Making Modelling Teachable – MMT

Carina Pöll[1], **Martin Bicher**[1], **Irene Hafner**[2],
Stefanie Winkler[1], **Andreas Körner**[1]

[1] *Vienna University of Technology, Institute for Analysis and Scientific Computing, Austria*
[2] *dwh GmbH Simulation Services, Vienna, Austria*
E-mail: carina.poell@tuwien.ac.at

Abstract

The "Mathematics, Modelling and Tools" (MMT) system is an E–learning platform which is used for teaching at the Institute for Analysis and Scientific Computing at the Vienna University of Technology. The examples treat especially modelling and simulation and basics in mathematics. The E–learning system is a useful tool for lecturers to show examples as well as for students who can also fiddle with the examples and learn more about them while testing the examples with different values for the parameters after the lecture. The memory system of the MMT is the Content Management System, which does not have any hierarchical structure, but each file has a unique and global ID. The hierarchical structure is induced by so called nodes where three different types of nodes are used. A new feature for the output of the results of MATLAB–files is a video of results of the simulation, which is created in form of an animated gif–file. Further now there are examples in AnyLogic in the MMT system where it is necessary to be able to run Java–applets. In the future it is planned that examples in R and Octave are going to work too.

1 Introduction

The MMT, which is an abbreviation for "Mathematics, Modelling and Tools", E–learning system is a tool which is used at the Institute for Analysis and Scientific Computing at the Vienna University of Technology. It consists of examples for modelling and simulation and basic mathematics. Therefore it is used in many lectures for mathematical modelling and simulation and courses in mathematics. The examples for modelling and simulation deal with different kinds of modelling, like cellular automata or agent–based models, and distinct applications of the models. The mathematical examples treat basic knowledge in analysis and linear algebra. Since 2006 the Vienna University of Technology offers an E–learning platform called TUWEL which can be used for general organisation but has not enough features for implementation of dynamic examples. This was the reason for the implementation of an E–learning system for mathematicians and engineers in the year 2006. A first solution was the web server environment, which was included in MATLAB 2006a, but Mathworks, the developing company of MATLAB, discontinued the support of the web server [1]. Afterwards it was decided to develop an E–learning system with MATLAB running in behind and a content management system (CMS) was created, see section 3. Since autumn 2010 the version of the MMT system that is currently used is running on the server. Presently there are about 500 examples implemented in MATLAB, two third are about modelling and simulation and one third are mathematic examples. About 50 examples are implemented in Simulink and about 20 in AnyLogic and Java. Most examples are in German because they are mainly used for German lectures, but the number of examples in English is steadily increasing. The Simulink, AnyLogic and Java examples are all about modelling and simulation. Another feature of the MMT system is that examples out of projects and bachelor theses can be stored and therefore are not forgotten since they are available in the MMT system. If an example is based on an m–file, how the MATLAB source code file is usually called, it is possible to download the file and therefore view the implementation and even adapt the model and work with it. An important job is the maintenance of the server of the MMT E–learning system. The server of the MMT system is hosted by dwh GmbH in Vienna which is a cooperation partner of the Institute for Analysis and Scientific Computing at the Vienna University of Technology. The dwh GmbH is responsible for the administration of the server of the MMT E–learning platform.
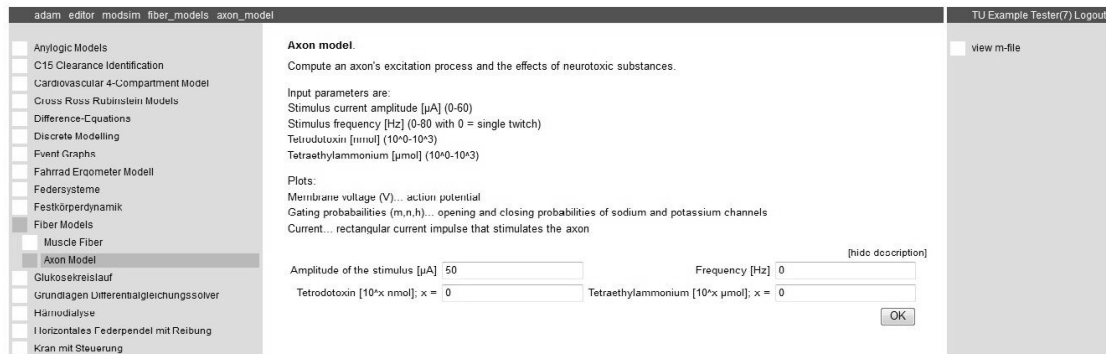
Figure 1: An Example of the MMT E–learning System

2 Interface of the MMT

When a student enters the website in the middle a picture of Adam Ries (1492 – 1559), who was a German mathematician, occurs, while on the right hand side there is the login button. After the login, all courses the student takes are listed on the left hand side. When the student chooses one course and in this course an example, the screen looks like Figure 1. On the left hand in Figure 1 side there is the navigation bar where the different topics in the selected course are listed. Each topic of the course includes the appropriate examples. On the right hand side there is a link which leads to the source code of the example, e.g. a MATLAB–file [2]. Furthermore there can be other files which can be downloaded like an explanation of the example as pdf–file. The availability of the source code is an important property of the MMT system, which is very useful since this can help the students to learn programming. In the middle section of the screen the selected example can be viewed and the parameters of the model can be chosen. With a click on the "OK" button the server computes the results with the chosen parameters and variables. This is done in two steps. First the communication between the user and the MMT server is done via html forms, second the communication between the server and MATLAB is carried out via php scripts. Below the explanation and parameters of the selected model the results occur like in Figure 2.

