CYBERNATIZATION OF ENGINEERING EDUCATION ON TECHNICAL UNIVERSITY

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Abstract — *All The authors would like to provide their basic philosophical ideas of cybernetic view of engineering education on the base of 100 years of educational experience. We are sure; the conclusions are general for each sphere of engineering education all over the world. We do respect the differences of technical study branches and areas.*

We can find some disproportions between the conception and practise of engineering education that is caused by advantages of technology. Designer of any product has to predict the useful values of the product on the base of product lifetime. Our products on universities are technical engineers. So we have to predict their professional needs and necessary skills that their will need in the future of 30 years. We see this task as very difficult, but very important to be competitive.

Our aim is to present our remarks for utilisation our 100 years experience (the sum of experience of all authors) for the design of engineering curricula for third millennium. As the authors have spent their professional activity by cultivation of cybernetics on technical university, the viewpoint and tools for CV prediction are based on cybernetic principles. We have got powerful computational tools for utilisation of complex models of complicated systems and experience for the system behaviour prediction.

INTRODUCTION - HISTORICAL EXPERIENCE

Cybernetics has significantly touched all the human society in the second half of last century, especially in the science and research. We (all authors) have got a lot of experience with engineering education and implementation of cybernetics into the curricula of engineers. We can characterise the education in technical sciences as very conservative in comparison to development of technique and science. The engineering education does not follow the acceleration and new dimensions of human society, which leads to disproportion between technique and education. Where are the reasons of such a situation? We do think that it is low respect and evaluation of technical education in society. We see one of aspects of our ICEE conferences in the field of activity to exchange above-mentioned disproportion. We have to prepare the CV of technical engineers such attractive to be competitive to economics and managers study branches. The form of up to date CV of technical engineer has to attract young people and provide them (in the content) basic knowledge for next 30 years of successful technical practise. Design of such predictive CV is a very difficult task. We have got some next experience from the discussion on last ICEE symposium in Taipei, regarding curricula of mining engineer [4] and consequently from international conference MRM 2001 – Mineral Raw Materials and Mining Activity of the 21st Century. The human community has to support next development of the society. So at the very beginning there are the raw materials and energy that together with human knowledge and skills provides potential and base for industry and goods production. Next management and market relations determine the economic effects of each goods production. Each of the activities needs information and understanding of feedbacks principles to be competitive. For example the “Green organisations” could be understand as “feedback to Earth”. We have to close natural feedbacks in our minds to see consequences of our production activities in the future and for this reason we do need a lot of information. We need implementation of cybernetics not only into industry and technical sciences, but also especially into management, where the feedback principle should be a law.

CURRICULUM OF TECHNICAL ENGINEER

From the point of view of the natural feedbacks understanding, there should be in each engineering CV something like systems cybernetics, which provides philosophical roots for university study. In technical sciences we are used to apply some steps to problem solving according cybernetics principles. It means analysis, problem abstraction, definition of criteria function, systems synthesis, system realisation and evaluation of results. This sequential line reflects cybernetic relation to problem solving: identification – prediction – control. Natural base for this activities are system theory, mathematics and cybernetics. In 21st century especially with development of informatics the position of cybernetics has significant role. Cybernetics aspects of engineering education are valid within education

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all over the world. Each part of engineering education has got its own philosophy and behaviour, structure and development. We can find common features through analysis and problem generalisation. As an example, we can show some designer. Each designer should predict the goods property and quality according the estimation of future utilisation. The product has to provide the user benefits for the whole lifetime of its utilisation. The basic tools that use designers are computers, SW packages and models of designed product. Products of engineering education are technical engineers. So the CV of technical engineer has to reflect the development that will come in next 20 - 30 years. Our aim is to predict necessary changes in conception of engineering education based on analysis of toady's and supposed future state of science and technique and apply this prediction to technical engineer CV for 3rd millennium. The product of our technical universities is basically determined by conception of engineering education created by university experts.

