TEACHING BASIC MEASUREMENT ALGORITHMS AT UNIVERSITY VIA INTERNET

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Abstract - Present-day measurement is oriented to processing digital signals, that is sequences of quantized samples of analog signal. Processing is performed by means of combinations of standard and special numerical algorithms. Knowledge of the basic signal processing algorithms is therefore necessary for successful design of complete algorithm for a given measurement task. The contribution shows a modern mean of teaching basic signal processing algorithms used in measurement without forcing students to come to computer laboratory. Students need only to have at their disposal a computer provided with a common web browser. The contribution describes materials for teaching three basic algorithms (DFT/FFT, digital filters, and correlation), but the described procedure can be used for teaching other digital processing algorithms as well. All what is necessary for using this type of teaching is MATLAB, the toolbox(es) necessary for the given application, and the new component of MATLAB, called MATLAB Web Server, installed on one computer only (the server). The described method need not of course be used only by university students.

Keywords: MATLAB, internet, distant teaching, signal processing.

1. INTRODUCTION

Present-day measurement is oriented to processing digital signals, that is sequences of quantized samples of originally analog signal. Processing of these sequences is performed by means of combinations of various standard and special numerical algorithms. Knowledge and understanding of the basic signal processing algorithms is therefore the basic condition of successful design of complete algorithm for solving a concrete measurement task. The contribution shows a modern way of teaching some basic signal processing algorithms used frequently in measurement without forcing students to come to the computer laboratory. The only channel they need is a computer connected to Internet, i.e. provided with a common web browser. The content of the contribution describes the materials to three already developed and tested selected algorithms (DFT/FFT, digital filters, and correlation filtration). The described procedure and mentioned software can be used for preparing teaching of other digital processing algorithms using the MATLAB environment (MATLAB and the suitable toolboxes). The necessary condition for realization of this procedure is to install the new component of MATLAB, called MATLAB Web Server [1]. The advantage of teaching algorithms using the further described procedure is among others cost savings for the University. It is not necessary to permanently upgrade MATLAB software at all the computers used in the computer laboratory, students ("clients" in the used "server –client" system) need even not to have MATLAB installed at their computers.

2. MATLAB WEB SERVER

The MATLAB Web Server enables to create MATLAB applications that use capabilities of the Internet (especially World Wide Web) to send data to MATLAB for computation and to display the results in Web browser. In the simplest configuration, a Web browser runs on client workstations, while MATLAB, the MATLAB Web Server, and the Web server daemon run on another machine – server. The MATLAB Web Server depends upon TCP/IP networking for transmission of data between the client system and MATLAB.
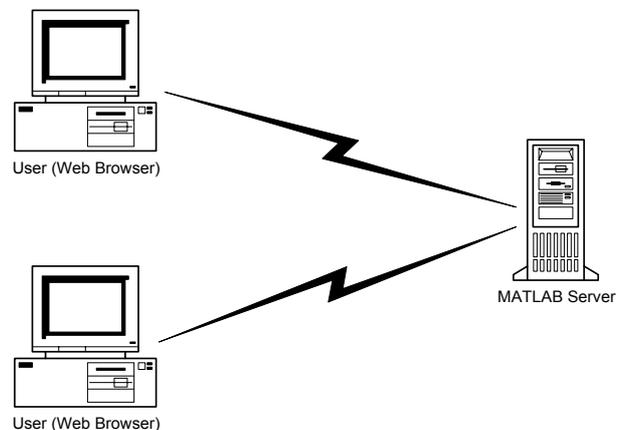

Fig.1 Using and configuration of the MATLAB Web Server

To submit input and to receive output from the MATLAB Web Server, a Web browser must be installed on client computers. Current version of the MATLAB Web Server has been tested with Netscape Navigator and Microsoft Internet Explorer. It is necessary to install Web server software on the system where MATLAB is running. There are a lot of suitable programs, for example freely distributed Apache Web Server or Microsoft Personal Web Server. MATLAB Web Server applications are a combination of M-files (source files for MATLAB), Hypertext Markup Language (HTML) [2], and graphics.

browser on client computer, so they show what sees the user.

