The MATH and the Vernier System at Faculty of Aeronautics.

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Abstract: This article describes two interesting and educational challenges whose we prepared for the students at faculty of Aeronautics, Technical University of Košice. The first is a software application MATH[4] used to teach Applied Mathematics, with focus on Numerical Mathematics and the second is the Vernier system, which we used in the Physics student's laboratory.

Key words: Numerical Methods, Step by Step Solutions, LMS approximation, error estimation, Vernier System

Introduction

Numerical analysis is the area of mathematics and computer science that creates, analyzes, and implements algorithms for solving numerically the problems of continuous mathematics. In the process of learning the mathematics and especially in the case of undergraduates, understanding the basics of numerical mathematics plays the key role. In order to be able to choose the best suited numerical method, one has to be aware of how those various numerical methods work, their advantages and disadvantages in a form of a calculation speed, precision and complexity.
There are several open source and web-based application with similar capabilities (that the author is aware of), but they are usually not designed for understanding the very basics of various numerical methods, which are very important and so not very well suited for education process.

Currently it is required to tie the theoretical university training more closely with the development of the students' practical skills. This can be achieved by laboratory experiments conducted by students. The our goal is to improve the methods of the practical training at Faculty of Aeronautics, Technical University of Košice by introducing modern automation and information technologies to the experiments and to the processing of acquired data.

1. Generally about MATH

The MATH is the software application which we developed at Faculty of Aeronautics for easier calculation numerical problems.

The Math application covers all methods needed by students for their further specialized studies. It provides so far these numerical methods for calculation and comparison [6] [7] [8]:

1) Nonlinear equation
   - Bisection method
   - Regula Falsi method
   - Secant method
   - Newton method
   - Iteration method
2) Definite integration
   - Rectangular method
   - Trapezoid method
   - Simpson's method
   - Monte Carlo Hit of Miss method
   - Monte Carlo Average method
3) Double definite integration (Monte Carlo method)
4) Numerical differentiation (up to 4. degree of differentiation)
5) System of linear equations
   - Jacobi Iteration method
6) Matrix calculation (basic numerical operations, transpose, inverse, etc.)
7) The least mean square approximation (LMS)

The MATH application can be extended by additional Numerical methods since it is open source. The Math is used as an education tool on several faculties of Technical University of Kosice. There are still many numerical methods and graphical capabilities to be implemented in the close future.

Before publishing, a trial run with students from Technical University of Kosice was performed, using input data (problem to solve) from lectures of Applied Mathematics in order to test its usability and detect any bugs. All final results were compared and checked against the results from Matlab [5] to ensure the desired precision of all used methods, as Matlab includes many, more advanced methods with higher precision. With Matlab we performed test of all methods available in MATH, also for limit values that could cause problems based on the principle of individual algorithms. These tests verify that all methods work correctly with desired precision. Although, various limit cases were tested, there still may occur some bugs considering special cases. For such occasion, there is support available through e-mail or MATH website. The MATH can be downloaded from MATH website [2] or from MATH source code repository [1].

As you can see on the Figure 1, in the lower part is a list of all built-in functions that can be used in function prescriptions with their brief description. The MATH supports also graphical output, to visualize used functions and results of numerical method calculations. Graph dialog window is shown on Figure 2. All information about the MATH and how to use it can be found at [1].

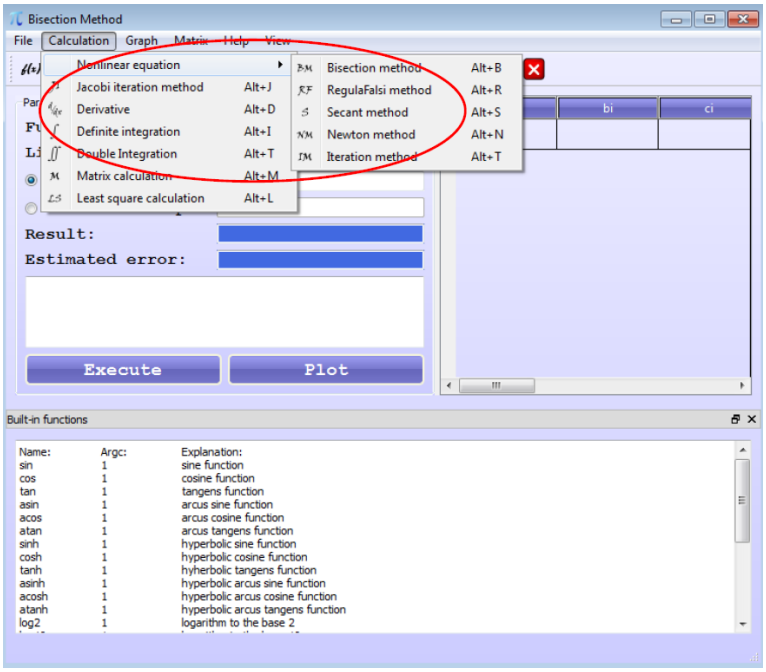

Figure 1. ***The MATH GUI and its main components***

Main GUI window can have various forms. Each form depends on the chosen method used for calculation, but is displayed in the same main window.

