MATLAB AT THE FACULTY OF AERONAUTICS

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Abstract. MATLAB is an internationally used platform that provides a friendly interface with widespread use. In this article, we focused on its university use. Also, within the framework of university use MATLAB offers many possibilities, which can work with either in education or research. This article deals with MATLAB as one of the universally applicable systems for the general professional community. The paper contains information about the application of the MATLAB system at the Faculty of Aeronautics in academic year 2018/2019. We investigated the possibilities of using the system in terms of the Faculty of Aviation.

Keywords: MATLAB, Faculty of Aeronautics, system application in teaching, increasing the citation rate of scientific outputs

1. INTRODUCTION

MATLAB enables mathematical calculations, computer simulations, and, last but not least, programming. So we are talking about the universal computer, data, and visualization environment from The MathWorks Company. This company was established in 1984. The essential data object in MATLAB is the matrix that is hidden in its name - MATLAB - MATrix LABoratory [1].

MATLAB is an engineering tool as well as an interactive environment for scientific and technical computing, data analysis, and algorithm visualization. MATLAB has its application all over the world, not only in the university environment but also in leading manufacturing and research companies. Solutions in the areas of mathematics, artificial intelligence, signal processing, robotics, manufacturing, but also chemistry, aeronautics, construction, and others provide a unique simulation environment.

Millions of engineers and scientists worldwide use MATLAB® to analyze and design a variety of systems and products. MATLAB is the world's most natural way to express computational mathematics. Built-in environment graphics make it easy to visualize and report data. All MATLAB tools and capabilities are rigorously tested and designed to work together [1].

Within MATLAB, it is possible to perform analyzes on more massive data sets and scale them on clusters and clouds. MATLAB code can be integrated into other languages, allowing deployment of algorithms and applications in web, enterprise, and manufacturing systems.

Many researchers use MATLAB to tackle research activities such as a robotics study where a four-finger robotic hand is analysed. The simulations were performed so that the hand grasped objects of different sizes and shapes, and the hand model was controlled in the MATLAB environment using the SimMechanics toolkit [2]. Further, a study [3] which was aimed to verify the reliability of a hybrid instantaneous theory (HIT) approach based on harmonic and non-linear conditions, where different test conditions were examined in different cases using MATLAB / Simulink software [3]. Another study is a study focused on a simple way of generating waves using digital control of a rotary valve, where a numerical analysis based on the theory of linear waves was performed in MATLAB environment [4]. Another research is the continuation of research into a stabilization system for an uncrewed aerial vehicle in vertical take-off and landing. The control system was written in MATLAB / Simulink software and implemented in the Arduino microcontroller [5]. A study [6] aimed to reverse the polarity of the Earth, which has geophysical significance and affects life on the planet. Numerical
simulations were performed in MATLAB environment [6]. It is not only based on the submitted studies that we can see an extensive application of the MATLAB system in various research areas. Against this background, the Technical University of Kosice decided to use the possibility to implement this system in multiple areas of its work.

MATLAB provides several licensing methods, with school licenses being offered on advantageous terms. As a result, MATLAB has found application in teaching, research, and project-oriented education at more than 5,000 universities worldwide. For easier licensing and administration, MathWorks has prepared a TAH license. The TAH license covers all teachers, researchers, students, but also other university staff. The condition for obtaining it is the use of university e-mail. Once a license is assigned, MATLAB can be installed on university computers, student and teacher computers, including their private computers. It gives them access from classrooms, home, out-of-the-box workplaces, but also outside the university, even without a network connection. It also simplifies the administration of licenses by administrators who do not have to manage permissions per department. The license always contains the current version of MATLAB with selected extensions [7].

The Technical University of Kosice is the owner of the Total Academic Headcount (TAH) license for MATLAB, Simulink, and supplementary products since the academic year 2018/2019. University staff, researchers, and students can use these products for teaching, research, and study. The license allows individuals to install products on both university devices and private computers. More than 85 modules currently available to TUKE under this license, which significantly advance the process of education, science, and research, as well as the practical application of candidates. An overview of the Toolboxes made available by TUKE can be found at [8].

