world need a separate discussion. We conclude that the methods of the real world analysis are fully applicable to the world of computer modelling. However, their actual application needs a different kind of intuition and different habits which require computer modelling analysis.

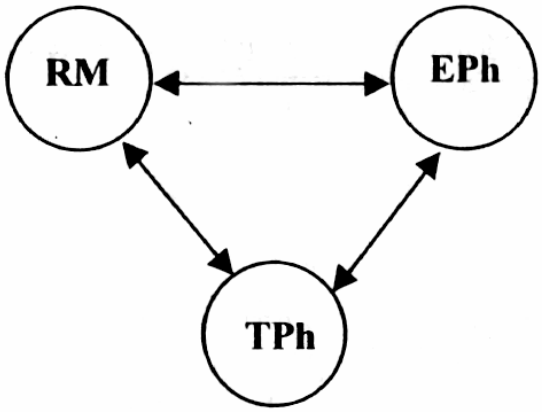

Fig. 1. RM - real world; EPh, TPh - experimental and theoretical physics.

The internal problems of EPh and TPh are solved by experimentalists (E) and theorists (T). A link between the RM and Eph is realized via E; a link between the EPh and TPh, as well as the RM and TPh, via T.

Remark: of course, only a tendency is manifested, because E and T take part in all stages of the real world study.

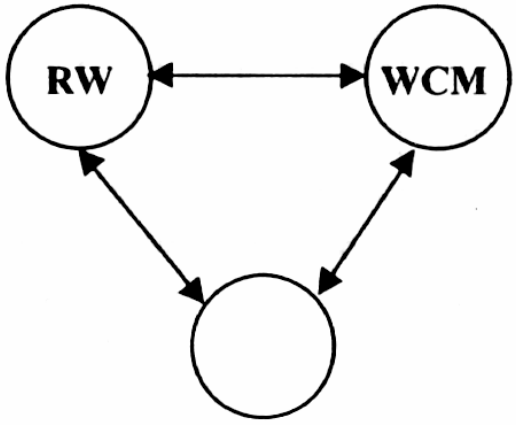

Fig. 2. WCM - World of Computer Modelling; WHM - World of Human Science.

Internal problems of the World of Computer Modelling are solved by programists (P); the links between the RW and WCM as well as between the WCM and WHS are realized by analysts (A) (see remark in Fig. 1)

7. References

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Professor I. V. Andrianov
Prydneprovye State Academy of Civil Engineering and Architecture
24a Chernyshevskogo St., Dnepropetrovsk 320005, Ukraine

Professor J. Awrejcewicz
Division of Automatics and Biomechanics, Technical University of Lodz,
1/15 Stefanowskiego St., 90-924 Lodz, Poland
e-mail: awrejcew@ck-sg.p.lodz.pl.