The example "Axon Model" computes an axon's excitation process, i.e. voltage, gating probabilities and impulse, and the effects of neurotoxic substances. The input parameters of the example are the amplitude and frequency of the stimulus and the amount of the neurotoxic substances (Tetrodotoxin and Tetraethylammonium). The results are figures of the time evolution of
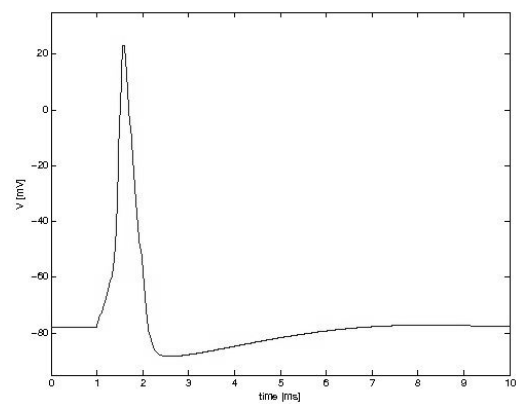

Figure 2: Result of the Example "Axon Model" of the MMT E–learning System

the voltage (see Figure 2), gating probabilities and impulse.

3 Content Management System

The Content Management System (CMS) is the memory system of the MMT E–learning platform [3]. This memory system basically does not have any hierarchical structure. If a file is uploaded to the server it is stored in the same level as all the other files, but is assigned a global and unique ID. The final structure of the system is realised by nodes. Each node has the possibility to contain a description as well as subnodes (except endnodes). There are three distinct types of nodes:

- Pages:
  These nodes are necessary to structure the system.

- Examples:

These nodes build the environment for a MATLAB example, i.e. besides the description the definition of parameters is possible.

- Bindata/Endnode:
  These nodes permit the upload of m–files, pictures, pdfs and other files. To upload a MATLAB example the bindata node has to be a subnode of an example node.

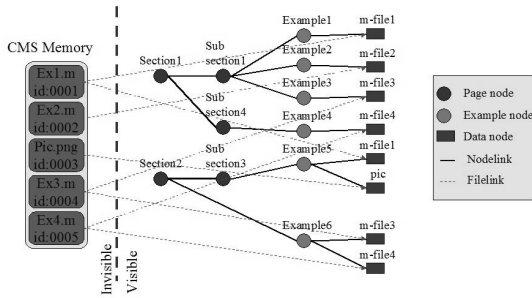In Figure 3 the functionality of the CMS is shown.

Figure 3: Functionality of the CMS

On the left hand side of Figure 3 the server with the stored files is illustrated while on the right hand side the examples of the MMT system are represented with the hierarchical order and linkings. The black lines symbolise the hierarchical order in the system, the red lines are symbols for the linking from the file on the server to the MMT example where the file is used. The nodes are represented by blue circles, endnodes/data nodes by blue quadrangles. For example: the file "Ex4.m" with the ID 0005 is linked to the endnode "m–file 4" of the example node "Example 5" and endnode "m–file 4" of the example node "Example 1" where "Example 5" is in the page "Section 1" and "Example 1" is in the page "Section 2".

One of the advantages of the system is, that each file is stored only once at the server and can be used in many courses with a link to this file using nodes. With this content management system it is also possible to use more than one m–file for one example.

4 Use in Teaching

The MMT E–learning system is a useful tool for lecturers to show examples as well as for students who can also fiddle with the examples and learn more about them while testing the examples after the lecture [4]. Therefore the MMT system is not only a tool for lectures but also an environment for studying for students. On the one hand students can learn how parameters influence

the result of the model and on the other hand they can learn about the different types of models. Furthermore it is possible to see how the model works by viewing the source code of the examples implemented in MATLAB and Simulink. For teaching modelling and simulation it is useful to show models and their applications which is possible with the presentation mode of the MMT E–learning platform, which enables to fit the screen according to the resolution and size of the projector. This is an important advantage of an E–learning system for modelling and simulation compared to many other E–learning systems. The students can learn more about the models in a "learning by doing" process at home [5].

