MATLAB BUILDER JA IN CONTROL ENGINEERING EDUCATION AT FCFT STU

M. Kalúz, Ľ. Čirka, M. Fikar

Institute of Information Engineering, Automation, and Mathematics, FCFT STU in Bratislava

Radlinského 9, 812 37, Bratislava, Slovak Republic

Phone: +(421) (2) 59325366, Fax: +(421) (2) 59325340, Email: martin.kaluz@stuba.sk

Abstract

This paper describes deployment JavaServer Pages (JSP) technology with integrated MATLAB methods and its application for control engineering education. MATLAB functions as m-files were compiled to Java code by MATLAB Compiler extension MATLAB Builder JA. Several web applications include mathematical operations with polynomials and matrices, pole-zero maps, graphs of step/impulse responses of LTI models, and process simulations of typical units in process industries.

Keywords: MATLAB Builder JA; JavaServer Pages; Virtual laboratory; Simulation

1 Introduction

For keeping quality of technical education in automation and process control today, it is important to provide contact between students and real or virtual experiments. Real plants can only be used by one user at one moment and experiments may take a long time. Virtual simulations became very popular, because they can be served by many users at the same time and their duration is much shorter compared to real experiments.

We have been using virtual laboratories for a few years at our department. The most commonly used technologies include client-side simulations using Adobe Flash [1], client-server web technologies using PHP+MySQL [2] AJAX, MATLAB Web Server [3], and MATLAB Internet Server used in MATLAB Internet Laboratory (MILab) [4]. However, MATLAB Web server support was discontinued after release of MATLAB 2006b and replaced by MATLAB Compiler extensions MATLAB Builder JA and MATLAB Builder NE. Therefore, we have explored the first named technology and started to rebuild our MATLAB Web Server virtual laboratory.

Many educational institutions in the world are using different technologies in the field of simulation processes, among others the various solutions with using Java. Easy Java Simulations (EJS) is open source technology designed for creating diverse Java computing applications, and simulations of real processes [5]. EJS can be used to develop client side Java programs and Applets, but do not offer server-side solutions for programs that needs other program resources, which can be realized only on side of server.

For our needs, it was necessary to select an appropriate technology to connect MATLAB computing potential with an application that will provide desired web user interface. It appears that JavaServer Pages (JSP) is suitable for such use. Idea of rebuilding MATLAB Web Server virtual laboratory is that we can use MATLAB functions as Java language classes and connect them with JSP technology to obtain complex web solution for our virtual laboratory.

2 MATLAB Builder JA

MATLAB contains several built-in components for application deployment. MATLAB Builder JA is a component designed for creating Java language classes from user defined MATLAB functions. MATLAB functions are encrypted by builder that generates a Java wrapper around them. Java classes are deployed by MATLAB Builder JA tool called Deployment Tool. M-files including m-code can be compiled into one or more distributable JAR package files, which can be imported and used in custom Java applications. Main advantage of using MATLAB code, compiled to Java, is that final

applications can be described as stand-alone applications. These do not need MATLAB to be run, but only need MATLAB Compiler Runtime (MCR). Another plus of this technology is that Java is programming language independent on platform. This means that programs and applications created in Java can be run on any operating system using Java Virtual Machine (JVM).

3 JavaServer Pages Technology

JavaServer Pages (JSP) is technology developed by Sun Microsystems. It is used for creation of dynamically generated web pages, based on HTML, XML, and some other document types. In our case JSP is used to serve communication between user of web application and server-side MATLAB methods presented by Java classes. Our created JSPs are declared as HTML document type, which contains static web content (plain text, tables, forms, etc.) and dynamic components (Java code, JavaScript). During the first execution of JSP on server-side, the Java code and user package classes are compiled into Java Servlet. Servlet is a Java server-side application that serves requests from client-side, and returns results of Java methods as static and dynamic content of web page.