3. THE BASIC ALGORITHMS TAUGHT USING MATLAB WEB SERVER

Our system offers teaching of three basic topics of signal processing applied frequently in digital measurement, namely DFT/FFT, digital filters, and correlation. In DFT/FFT part leakage is demonstrated, various windows are introduced, methods of changing frequency bin width can be
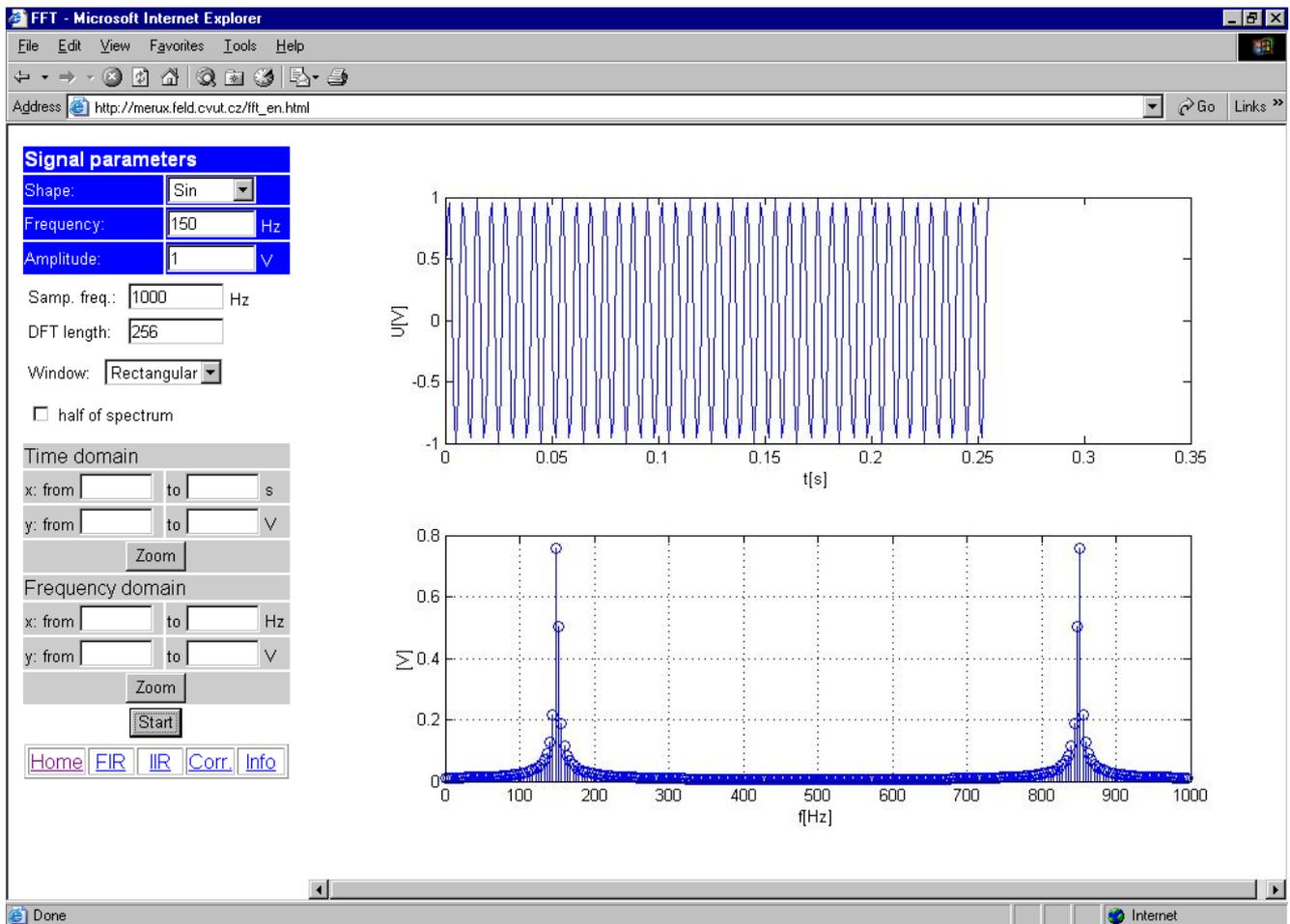

