Volume 21, January-December 2023, ISSN: on request

MONOGRAPH

CIENCIAS UNIVERSITARIAS

Journal site: https://revistas.unah.edu.cu/index.php/cu Cu-ID: https://cu-id.com/cu/v21e04

EASYMN 1.1: DIGITAL TOOL FOR NUMERICAL MATHEMATICS IN THE INDUSTRIAL ENGINEERING COURSE

EASYMN 1.1: HERRAMIENTA DIGITAL PARA LA MATEMÁTICA NUMÉRICA EN LA CARRERA DE INGENIERÍA INDUSTRIAL

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In the career of Industrial Engineering of the UNAH ¨Fructuoso Rodríguez Pérez¨ the Numeric Mathematical subject is imparted. In this it becomes basic in the practical classes to solve mathematical problems through numeric methods. For what becomes necessary to use a software designed for the teaching of these contents. The EasyMN 1.1 constitute a digital tool that has had an impact in this technical career whose profile is not guided directly toward the computer programming. The users have expressed satisfaction for the facilities and advantages that it provides in the solution of problems, being motivational their employment to be pleasant the atmosphere, and easy their handling in the classes. In their treatment one kept in mind the contents imparted in the subjects you tune to the mathematical one that one receives in the technical careers of the Cuban University. Starting from the migration program to the free software proposed in Cuba, this software was made elaborated in free platforms and with open code as contribution to this politics to continue.

Keywords: Computer science, calculations numeric, mathematical calculation, numeric analysis

En la carrera de Ingeniería Industrial de la UNAH ¨Fructuoso Rodríguez Pérez¨ se imparte la asignatura Matemática Numérica. En esta se hace básico en las clases prácticas resolver problemas matemáticos a través de métodos numéricos. Por lo que se hace necesario emplear un software diseñado para la enseñanza de estos contenidos. El EasyMN 1.1 constituye una herramienta digital que ha tenido un impacto en esta carrera técnica cuyo perfil no está orientado directamente hacia la programación informática. Los usuarios han expresado satisfacción por las facilidades y ventajas que proporciona en la solución de problemas, resultando motivador su empleo por ser agradable el ambiente, y fácil su manejo en las clases. En su tratamiento se tuvo en cuenta los contenidos impartidos en las asignaturas afines a la matemática que se recibe en las carreras técnicas de la Universidad cubana. A partir del programa de migración al software libre propuesto en Cuba, se confeccionó este software elaborado en plataformas libres y con código abierto como contribución a esta política a seguir.

Palabras claves: Informática, cálculos numéricos, matemática computacional, análisis numérico

INTRODUCTION

Numerical Mathematics or Numerical Analysis or Numerical Calculus is the branch of Mathematics in charge of designing algorithms to simulate approaches to solving problems in mathematical analysis. It is distinguished from symbolic computing in that it does not manipulate algebraic expressions, but rather numbers. Álvarez (2007) and Hoffman (2001) state that Numerical Mathematics proposes, develops, analyzes and applies numerical algorithms and methods to obtain approximate solutions to problems.

At the Agrarian University of Havana (UNAH) "Fructuoso Rodríguez Pérez" located in the Mayabeque province, the Numerical Mathematics subject is taught for students pursuing the technical degree in Industrial Engineering. This basic subject proposes among its objectives to solve mathematical and practical problems using numerical methods (MES, 2020). For his work he needs to feed on the

Received: January 18, 2023
Accepted: February 23, 2023
Conflict of interest: The authors of this work declare that they have no conflicts of interest.
AUTHORS' CONTRIBUTION: The authors participated in the design and writing of the work, in addition to the analysis of the documents.

advances in Mathematics and at the same time he is enriched by being nourished by a series of methods and algorithms that allow numerical results to be given for the vast majority of the problems of Continuous Mathematics. This interaction is what makes possible the close relationship of this discipline with the rest.

