DISTANCE LEARNING COURSES ON NUMERICAL METHODS WITH ACCESS TO SOFTWARE LIBRARIES

Volodymyr LYUBCHAK & Liudmyla OSTRIVNA

Sumy State University, UKRAIN

ABSTRACT

An approach to development and technology of realization of distance learning courses for mathematics subjects is suggested. Courses "Methods of optimization" and "Elements of calculus" are described. These courses are used in the Sumy State University (SSU) for teaching the full-time and correspondent students and require usage of software. For computer practical lessons in the distance courses we have provided description of libraries of numerical methods programs, organization of access to them, adaptation of the programs to the user.

Let's have a look at the opportunities of the course "Methods of optimization". The course includes 4 stages of learning: studying of theoretical material; self-control of received knowledge; mastering practical skills; evaluation of received knowledge and skills.

Lectures are designed as a tree structure of text documents. Testing is organized both on each topic and on the course as whole. Evaluation procedure is possible through an e-mail or on-line answer.

For fulfillment of laboratory tasks we have provided an access to programs of numerical methods. Software was written in C++, Pascal and Object Pascal by students of SSU. Moreover, original texts of programs are well documented and directions on self-programming of numerical methods of optimization are given. System of access to library files is offered. The library of programs is divided into blocks and can be accessed in the distance courses as archive files. Students can copy these files to his computer, unpack them and start working with programs immediately.

The course has a chapter with examples of applied engineering, economical tasks and their solutions. Features of applications such as Maple, Excel and scientific Fortran-library are described.

The distance course is open for free usage on the following address: http://dl.sumdu.edu.ua/mo/index.html and designed for Russian-speaking audience.

Keywords: Distance learning courses, numerical method, optimization, mathematics, the structure of the lecture, self-control, test, hyperlinks, program complex, software library.

1. Introduction

An approach to development and technology of realization of distance learning courses for mathematics subjects supposing use of application software libraries is offered. The features of construction and presentation of the material in mathematics courses are taken into account. The mechanisms of access to the software on studied themes are thought over, and methods of programming for solving applied tasks are described.

The realization of courses "Methods of optimization" and "Elements of calculus mathematics" is described. These subjects are included into the bachelor's educational plan on teaching the students of Sumy State University of "Applied Mathematics" and "Computer Science" specialties, both full-time and correspondent. The educational programs stipulate lectures, laboratory work and monitoring of knowledge. The laboratory work supposes computer realization of appropriate numerical methods by use of application packages, and also writing the programs with the help of algorithmic languages Pascal, C, Fortran. As the final task students are offered to solve one of the applied engineering or economic tasks. In distance courses the appropriate sections - lecture, laboratory work are foreseen, and most important - the problems of description of the numerical methods software libraries , organization of access to them and adaptation of the programs to users are solved, the methods of programming of applied tasks are explained.

The innovation consists in the following: in our course we have tried to offer complex solution to the question of electronic course filling. This means that theoretical description of the methods of optimization are made and access to computer programs is made possible (most of them are being developed by us). We had put a lot of examples of usage of this methods and programs to solving of application tasks.

There exist similar electronic textbooks, but they only contain description of software (http://ahp.tstu.ru/ido/Matiss/matiss.htm, http://www.srcc.msu.su/num_anal/lib_na/libnal.htm), or set of lectures and tasks without software maintenance (http://www.mpri.lsu.edu/bookindex.html, http://www.path.berkeley.edu/~varaiya/).

Our solution is innovative among Russian-language distance courses.

2. Structure of the distance course

Let's look more close on possibilities of a course "Methods of optimization".

The course is composed as a tree structure of text documents. It is divided on topics, each of them in it's turn contains lecture material, test for self-control, exercises and questions. All subsections are connected with each other. The connection is carried out with the help of hyperlinks due to use of hypertext technologies. I.e. each subsection is a text file with appropriate mark-up, so-called html-file. The course consists of hundreds of such files. The division of a lecture material was made mainly to reduce the load time of the file into the computer (as the speed of data exchange in Ukraine keeps to look for the best). The material is divided into the logically completed parts.

The material is represented in 2 languages - Russian and Ukrainian. Division into fragments is the same in both versions. Language can be selected on the title page of a course (http://dl.sumdu.edu.ua/mo/).

Work with the course begins with acquaintance with the structure and description of possibilities. I.e. student opens "About a course" section first. During work with this section student gets acquainted with the purposes and tasks of a course, its contents, peculiarities of work with a course (section "Work with a course"). Also the contact information about the developers,

teacher and tutor of a course and access to auxiliary material is represented to his attention. As an auxiliary material the list of the references is offered which can be useful in work with a course. (For example, reference to the table of derivatives, to the used archiver.)