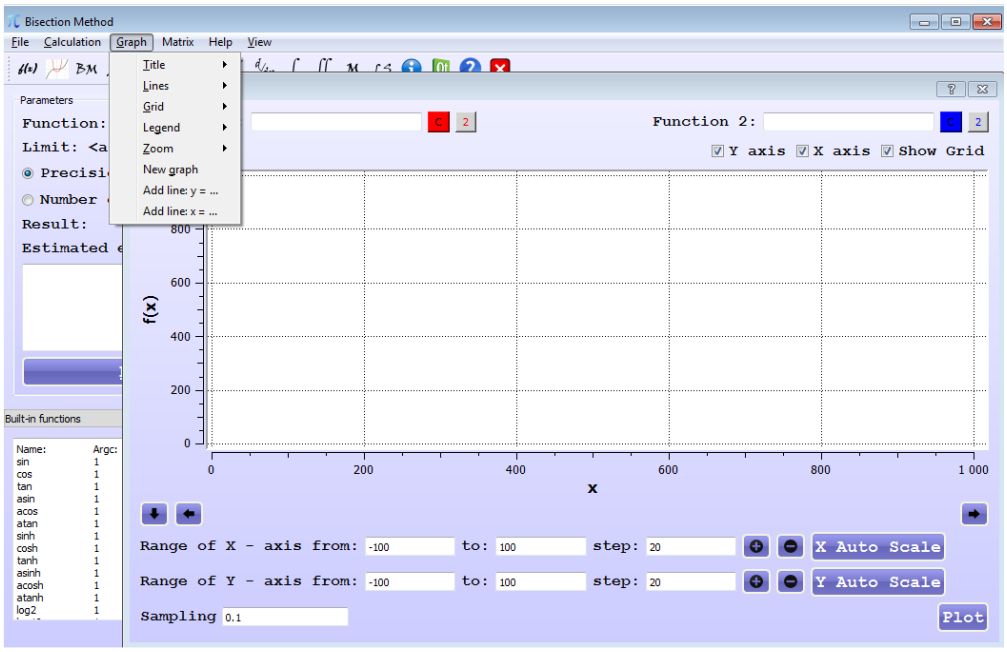

Figure 2. ***The MATH Graph Dialog Window.***

There are many properties that can be modified directly from GUI as shown above on Figure 2. Adjusting the graph dialog widnow is very intuitive as well as using the main GUI for numerical calculation. This plotting tool has most of commonly used options like changing lines color, width, zooming, adjusting grids, axis, title, labels, etc.

2. The MATH in education process

We use the MATH application while teaching Numerical methods during the course named Applied Mathematics in Sensors and Avionics System program at the Technical University in Kosice. During the lectures of Numerical methods we focus on methods which are necessary for further studying of vocational subjects. We use a calculator as primary tool to solve simple problems. This hand calculation is important because it helps students to better understand each method. Finally we use MATH in practice of Applied Mathematics course for controlling hand calculation problems. Because Math is available for free, students can use it at home to check their hand calculation. They can compare the calculations to find a mistake if any.

Another great advantage of MATH is that it is an open source, meaning that anybody can contribute and broaden the options and list of all numerical methods. In this way, students that are more advance, as it happens in every class, can program new methods right into MATH. This kind of contribution requires along with some programming skills, deeper understanding of that particular method and considering all limit situations that can be experienced.

To help the students with learning on how to use the application, there has been published a publication with examples from numerical mathematics using MATH as a tool [3].

3. Generaly about Vernier

Vernier Software & Technology was founded in Portland, Oregon in 1981 in the home of David Vernier, a high-school physics teacher, and Christine Vernier, a local business manager. The company is located in a Leadership in Energy and Enviromental Design gold-certified building, David Vernier serves as CEO of *Vernier Software & Technology* and oversees product development and Christine Vernier serves as COO and oversees company operations. The company creates world-class data-collection solutions, sensors, software, and curriculum that help engage and excite students through scientific exploration. Measurements using Vernier technology get students excited about science and deepen their understanding of complex concepts. It gives students the tools to analyze data and think like real scientists. Main benefits to use of this system are:

- It improves student understanding of science concepts.
- It supports engagement in higher order thinking skills, such as analysis, synthesis, and evaluation
- It enables students to perform many new experiments and measurements not only in the laboratory.

The basic set for measurement includes Interface LabQuest, sensors and software see Figure. 3.

Figure 3. ***LabQuest*** **[9]**

More about the Vernier System you can see in[9].

4. The Vernier in education process

We chose the Vernier System as the best way of achieving a higher quality of teaching. We have updated our Laboratory with this system and have automated experiments using it. First of all are the measurements of the physical pendulum period, the free fall acceleration, the magnetic field explorations and determination of kinematic viscosity.

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References

[1] MATH documentation and source code, Available at http://sourceforge.net/projects/nummath/ [Last Accessed 28. November 2015]

[2] MATH website, Available at https://sites.google.com/site/mathnumapp/ [Last Accessed 28. November 2015]

[3] Budajová, K. – Glaser-Opitz, H., (2014), Súbor riešených príkladov z numerickej matematiky s využitím aplikácie MATH, Technical University Košice, ISBN: 978-80-553-1727-4 Available at http://web.tuke.sk/lf-kas/ucitelia/budajova/subor_riesenych_prikladov_z_numerickej%20_matematiky.pdf [Last accessed 28. November 2015]

[4] Glaser-Opitz, H and Budajová, K 2016 MATH: A Scientific Tool for Numerical Methods Calculation and Visualization. Journal of Open Research Software, X: eX, DOI: http://dx.doi.org/10.5334/jors.55

[5] Todd Young, Martin J. Mohlenkamp, (2014), Introduction to Numerical Methods and Matlab Programming for Engineers, Department of Mathematics, Ohio University

[6] R. W. Hamming: Numerical Methods for Scientists and Engineers, second edition, 1962m ISBN 0-486-65241-6

[7] Thomas R. Bewley: Numerical Methods in Science and Engineering, UC San Diego

[8] Riccardo Sacco, (2013), Numerical Methods for Civil Engineering, Milano

[9] www.vernier.com