

UNIVERSAL TOOL FOR DATA ANALYSIS

Lubor Zháňal ¹, Petr Porteš ²

Summary: This article describes the main parts of an open and universal data analysis software TeleMatrix V3 based on MATLAB. It helps simplify and speed up most of the processes of the measurement data evaluation.

Key words: data analysis, telemetry, Matlab.

INTRODUCTION

Nowadays the development of modern vehicles consists of many essential processes. One of them is the operation of the prototypes which are fitted by numerous sensors and measuring devices which together produce a large amount of data. This data is subsequently evaluated and based on the obtained information, then it is possible to modify the final vehicle setup.



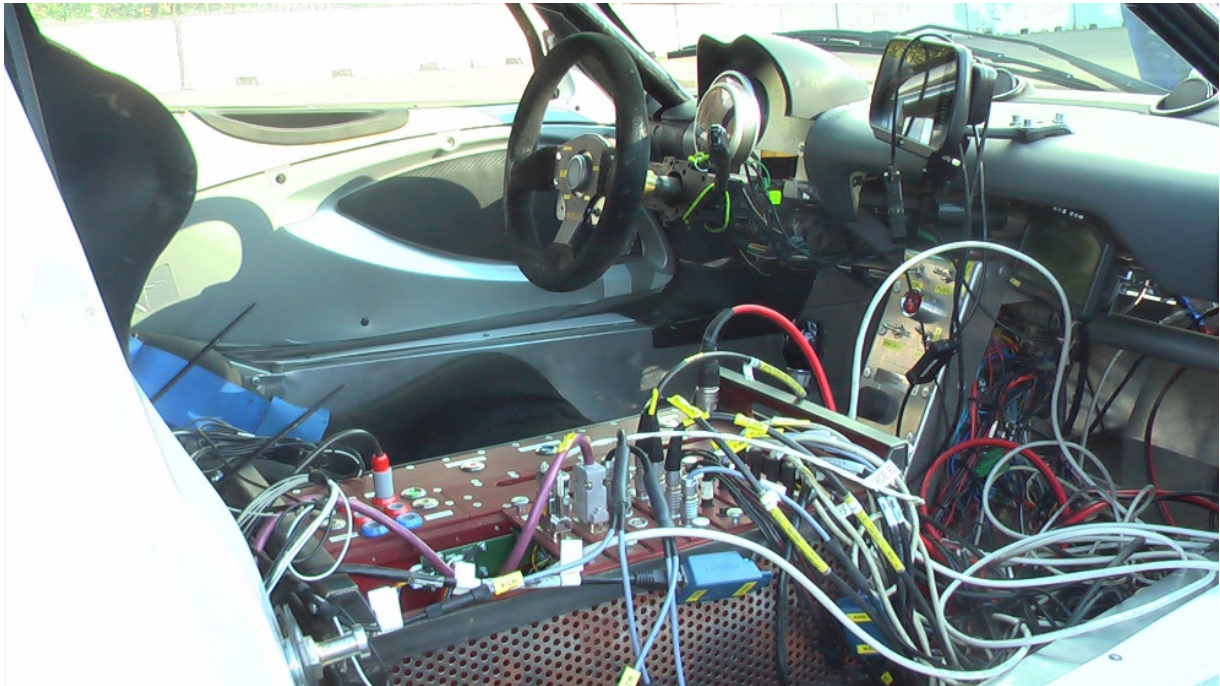
Source: Authors

Fig. 1 - Car measurement

Another typical area where the measurement of vehicle is really important is Motorsport (Fig. 1, 2). Precise measurement of the vehicle state and its subsystems has been a critical means of improving vehicle performance for many past decades.