Under the MATLAB TAH license, students and educators also have access to the following services:
- MATLAB Online - MATLAB in a web browser without having to be installed on a computer
- MATLAB Drive - 5GB cloud storage
- MATLAB Mobile - MATLAB on a mobile device

2. MATLAB SYSTEM APPLICATIONS AT FACULTY OF AERONAUTICS

After obtaining a TAH license on the Technical University of Kosice (the same license is at MIT and Stanford University), the Faculty of Aeronautics sought to include it in the teaching process and to familiarize students with the platform. By November 12, 2018, there were more than 600 installations of MATLAB under the TAH license at TUKE. As MATLAB provides many toolboxes for different areas, it can use in various study programs of the Faculty of Aeronautics, from technical to managerial. MATLAB offers multiple applications not only for students but also for teachers and researchers, especially in the research, publication, and citation areas.

Several activities have been undertaken at the faculty to bring this software to the attention of the students.

2.1. Seminar: MATLAB and current research

On April 2, 2019, at 13:30 in the auditorium B19 / 01 in the premises of the Faculty of Aeronautics, Humusoft experts (MATLAB system distributor, lecturer Michal Blaho, Martin Foltin) presented a new version of MATLAB system - R2019a. More than 50 participants attended the seminar: students, PhD students, Faculty of Aeronautics teachers, and guests from other faculties. The contents of the lecture were general information about the system, modelling of differential equations, Simulink, Simscape, Artificial Intelligence - Deep Learning, Machine Learning, Predictive Maintenance, Aerospace toolbox, and Optimization toolboxes.

At the seminar, essential and new MATLAB functionalities were introduced, such as:
The online live editor has been extended with additional features. It already has integrated HTML5, Latex, computing, and the related technologies that make it easier to publish research results.

File exchange server - this technology uses to exchange results within the MATLAB community; thus, it is possible to increase the citation of results.

New toolboxes such as Bioinformatics or Aerospace toolbox with CubeSat extension

New technologies, e.g., predictive maintenance based on the application of Deep Learning technology.

The Seminar also attended Prof. I. Podlubný (BERG Faculty, a researcher with the highest number of Web of Science citations in Slovakia) and Assoc. prof. M. Šujanský (Faculty of FEI), who actively use MATLAB.

2.2. Including MATLAB in the teaching

To familiarize students with the MATLAB platform and its application in teaching, MATLAB was used in teaching Applied Mathematics. Students were acquainted with the necessary specifics of the system and participated in the self-courses offered by the company. Individual functionalities of the program practice in the section Statistics and Probability, where students learned to work with the online technologies MATLAB live editor and MATLAB Drive (Fig. 1). In the given section, students completed the course Introduction to Statistical Methods with MATLAB.

![Figure 1 An example of a summary within the MATLAB course](image)

Within the subject, a total of 613 certificates were performed, which were obtained in the period from 10.10.2018 - 10.6.2019. Table 1 and Table 2 provide a more accurate overview.

| Study group             | Number of students | Number of certificates obtained |
|------------------------|--------------------|--------------------------------|
| Air Traffic Control    | 78                 | 378                            |
| Pilot, Air Traffic Controller | 24               | 171                            |
| Individual study plan  | 12                 | 64                             |
| **Together**           | **114**            | **613**                        |
To increase students’ motivation to participate in the MATLAB program, the Faculty of Aeronautics organized a competition - MATLAB Academy Challenge - within the courses “Numerical Mathematics” and “Applied Mathematics.” The competition ran from 9.10.2018 to 10.12.2018. As part of the race, it was necessary to obtain as many MATLAB certificates as possible. Seventeen students (out of 25) participated in the competition. Students received 107 MATLAB Academy certificates worth more than € 24,000. In the competition, students received various certificates. Their overview is provided in Table no. 3.