Some researchers (Shampine, *et al.,* 1997; Hoffman, 2001; Press, *et al.,* 2002) consider that the purpose of teaching this Numerical Mathematics subject is to train students in the use of different numerical methods, developing the ability to use numerical methods as procedures included in other programs, also to decide whether analytical or numerical models are used in a given problem and finally analyze the results of the computational solution and draw conclusions about the validity of the model and of the answer obtained, through the use of mathematical assistants.

Currently the use of numerical methods is of crucial importance in almost all fields of science. Classical mathematics provides the basis and theory for development, but when the complexity of the problem increases or depends on many variables, analytical solutions, when they exist, become too complex to evaluate and generally impractical. For some time now, Galantai (1992) and Yamamoto (2000) consider that the rapid development of computing and data processing means has led to the use of numerical methods spreading very strongly even in fields where solutions are available. analytics to problems. Furthermore, the development of greater computing power in home computers has led to the development of tools and programs at the core of which numerical methods are used to solve the most varied problems, from the gradient of a color in an image editor to the calculation of stresses of engineering structures.

The technical degree programs address topics on numerical methods, in some cases embedded within Calculus I and II or in others as an independent subject.

It is important to keep in mind that not all careers have the same needs and levels of knowledge in all fields. Due to this, it is essential to adjust the level of demand for the same knowledge taking into account the individual needs of the career in question.

In the specific case of numerical mathematics, an industrial engineer must master elements of information with a level of depth and detail. In addition, they must have programming skills and use of computer and computing technologies, for example, they must focus their attention on the efficiency of the convergence process, as well as the optimization of intervals and so on.

In higher education worldwide, these differences in levels of knowledge are recognized, in many cases to classify the level of mastery of a certain professional with respect to a specific program or their programming skills. That is why numerical scales or 3 to 5 values (example: expert, developer, user, hobbyist...) are usually included in the forms or surveys.

In the case of numerical mathematics and with the aim of improving the quality of graduates both in mathematical knowledge and in the use of Information and Communications Technologies (ICT´s), it has been introduced into technical careers whose profile does not is directly related to programming, the use of programs and software packages to solve problems through numerical means. However, the strategy used so far has not been unified, not only between the different careers, but also between the same career studied in different places. One of the impediments that this unification has had has been fundamentally the variety, diversity and in some cases complexity of the available programs, in addition to the requirement of patents, and in some cases of overly sophisticated computers not always available to educational centers. or of the students.

That is why this work shows software that responds to this problem and considers the pedagogical and academic needs of our students.

In addition, a comparison of our proposal is made with other existing alternatives and some details of its structure and license are presented for its generalization. The criteria given by the students of the Industrial Engineering career at UNAH (from the Day Course and the Meeting Course) are provided when using the software in the subject of Numerical Mathematics.

DEVELOPMENT

About the program of the numerical mathematics subject

From the study of the program of the numerical mathematics subject, it is found that most of the topics are common to almost all careers in which this subject is taught independently. This gives meaning to the development of software that can be used from a teaching point of view in the largest possible technical careers. Furthermore, the courses in which some topics are taught within calculations I and II did not have special or extra topics included, so this case would not affect the generality of the program.

The topics and methods included in all the programs consulted were:

Topics	Methods
Roots of equations.	Graphic separation of roots. Bisection method. Regula-Falsi method. Newton-Raphson method. Method of Secants.
Systems of linear equations.	Gauss method. Jacobi method. Seidel method.
Approximation of functions.	Polynomial interpolation. Lagrangian interpolation. Newton interpolation. Curve Fitting (Least Squares).
Numerical Integration.	Trapezoid Method. Simpsons method. Gauss method. Rombert method.
Numerical Optimization.	One-dimensional optimization without restrictions. Optimization in an interval. Gradient Method. Powell method. Sequential Simplex Method.
Ordinary differential equations.	Euler method. Runge-Kutta methods order 2, 3 and 4. Predictor-corrector method.

In most programs for the subject of numerical mathematics, the management and use of information technology and computing technologies is explicitly indicated as one of the objectives of the program. But a methodology is not indicated or guided, nor are indications given on how or with what to do it and it is not part of the indications for the evaluation process.