¹ Ing. Lubor Zháňal, Ph.D., Brno University of Technology, Faculty of Mechanical Engineering, Institute of Automotive Engineering, Technická 2896/2, 61669 Brno, Phone.: +42054114 2275, E-mail: zhanal@fme.vutbr.cz

² doc. Ing. Petr Porteš, Ph.D., Brno University of Technology, Faculty of Mechanical Engineering, Institute of Automotive Engineering, Technická 2896/2, 61669 Brno, Phone.: +42054114 2268, E-mail: portes@fme.vutbr.cz



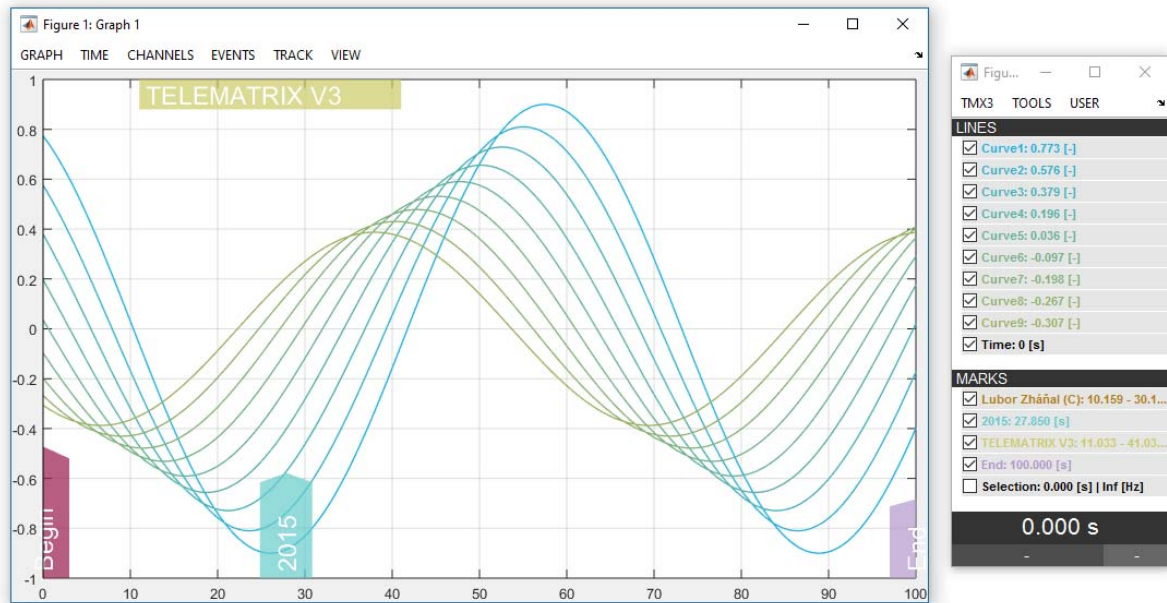
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Fig. 2 - Racing measurement setup

For these purposes are utilized many different software tools which are usually supplied by the producer along their measurement products. Each such tool has very different abilities, functional equipment, control and, predominantly, fairly limited compatibility with other programs. Therefore, there is a need to develop an open universal tool for evaluating data from various data loggers. To ensure broad compatibility this tool is being developed as an extension of MATLAB which is the industrial standard in the field of engineering development, mathematical programming and data processing.

1. TELEMATRIX

The TeleMatrix program (Fig. 3), in the current version V3, consists of a set of functions and scripts written entirely in MATLAB code. This makes it easily portable and modifiable for various specific needs. In addition to its own graphical user interface, where most of the functions can be controlled using a mouse and keyboard, it is also a full program designed so that its individual functions could be controlled programmatically and used to create custom extensions, modules or specialized graphs.



Source: Authors

Fig. 3 - User interface of TeleMatrix V3

The program interface is made up of the main window as a sidebar, and one or more windows with charts, reports and other tools. All windows are interconnected using the time cursor. This means that the information in all the windows are automatically updated depending on the current cursor position or selection area.

1.1 Data structure

All channels are stored separately in one global data structure. Each channel, in addition to its name, units, labels, and many additional information, can have different settings, sample frequency, offset and gain coefficients and the actual length, without limiting the mutual use of such channels in graphs, computational functions and analytical tools in any way.

1.2 Events

One of the main highlights of the TeleMatrix is an integrated system of events (Fig. 4) that may describe the selected time points or intervals. Based on these events, then, for example, you can easily create different views, describe typical situations or anomalies in the data, mark segments of tracks, adjust visible area and generate comprehensive reports.



Source: Authors

Fig. 4 - Example of events in TeleMatrix

Events also allow an extension of additional charts, what can extensively simplify the subsequent presentation of the results.

