Fuzzy Control System Training for Engineers

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Abstract: This paper deals with the necessity of changing the current approach to teaching mathematics and new, fuzzy control based models in higher education in engineer training, mainly based on the experiences gained at the Polytechnical Engineering College of Subotica.

Keywords: enginnering traning, FLC, e-learning

1 Introduction

In the higher education system for engineers, as well as in the global education system the teaching of new mathematical models plays important role. Even though every teacher would like his students to acquire mathematics as part of their basic knowledge, and to use mathematics in their practical work, usually the educational system is based on preparing students only for the examinations. Nevertheless it has been shown to them how to use mathematical tools when they

are confronted with mathematical problems in other technical and engineering fields.

The virtual school was a fantasy until recently, but now it has become the focus of interest thanks to the computer technology. New educational methods are being introduced, from elementary to higher education, using various software tools. The possibilities of presenting the curriculum by means of computers, or in the form of electronic written material instead of traditional books are very important fields of computer technology application in teaching mathematical subjects [2], [3], [4], [5].

The interactive visualization of some mathematical models and simulation of the behavior of dynamic systems contributes a lot to the understanding of the curriculum at the technical universities, and supports the application of those mathematical models by the problem-solving using software tools.

There are several problems during the realization of those training programs. First of all, there is the problem of the previous mathematical curricula and the subjective capabilities of the students. Students should be coming from the secondary schools with a good (rather than bad) basic mathematical knowledge. Anyway, in practice the problem is that a sufficient level of mathematical knowledge should be acquired by all the students, therefore all students have to be taught the ways of acquiring the basic curriculum of mathematics equally. The teaching of this lecture can be supported by some mathematical software package and should be organized as special lecture accompanying the basic mathematical classes.

The second problem is the choice of the useful software background. The MATLAB package is widely used and has many possibilities for the building complex technical simulation systems based on several mathematical models. If the institution in higher education has the possibility to pay for it, it is the best choice. Nevertheless, there are other, free trade software packages of similar efficiency.

A further problem is the following: which kind of trends to teach from the wide palette of the new mathematical models. The experiences in mechatronics and practical control problems show that from now the soft computing technologies should be introduced at the basic higher education level for engineers, as one of the perspectives for the future.

The problem of remaining with the written teaching material in those classes should also be solved. There are numerous e-learning and classical written books in this topic in English, but there is a definite lack of these books in the languages of education in minor European languages. There are two possible solutions: one is to prepare the necessary materials in those languages, but this is a long term work, and because of the weak population, not effective. The other solution would be the use of the existing English language teaching-materials and their further

development. This solution is congruent with current trends that the student should learn foreign languages through the technical texts, and not in the classical form. If this kind of the usage of English teaching materials can be supported with online technical-oriented dictionaries, the goal will be accomplished [9].

Many universities and colleges have experiences in the realization of some parts, details of the software supported training in mathematics, soft computing technologies or control problems, but on the start of the new, Bologna Convention-based model in engineer education, a systematized lecture-plain should be assumed, with the necessary courses for the final, soft-computing and fuzzy based control system training. The paper gives one of such possible models.

2 Preconditions

2.1 Mathematics

We have to keep in mind the new teaching trends, by which we should be creating professionals in specific fields, and not engineers of broad basic knowledge. While in Europe universities which give detailed basic education are considered good, there are now more and more adversaries of this new trend: specific education. The worst possible choice of the educational method is forcing both methods: the broad and the detailed, deep approach to all the fields.

The detailed approach to Mathematics on technical colleges is questioned. While there are demands for the knowledge of new methods, like soft computing, students are expected to know all the classical fields of Mathematics, from vectors to complex analysis [8].

If there is a rationalization of the number of classes due to the possibility of using new tools, like mathematical software packages, the amount of tutoring is reduced. Nevertheless, the practice, the problem solving controlled by the teacher cannot be replaced by watching computer demo programs.

According to the curriculum of the engineering colleges and BSC levels in their first semester, students take the subjects in college algebra, while in the second term, the basic elements of calculus: basic properties of series, real functions, differential-calculus, integrals, differential equations [1]. Those courses usually carry 6 points. The third class should be in basic numerical approximate calculus methods with knowledge about using software tool for algebra, calculus and numerical approximate calculus methods and practical work on computer. Because of the complexity of the class, it can carry 6 points too.