Fig. 2 Screen appearance of WWW browser for demonstration of the FFT

Fig. 1 shows philosophy and configuration of the MATLAB Web Server. The application development process requires three simple steps. Creation the HTML documents for collection of the input data from users (left part of screen in Fig. 2) is the first step. Next step is creation of the HTML document for display output from MATLAB (right part of screen in Fig. 2). The last step is writing a MATLAB M-file that receives data entered in the HTML input form, analyzes the data and generates any requested graphics. All communication between the user and MATLAB proceeds therefore only through WWW interface. The user even need not to know that generated output comes from MATLAB.

In the following parts there are described three examples of some basic teaching items using the MATLAB Web Server. Fig. 2 to Fig.4 are copies of screens of WWW

learned etc. In digital filters part both FIR and IIR filters are introduced, their frequency and impulse responses can be investigated and using chosen filter to filtration of various signals mixed with noise can be tried. In correlation part both auto- and cross-correlation functions can be computed, displayed and used for requested tasks.

3.1. Demonstration of discrete Fourier transform

Some characteristic features of the discrete Fourier transform, e.g. leakage in DFT spectrum, can be studied. The user can choose one from the offered types of periodic signals, enter its parameters (signal frequency, amplitude and sampling frequency), the type of data window, and the DFT length in the left part of screen (Fig. 2). There they pass on by means of HTTP server and MATLAB Web
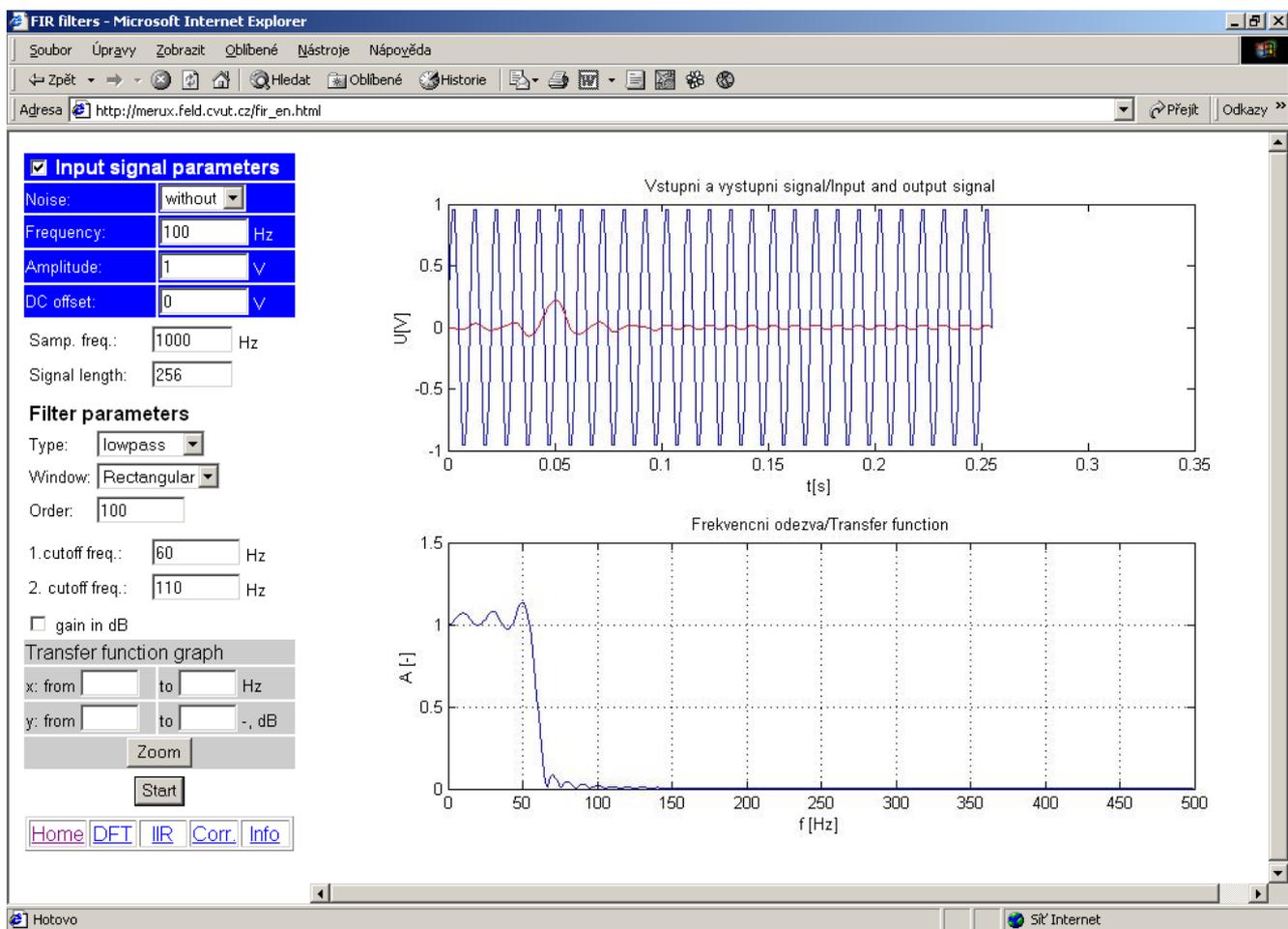
Fig. 3 Screen appearance of WWW browser for demonstration of design of a digital filter type FIR

