A Matlab Tool for Experimental and Analytical Shock and Vibration Data

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A new Matlab® tool provides the shock and vibration community with the ability to display and analyze data while minimizing the probability of bookkeeping errors.

Test and analysis operations often result in the generation of large quantities of experimental and analytical data. Often this data must be processed in a variety of ways and then plotted and compared with data from the same test series as well as historical data. Many times, there is a significant amount of metadata that accompanies the data of interest that is critical to the understanding of the analysis and comparisons. A Matlab tool was developed to ease these processes and minimize the probability of analysis and comparison errors.

One of the key features of this tool is that it couples all of the available metadata with the measured/computed data set and provides easy access to that metadata. This tool supports a variety of specific data analysis methods as well as many standard data analysis methods. Its prime focus has been on enabling the user to easily display both the data of interest as well as the descriptive attributes that give the data meaning.

This tool takes advantage of Matlab's object oriented constructs and thus is very simple to use for an individual who is already familiar with it. Most of the relevant operators have been defined to operate on these datasets in a meaningful fashion. In addition, Matlab's plot routine has also been extended to work directly with these data objects.

Often times the datasets utilize extremely long record lengths. This fact often complicates analysis simply due to memory and speed constraints. The tool was implemented in an optimized manner in recognition of many of the complications that arise from this fact.

Introduction

Many years of testing and simulation have resulted in the use of a wide variety of data collection and storage systems. Each of these systems is well suited to using the data that it generates. However, the data storage formats used are generally proprietary and not well suited to interoperability. Due to the rapidly changing nature of current data acquisition hardware and software, older systems rapidly become obsolete and often render data collected by them difficult or impossible to access. Although many of these systems are capable of writing their data in commonly used formats, often times some of the metadata as well as the precision associated with the original data are lost during the conversion process.

These factors have lead to the development of a toolbox for addressing experimental and analytical datasets, with time or frequency as the independent variable. XYData is a toolbox that was developed in Matlab to address these needs. This new toolbox was motivated by the need to bring collected data from disparate data acquisition systems and analyses together into a common framework. It is important to be able to analyze data from legacy, current and new acquisition systems together as well as including data generated by finite-element (FE) or other simulations. It is also often necessary to include data generated by external organizations.

Another significant motivating factor in the development of XYData is the management of the metadata associated with a measurement set. It is trivial to store numeric data in a common format that is easily accessible. However, data without context is often meaningless. The inclusion of complete metadata becomes critical when large-channel-count tests and large numbers of datasets with varying conditions are considered. XYData was designed from its roots to retain all of the metadata available for any dataset as well as tightly coupling the metadata to the numerical data. Modern data acquisition systems are capable of storing a large quantity of data, both in terms of number of channels as well as sample size. XYData was designed with this in mind, easily allowing the analyst to consider partial datasets without the need to waste time loading irrelevant data. XYData is ideally suited to batch processing large quantities of data through a common set of analysis routines.

A number of considerations lead to Matlab® as the choice for a development platform. Matlab is a very common platform in the academic environment; almost all graduating engineers have some minimal familiarity with it. Matlab includes object-oriented programming constructs and is designed to be very extensible, including the ability to develop graphical-user-interface (GUI) elements. Matlab's implementation of these features is platform independent so that the same routines can run on the simplest laptops as well as the highest performing supercomputers without modification. One significant drawback posed by Matlab is its significant up-front and maintenance costs. There is an open-source package called Octave that implements many of the same programmatic elements as Matlab. It should be a trivial matter to port XYData to Octave, eliminating the costs associated with Matlab with, perhaps, a performance penalty.

Design Philosophy

The design goals of XYData were developed to ease and encourage its use as a widespread engineering tool for the analysis of a wide variety of experimental and analytical data. They can be summarized by extensibility, ease of use and management of large datasets.

XYData was specifically developed using object-oriented programming (OOP) techniques. The use of OOP allows XYData to realize an extremely tight coupling of data and metadata. This coupling is critical to minimizing the probability of data description errors. Appropriate use of OOP principles dictates that access to a record's data occurs only through specific interface methods designed for that purpose. All data is accessed through get and set functions that are aware of the specific data storage algorithm. As a result, the underlying structure of the data can be changed and optimized as the need arises without any detrimental effect on currently existing algorithms.

Using OOP allows XYData-type variables to be used as any other Matlab datatype. All of the common arithmetic and array reference operations are implemented with XYData. As a result, two XYData objects can be added together as easily as two scalars using the same operator and syntax. Many of the common functions have also been implemented in XYData as well, including min, max and sqrt. Most importantly though, the plot function has been implemented in XYData in a manner that eliminates the need for the user to track data and its descriptors separately.

The ability to handle large datasets implies both an efficiency of storage and I/O operations as well as the ability to select and manage large numbers of records and their descriptive attributes. XYData permits loading of partial datasets either through the loading of a subset of records from the complete dataset or loading partial records. To this end, the loading of only the metadata is supported so that the choice of which records to load can be made on the basis of the metadata. Most of the implemented data analysis methods use highly efficient memory management and vectorized algorithms, improving analysis speed for large datasets.

A large portion of managing large datasets is ensuring that the data are properly documented. XYData permits inclusion of an

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