After acquaintance with this section student immediately goes to work with a thematic material. This work assumes 4 grade levels:

- Study of a theoretical material of a course (Lecture);
- Self-control of obtained knowledge (Test);
- Mastering of practical skills (Laboratory work);
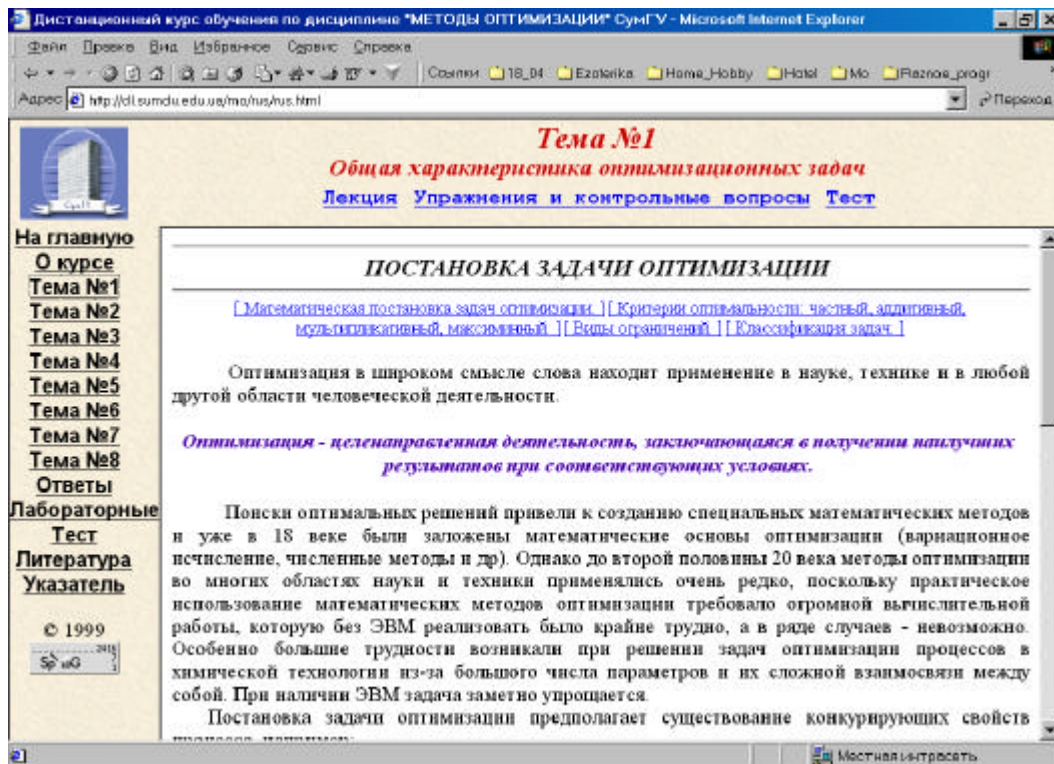- Monitoring of obtained knowledge and skills (Monitoring).

Figure 1: *View of one of the themes of a course*

Lecture material is presented as sequence of loaded files. Student selects the order of files by himself. He can use buttons "Next", "Back" and others, located in the bottom of each page, for navigation in the course. In this case he will look through material in a strict sequence determined by the teacher. When Mouse is moved on a button "Next" there appears prompting about the following section, which will be loaded after pressing this reference. Student can use submenu of the lecture located above on the first page of a theme and below - on all remaining pages.

The structure of the lecture is presented as a scheme (Figure 2).

The course contains the following themes: "Formulation of optimization problems", "Single variable search techniques", "Nonlinear programming", "Linear programming", " Application of optimization methods", "Elements of calculus of variations multivariable optimization procedures", "Optimization of the graphs". Let's stress, that the authors did not have a purpose to develop a full course "Methods of optimization". Some topics, such as, for example, "Linear programming" or "Optimization of the graphs" are presented in abstracts. Some, for example, "Dynamic Programming", - are absent. In a distance course it is recommended for a student to

address to more detailed electronic issues (such as http://www.dvo.ru/studio/linpro/ – Å.Nurminsky. Course of the lectures on linear programming),
 http://www.srcc.msu.su/num_anal/index.htm - server of library on numerical analysis SUCC MSU, http://www.mpri.lsu.edu/bookindex.html - electronic text-book "Optimization for Engineering Systems" Louisiana State University). Moreover, the course contains a subsection: the information review of Internet-resources on problems of a course. In particular, it has a link to such materials, as existing kinds of software for problem solving of nonlinear programming and conditions of its purchase and use (for example, paid software for problems of quadratic programming can be found on the server of Optimization Technology Center of Northwestern University and Argonne National Laboratory - http://www-unix.mcs.anl.gov/otc/Guide/faq/linear-programming-faq.html or free distributed listings of Fortran - programs and procedures for mathematical calculations on the server of Network library NetLib - http://ww.netlib.org/). The authors have paid attention to problems of numerical realization of optimization methods, description of the software, technology of programming.