2. BASIC FUNCTIONS

There are basic computing functions included in TeleMatrix:

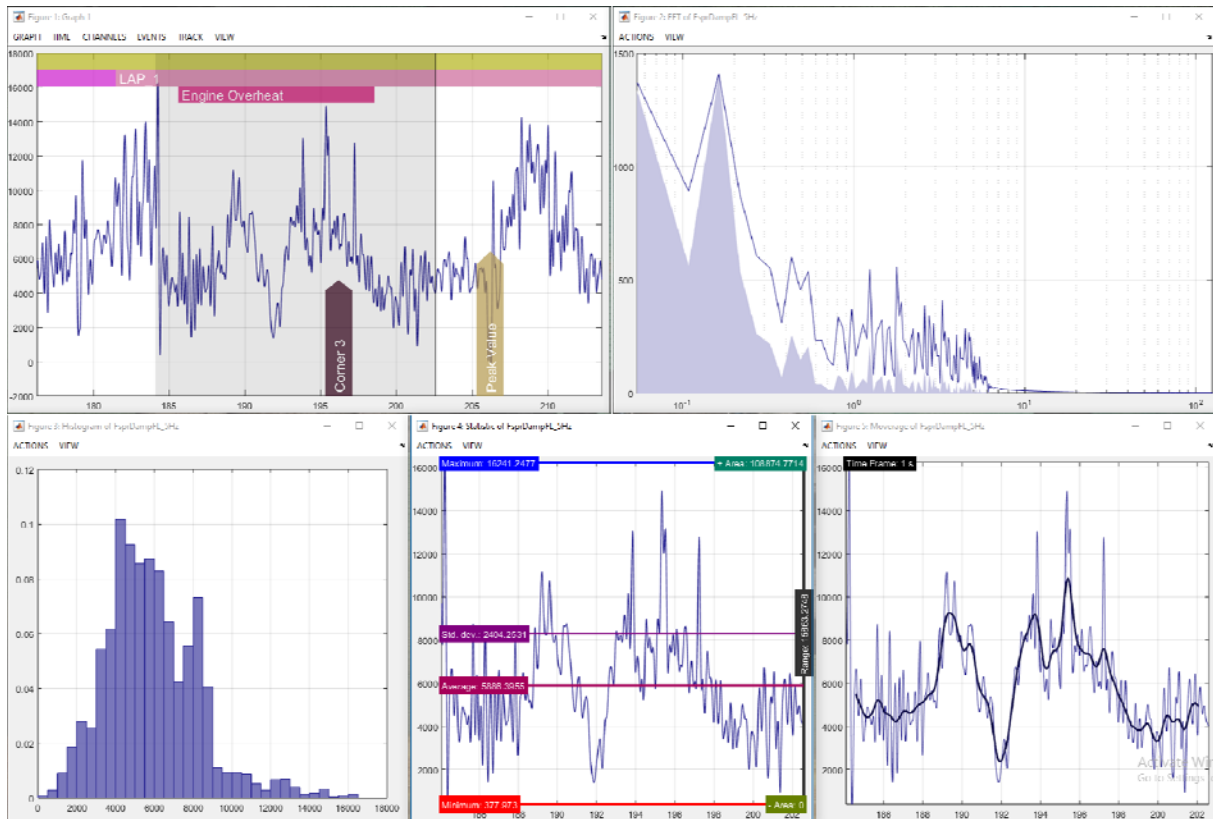
- addition, subtraction, multiplication, division and exponentiation,
- integration and differentiation,
- interpolation and trimmings,
- reconstruction and automatic error correction (signal peaks and failures)
- correlation between channels,
- masking, mapping, etc.

These operations, based on the type, can be carried out in bulk or individually over the entire channel or its selected parts. It is also possible to easily use pre-built templates to design a custom user functions.

2.1 Filters and analysis

In addition to the features described above TeleMatrix allows performing of quick filtering and signal analysis in many interactive tools. These include

- frequency spectrum and spectral density,
- low pass and high pass filters,
- histogram and statistical analysis,
- moving average, etc.



