

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 - *MAT*rix *LAB*oratory [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, Math Works 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, Simspace, 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.

Summary: Exploring Data

Visualizing Data

`fx histogram` Bar plot of frequencies of data values.

`fx boxplot` Box-and-whisker plot based on median and quartiles.

`fx scatter` Plot relationship between two variables.

Measures of Centrality and Spread

Mean and standard deviation are useful for symmetric, normally distributed data.

`fx mean` Arithmetic mean or average of a data set.

`fx std` Standard deviation of a data set.

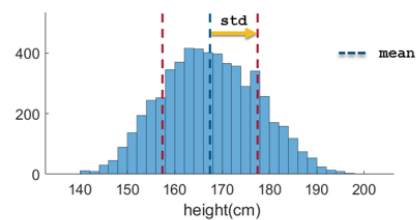


Figure 1 An example of a summary within the MATLAB course

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.

Table 1 Number of obtained certificates to the number of students studying the subject [9]

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

Table 2 Number of commercial certificates obtained [9]

The name of the certificate	Number
MATLAB Fundamentals	75
MATLAB Programming Techniques	74
MATLAB for Financial Applications	68
MATLAB for Data Processing and Visualizations	66
Together	283

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.

Table 3 Number of certificates obtained during the MATLAB Academy Challenge [10]

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.

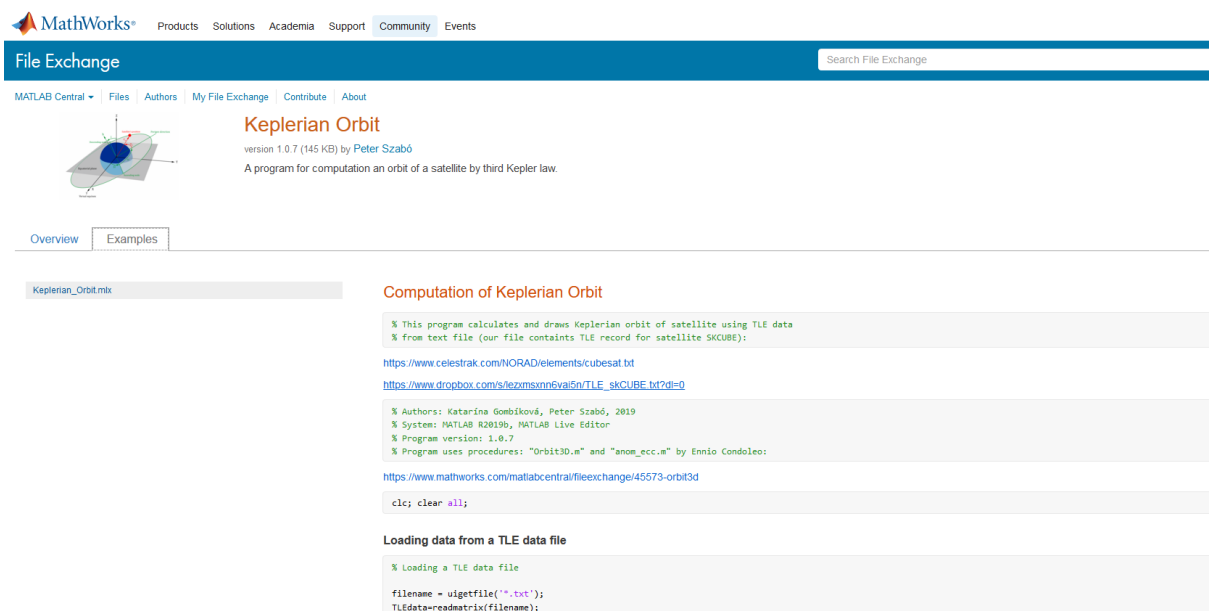
The first step in the citation-raising process is to save the work output, in the form of programs, for the MATLAB community on a File Exchange Server. You should then refer to the File Exchange Server (FES) in the publication output.