5 Recent Developments and Outlook

An important step in the development of the MMT system are the different types of output formats of results of MATLAB examples. There are many different types, like textual output and graphical output. A new feature for m–files is an animated output of the results with so called animated gif–files [6]. The output is a video which runs in the middle section of the MMT interface. This is very practicable for results of models like cellular automata or agent–based models. For creating this video it is necessary to produce a series of pictures and create the animated gif–file for the video with them. In the MMT system there is an example which is called "rotation and translation of a triangle" which has a video–output. The m–file in behind the example first computes the coordinates of the rotated triangle with the chosen angle for the rotation. Afterwards these coordinates are translated by the coordinates chosen for the translation vector. In Figure 4 a static picture of the output is shown.
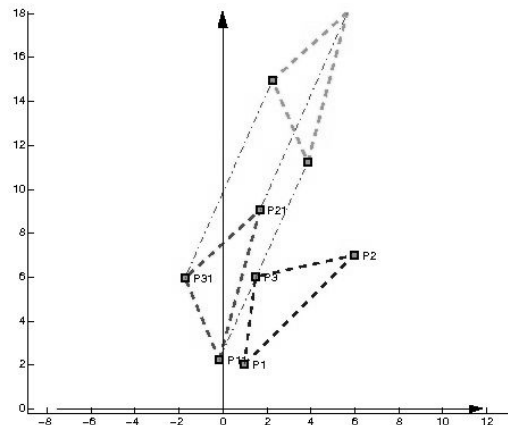

Figure 4: Rotation and Translation of a Triangle

There are also other types for the output of the results like text, numbers, figures, etc. and optionally they can be combined in a slideshow, which can be chosen by buttons below the "OK" button.

Another new feature in the MMT system are examples developed in AnyLogic where Java–applets are used. AnyLogic is a simulator which can export the created models as Java–applets. Therefore it is possible to produce models developed in AnyLogic for the MMT system, the part of an AnyLogic example which shows the AnyLogic model is illustrated in Figure 5.
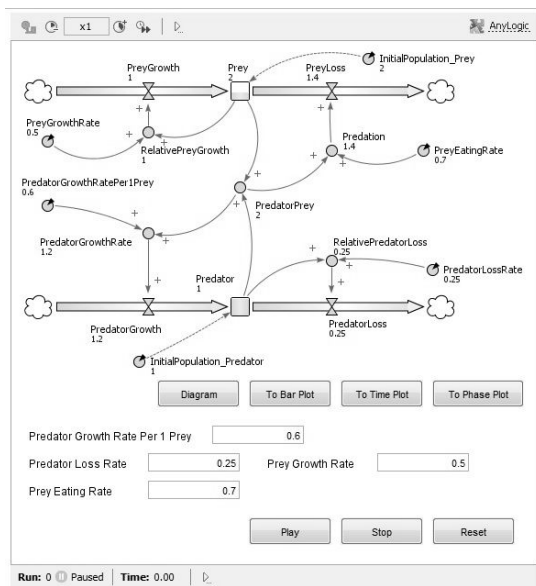

Figure 5: An AnyLogic Model of an Example of the MMT System

One plan for the future is that there will be examples in R and Octave running on the server. The concentration on these programs is because the licenses are free and therefore available for a huge number of persons. Using R it would be possible to create examples on probability calculation and statistics.

6 Conclusion

Summing up the MMT E–learning system is a useful tool for teaching for lecturers and students and its applications are steadily reaching more and more fields of modelling and simulation and its applications. The new methods for the representation of the outputs of examples based on m–files present the results in a reasonable way. These new developments are an important improvement for students working with the E–learning system. Apart from being a tool for teaching it is a collection of the work of the research team, which covers a lot of different approaches in modelling and simulation. Furthermore with the system it is possible for experienced students to improve the existing examples when downloading the m–file, changing the code and uploading the new version if they are given permission.

References

[1] G. Zauner, G. Schneckenreither, F. Judex, F. Breitenecker: A WEB-BASED E-LEARNING SYSTEM FOR TEACHING MATHEMATICS AND SIMULATION WITH MATLAB in MATHMOD 2009, 11. - 13. February 2009, Vienna, Austria

[2] A. Körner, I. Hafner, M. Bicher, S. Winkler, U. Fitsch: ABOUT THE INTEGRATION OF SIMULINK INTO THE MATLAB-BASED SIMULATION AND EXPERIMENT SERVER MMT in EMSS 2012, 19. - 21. September 2012, Vienna, Austria

[3] S. Winkler, A. Körner, N. Popper: MMT – Mathematics, Modelling and Tools: An E–learning Environment for Modelling and Simulation in Simulation News Europe 2011, Volume 21 Number 2

[4] I. Hafner, M. Bicher, S. Winkler, U. Fitsch: MMT – An E–Learning System Based on Computer Numeric System for Teaching Mathematics and Modelling in MATHMOD 2012, 15. - 17. February 2012, Vienna, Austria

[5] A. Körner, I. Hafner, M. Bicher, S. Winkler, F. Breitenecker: MMT – A Web Environment for Education in Mathematical Modelling and Simulation in ASIM 2011, 07. - 09. September 2011, Winterthur, Switzerland

[6] M. Bicher, U. Fitsch, M. Atanasijević–Kunc, N. Nagele, W. Wild, F. Breitenecker: MODELLING AND SIMULATION E-LEARNING SET OF HYDRAULIC MODELS in I3M 2012, 19. - 21. September 2012, Vienna, Austria