Source: Authors

Fig. 5 - Multiple analysis of source signal

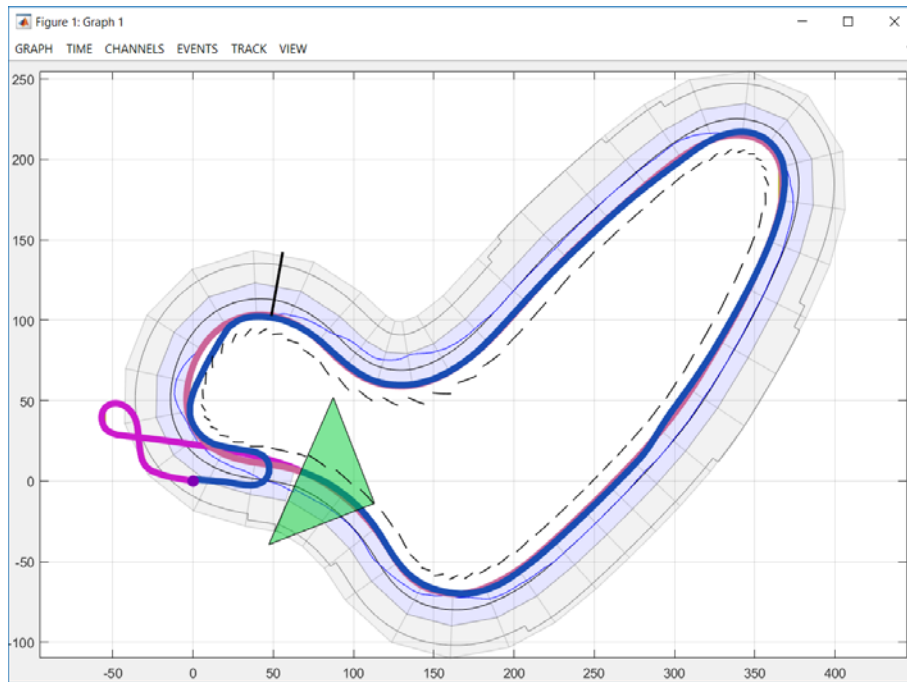
These tools always work with one selected signal and respond live in real time to the changes in the selected time field. It is possible to easily move surveyed interval with the mouse and monitor the development of the filtered signal or results of the analysis (Fig. 5). Moreover, they allow to set many additional parameters, i.e. filter coefficients, sizes or shapes of filtering windows (Gaussian, Hamming, Hanning, etc.).

3. ADVANCED TOOLS

TeleMatrix also contains purely dedicated tools focused on processing data from vehicles, predominantly, the tools used in motorsport. Due to the system's openness, it is possible to create tools designed for any orientation.

3.1 Equidistant view

All data, measured in reality, are recorded depending on the time (whether from one or more different data loggers) and are shown in graph alike. For cases of motorsport, where the vehicle rides on a circuit (Fig. 6), it is advisable to have the ability to view data depending on the position of the car on the circuit. However, if the timeline was simply exchanged for the distance traveled, a problem in desynchronized data arises, because of the influence of different driving tracks and other circumstances is the real distance traveled in each circuit different. Therefore, the program TeleMatrix includes a sophisticated tool that maps the distance traveled using GPS data from the measurement at a real position on the circuit. It is then possible, for example, to easily and accurately compare of the individual passages.

