A Multimedia Tool for "Signal Processing for Acoustic and Vibration Diagnosis of Rotating Machines"

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Abstract

We present in this paper the preliminary results of a project developed in the scope of the EC Leonardo da Vinci program. The objective of this project is to develop a CD-ROM for education and training in the domain of signal processing for the acoustic and vibration diagnosis of rotating machines. The project will cover basic methods of signal processing, which apply in the relevant domain. The CD-ROM is organised in three modules: basic methods of signal processing, mechanics of rotating machines, and a guide for the choice of appropriate methods according to real problems. It contains interactive consultation modes, with several levels of input, complexity, and purpose. In addition to ease of use, the multimedia support offers access to interactive simulations and training, which shows the comparative performances and limits of certain methods. There is an intensive use of real signals taken from a data base of real industrial installations.

1. Partnership[1]

We present in this paper the preliminary results of a project developed in the scope of the EC Leonardo da Vinci program with the following participants:

- *CNRS-Heudiasyc Laboratory* (University of Technology of Compiègne-F) (Co-ordinator)
- *ISVR* (University of Southampton - UK)
- *DIEM* (University of Bologna - I)
- *CETIM* (Mechanical Industry-Study Center - F)
- *MVI technologies* France
- *DUCATI* motor cycles

2. Motivations and Objectives

Rotating machines are of significant importance in industry, according to their number, their variety, and their critical role in the production process. In the present context of competitiveness, it is mandatory to improve their reliability, to decrease the cost of their use and maintenance, to control the quality of their manufacturing, and to take into account their noise and vibration pollution. It is now recognised that the analysis of noise and vibration measured on these machines is one of the best ways to reach these objectives. However, the use of the available techniques, based on advanced signal processing methods, is not publicised sufficiently in industry, mainly due to a lack of education and practice.

Effectively, obtaining significant results calls for mastering a multidisciplinary knowledge. They are, for example, knowledge in the mechanical engineering domain and the mastering of signal processing techniques. Specially in the signal processing discipline, the improvement of computing capabilty gives rise to techniques, which are difficult to use by practitioners and indeed for people with a mechanical background. Signal processing is a discipline originated from high tech applications (telecommunications, speech processing, radar, etc), and mechanical engineering people have less experience and knowledge of this domain. The vocabulary is even different. Availability of all competence and experts is expensive, continuing education programmes lack of follow up training, and initial education for technicians and engineers is considered too far from actual industrial reality.

In this context, the objective of the project is to develop a tool for education and training in the domain of signal processing for the acoustic and vibration diagnosis of rotating machines. This tool, based on a multimedia CD-ROM, will be realised by a multidisciplinary team. It is to be used as a follow up of previous training, permitting progressive development for the personnel, while in their actual professional environment and according to their availability and needs.

This tool will be also introduced in initial engineering as well as post-graduate education programs. It will have an impact in the teaching of technology in general, where the multidisciplinary aspects are important, as well as the use of simulation software. The industrial examples are

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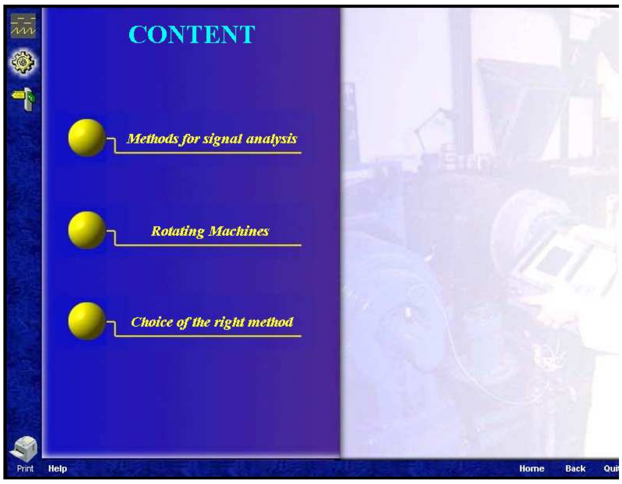

Figure 1: Introduction page to the three modules

also of importance to link the theory with the main application domains. For example, in mechanical engineering domain, signal processing may be viewed as a

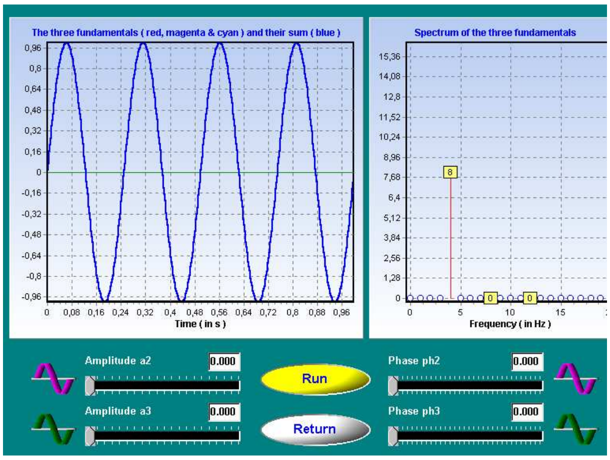

Figure 2 : Example of the interactive use of the simulator for signal synthesis

tool to solve mechanical problems

3. Structure of the CD-ROM

The CD-ROM is organised in three modules: methods for signal processing, rotating machines, choice of the right method. Figure 1 presents a screen capture of the corresponding page.