Our next aim is to highlight the role and social evaluation of technical engineers. The scale of values in human society determines the values in education generally and engineering education is not an exception. History gives us a lot of proofs that investment into education is the best investment and has a key role for future. We are sure that key role in creation of new values has got utilisation of advantages of science and research in practise. From this point of view, the key roles for future development of our society have technical universities and applied research. So technical engineers will determine society development by creating new inventions and solving of technical projects. But there is the problem of complexity of technical tasks. Only in last years we are able to create models of complicated systems behaviour and utilise the systems theory in modelling of properties of real objects and technical systems. But this needs high performance computing facilities provided in parallel computing centres and high performance parallel models of studied systems.

CYBERNETICS EXAMPLES

As an example we can show one problem of areas after underground coal mining. After closing of underground coalmines there arise a problem of methane emission from underground. The mining technology has not the possibility to extract all the coal mass from coal seems. Inside the hard coal seems there is some amount of methane that after the closing of mines outflows onto surface. Methane in mixture with oxygen can cause an explosion, so it is dangerous for people and buildings. To prevent any methane explosion accident in former colliery area we have to predict the methane emissions. And here is the cybernetics task: create complex model of methane emission to the surface.

DETERMINISTIC MODEL

The main problem is that we do not have enough information about the underground situation (nature is almost unpredictable) and the deterministic models need a lot of empiric parameters. As we solve the above-mentioned task in "Project of the realisation of the security of the atmosphere against elusion of methane from closed collieries in Ostrava's agglomeration" GAÈR #105/98/K045, we tried to use some analytical models based on the modulation of the gas convection through the rock environment and the model of the rock environment for determination of gas flows.

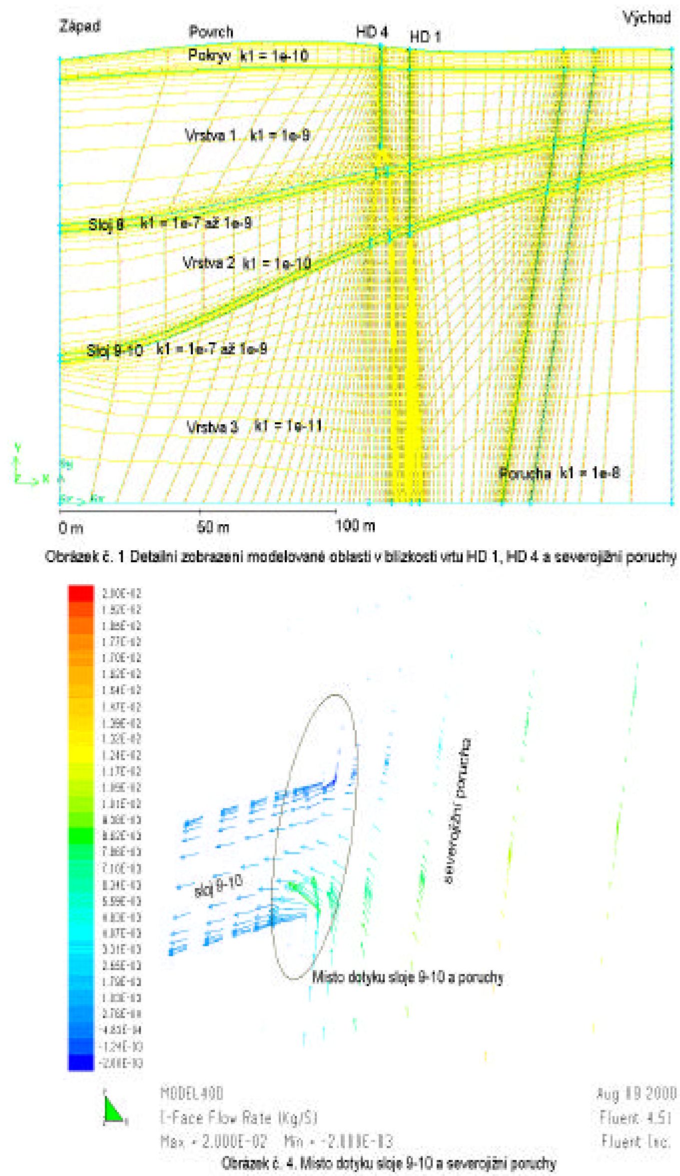

FIGURE. 1
METHANE FLOWS IN ROCK ENVIRONMENT IN SW PACKAGE FLUENT WITH A DETAIL.

