Teaching transport network theory with computer

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Abstract. Эта статья посвящена моделированию с помощью транспортных сетей, а также методике обучения этой задаче студентов старших курсов и магистров компьютерных наук. Методика обучения основана на трехуровневой модели с элементами интерактивности. Для повышения эффективности обучения теории транспортных сетей предлагается интегрирование интерактивной модели транспортной сети и специального редактора для создания траспортных сетей любой сложности, связанного с ней.

Introduction

It is hard to overrate the contribution of mathematics in development of science and technology and consequently in development of the modern society. Though at all educational levels (at extension courses as well as at school) the necessity of deep mathematic knowledge receiving often is impeached. One of the reasons is just the nature of mathematics that is a certain abstraction over the real world. Some topics of mathematics are even teaching without real application examples. And as the abstraction level grows, this hostility increases. The other reason is the dual influence which modern technology exerts on the learning process. Naturally, technology facilitates learning process. It shoulders the execution of some incidental as to the problem domain operations which are still necessary to execute. For example, while learning matrix determinant calculation algorithm, the execution of numerous arithmetic operations is needed. These operations are incidental as to the algorithm learning process. Though the execution of these operations takes much time especially with multitudes. Calculator can speed up the process. From the other hand, in elementary school there is a task of teaching pupils calculate simple arithmetical operations mentally. In this case calculator interferes the learning process.

This article is dedicated to computer modeling of transport networks of different construction and technique for teaching of higher education students and training of master of computer science. This technique is based on three-level model with interactive elements. We propose to integrate special graph editor that allows to generate transport networks of any complexity, to set and to change their states. Given technique was implemented by our laboratory in developed project «Teaching complex» that is used to teach students «Discrete mathematics» discipline.

Transport network theory (TNT) is an effective tool to formalize actual engineering and scientific tasks in different areas. Thus TNT language is convenient for system analysis, automated operations and also it is enough common tool for a wide area of practical optimization tasks research. In these later days the general

application for graph theory are modern computer technologies and software systems: in algorithms verification, for different digital devices developing, for computer networks and databases construction, in automatic control systems.

In regard to these tasks mathematical modeling is an opening stage. It is governed by sizes of real objects liable for modeling that can be very huge. Thus computer and transportation networks can contain thousands of nodes and tens of thousand of edges. Manual calculation of required parameters of such networks is just impossible. Besides there are tasks of optimal network parameters determination that require taking into account some physical processes that take place in real objects. So the main value and advantage is being brought by program models that simulate real object processes step by step.

Obviously computer much facilitates solving of all above-mentioned tasks where the transport network theory is using as it brings the abilities of quick network construction and the ability of real processes imitation. But what influence does computer technology exerts on the learning process?

Computer training

While using specialized mathematical software, that allow to solve a wide area of different tasks, including and transport network tasks, students often ask: why is it necessary to learn building network cuts, finding minimal pathes and maximal flows, learn different algorithms, associated with these operations if computer is able to do it instead? And the only way out of this conflict is to show students main principles for solving real world tasks, that requires applying of combinations of different areas of mathematics knowledge, as well as didactic tasks at the beginning.

One of the central tasks for teaching of modeling using transport networks with the means of computer is a visual and interactive presentation of mathematical models that have complex data structures and transport networks in particular. In presented contribution current task is solved through the development of a transport network program model.

Program model development and it's following implementation in the „Teaching coplex» project eliminated inconviniences that had appeared during the learning process for solving of TNT tasks. Viz allow to integrate special graph editor, that automatically redraw networks in avoidance of overlay of old and new parameters of the network elements such as labels, capacities and numbers. This approach decreases duration of whole task solving process and allows to free additional time for improvement of received skills by solving the tasks of higher complexity.

Transport network program model

Transport network program model is a special computer program that allows to build and hold the structure of a network, change it and to set parameters of the network elements such as capacities, flow values, labels etc. There are following principles that determine the effectiveness of program model:

- Conventional visual image of the network
- Interactivity of the model
- Convenience of network elements editing

Conventionality of the visual image is determined by its compliance to the standards used in teaching aids and scientific papers. The terms of education processes of building and definition of transport network program models must have maximal visualization. A t7ransport network visualization is also the task of the program model. As the image would be closer to the custom ones so higher would be the effectiveness of the work with a transport network program model.