4 MATLAB JSP Applications

The following products are required to build MATLAB JSP application using MATLAB Builder JA:

- MATLAB R2008b or later (including MATLAB Builder JA and MATLAB Compiler)
- MATLAB Compiler Runtime
- Java Development Kit (JDK)
- Platform Java 2, Enterprise Edition (J2EE)
- Web server supporting Java Servlet and JSP technology (e.g. Apache Tomcat)

All web applications have been created as JSP. Web pages are declared as HTML document type with static and dynamic content. Graphical user interface (GUI) consists of HTML components like forms and buttons, and by server-side returned content (calculated results, graphs) dynamically generated by Java Servlet. Errors handling of application inputs (HTML forms) are provided by servlet itself to avoid incorrectly formatted data in MATLAB functions. All errors that occur inside Java code are handled by exceptions. Exception defined for MATLAB classes is called MWException. After occurrence of error in MATLAB methods, MWException returns object with error message, which is similar to error message that can be seen in MATLAB command window.

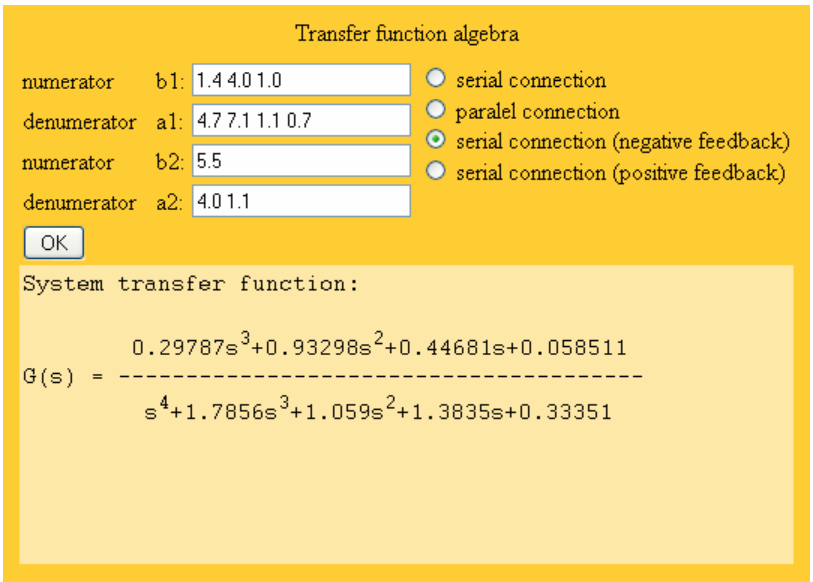
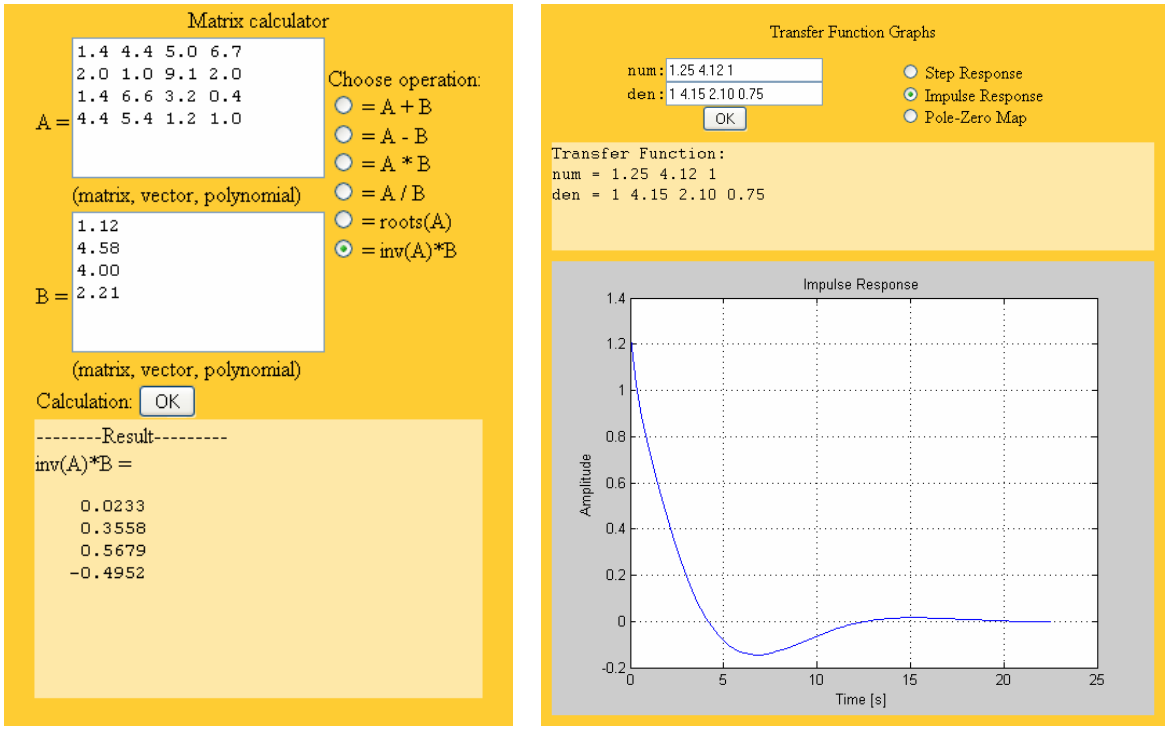