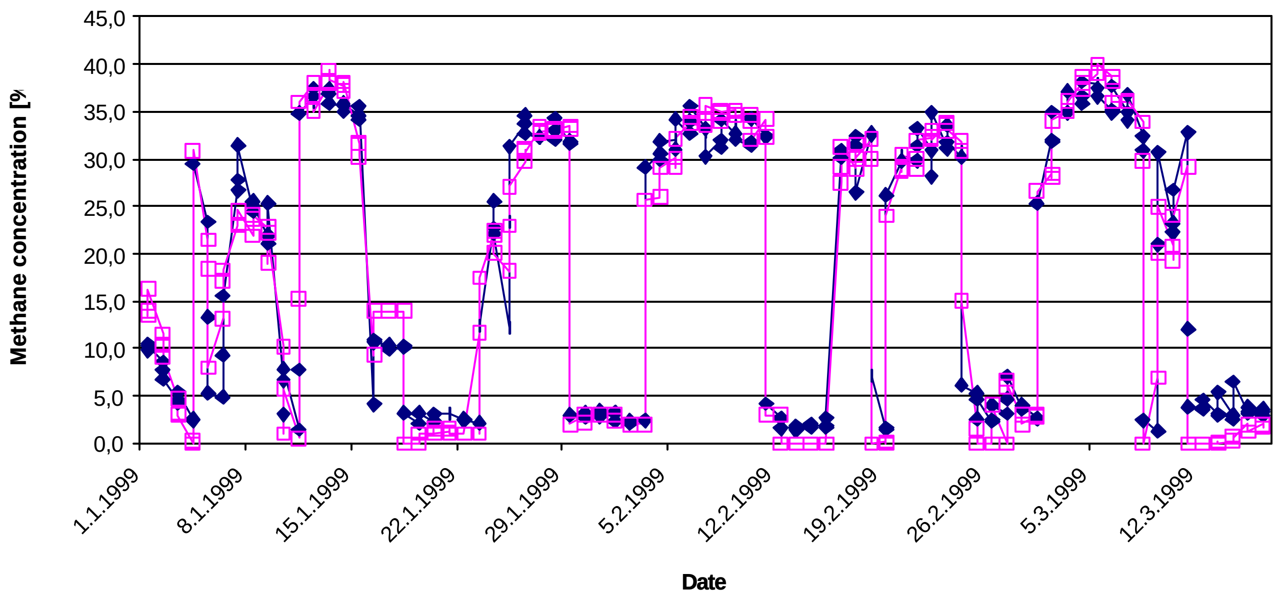

FIGURE. 2
SIMULATION OF METHANE CONCENTRATION BY ARTIFICIAL NEURAL NETWORK.

For models verification we have used data of methane concentration from some measuring points and all possible information regarding geological structures and former mining activities. As an example you can see result from deterministic modelling of methane flows in some small area, figure 1 [1]. Calculation of this model needs powerful computer, takes a few hours and the model is valid only for small part of studied area.

INTELLIGENT MODELS

But we do need model that could be used generally. The measured data can be understand as training set for next type of model – artificial neural network - ANN. And here is quite new type of model, where we do not know the dependence between input and output, but the model works, is robust and generally valid. The use of "Black Magic of ANN", as it could be understand for some people, is not easy at all. There are some problems to create and learn model on the base of ANN. We have to define neuron network type and structure, prepare training and testing sets, etc. and it needs a lot of experience.
Some results of simulation of methane concentration by artificial neural network are on figure 2. We have used for the modelling SW package NEUREX and very simple artificial neural network (10 neurons in three layers) provides us results with error about 5%.

Generally, solving of mentioned methane problem was impossible a few years ago, as the models are so complicated that our supercomputers are not powerful enough and there were no suitable tool for modelling.

ARTIFICIAL LIFE

Science continually searches for new research methods and takes inspiration and patterns in biological systems. It tries to understand how lifelike processes can be embodied into virtual environment. This idea leads to constructing of biological phenomena with intelligence on the base of artificial components. The new scientific methods are different from artificial intelligence approach, as the aim is simulation of new instances of life in a general sense. The computer is not a physical/biological environment it is logical/informational environment. The same laws do not govern the new artificial instances of life as natural life. The data patterns in instantiations are considered to be living forms in their own right and not models of any natural living forms.
For example we can use artificial life for modelling of banks environment and model the banks – agents – and their investments in artificial environment, figure 3. The example is from demo-version of SW package SWARM, which is well known artificial life simulator for multi agent simulation of complex systems.