Interactivity principle must also be implemented in a new transport network program model. It is better to use Drag-and-Drop technology. I.e. all the changed performing in the structure or parameters of the network must be performed by the means of mouse manipulator directly through the visual image of the network shown on the screen.

Parameters of network elements must be set also directly through the visual images.

Graph editor

All above-mentioned principles were implemented in «Graph editor» program developed in or laboratory. The editor is a universal tool for different graph types modeling. But it's main purpose – transport network modeling. «Graph editor» allows quick modeling of transport networks and setting their parameters (flows, capacities, indexes, labels and so on) and of course modifying previously created networks. The main advantage of the editor is an interactive modeling process. Program model for «Graph editor» is based on two models of presentation of graphs in computer memory: data list and matrix presentation. Both models are synchronized, i.e. some changes in the first model automatically produce according changes in the second model. Each model provides it's own essential contribution in editor's operation. Thus data list presentation allows to store visual image of the network (it's dimensional structure) and to react interactively to the user's course. Matrix presentation is designed for implementation of different algorithms using for transport network processes modeling.

All the modeling and modification process is produced directly through the visual image of the network with the use of the mouse manipulator. For example, creation of new node requires only specification of it's position by cursor and new edge creation requires specification of two nodes to connect. Deleting, direction swapping (of edges), modification of network elements condition take place after concrete element has been selected through the image of the transport network. All these details provide evidence of the network visual image and allow to concentrate directly on task solving process instead of the way this process is implemented in computer program (look Fig.1).

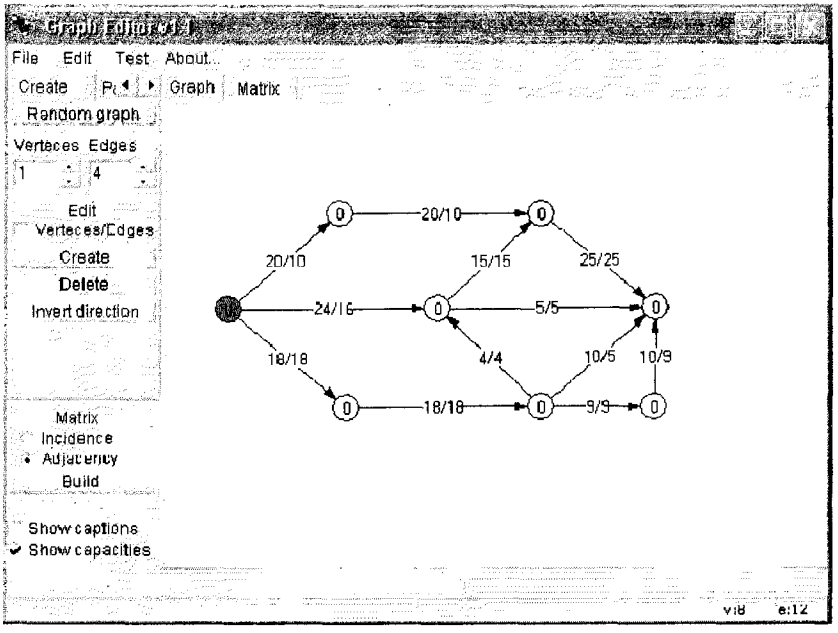

Fig.1. Graph editor

As it is mentioned above transport network modeling by the means of «Graph editor» is an interactive process. It allows to eliminate duplicate links, dimensional and visual complexity of network image. Program is able to check flow distribution in the network, to determine if the maximal or full flow in the network is produced. And etc. Implementation of such interactive approach gives essential advantages while using «Graph editor» in teaching of transport network modeling process.

The editor allows to implement some typical algorithms by the means of received transport network model: determination of minimal path between two nodes, building of full and maximal flows in the network and others.

Besides output data format is very simple what brings the abilitie to use transport networks modeled by the means of the editor as a taks database for „Teaching complex». „Graph editor» also allows to determine if a network is able to be used as a part of tasks database.