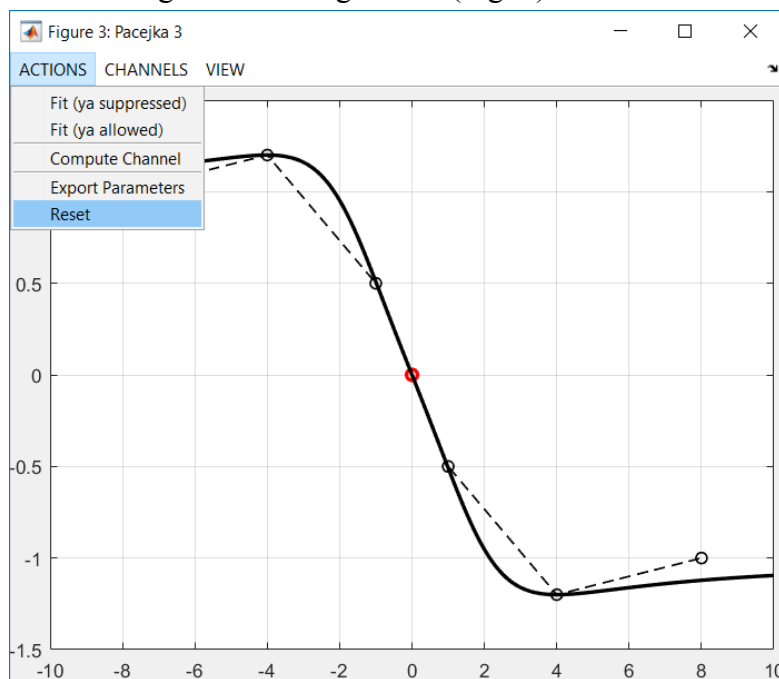


Source: Authors

Fig. 6 - Signal mapped to real track

3.2 Pacejka

The program is also equipped with special functions which are typical for modeling of vehicle subsystems. An example is the so-called Magic Formula (3) used in the models of tires. Thanks to the proposed interactive control of curve parameters, a consensus of waveform with the measured data can be quickly reached. The program also allows to acquire or refine the parameters using nonlinear regression (Fig. 7).



Source: Authors

Fig. 7 - Pacejka's curve

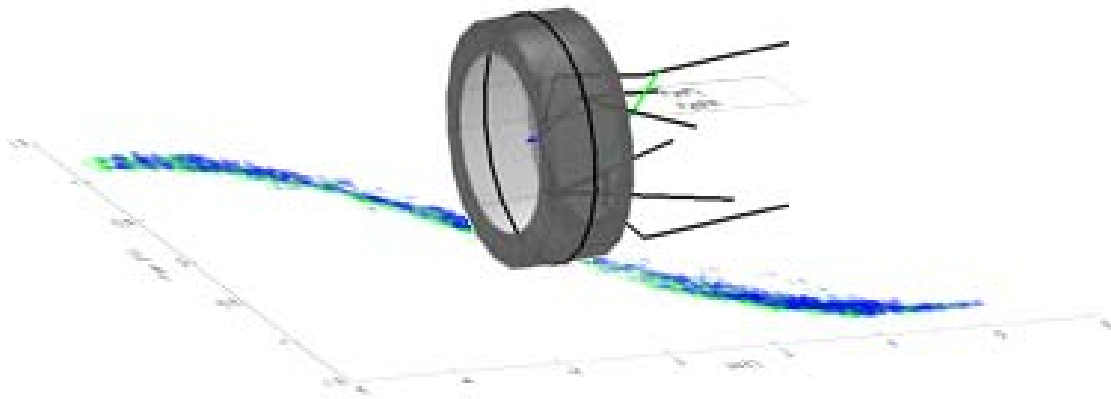
3.3 Reports

Powerful means related to the system of events is the automatic generation of reports. Based on the labels which the user entered into the individual events, it composes a report in real-time which relates to the selected time, interval or the whole project.

This data is stored, along with the channels, in one common project file, so they are always at hand. Thanks to the system of partial imports and exports several people are able to work on the same project and simply put together their posts.

3.4 Next development

Other elements of the TeleMatrix system which allow major advances in the analysis of data are currently under development. One of them is the integration with the multibody program SAMS (4). This allows to realize an interconnection of the measured data with a dynamic vehicle model.



Source: Authors

Fig. 8 - Dynamic state of vehicle wheel

This will allow to compute non-measured variables and identify the missing ones, or refine the specified vehicle parameters. At the same time, thanks to the proposed method of data linking (5), the system will obtain the entire dynamic vehicle state, and all necessary parameters needed for animation of measured processes will be acquired (Fig. 8).

CONCLUSION

TeleMatrix proved to be a very powerful and useful tool. It significantly accelerates most of the general data analysis processes as well as specific automotive tasks and can cooperate with many types of data loggers and other applications. Thanks to open architecture based on MATLAB is easy to develop new features and custom tools.

ACKNOWLEDGMENT

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