EXPERIMENTAL MODAL ANALYSIS TOOL FOR MATLAB

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Introduction

Experimental modal analysis (EMA) of vibrating structures is continuasly receiving increased attention from industry and thus rapid development of theory and tools occurs. EMA provides reliable and time efficient way for analysis of behaviour of mechanical structures, their eigen frequencies, mode shapes etc. and validation of FEM computational models. This makes possible widening model based design approach to virtually any, even simple construction.
However, existing commercial EMA equipment and software are quite expensive and thus field of problems for EMA is still restricted.
On the other hand, there is available variety of sensors and DAQ cards ranging from very expensive ones suitable for space ship design to cheap hardware still acceptable for many simple engineering applications.
Based on long tradition of both EMA tools development and application (Milacek,2001a; Milacek, 2001b) in our department it was decided to transfer and consolidate existing isolated tools for EMA data acquisition, regression and animation on Matlab platform. Data acquisition is using on Real Time Toolbox. This ensures support for virtually any DAQ card. Matlab strong and fast computational kernel together with effective data structures and easy to design GUIs nearly provoked EMACTU project.

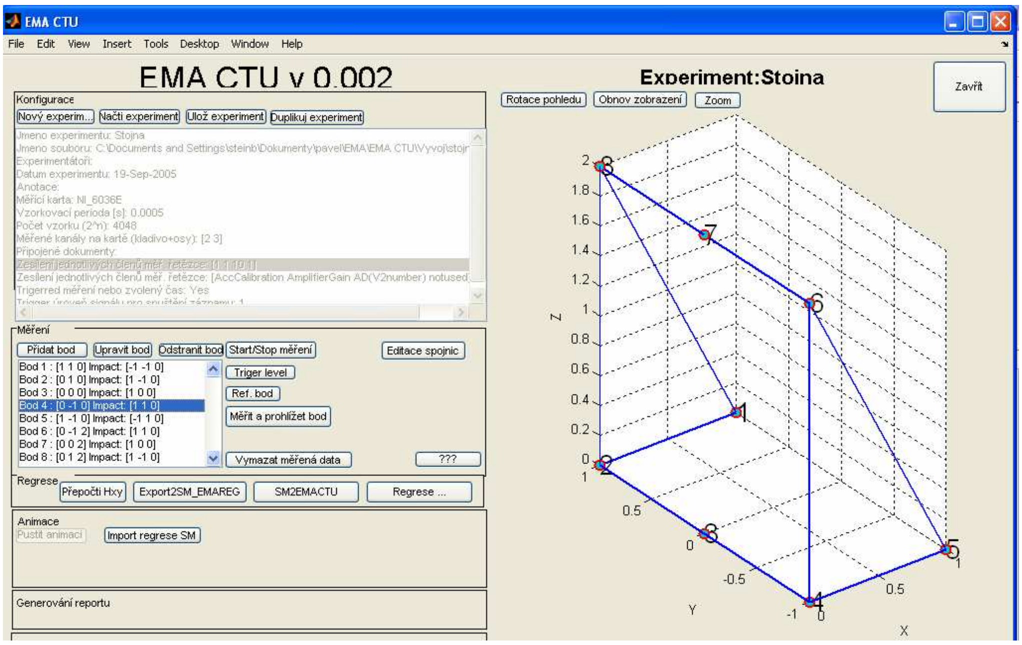

Figure 1 EMACTU main GUI with animation

Our implementation of EMA methods was driven by following objectives: Simple, unified tool supporting whole EMA chain - fast structure modelling, measurement arrangement, data acquisition, storage, polishing, regression and evaluation – animation; Open, clear code and architecture for education and further research; Transfer of well proved methods and algorithms from our previous tools for EMA and extensibility by new algorithms; Support of wide range of measurement and excitation equipment.

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Strong emphasize was given to measurement, data acquisition phase of EMA procedure. It was designed to support proven measurement methodology while still maintaining flexibility. Further, each measurement step can be repeated and tuned to receive high quality input data for further EMA steps.

Structure of EMACTU

EMACTU tool is driven by main gui window where most functionality is available. EMACTU consists of several modules:

Experiment definition

Integrated into main window it enables definition of new experiment and its parameters. This module also provides means for capture and maintenance of related information (annotation, related documents, snapshots etc.). Also hardware parameters, sample frequency etc. are defined. Most of the parameters can be later easily modified.

Simple modeler

It is also integrated into main window. It provides basic functionality necessary to construct wireframe model of investigated system which consist of points and links. Annotation information including file link (e.g. snapshot) can be attached to particular measured point. Wireframe model can be simultaneously viewed in the figure.

Measurement module

Currently EMA methodology which use successive measurement of transfer functions for individual points of measured structure is supported.