Graph editor implementation

The implementation of «Graph editor» in the learning process allows to simplify trainee's work with transport networks while solving modeling tasks.

Sometimes it is very important to know how did the student reach the result. For example, it is important for correct estimation of knowledge of some algorithm. Surely one can divide whole algorithm on several subtasks but such approach disturbs practical knowledge integrity.

So there is a necessity to force computer to trace every action of the trainees and also to estimate if the task is solved correctly in a whole.

All discovered limitations of the learning system were reduced in a newly developed module which is the first from the transport network theory division. It is dedicated to Ford-and-Falkerson algorithm of the maximal flow seeking. Module was based on the interactive program model implemented in «Graph editor». It was tested by students and the effectiveness of the approach used was checked out. The duration of learning process for current algorithm decreased. It is possible to implement received effective program model in other teaching programs dedicated to the modeling of transport networks and processes carrying inside of them.

Computer-based learning technique

We propose to use the following teaching process structure while constructing teaching programs. It is based on three different levels.

At the first stage called «Access» (or preliminary stage) test trainee answers simple questions over the current topic. This stage allows to test the presence of minimal knowledge over the topic required to pass the next stages. So if the trainee do not pass access test stage he(she) is not allowed to follow the next stages.

Second («Training») stage contains theoretic and practical parts. This stage provides access to electronic guide. The trainee is allowed to view it only if he passed the first stage. Electronic guide must contain examples in addition to theoretical material. Practical part follows theoretical. Passing this part trainee must interactively solve some tasks under control of a computer. The interactivity of the way trainee solves tasks is produced by implemented interactive program model of the transport network and special messages which program generate accordingly to the actions of the trainee. Messages may ensure the trainee if the task is solved correctly or show his mistakes which were made by trainee. If trainee makes too much mistakes program can offer the trainee to learn theoretic material again. So this stage provides step-by-step learning that is controlled by the program. Accordingly to the number of mistakes which trainee made here the estimate for practical level is calculated.

Finally «Total test» stage contains a sequence of tasks ordered by level of complexity. Each task accords to the stages of algorithm. A trainee solves the tasks of this stage without any help, neither theoretical nor interactive.

The final estimate of the trainee's work is a complex estimate calculated from three intermediary estimates received for each stage of the learning process.

The application of game approaches increases the interest of the students and training duration. Actual tasks compilation advances better remembering and produces application-oriented knowledge.

Conclusions

Sometimes computer technology interfere the normal flow of the training process. But correct and consequent application of modern computer technologies much

increases its effectiveness. We discovered the next advantages of computer-based technology of education:

- facilitating of routine, none-creative mathematical operations
- increasing effectiveness of learning process through the use of correct visualization
- bringing interactivity to the learning process
- the ability of recurring learning
- facilitating the work of teacher
- effective distance education
- solving tasks based on modeling algorithms, which hold real process analogy in some degree;
- learning accelerated analysis of multitudes of accepted alternatives while seeking optimal solution.

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Использование стандарта LOM для интеграции библиотек и систем дистанционного образования.

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Abstract. IEEE 1484.12.1 Learning Object Metadata (LOM) standard was developed to improve metadata of digital and non-digital documents that are used in educational processes. Besides general sections of metadata, that are mostly common for all metadata standards, it takes into account educational, technical, legal, relation and other aspects that are needed for educational documents. Widening of metadata schema gives great possibilities for developers of distance-learning systems and some problems for library workers.

Одним из направлений развития библиотек на сегодняшний день является работа по их интеграции с образовательными системами и системами дистанционного образования в том числе. В подобных системах наблюдается тенденция по организации семантического анализа обучающих материалов для более качественной организации процесса обучения. Несмотря на то, что семантический анализ имеет своей целью выявление смысла нечетко структурированных материалов, на современном этапе развития этой технологии требуется наличие специально подготовленных материалов для более качественного анализа.

Основной задачей библиотек является хранение, обработка и предоставление различных документов. Для качественного предоставления сервисов в рамках взаимодействия с системами дистанционного образования