At first, traditional computer languages in order to describe algorithmically can be used for:

- the problem of interpolation
- numerical solving of equations
- numerical integration
- numerical solving of differential equations
- developing functions into function series
- drawing and examining functions of one independent variable.

After algorithmically establishing the problem at hand, students write programs and apply them to the given tasks. This proved to be helpful in getting students accustomed to algorithmic thinking in solving problems and establishing of mathematical models. On the other hand, it contributed to their understanding of what is the essence of interpolation, numerical integration or numerical solving of differential equations.

We realized very quickly that visually presenting a series of interpolation points or solution points of a differential equation, or other models has a greater effect than any other theoretical explanation.

As it can be noticed, we have concerned ourselves a lot with numerical methods and with introduced parameters it has been clearly revealed how important the initial conditions or the required accuracy of solution are.

The problem was that the programming required a lot of time during the class, and sometimes distracted the students from the real essence of the task.

Due to this approach, we mainly focused on numerical mathematics as a topic, since it was not incorporated in the curriculum, and the engineering courses revealed a need for such models.

As a result of insufficient supply of computers, the application of these introduced methods begins usually at the end of the studies, when it helps students in preparing their seminar papers and final papers in their engineering courses, and as the basic of the fuzzy system control training.

2.2 Programming

All BSC programs at the technical universities include some basic courses in informatics, and one of the basic programming languages. Usually the basic algorithms are presented through the basic approximate calculus methods, like, for example, interpolation, numerical methods for integration [6].

If the education institution has the possibility to use MATLAB environment there are two advantages: the programming language used in MATLAB environment is very simple, similar to basic programming languages with a useful written help background. The only complicated field is the work with matrixes and vectors, but with the theoretical introduction of this mathematical topic it is easy to understand and use.

The second advantage is that it is very easy to integrate programs written in other programming languages into a main MATLAB program or simulation program constructed in Simulink environment.

2.3 Fuzzy System Control Training

Depending on the topic of studies, the student is usually getting to know the basic control problems and models after four semesters in his own area of studies, therefore in the fifth semester. After the basic courses he is ready to accept new mathematical approaches, and software-supported simulation training.

The first part of the courses to be completed includes theoretical basics of fuzzy sets, fuzzy operators, approximate reasoning, decision making, in the case of the dynamical system control training the Mamdani type fuzzy control systems.

An interactive learning environment has been developed around the concept of the electronic book. The architecture of the environment allows the integration of hypertext with simulators of first and second order control problems and process operation. The simulators are specially designed to serve an application-oriented, teaching approach, which involves the student in the simulation setup and the running of the application. They are able to simulate not only the execution of the software that realizes the regulatory control algorithms but also the start-up and emergency control strategies of an industrial process, the manual, automatic, and cascade modes of controller operation, and the man-machine interface of for example a DCS- or PLC-based control system. As an example a second order problem can be simulated, which is described in [7].

Conclusions

Although the software package has been enriched with a set of examples and demo presentations, there are still many such areas especially those necessary for technical engineers, for which such presentations would be needed, in which, by setting parameters, several problems can be solved.

Due to the already mentioned limitation in the number of traditional lectures and exercises in mathematics, some very important areas were omitted: complex analysis, mathematical statistics, numerical mathematics and others. For these areas, we would like to offer students teaching in the form of compact demo programs.

Another branch of development is supplementing the module of the soft computing type, above all by fuzzy mathematics. The aim is to make the presentation visual in character.

We would like to stress that we are advocates of the idea that these additional packages should certainly be presented to the students directly, through individual tutorial classes, at least in major points. Naturally, through obligatory tasks and problems which they have to solve by themselves using these software tools, they will gain experience, but a lot of effort is spared if their attention is drawn to the essence of the problem through personal contact, and above all, if they are introduced at least in essence to the theoretical background of software solutions.

Distance learning is always accompanied by the use of reference books, since tutorial classes are always limited in time. We realized how necessary these are in the last several years, when on the one hand, we have had lots of publications in forms of reference books, but on the other hand we have also been unable both to obtain these and to study them all.

Adapting to the Bologna convention the present concept of teaching this software package in all ought to be changed, but the main principle remains: first the theoretical basis, then solving tasks with algorithm, and only then using software aids.

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