Fig. 1: Applications for transfer function algebra

The user of application enters correctly formatted data into input forms and sends them to the servlet by clicking submit button. After data processing on the server side, the user will receive a HTML page with results. For text output applications (Fig 1, Fig. 2a), the results are displayed as formatted HTML text in distinct color blocks. Applications with graphic results (Fig. 2b, Fig. 3) returns to user a dynamic object called WebFigure, which contains graphical output of MATLAB plotting functions. Input data must be entered in the correct format, e.g. polynomials (Fig. 1) are entered as text strings with blank spaces between coefficients. Matrixes (Fig. 2a) are entered without brackets, with blank spaces between the elements of row. Each row of matrix has to be defined on the new line of input box.



a) b)

Fig. 2: Applications for matrix operations (a) and for dynamic system responses (b)

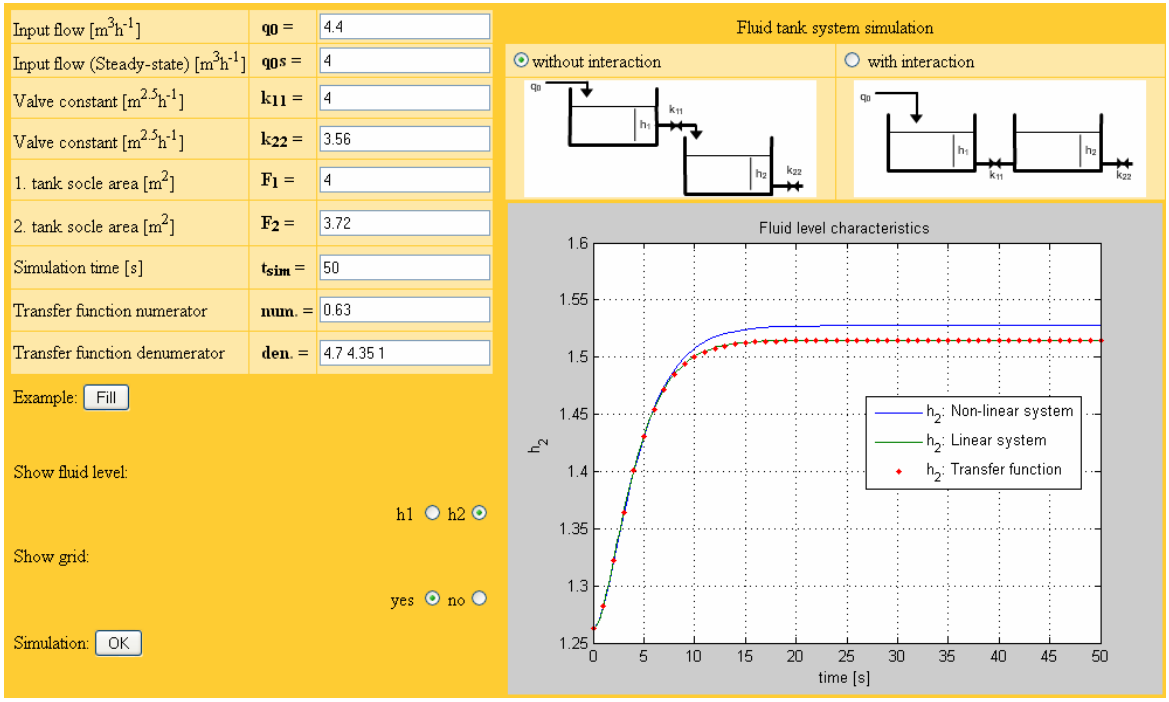


Fig. 3: Storage tank system simulation

In fluid tank system simulation (Fig. 3), user enters all required technological parameters in displayed engineering units. Application provides a choice between two different mathematical models of system (with or without interaction between tanks). User can also enter own transfer function to compare it with result from MATLAB simulation. Application provides simulation of linear and non-linear mathematical model, and shows both results at one graph.

The following set of automatic control related problems can be solved with the recent version of the JSP applications:

- Transfer function algebra (serial/parallel connections with positive/negative feedback)(Fig. 1)
- Polynomial mathematical operations (Fig. 2a)
- Polynomial roots finding (Fig. 2a)
- Matrix mathematical operations including solution of a matrix equation $\boldsymbol{Ax} = \boldsymbol{b}$ (Fig. 2a)
- Pole-zero map of LTI models (Fig. 2b)
- Step response of LTI models (Fig. 2b)
- Impulse response of LTI models (Fig. 2b)
- Process model simulations (including storage tanks (Fig. 3) and heat exchangers)

5 Conclusion