Any section of a course can be accessed also from "Pointer". It contains references to all materials of a course.
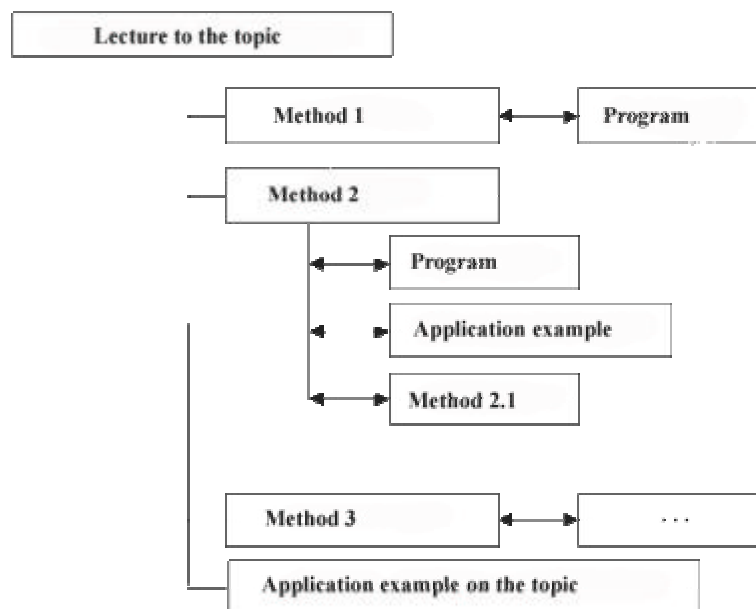

Figure 2: *Scheme of the lecture*

3. Program Complex

Software library which are presented in a course, we shall name a program complex, to prevent confusion. The program complex consists of several parts (libraries), each of them has subsections. These subsections also have ramifying. Such structure of a complex is connected with features of it's development. Firstly, the parts were written by various people and in a different time. Secondly, each part was planned as a separate software product. Therefore a distance course is presented as a whole complex, and as separate parts. The complex contains:

- Software Library, which is realized in Pascal;
- Software Library, which is realized in Ñ;
- Optimization methods software library, which is realized in Fortran;

- Software Library, which is created with the help of Delphi environment;
- Software package LP-88 for problem solving of linear programming.

A lot of the methods are programmed in different languages and are compiled with the help of various compilers, what allows to use the same method by the people who have skills of work with only one programming language, for example, Pascal. In a course student is offered the programs for methods of one-dimensional optimization, Hooke-Jeeves method, Nelder-Mead method, gradient method, Davidon-Fletcher-Powell method, Fletcher-Reeves method, complex method, penalty function method.

These software libraries in C ++, Pascal, Object Pascal are composed by the students and post-graduate students of SSU. Moreover, the original texts of the programs are described, and explanations on self-programming of the numerical optimization methods are made. In a course it is possible to work with the programs from libraries on several schemes. First: to use already compiled exe-files (for example, for realization of the comparative analysis of application of different optimization methods for solving standard set of functions). Second: to take advantage of the original texts from the site and set of procedures (modules) - i.e. to make the program using compiled modules, which contains a set of certain procedures. In this case student writes the main program by himself (probably by analogy with those offered). He specifies the function, optimal solution to which is necessary for get, and modules, which he will use in his solution (for example, module of multivariable optimization methods). After writing the program student compiles it with the help of any accessible compiler, which understands language of the program (for example, Borland C ++ 3.1 or Watcom C/C ++ 11.0, if the program is written in C or C++). Third: to write the program, which realizes this method, possibly more improved, on the basis of suggested computer realization of method. I.e. the distance course can be considered as a simulator on programming for improvement skills of writing programs realizing the numerical methods.

The system of access to software library files is offered. The software is divided into blocks and is accessible in a distance course as archive files. Student can write this file on his computer by several standard methods. For example, open the context menu of the link to such file (such menu occurs on right button click), select an item ("Save As …") and select a path, where the file will be saved. The archive file with zip extension will be saved on the computer. Student can unzip it with the help of any archiver, which supports unpacking of the zip-format (libraries are added to archive by WinRar of version 2.5). After unpacking it is possible to begin to work with the program on the spot.

The programs do not require additional installation of any software. The software library is designed for a COMPUTER with simple performances (i.e. even for low-power computers working only with DOS operation system).

4. Applied character of a course

The possibilities of software packages Maple, Excel and scientific Fortran - library on problem solving of optimization are described in a course. Algorithm of work with an Excel procedure "Search of a solution" is described in details. There is also a section with examples of applied engineering, economic problems and their solution. In particular, the examples of problems from [3] are realized. Except verbal statement of examples of applied problems, the mathematical statement of a problem, algorithm for solution and recommendations to choose a method of a solution, outcomes received in solution by different methods are presented. One of such examples - problem of optimal designing of the disk of a turbine.