Measured point is selected in main window (Figure 1) and EMA measurement interface is opened (Figure 2). Repeated measurement of transfer function for each direction is done as long as good coherence is reached.

Strong emphasize is given on support of procedure enabling to obtain high quality data, by detection and visualization of known issues (overshoot, double hit, lack of coherence etc.). Measurement can be repeated, readjusted or bad measurements can be thrown away. It contains modular structure interfacing with various DAQ cards. Measured data are on the other side stored through data API module.

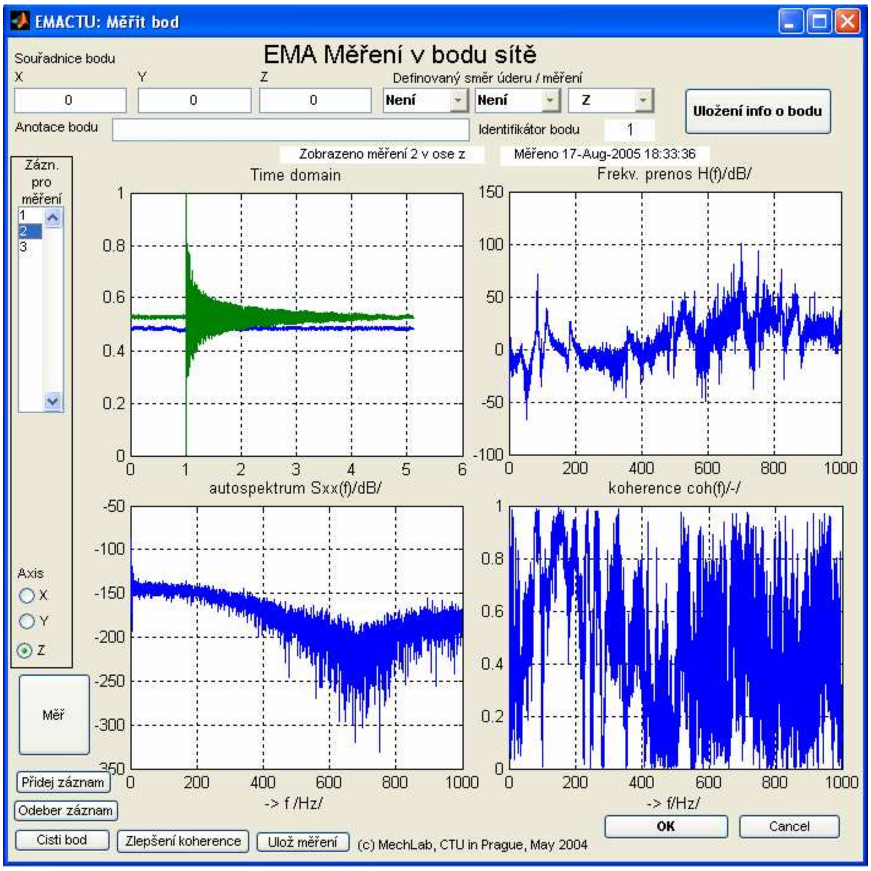

Figure 2 Measurement of one point transfer function

Regression module
It works with transfer matrix which is obtained as output of Measurement module. Individuals transfer functions are visualized (Figure 3) by various methods (addition, crisscross). Eigen frequency suggestions are then selected by user (automatic procedure for eigen frequency selection is also possible, but usually manual approach is more reliable). These suggested eigen frequencies are then used by selected regression algorithm. Currently SDOF Nyquist circle regression algorithm is used.