Current alternatives for solving basic numerical problems through the use of ICT´s

Currently there is a wide variety of programs that could be used to solve numerical problems, but most of them have drawbacks that do not make them suitable for teaching use. As part of the previous study, most of them were investigated and discarded for the reasons set out below.

It should be noted that none of the previous programs offer the facilities of showing the convergence process step by step. Almost all of them require a fairly large set of steps to be able to graph the results and very few allow a summary of the results or operations to be saved in plain text format in a simple way.

These drawbacks mean that its use for teaching purposes is not entirely appropriate, since it implies focusing on a specific syntax and not on the essence of the method, its convergence or efficiency, which is really one of the objectives of the subject.

Some notes on the EasyMN 1.1 software

The non-use of any computer package affects the educational teaching process from several points of view:

- Attacks the curricular strategy of using ICT´s.
- It directly affects the quality of graduates regardless of their specialty in the current context of technological development.
- Motivation is also affected since the student would not see the reflection of what he knows in a practical environment or its usefulness.

The use of licensed programs affects the teaching process even from an economic point of view since to use them it would be necessary to pay licenses, as it would be used in the education center a high number of licenses would have to be paid and the student would have to pay yours.

In contrast, failure to do so goes against the formation of values since the use of proprietary programs without licenses is theft punishable by copyright law. This also brings with it a whole set of legal implications.

Facilities and contributions of the EasyMN 1.1 software

Taking into account the lack of software that satisfies all the current needs of our Numerical Mathematics subject programs. A first version has been prepared and corrected taking into account all of the above. The program presented to you has been prepared based on the needs and in addition to including all the topics of the subject, it has the following advantages that would respond to the previous drawbacks:

- **Friendly interface:** It has been developed completely in graphical mode, which makes it intuitive and accessible to the general public. All the availabilities are found from various places so that the interface does not hide the functionality. This allows the user to concentrate on the

Program	Description	Disadvantages for teaching use
MatLab, Ansys, Mathematics.	Very powerful programs for advanced levels and research.	Require License. Text mode and requires programming knowledge. Newer versions require powerful computers. They require a lot of disk space.
Maxima, WxMaxima, Octave, R.	Open source programs (Free). Used in several universities around the world.	They require fairly deep programming knowledge. Only for Linux platform to use all availabilities. Difficult to install. Unfriendly interface.
Mn, Mn2000.	National invoice programs. Prepared for teaching purposes.	They have no support. It does not include all the topics and methods of interest. Only for Windows platforms. They have quite a few known bugs that have not been fixed.

work and the methods to be used without having to spend time learning syntax or command combinations.