| Course name                                      | Number of certificates obtained |
|--------------------------------------------------|---------------------------------|
| MATLAB Onramp                                    | 17                              |
| Simulink Onramp                                  | 11                              |
| Deep Learning Onramp                             | 15                              |
| MATLAB Fundamentals                              | 12                              |
| MATLAB Programming Techniques                    | 12                              |
| Introduction to Linear Algebra with MATLAB       | 13                              |
| Introduction to Statistical Methods with MATLAB  | 11                              |
| Solving Nonlinear Equations with MATLAB          | 14                              |
| Solving Ordinary Differential Equations with MATLAB | 2                              |
| **Together**                                     | **107**                         |

* The value of MATLAB Fundamentals and MATLAB Programming Techniques is 1000 Euros

The MATLAB program and its inclusion in the course Applied Mathematics had a positive response among students. Some decided to develop the plan further and use it for further study or preparation of diploma theses. TUKE students received approximately 2000 certificates for 2019. It is the highest number of certificates obtained in Slovakia, followed by STU Bratislava, with around 1000 certificates.

3. INCREASING CITATIONS OF SCIENTIFIC OUTPUT USING MATLAB

Programming in the MATLAB interface also helps to increase the citation rate of articles within relevant scientific databases. Prof Podlubný of the BERG faculty has tested this fact. Podlubný of the BERG faculty. That is why we decided to test this way of increasing citation.

The first step in the citation-raising process is to save the work output, in the form of programs, for the MATLAB community on a File Exchange Server. You should then refer to the File Exchange Server (FES) in the publication output.

File Exchange Server lets you find and share custom applications, code examples, drivers, features, Simulink models, scripts, and videos. With File Exchange, you can:

- Send files
- Connect to GitHub repositories
- Share a web page that contains MATLAB code
- Search for data using content type, search box, and search guidelines
Adding comments for future searches, personal use ratings, and comments that support individual ratings

Recommendations for other members to cite your work [11]
  o Citation guidelines help community members to refer to your work when it uses in their research or derivative works. There are many recommendations for citations, such as a page citation request, a research article, a working group, or a combination of resources. New file exchange records are created with the default citation instruction, which you can delete. Also, it is possible:
    ▪ Enter your citation instruction using your text
    ▪ Outsource DOI to your work
    ▪ Create multiple citation instructions [11]

To verify the possibilities of the MATLAB system and subsequently the FES server, we programmed and published a paper called "SkCube orbit calculation." Its display on FES servers is shown in Figure 2.

Figure 2 Example of program display at FES [12]

Figure 3 shows an overview of the program with parameters set for citing.
4. SUPPORT FOR STUDY WITH MATLAB - PUBLISHING CALCULATIONS AND ALGORITHMS

MATLAB can serve various purposes. A collection of tasks has been created in MATLAB [15]. This collection contains algorithms, solved problems in MATLAB for Linear Algebra.

- The collection includes the following chapters:
  - Line operations
  - Matrices and vectors,
  - Matrix operations,
  - Regular matrices and inverse matrices
  - Determinants,
  - Cramer rule,
  - Gaussian elimination method,
  - Jordan's elimination method,
  - Linear dependence and independence of vectors
  - The rank of the matrix and the Frobenius theorem,
  - Linear transformations - matrix multiplication and elementary operations
  - Linear dependence and independence of vectors
  - Vector spaces.

The collection is designed as one particular file in the MATLAB Live editor. Naturally, it is possible to find the required example and run the calculation while learning the calculation algorithm. Figure 4 shows the collection in the MATLAB Live editor.
5. CONCLUSION

The MATLAB system is an internationally used platform that offers a user-friendly user interface and many support activities for working with it. Learning how to work with these systems is possible individually based on the MATLAB Training program, which is fully adapted to the specific topics.

The MATLAB system has extensive application possibilities and applications. It can be used in the field of science and research in the form of programs. MATLAB also raises the awareness of the scientific community about the research activities of the individual and the organization. The MATLAB system found its application even in the conditions of the Faculty of Aeronautics. The main possibilities of its use at the faculty include support for teaching basic (mathematics, physics) and vocational subjects, support for publishing research results, and creating an interface for the transfer of new technologies into practice.