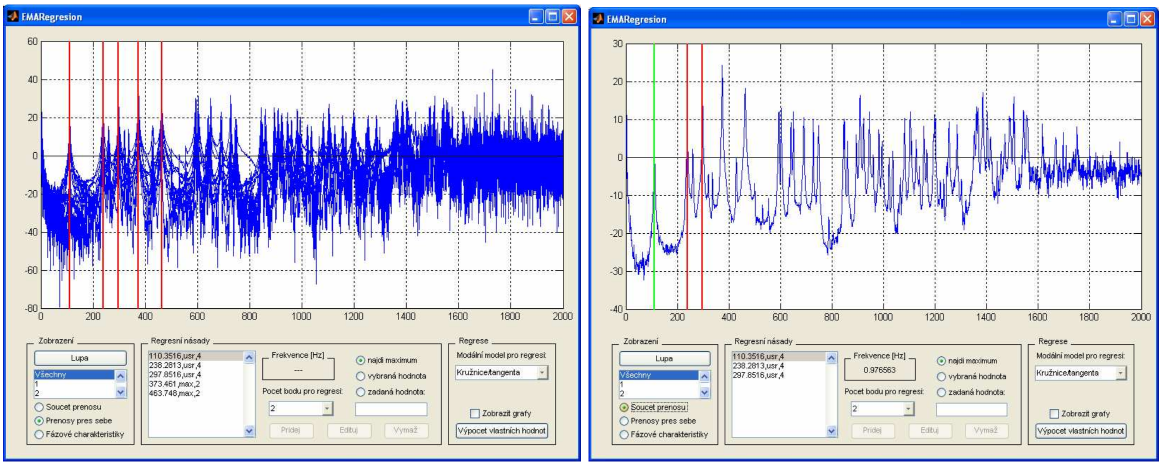

Figure 3 Regression procedure

Animation module
Final evaluation of measured data based on computed eigen frequencies and eigen modes is most easy using animation of structure motion for different eigen modes. It is again accessible through main window (Figure 4) which contains controls for animation. Using Matlab standards animated structure can be exported.

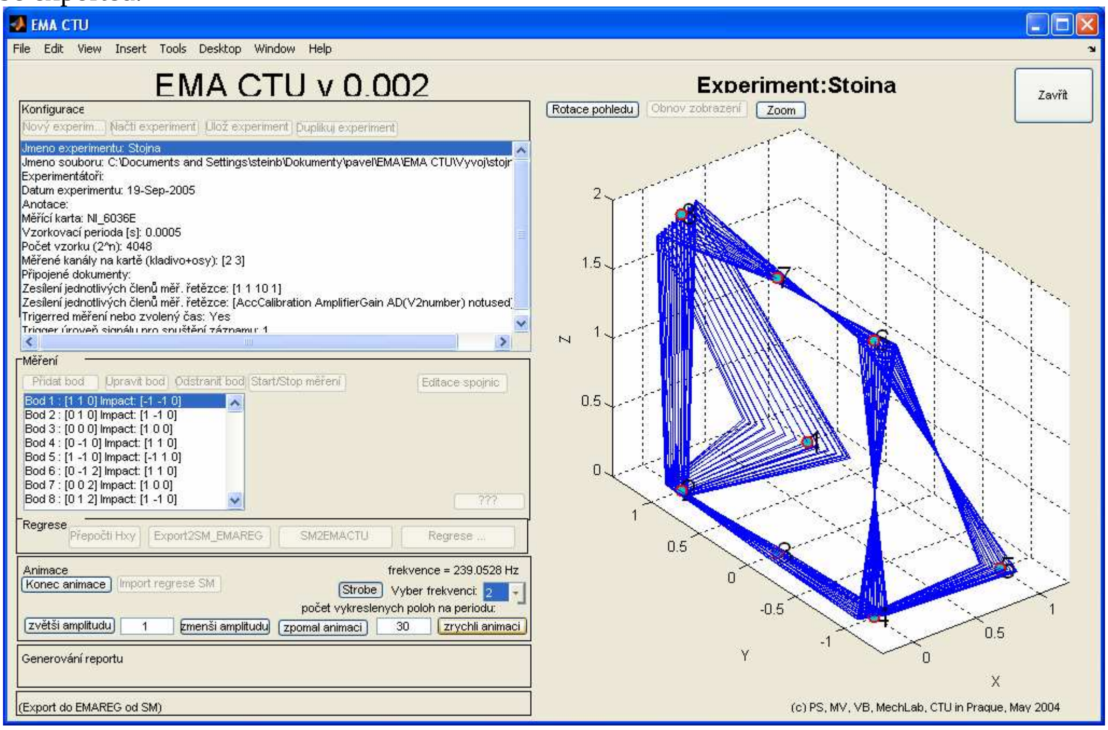

Figure 4 Frozen animation of investigated structure

Data storage module
It is kernel of the system where all the information related with EMA experiment are stored. Currently standard Matlab data structures are use. The data API approach however provides way to easily

separate data storage module completely. Thus data can be stored into external (SQL) database, files etc.

Conclusions

The tool is currently oriented to measurement with impact modal hammer and one uni or tri axial accelerometer measurement Regression procedure is completely open. Currently SDOF algorithm based on Nyquist circle is used.
Further development will be directed towards measured data export into standard format for other EMA software which do not cover measurement phase (e.g. Structural Dynamics Toolbox); support of various exciters, multiply sensor measurements, interaction with FEM software.
EMACTU tool is still not mature. It however contains basic functionality necessary to complete basic experimental modal analysis and show EMA internals to student audience.

References

[Milacek, 2001a] Miláček, S.: Modální analýza mechanických kmitů, CTU in Prague, 2001
[Milacek, 2001b] Miláček, S.: Měření a vyhodnocování mechanických veličin, CTU in Prague, Prague, 2001