- **Multiplatform:** The complete program has been developed on the open source Qt4 platform. This platform can be used on devices with Windows, Linux, Mac and even Android. This was done with the intention that it could be used in any university and that it would not prevent the migration to free software (one of the current objectives of our country) as occurs with a large number of software packages that are currently used and whose dependence is due to the delay in the migration project. In this way, it is consistent with the value system that we want to form in our professionals, by not inducing them to use programs illegally or without licenses that have legal support.
- **Allows you to modify all the parameters of the method used:** One of the main problems of existing programs is the fact that they do not allow modifying some of the parameters of the methods, such as the step or number of iterations, in some cases it is allowed to vary one but not the others, this, from a didactic point of view does not provide the student with much information about the importance of each parameter in the method so that the program is not a black box. In the current project, this has been taken into account, giving the user total freedom in this sense, with which the user can reach greater levels of depth in terms of knowledge and allows him to experiment so that he can draw conclusions from his own experience, favoring the development of own investigative skills.
- **Provides information about the convergence of the process:** It is possible to obtain a lot of information about the progress of the convergence process. Functionalities have been included to show not only the values of the convergence factors, but also graphs can be presented with the dependence of the error and the values with respect to the iteration. This availability is very important from a didactic and pedagogical point of view since it allows the student to verify the importance of the convergence factors and interpret their meaning. Together with the functionality mentioned above, it is one of the main advantages for its teaching use.
- **Timer:** A small time indicator has been included, which shows the time consumed by the most recent operation. This functionality is also a measure of the efficiency of the process and has not been found in any of the previously available programs.
- **Quality graphics:** For the creation of graphics it has been decided to use the Mathgl library that uses the quality of the OpenGL system for the creation of graphics with good appearance and high precision. This library is also cross-platform and open source. The quality of the graphics is important in terms of motivation by making the program more interesting and attractive. And the graphics can be used in work and research.
- **Well-developed help:** Although the program interface does not require reading help for its use, a help system has been developed that allows you to know all the program's functionalities and the ways to access them, as well as essential information about methods. In this way, the aid functions indirectly as a source of theoretical-practical information about the methods.
- **Allows you to make summaries:** All operations have a functionality that allows you to save a summary of the most recent operation carried out. This summary contains the type of problem, method used, initial data, results obtained and in the case of iterative methods, a table with partial results is included. In addition to the date and time of the operation. It is allowed to save more than one summary in the same file. This is done in the manner of many similar professional programs so that the results and data can be manipulated more easily or analyzed later for investigative or other purposes.
- **Facilities for exporting graphics:** A functionality has been included to export the graphics obtained to different png, jpg and pdf formats. All with high quality and precision and in a simple way. In this way, the feasibility of preparing reports and works using the program is guaranteed, with the aim of being able to develop extra-class tasks and investigative projects that contribute to the systematic evaluation process.
- **Open structure:** An open structure makes it easier to add new functionality to the program. Although it has been initially developed for the Numerical Mathematics subject, it would be possible to add content from other subjects such as statistics or probabilities. That is why the structure has been left open so that it is not too complicated to make annexes and so that they do not look as such. This leaves the door open for the subsequent evolution of the program to add functionalities for use in other subjects.
- **Efficient:** All the code has been developed in C and C++ language. These languages are on the list of the most efficient and numerically best available today, surpassed only by Fortran and Assembler in these aspects. As they are compiled languages, they make optimal use of resources and do not require installed platforms to function. As the libraries used are free, they can be distributed with the program installer itself, making the calls more efficient, so very powerful computers are not required to use it. With this, the real availability of computer resources at our universities has been taken into account so that the program can be used massively.

- **Easy to install:** Installers have been developed for Microsoft Windows (.exe), Linux (.deb and .rpm) so that installation is a very easy and fast process on both platforms. This also protects you from possible virus infection or the devastating action of some antiviruses on the Windows platform.
- **Infinite loop protection:** This functionality has been included so that users have complete freedom to experiment with method parameters without disastrous consequences. A very high limit has been imposed on each method for the number of iterative operations so that there are no infinite loops that can make the program unstable.

All of the above characteristics provide a direct response to the difficulties detected in the current options, providing the greatest amount of information possible and total freedom for research and study. From a pedagogical point of view, the program has the advantage of not being a black box since it shows each of the steps it performs and the help presents an explanation of the methods and equations used.

As it includes all the chapters of current numerical mathematics programs, it can be used by almost all careers that consider it necessary and even in some research. It is not advisable to use it in large-scale investigations since that is not the purpose for which it was created and for that it is first required to validate it, which, being a program that uses graphics and external libraries, becomes more complex when Rigorous validation of the libraries used with authorization of their authors is required.

Tool proposal and technical requirements of the application

A computer allows us to obtain numerical solutions to different problems very quickly. In applied mathematics, a problem has a satisfactory solution if an algorithm can be provided on a computer in such a way that numerical solutions are available.

In this tool we will find all the essential components when teaching the Numerical Mathematics subject, being an access route for all those students who wish to exercise this topic, as well as a very significant resource when teaching it.

Through the  EasyMN.exe icon (executable) you directly access the software proposed as a work tool. The main menu (Figure 1) has two options related to (1) Actions and (2) Help:

Each of these options is described below:

1. **Actions** provide the options to graph functions (Figure 2), calculate roots (Figure 3), solve systems of linear equations (Figure 4), numerical interpolation and integration (Figures 5 and 6), and solve differential equations (Figure 7). Each of them offers work possibilities that facilitate the performance of specific operations.