Server into MATLAB for calculation. MATLAB returns signal waveform graph and signal spectrum, both displayed in right-hand part of window of client WWW browser. Because all graphs are returned as JPEG figures, it is impossible to check appropriate details in graphs. We have therefore provided a zoom, by means of which the user can choose a region of graph for detailed inspection.

3.2. *Demonstration of digital filtering*

Next task is focused on design of digital filters, both the FIR and IIR types. User sets parameters of signal, which will be filtered, as frequency, amplitude, DC offset, sampling rate and type of additive noise. As parameters of filter there can be set the type of filter (lowpass, highpass, bandpass or bandstop), the cut-off frequencies and the order of filter (Fig. 3). It is possible to choose the type of window with FIR type digital filter and to choose the analog model with IIR type filters. The MATLAB generates required signals and computes coefficients of the desired filter. Graphs of input waveform, filtered signal and frequency response of the designed filter are the tasks' outputs.

3.3 *Demonstration of correlation*

Correlation algorithms are demonstrated in this task. The user can again choose signal characteristics as its frequency, amplitude, phase, type of additive noise and value of

sampling rate. He then selects the time length of measurement (number of samples of the generated signals). It is possible also to select type of correlation function (autocorrelation of the first or of the second signal or cross-correlation of both signals). The results are waveform graphs of particular signals and the correlation graph (Fig. 4).

