Applications

Kremm: an E-learning System for Mathematical Models Applied to Economics and Finance

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Abstract

The widespread use of computing tools and Internet technologies that allow both distance learning and access to large amount of data and information, makes the process of solving a technical/scientific problem, much more realistic, exciting and stimulating than a few years ago, due to lack of appropriate calculation tools. However, usability of information by students and teachers at various levels, seems to be extremely limited, both due to the diversity and fragmentation of the available material, and for the large gap between the different components that should characterize science and, in particular, modern mathematics. KREMM (Knowledge Repository of Mathematical Models) is an e-learning system for the study of mathematics for economics and finance. The purpose of KREMM is to provide a significant aid in educational and pedagogical use of mathematical and statistical techniques in the context of economic and social disciplines, which starting from the creation of material on these issues, comes to propose a complete learning path.

1 Introduction

In the evolution of distance learning framework, the "third generation" sees the emergence of online education, to disadvantage of distance education on which were based the first two generations (Nipper, 1989). An analysis that contemplates only the evolutionary aspects of this process does not provide an adequate understanding of the phenomenon itself; it is necessary to observe both the development of instruments related to information and communication technologies, and the research on new technologies and new theoretical paradigms that affect the root of the philosophy of training. There is, in this context, a development from distance education to models of open learning, a transition from multimedia technology to web-based training, the emergence of epistemological and theoretical models for the training that enhance especially the autonomy and a contractual construction of knowledge as the "humanistic psychology" and "constructivism".

Learning strategies based on collaborative production are of increasing importance: recent models of open and collaborative learning fit perfectly with the concept of "collective intelligence" (Levy, 1996), which is due for the trainer to manage and stimulate. "Today, if two distant people know additional things, by means of new technologies they can really communicate with one another, exchange knowledge, collaborate. Said in a very general way, this is basically the collective intelligence" (*Ibidem*).

KREMM is an e-learning system for management of multimedia data for mathematical models applied to economics, developed in the perspective of flexible and modular collaborative learning.

The collaborative learning approach is based on a virtual circle in which the information contained in the system is organized and updated using the feedback of users. Users can be classified into producers and consumers of the information contained in KREMM. The producer is the one providing the information, filling out all sections of the repository of data. This generates the core of knowledge of the system and starts the process of population. The consumer can be classified in two behavioural patterns:

- those using the system knowing to find the answer to their need;
- those seeking a first definition of its needs and thus its solution.

The first case is similar to when the students using a Learning Content Management System (LCMS) (McCormack, Jones, 1997), know that the teacher has already put the information they seek.

In the second, the consumer logs on to find out how to solve a problem he is facing. The process is gradual, he first identifies if the problem is already described, or is similar to one present in the system; in this case, according to information in its possession, the user can navigate the system, in order to get a definition of the model and to select algorithms, methods, tools and useful available information. If the problem is not available and the user is able to solve it, this new problem can be added to the database. The consumer becomes a producer of knowledge, realizing an economy of thought and beginning a process that is fuelled by the use of the system itself. All this represents a paradigm change from the use of LCMS: there is no static knowledge which is provided to users, but rather the knowledge is gained by the users themselves and the use of information generates new knowledge (Marchioro, Landon, 1997).

This approach requires tools and techniques that are quite different from classical ones, since interdisciplinary, together with technologically advanced tools, becomes an integral part of the educational process. The system is proposed as a tool that allows joining the vast amount of heterogeneous information, which is involved in the understanding of scientific phenomena, the construction of simulation models, the analysis of experimental data, the development and use of computational tools.

In particular, KREMM can be seen:

- as Learning Environment for mathematics applied to economics, for the implementation of courses that want to emphasize modelling and computational aspects;
- as a link between mathematics and the real world, and especially as an easy-to-use platform that allows to learn the key concepts of mathematics from business applications or financial commitments and, conversely, to give a smooth access to essential concepts of mathematics for the understanding of the disciplines of economics and finance in which mathematics has a significant role.

The basic idea is to provide a flexible and adaptable tool that can be used with different levels of detail and as alternative educational pathways that meet the needs of different types of students.