1. The other part, the **Help** option provides an essential commentary on the software (Figure 8) and help documentation for its management with 6 tabs that cover the contents proposed by the Main Menu (Figure 9).

Technical requirements

The application does not require a computer with high hardware and software conditions. This must meet at least the following requirements.

Hardware: Processor: Pentium III; speed: 650MHz; RAM: 128 MB.

Software: Operating System: Windows 7 (or higher). In addition to this, the type of material to be used must be considered since users who use this tool must have a CD-ROM reader on their computer or a USB port. On the other hand, users who access through a network depends on their connection conditions.

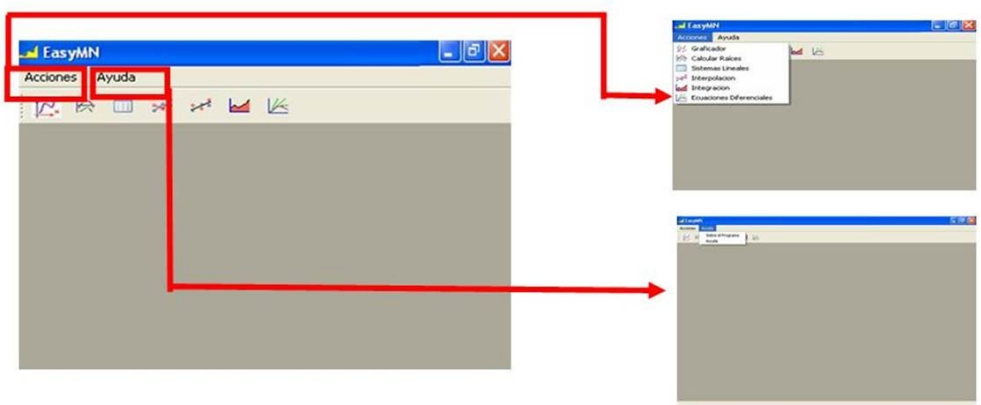

Figure 1. Main Menu Options.

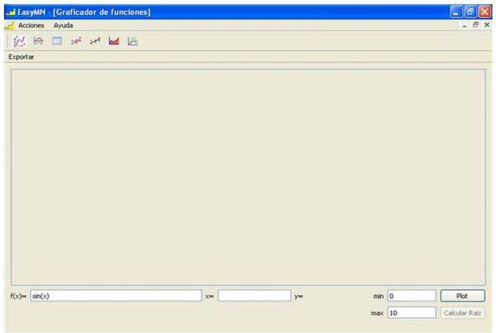

Figure 2. Plot Functions Options.

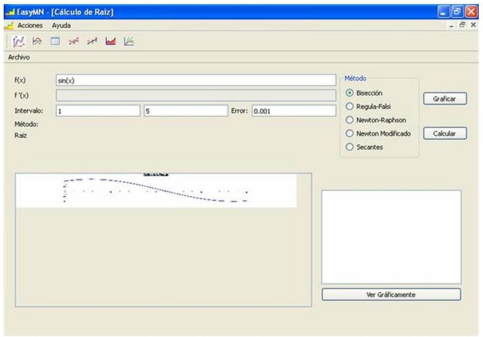

Figure 3. Calculate Roots Options

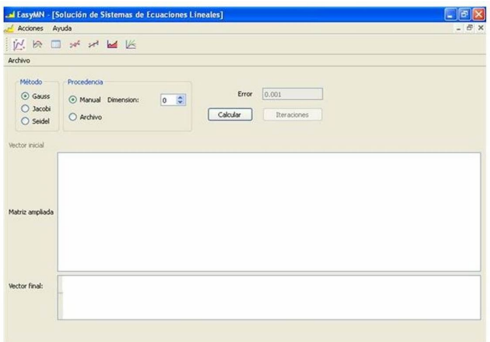

Figure 4. Linear Systems Options.