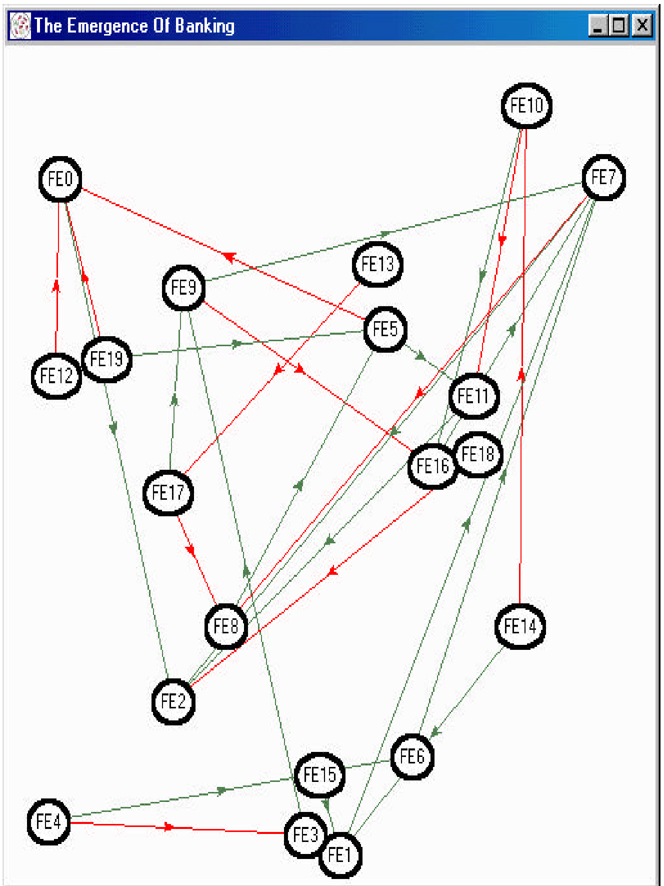

FIGURE. 3
MODEL OF BANKS IN ARTIFICIAL LIFE ENVIRONMENT.

This way we can model almost all systems, for example underground coal mine. The mine ***environment*** is determined by geological structure (coal seems, surrounding rocks, fractures, etc.) and mining technology (corridors, faces, shafts, etc.). The ***agents*** can be machinery and miners (intelligent agents) and with connection to virtual reality tools we can study the mine activity in whole lifetime of such an artificial mine. This way we can study all processes connected to nature like waste management. The production of waste materials is global problem of Earth biosphere. Modelling of such complex problem is not possible, but models of wastes deposit help us to understand and control natural life of bacteria in waste materials.

CONCLUSION

The three above mentioned examples illustrate the evolution of scientific methods based on utilisation of cybernetics principles and biological patterns. The future engineers will not be able to evaluate the complex processes behaviour without the utilisation of general cybernetic view on technological processes. We can see evolution of cybernetics models of the same reality from technical and economical to social and biological. It could be signal of changes in scientific paradigm. Top-down approach typically used in traditional artificial intelligence is in artificial life changed to fundamentally different approach bottom-up. This has to initiate next changes in the forms of information processing. We can see the problems and low efficiency of knowledge processing by conventional computers. Modern science needs intelligent computing systems based on biological similarity to nerve system of human. For the evaluation of cybernetics models of technical systems we can ask a question. Will the modern complex analysis of technical systems need detailed description of their structures and behaviour – description of dynamic properties, with respect to essential connections to the environment and with respect to internal complexity? We do need these models for systems understanding and design of new ones. Authors of this paper are sure, that modern cybernetic methods are not utilised and presented in engineering education yet [6]. We do some research projects, to join the engineering education with cybernetic analysis and principles. We believe, that cybernetic sensing of engineering problems and technologies will be the most important base for effectiveness of all human activities, from the very beginning of next millennium. The cybernetic view of human activities has to create basic part not even of engineering education, but necessary educational base of all specialists, that will influence future development of human society.

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