4. CONCLUSION

For the creation of a MATLAB Web Server application it is necessary to have the elementary knowledge of the HTML and of programming in MATLAB. Creation of applications or their modification is therefore not too time-consuming, nevertheless the resulting effect is indisputable. Our system is currently being introduced into the classwork, both in Czech and English version. Present experience and perceptions reflect its advantages: availability by means of Internet and WWW browser, simple control from WWW browser environment, high-speed response of MATLAB, and last but not least also the financial savings in hardware. You can find the described web server on the URL address http://merux.feld.cvut.cz. On-line measurement of instantaneous frequency and spectrum analysis of power line voltage in our laboratory has been lately added to the tasks described above.
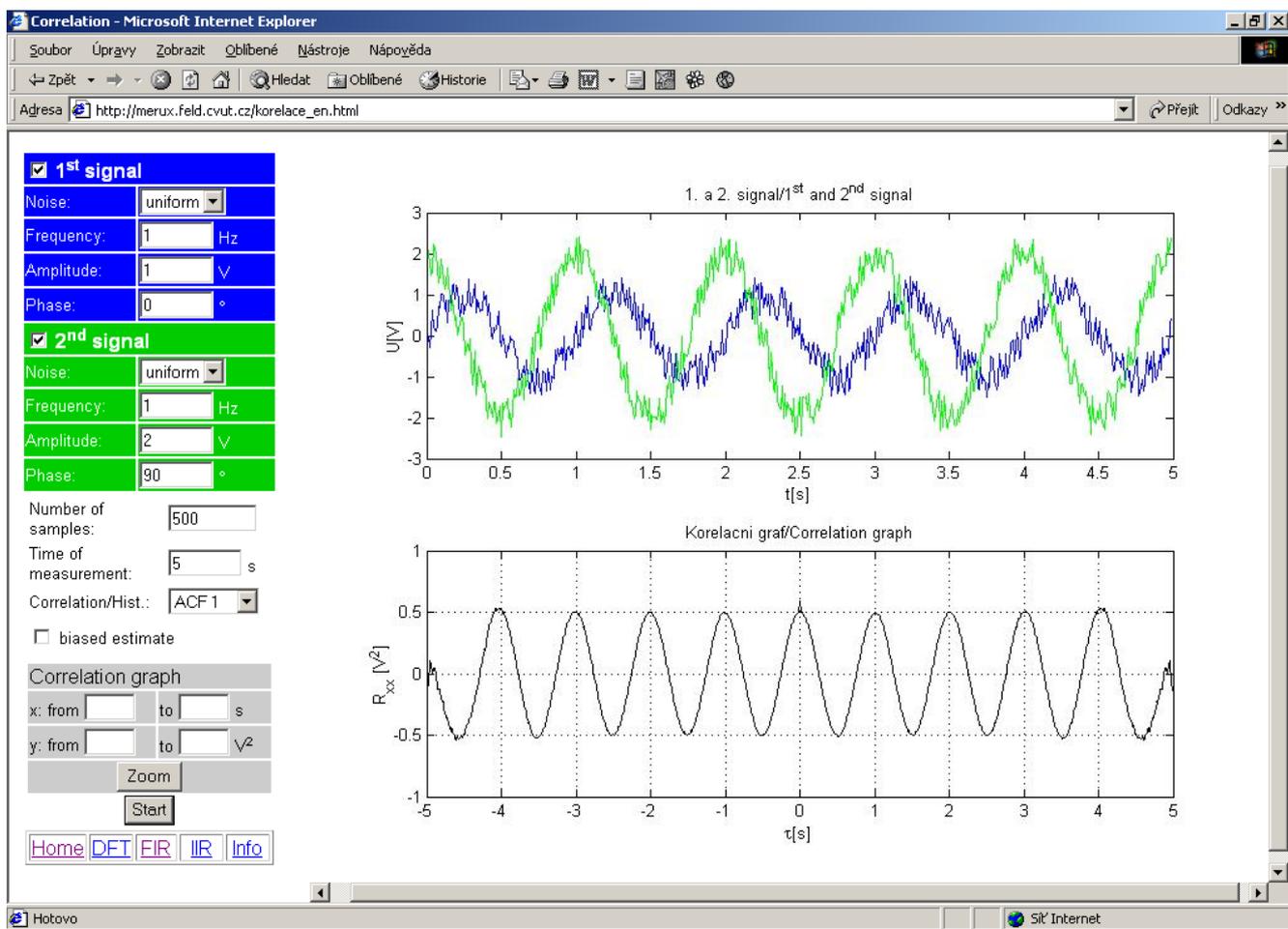
Fig. 4 Screen appearance of WWW browser for demonstration of correlation techniques

Preliminary information about this www application in teaching was presented at the ICPR-16 conference (16th International Conference on Production Research) which took place in August 2001 in Prague [3].

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