Statement of a problem is the following: it is necessary to design the disk of the turbine with other equal conditions, that the mass of the disk should be minimum and the request on durability should be satisfied, and the accounts should be made with specific restrictions on limits of modification of the disk thickness.

The minimum is achieved by selecting a function of modification of the disk thickness from a radius - h(r) so that the requests to durability of the disk under forces induced during its rotation, and also restriction on limits of modification of the disk thickness were executed. The appropriate mathematical model is composed. To present a task of optimization as a task of variation of vector of construction parameters, the approximation of dependence h(r) by some piecewise linear function is made. With this purpose a partition of a radius of the disk on m of parts is made. On each section the linear function, approximating appropriate section of a modification h(r) is created.

The criteria of optimality is represented as nonlinear function of finite number of variables, which defines geometry of the disk. A task of optimum designing of the disk of the steam turbine consist in search of a minimum of a optimality criteria with restrictions and by variation of the vector of parameters. For its solution the program is developed, in which a method of a random search, method of penalty functions and combine method are programmed. The program is written in Borland Builder C ++ Professional.

5. Testing

Testing is organized in a course. The test is an independent (autonomous) program developed by Khazhanez V.A. (programmer, graduate of Dep-t of Ap.M. SSU) for testing of various educational disciplines in SSU. The program is written in Perl. The test envelope includes program for testing, base of test questions and outcomes of testing. The envelope is placed on one of the university servers. For example, for our course the test problems allow to pass the test on each topic, and also so-called general test, in which questions concerning all course are gathered. When addressed to the reference "Test" the form for input of a surname and initials is loaded to the screen of the computer. Registration in base of tested students happens first. After verification of the entered data the test begins. The questions for a students answer are loaded on a screen sequentially one after one by pressing a button "Next". Under each variant of the answer there is a small window, in which student should mark correct to his judgment variant. There can be several variants of the correct answer. Student can interrupt testing, by pressing a button "stop the test". By pressing a button "complete" student confirms, that he has answered all questions and is ready to view his results. At end of testing the student is offered to look through the results of his answers, where the incorrect answers to the question are marked in red, and correct in green, and also the answer, selected by the student, is indicated. We offer the student to use this test for self-control of obtained knowledge after study of the lecture.

For final monitoring the scheme of dialogue with tutor is foreseen. The control tasks are composed with account of answering them by e-mail or on-line. Forming of control session is possible. Time and mode of its realization are negotiated in the beginning of tutoring. The session can be conducted in on-line mode.

6. Conclusion

The distance course is constantly improved. It has been used in educational process of the students for 3 years. During this time about 80 persons of "applied mathematics" speciality have

passed tutoring. The students worked with a course on computers, connected to a local network in Intranet mode and having access to the server of university. The course is also actively used through Internet. It is confirmed by recalls, obtained by us. The users of the course mainly were the citizens of CIS (Russia (Moscow, Byjsk), Byelorussia (Bryansk), Armenia, Kazakhstan (Karaganda)).

The Distance course is open for free use at the address http://dl.sumdu.edu.ua/mo/index.html and is designed for a Russian speaking audience.

BIBLIOGRAPHY (in Russian)

1. Lyubchak V.O., Ostrivna L.G. Distance learning course «Methods of optimization» http://dl.sumdu.edu.ua/mo/

2. Lyubchak V.O., Ostrivna L.G. Using possibilities of the distance learning course «Methods of optimization» // Science and social problems of society: man, technique, technology, environment: Materials of the international scientific - practical conference, Kharkiv, 14-16 May 2001. – Kharkiv: NTU «KhPI», 2001. – p.134-137 (http://users.kpi.kharkov.ua/lre/MicroCAD/microcad2001/11.htm).

3. Reklaitis G.V., Ravindran A., Ragsdell K.M. Engineering Optimization, Methods and Applications, John Wiley and Sons, Inc., New York, 1983.

4. Voronina T.P., Kashitsin V.P., Molchanova O.P. Education in epoch of new information technologies (methodological aspects). – M.: «Informatics», 1995. – 220 pages.

5. Domrachev V., Bagdarasyan A. Distance learning on the basis of e-mail // Higher education in Russia – 1995. - ¹2. – p.79-87.

6. Khutorskoy A.V. The principles of distance creative learning // EIDOS-LIST, 1998. ¹2 – http://www.eidos.techno.ru/list/serv.htm

7. Lazaryev M.E., Sobayeva O.V. Basics of pedagogics. – http://dl.sumdu.edu.ua/ped/

8. Kukharenko V.M., Rybalko O.V., Sirotenko N.G. Distance learning. Conditions of application. Distance course. Kharkiv: Torsing. (2001) - 320 pages.