This paper described application of MATLAB JSP technologies for use in control engineering education. These gradually replace the existing solution based on MATLAB Web Server. All created web applications have been integrated into one e-learning web module that is freely accessible through Learning Management System (LMS) Moodle in FCFT.

In future, we will extend the existing web module with new MATLAB JSP applications representing processes of continuously-stirred tank reactor, tube heat exchanger, rectification column, and some other unit operations used in process industries.

We would like to cooperate with other groups in developing JSP technologies. We can provide source code of application to interested readers.

Acknowledgments

The authors are pleased to acknowledge the financial support of the Cultural and Educational Grant Agency of the Slovak Republic under the grant No. 3/7245/09 and of the grant (No. NIL-I-007-d) from Iceland, Liechtenstein and Norway through the EEA Financial Mechanism and the Norwegian Financial Mechanism. This project is also co-financed from the state budget of the Slovak Republic.

References

[1] Ľ. Čirka, M. Kalúz, M. Kvasnica, M. Fikar. *Virtual Laboratory*. In *Proceedings of the 9th International Scientific - Technical Conference Process Control 2010*, Kouty nad Desnou, Czech Republic, pp. C029a 1 – 8, 2010.

[2] Ľ. Čirka, M. Bakošová, M. Kvasnica, M. Fikar. *Internet Module for Process Modelling and Simulation*, In *Principia Cybernetica 2010*, Technical University of Liberec, Liberec, Czech Republic, pp. 22 – 26, 2010.

[3] Ľ. Čirka, M. Bakošová, M. Fikar, M. Herceg. *Dynamic Simulations of Chemical Processes via the MATLAB Web Server*. In *Proceedings of the 15th Annual Conference Technical Computing Prague 2007*, Congress center CTU Prague, Czech Republic, pp. 34 – 34, 2007.

[4] Ľ. Čirka, M. Fikar, T. Hirmajer, M. Bakošová. *On new trends in control engineering education at FCFT STU*. In *Proceedings of the 6th International Scientific - Technical Conference Process Control 2004*, University of Pardubice, Kouty nad Desnou, str. CD ROM R015, 2004.

[5] W. Christian, F. Esquembre. *Modeling Physics with Easy Java Simulations*. In *The Physics Teacher*, ISSN 0031-921X, Vol. 45, pp. 475 – 480, 2007.