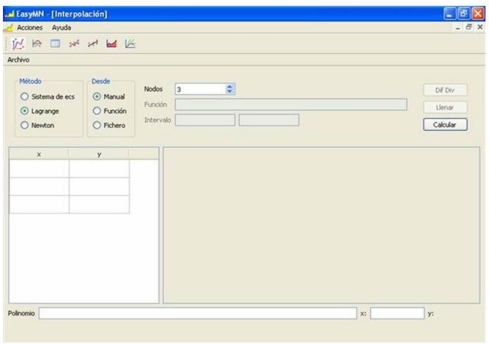

Figure 5. Interpolation Options.

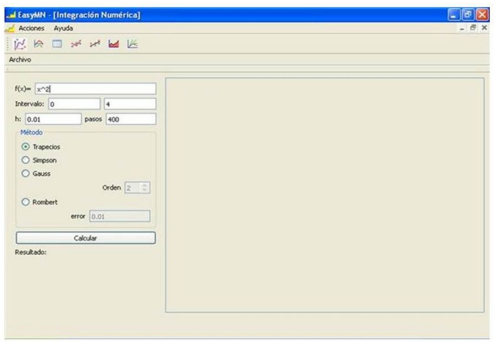

Figure 6. Numerical Integration Options.

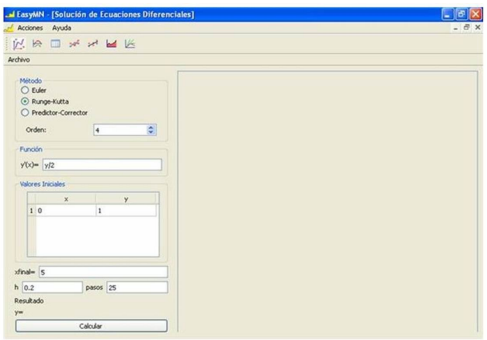

Figure 7. Differential Equation Options.

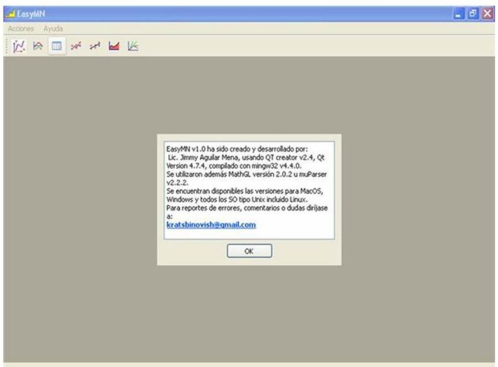

Figure 8. About the Program Options.

Figure 9. Help Options.

Criteria for using the application as a digital tool

At the end of the Numerical Mathematics subject, a simple survey is applied for CD and CPE. The students of the Industrial Engineering degree were provided with criteria for the use of EasyMN 1.1 in the teaching activities of the Mathematics IV subject, which allowed them to reach the following evaluations by the work team of this research. Below is a summary of the results obtained:

- This tool facilitates the use and management of calculation in numerical mathematics. 98.67% of the students of the Day Course (CD) and 99.02% of the students of the Encounter Course (CPE) have expressed satisfaction with their employment.
- When using it in independent work activities, 100% of the students (CD and CPE) express full satisfaction with its use, considering the Help very effective and necessary to confront it in individual work.
- In its generalization and application in the solution of problems posed in Numerical Mathematics, students (CD and CPE) express feeling 100% motivated by its use, and find the software pleasant in its proposed environment that it provides for easy handling.
- 95.25% of CD students consider that the software has different and advantageous characteristics, when comparing it with other similar applications previously used. For CPE students, 100% of learners fully support it.

CONCLUSIONS

- The EasyMN 1.1 software is a support tool for teaching numerical mathematics in the technical career of Industrial Engineering and users (98.67% of the CD and 99.02% of the CPE) express satisfaction with its use.
- It is used to work on solving problems related to numerical mathematics in technical careers whose profile is not directly oriented towards computer programming.

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