2 Conceptual Architecture and Database Population

The development of lesson plans geared to the problem requires a strong interaction between the disciplines related to Economics, Finance, Mathematics and Computer Science. In order to develop a complete learning path, that starting from the formulation of the problem leeds to its resolution, are necessary skills ranging from knowledge of the specific discipline, to mathematics at various levels, ranging from the knowledge of the theory, to computational techniques and finally to elements of Computer Science. The software tools included in KREMM, suitable to make feasible the implementation of problem-oriented courses are those that are called

Problem Solving Environments (PSE) (Houstis, Rice, 2002). A PSE is a specific software environment for the resolution of a class of problems. A PSE can be seen as a structure divided into layers, ranging from hardware to user-friendly interface through which a user can dialogue with the system in natural language without necessarily knowing the mathematics that expresses the model, or the mathematics for the numerical resolution the model itself.

The logical architecture of KREMM, shown in Figure 1 consists of two layers. The top layer is in relation to applications while the lower refers to mathematics. The connection between the two layers is realized in the mathematical model.

At the application layer there are:

- Discipline - Contains application-oriented disciplines related to the fields of economics and finance.
- Problems - Contains for each discipline, a class of application problems.
- Examples of solved problems.

As a link between the two layers, we have Models**:** for each application problem that is covered in the database, KREMM proposes a mathematical model for the description of the problem.

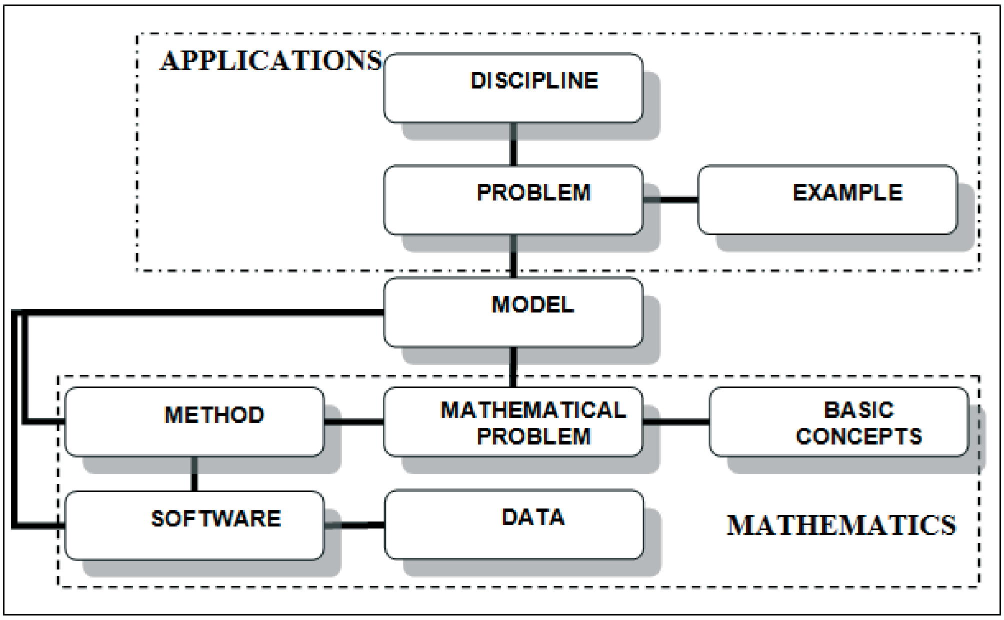

Figure 1. Conceptual architecture of KREMM

In the layer of mathematics are:

- Mathematical Problems - For each model, KREMM proposes a description of the central mathematical problem of the model.
- Basic concepts - For any mathematical problem, KREMM contains a discussion of related mathematical concepts.
- Method - For any mathematical problem, in addition to the basic concepts, the system propose some numerical methods, algorithms and their solutions.
- Software - For each algorithm present in the database, the system provides software in the form of PSE, which implements the algorithm.
- Data - For each software contains data for use.

3 Software Architecture

The logical model adopted to develop the software architecture of KREMM is a layered model. The functionalities of the system are divided and implemented in software elements named components. Each component uses the capabilities of those of lower layer and provides functionality to the next layer. This allows to add new features at one level simply knowing how to invoke the functionality of the lower level. Such a system is called open system; defining an open system means to define the interfaces between layers software components. The advantages of this choice lie in the modularity of development, the ability to use the transparent feature of a lower level and the possibility to identify in a simple and fast way any errors or deficiencies in the implementation.

The components have been divided in four layers:

- System Software - provides the system components not included in the core of the operating system.
- Middleware - contains the essentials components to create secure communications, for the authentication, the Java virtual machine and libraries for remote access to system services.
- General Application Software - includes all components of management that operate on data, metadata and file.
- Specific Application Software - this is the layer that contains components that have been developed specifically for KREMM.