The first module is the description of the current methods used in the domain of signal processing. There are currently four chapter. The first one concerns signals (periodic signals, transient signals, random stationary signals, and random non-stationary signals). The second concerns the Fourier series (first three terms of the Fourier series, synthesis of signal with Fourier series, synthesis of a periodic impulse response, synthesis of experimental data, synthesis of signals and their sounds, and the Parseval law). The third chapter concerns the Fourier transform and the last one concerns spectral analysis

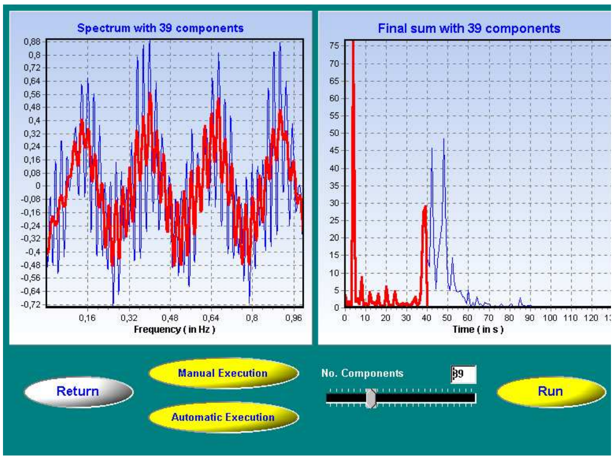

Figure 3: Example of the interactive use of signal re-construction

(frequency resolution, leakage, segment averaging techniques, triggered vs. free run analysis).

For each section, there are several description pages, which go deeper in details with the progression of the student in the section. Each page is linked to a number of exercises. An exercise most often consists of the description of a signal and asks the student to simulate the signal or compute some characteristics with the simulators available. The simulators such as signal synthesis, FFT, etc. have been developed in our laboratories and integrated in the whole structure. They are used by setting the corresponding parameters such as shown in figure 2. And 3.

The second module is the description of the mechanical laws, which govern the behaviour of different rotating machines during the occurrence of faults. In the current version of the system, four major faults occurring in rotating machines are described from the mechanical point of view, with an emphasis on the symptoms of these faults, i.e., the effect of the faults on the signals. They are: unbalance, misalignment, roller bearing, and grinding wheels, such as shown in figure 4.

As in the preceding module, the successive pages in each section use different interactive multimedia tools such as oral registered explanation, movies or objects animation to illustrate the different concepts For example, figure 5 shows the first page of the section concerning misalignment. In this page some words are linked to a glossary of terms, other words are anchors of links toward other pages of the section, and the shafts in the figure are animated.

You can note also that each page contains direct links to other modules or even direct links to sections of other module. It is also possible within a section to go directly to any page of this section.

The third module contains a set of data coming from real example of defaults on rotating machines. For the present time we have gathered several typical example and organised the data set for further integration in the system.

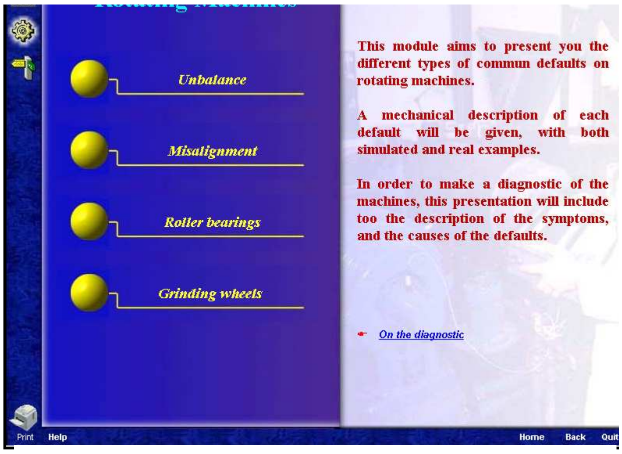

Figure 4: Introduction page to the second module.

5. Implementation

The CD-ROM has been written in the Authorware environment. In a previous version the simulation exercises (about 25 programmes) were developed in the Matlab environment. We have rewritten all MatLab modules in the C++ language in the Builder environment and integrated the executable files as Active-X files in the system. These modules, including the graphic libraries,

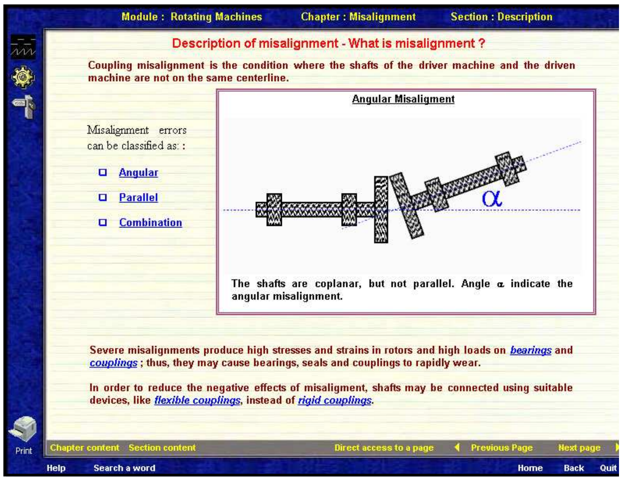

Figure 5: A page of the rotating machines module

are now libraries, which can be managed straightforward by the Authorware modules. The CD-ROM is then a self-contained executable system. The system has been built modular to allow the addition of new signal processing techniques, other mechanical faults description, and other real signals.

6 Conclusion and future work

The main characteristics of the system are as follows:

It is multidisciplinary in the content: signal processing techniques and mechanical description of the physical phenomena,

It makes an intensive use of simulation for illustrating the theoretical and practical aspects of the problem.

A specific module will use signals on real machines to develop exercises in which the he learner works as in an actual situation.

It allows the addition of new modules easily.

So far the first two modules are almost complete and available on a CD-ROM. The material for the third module is ready to be integrated in the system. Samples of the system have been successfully tested with engineers and students.

Acknowledgement

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