References

[1] Baumann, M. The MATLAB engineering tool helps students improve their skills [Inžiniersky nástroj MATLAB pomáha študentom zlepšovať ich zručnosti], 2017. Available at: https://www.ucn.sk/z-domova/inzinersky-nastroj-matlab-pomaha-studentom-zlepsovati-ich-zrucnosti
[2] MATLAB overview. Available at: https://uk.mathworks.com/products/matlab.html
[3] Neha, E., Suhain, M., Asthana, S., Mukherjee, S. Grasp analysis of a four-fingered robotic hand based on MATLAB simmechanics, Journal of Computational and Applied Research in Mechanical Engineering, Vol. 9, Issue 2, Winter-Spring 2020, Pages 169-182. DOI: 10.22061/jcarme.2019.3427.1390
[4] Sahoo, B., Routray, S.K., Rout, P.K., A novel control strategy based on hybrid instantaneous theory decoupled approach for PQ improvement in PV systems with energy storage devices and cascaded multi-level inverter, Sadhana - Academy Proceedings in Engineering Sciences, Vol. 45, Issue 1, 1 December 2020. Article number 13, DOI: 10.1007/s12046-019-1243-5
[5] Liu, Y. Et al., Simple Push-Type Wave Generating Method Using Digital Rotary Valve Control. Chinese Journal of Mechanical Engineering (English Edition), Vol. 33, Issue 1, 1 December 2020, Article number 5, DOI: 10.1186/s10033-019-0429-4
[6] Bęben, K., Grzesik, N., Kuźma, K. Using Fuzzy Logic to Stabilize the Position of a Multi Rotor [Zastosowanie logiki rozmytej do stabilizacji położenia wielowirnikowca], *Journal of Konbin*, Vol. 49, Issue 4, 1 December 2020, Pages 441-461, DOI: 10.2478/jok-2019-0095

[7] Khan, A., Trikha, P. Study of earth’s changing polarity using compound difference synchronization, *GEM - International Journal on Geomathematics*, Vol. 11, Issue 1, 1 December 2020, Article number 7, DOI: 10.1007/s13137-020-0146-2.

[8] The first Slovak universities use MATLAB in a TAH license [Prvé slovenské univerzity využívací MATLAB v licencii typu TAH]. 2017, *Humusoft, s.r.o*. Available at: https://www.humusoft.cz/DOCS/articles/matlab-atp-2017-9.pdf

[9] MATLAB for Technical University of Košice [MATLAB pre Technickú univerzitu v Košiciach], TUKE. Available at: http://www.tuke.sk/matlab/

[10] Podlubný, I. – Szabó, P. Matlab at the Faculty of Aeronautics in Academic year 2018/2019 [Matlab na Leteckej fakulte v AR 2018/2019]. 2019. Available at: https://1drv.ms/p/s%21AypDyUNjSUjBiaJO6o16QN_jJMSxNw

[11] Szabó, P. Competition - Matlab Academy Challenge [Súťaž – Matlab Academy Challenge], 2018. Available at: https://lf.tuke.sk/2018/12/13/sutaz-matlab-academy-challenge/

[12] About File Exchange. Mathworks. Available at: https://uk.mathworks.com/ matlabcentral/about/fx/

[13] Szabó, P. – Gombíková, K. Keplerian Orbit. Mathworks File Exchange, 2019. Available at: https://uk.mathworks.com/matlabcentral/fileexchange/72098-keplerian-orbit

[14] Gombíková, K. - Szabó, P. Linear Algebra - a Collection of Tasks in MATLAB. Mathworks File Exchange, 2020.

[15] Szabó, P. - Ferencová, M: A Brief Introduction to the Linear Algebra - Systems of Linear Equations, 2019. Available at: https://www.researchgate.net/publication/337284898_A_Brief_Introduction_to_the_Linear_Algebra_-_Systems_of_Linear_Equations

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