In order to simplify the description of the system, we use the graphical UML usable for the description of software architectures and we provide a description of the functionality of each component. Figure 2 describes the whole architecture: it identifies the components, shows the layers and gives the dependencies between the components of the various layers.

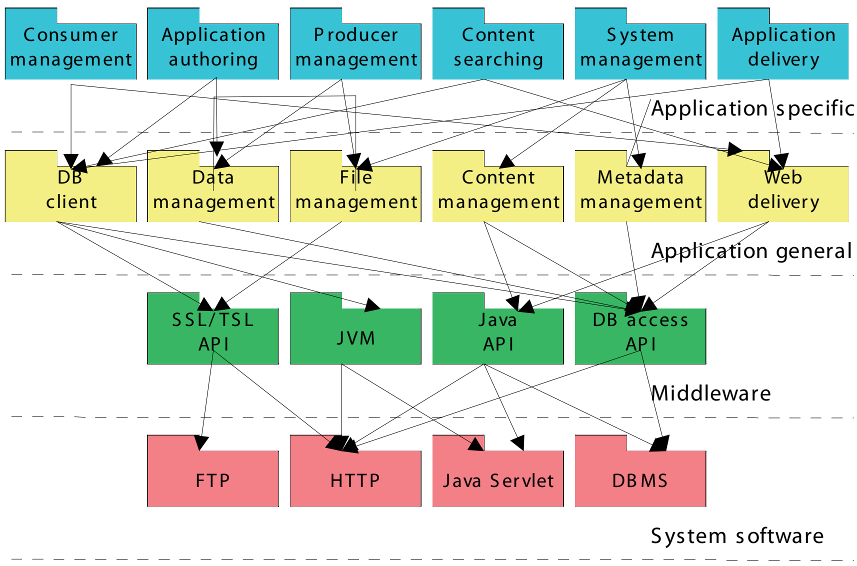

Figure 2 Software architecture

KREMM interacts with users through interfaces with:

- a header, which contains the logo and the horizontal navigation menu that provides links to access all the sections that characterize the system; through this menu, a user can decide to go to section Navigazione, Contributi e Corsi;
- a central part in which, dynamically, the required information are displayed;
- a footer which closes the window and gives information on the copyright and on system administrators via the Contatti link that allows you to contact the system administrators.

Users can be anonymous or authenticated. Only authenticated users are able to add, edit or delete the contents of KREMM. When a user logs on, the footer also shows additional links to sections that provide the ability to change their information, released at the time of registration, or to leave the section reserved for authenticated users.

In section Navigazione the web interface is enriched by fourth element (Figure 3): the side menu, a dynamic menu which in every time of the navigation will only display the entity in connection with the information displayed on the page.

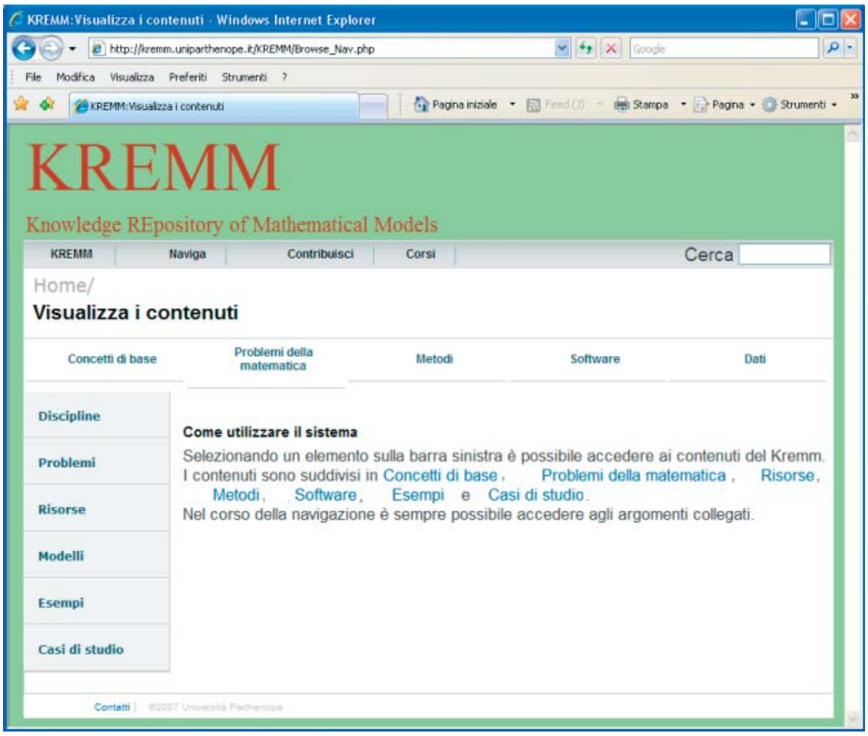

Figure 3 Web interface in section Navigazione

For example, if the user is reading information related to a specific numerical method, then from the side menu will be accessible only Problemi matematici, Risorse, Software and Esempi related to it, representing a deepening and a completion of the learning pathway.