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]
 - 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.



The screenshot displays the MATLAB File Exchange interface for a file named "Keplerian Orbit" by Peter Szabó. The page includes a search bar, navigation links, and a code editor showing the following MATLAB code:

```

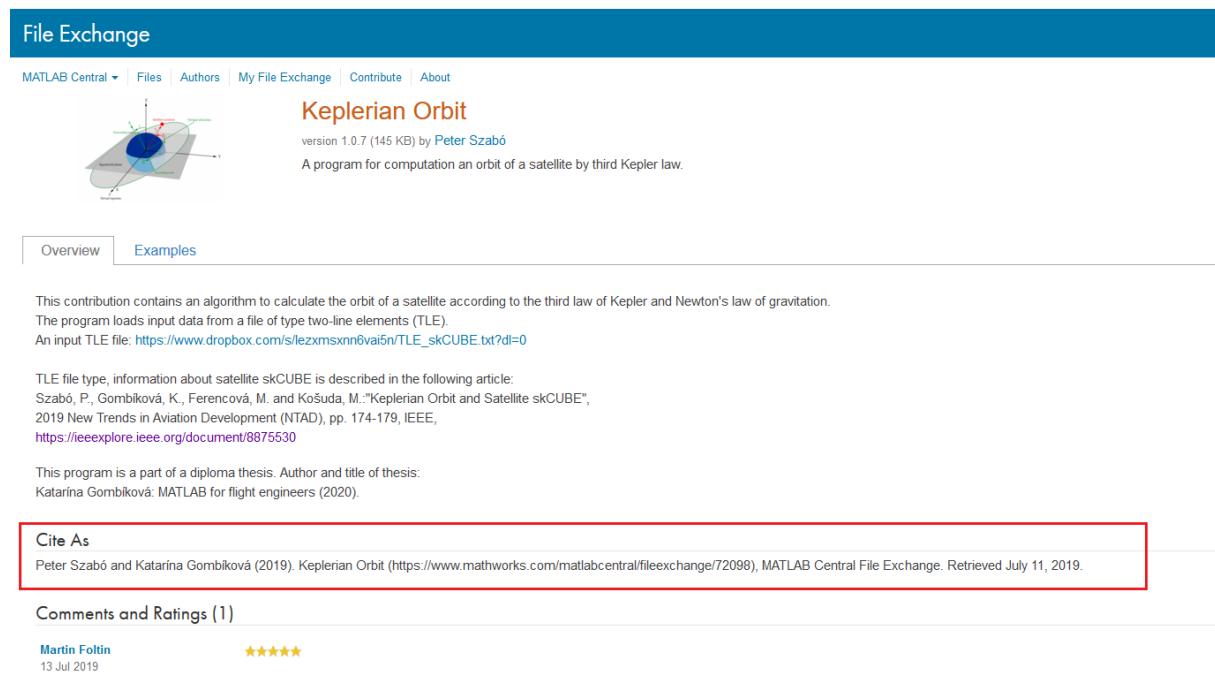
% This program calculates and draws Keplerian orbit of satellite using TLE data
% from text file (our file contains TLE record for satellite SKCUBE):
https://www.celestrak.com/NORAD/elements/cubesat.txt
https://www.dropbox.com/s/ezmsxnn6vai5n/TLE_skCUBE.txt?dl=0
% Authors: Katarína Gombíková, Peter Szabó, 2019
% System: MATLAB R2019b, MATLAB Live Editor
% Program version: 1.0.7
% Program uses procedures: "Orbit3D.m" and "anom_ecc.m" by Emio Condoleo:
https://www.mathworks.com/matlabcentral/fileexchange/45573-orbit3d

clc; clear all;

Loading data from a TLE data file
% Loading a TLE data file
filename = uigetfile('*.txt');
TLEdata=readmatrix(filename);
  
```

Figure 2 Example of program display at FES [12]

Figure 3 shows an overview of the program with parameters set for citing.