In the section Contribuisci user can enter new information into the system or change information already previously entered. The acquisition and storage of data is done by means of the forms, that allow to define the fields where the user will insert the desired values. Through masks we will also import files in various formats (like Excel, Word, ...), pictures, links to external or internal data, and equations, symbols and mathematical formulas. In particular, the inclusion of mathematical formulas is done using a modified version of the format already used by the Wikipedia project (Wikipedia, 2008).

4 Examples of use of KREMM

Each user accessing KREMM can attend at any level and navigate through the system through several steps following the favourite paths.

The goal is to build a general framework, with a large sample of problems that can be representative of the wider range of applications in the fields of finance and economics. A user may start navigating the system from any link in Figure 3, follow the existing links, and thus gaining a view of the information contained in the system. Suppose a user begins to explore navigation in KREMM from link Discipline, and among them, he chooses the Macroeconomics. From here he could move about the issues that are related to Macroeconomics. The user could select the input-output system (Chiang, 2005), before moving to the model, where he can find, among others, the Leontief model, for the mathematical description of the problem mentioned. In particular, the major computational kernels of the model will be emphasized. In our specific example, one of the main computational cores is the solution of linear systems. At this point, the user can switch the link Metodi, in order to explore numerical methods for solving linear systems, and here he can find the description of the method of Gauss. Finally, he can accesses Software, where he find a PSE to solve linear systems. If user is not interested in algorithms to solve linear systems, it could go directly from Modelli to Software. On the other hand, he might be interested in the algorithms for solving linear systems and, therefore, start browsing directly from Metodi. From here he could then seek models based on this algorithm (box Modelli) and the related mathematical problems (box Problemi matematici). Finally, the user could get at the problem tied to chosen algorithm. This path connects the Gauss method and the Leontief model in the opposite direction compared to the previous example.

5 Progress report of the project and evaluation of the quality of the product

KREMM is a dynamic and continuously evolving system, in the initial phase we attend to:
1. define the hardware architecture, software and database structure
2. include classes of application problems for economics and finance
3. identify and develop PSE for their resolution
4. develop learning objects.

While step 1. is well established and has therefore reached a point of equilibrium, steps from 2nd to 4th are constantly evolving and continues, therefore, the phase of the peopling Database.

In future is planned both the design of tests for self-evaluation for learners and the evaluation of the system. While the tests for self-evaluation, inserted in KREMM, will allow users to validate the acquired skills, the evaluation of the quality of the product will be tested through online questionnaires.

Considering that this is a collaborative learning environment, the evaluation of the system should be primarily focused on users, and determined by a subjective analysis of stakeholders, collecting information in order to establish a joint of the quality taking into account points of view of different types of user.

The communication on the quality of the system will consider:

- The type of user and his vision for the application. For example, a user-student might perceive and define the quality of the e-learning course according to criteria such as relevance and consistency of experience with their own needs and the context in which it operates the ability to be supported and motivated and simplicity to use resources. While a producer could speak in terms of technical quality, system efficiency, reusability and interoperability of resources.
- The object of quality: the experience of learning.

6 Conclusions

The objective of KREMM is to provide significant educational and pedagogical techniques in the use of Mathematics in the disciplines of Economics and Finance. The realization of KREMM has led to the development of an interactive and flexible, interdisciplinary and multimedia environment, available via the web, which incorporates business and financial applications. The flexibility is achieved by the appropriate choice for the user of the level of detail of the covered topics: for every application problem in the application database, the user can find in KREMM a detailed description, a mathematical model for the description of the problem itself, an analysis of the central mathematical problem related to the model and its basic mathematical concepts, but also algorithms and software in the form of PSE, usable by non experts in the settlement process.

The natural evolution of KREMM, which is mainly a completion, foresees the creation of a Semantic Web in order to implement semantic searches to find information by providing a phrase that identifies an object (Guha *et al*., 2003). In this way the user does not attempt to identify a particular document within the system, as in traditional web search results, rather tries to identify a set of documents, which will help to provide a complete picture on the object of the research.

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