The screenshot shows the MATLAB Central File Exchange interface. At the top, there is a blue header with the text 'File Exchange'. Below this, a navigation bar includes 'MATLAB Central', 'Files', 'Authors', 'My File Exchange', 'Contribute', and 'About'. The main content area features a 3D diagram of a satellite orbiting Earth, with the title 'Keplerian Orbit' in orange. Below the title, it states 'version 1.0.7 (145 kB) by Peter Szabó' and 'A program for computation an orbit of a satellite by third Kepler law.' There are two tabs: 'Overview' and 'Examples'. The 'Overview' tab is active, displaying a description of the algorithm, an input TLE file link, a reference to an IEEE article, and a note about its origin in a diploma thesis. A red-bordered box highlights the 'Cite As' section, which contains the citation: 'Peter Szabó and Katarína Gombiková (2019). Keplerian Orbit (https://www.mathworks.com/matlabcentral/fileexchange/72098), MATLAB Central File Exchange. Retrieved July 11, 2019.' Below this, the 'Comments and Ratings' section shows one comment from 'Martin Foltin' dated '13 Jul 2019' with a five-star rating.

Figure 3 Example of setting the citation to FES [12]

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.

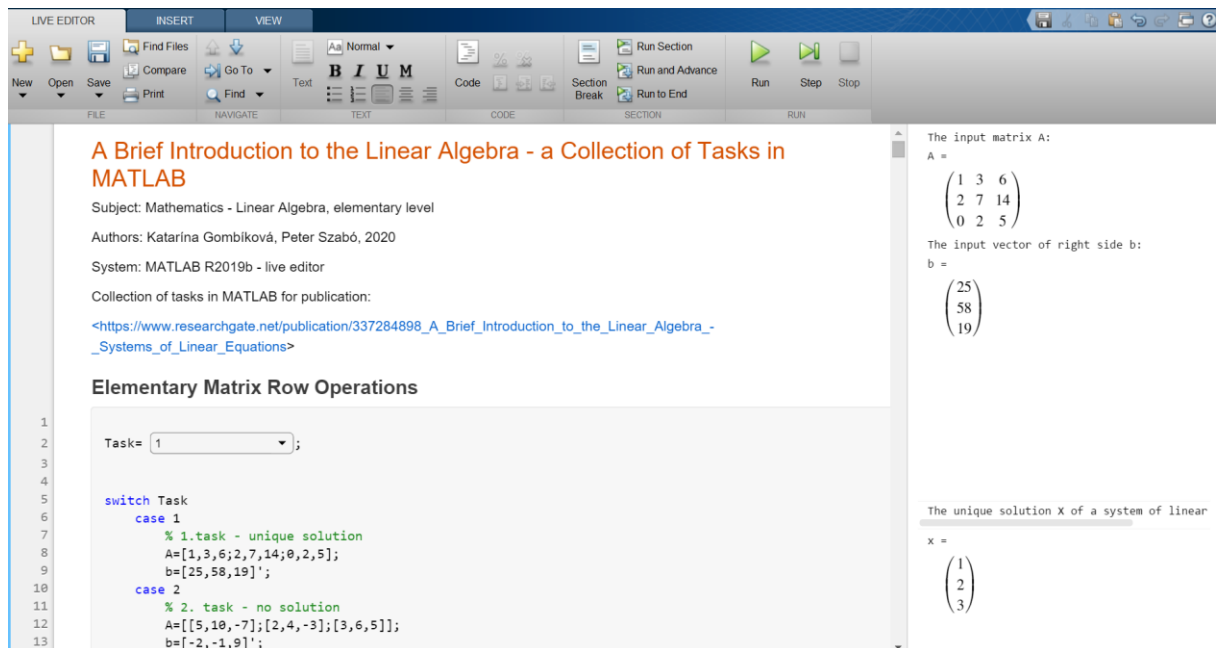


Figure 4 Collection of linear algebra problems [12]

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.

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