

An Internet-Based MATLAB Learning Environment

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Abstract

An internet-based learning system for the course “numerical linear algebra” is developed. It is based on the software MATLAB and a MATLAB web server to form a real time, efficient interface to enhance students learning when they are involved with matrix computation. This interface contains almost all functions which are often used in matrix computation. All the options are included in a panel that students can choose from either function they want to implement. All they have to do is to input a matrix and sometimes a right-hand-side vector for which is used in a linear system solver. The result can be shown either step-by-step or only a final output. Help for description of how-to-use and algorithms of these functions are also available separately. A multimedia instruction for the first time user is also available.

Key Words. Numerical Linear Algebra, Numerical Analysis, MATLAB, MATLAB Web server, Matrix Computation

1. Introduction

Matrix Computation [6] is becoming an important course in the college education. Part of the material of this course are also covered in the course of Numerical Analysis [11]. There are so many matrix computation techniques used in engineering, but are usually not able to be covered in the regular Numerical Analysis course. In addition, students have not enough opportunities to do a lot exercises involving techniques of matrix computation; e.g., transformation of a square matrix into a product of lower triangular matrix and upper triangular matrix by Givens transformation, Householder transformation, and Elementary transformation; a linear system solver by direct methods or iterative methods; stability of a transformation used in linear system solver; and condition number of a given matrix [8, 9, 10] etc.

In the numerical analysis community, there are a lot application packages used for numerical linear

algebra; e.g., LINPACK [4], EISPACK [5], NETLIB, IMSL, NAG, LAPACK, ITPACK, and SPARKIT, etc. But these are usually written in FORTRAN, and the algorithms are very complex, whose purpose is not used for teaching, and of course, some of them cost a lot. The object of this paper is to present an internet-based learning system which is based on the software MATLAB [1, 2, 3] and a MATLAB Web server to form a real time, efficient interface to enhance students learning when they are involved in exercises with matrix computation. In addition, they can use this system to know many fundamental issues in leaning numerical linear algebra, e.g., what stability means in linear system solver; what is the condition number of a given matrix; and flops counts of a given algorithm [8]. The advantage of this system is that users do not have to own this software MATLAB, they just need to know how to access the system through internet. All they have to do is to insert a matrix and sometimes a right hand side vector through the internet, the system will perform calculation for you. The variety output formats can be displayed either step by step or a direct final result. Help for description of how-to-use and algorithms of these functions are also available separately. A multimedia instruction for the first time user is also developed. Eventually, the content of this MATLAB environment will be put in the Internet to let user to use either in the distance learning or just for calculation. The web page will include material of every subject to let user know what is the basic knowledge before they use, and exercises for them to strengthen their ability of this subject.

2. Developing Methods

To use modern technology to assist students' learning is being studied a lot recently. To use computer multimedia system as a teaching and learning tool becomes trend of modern scientific education. To use this carefully designed internet-based system will help users execute examples or exercises that usually can't be implemented in the regular course. Students can use this tool to check their results at each step or just to see if their final solution is correct or not. The web page will contain functions such as *transformations*, *direct linear system solvers*, *indirect linear system solver*, and *condition number of matrix*. In each category, e.g., *transformation*, it will contain *Gaussian elimination*, and *QR decomposition* two subcategories. In the subdirectory *Gaussian Elimination*, it contains sub-functions such as *without pivoting*, *with partial pivoting*, and *with full pivoting*. Materials for each directory will be given as hyperlink to let users read if they are not familiar with these subjects. Selected exercises will be given in each category. A multimedia file will be build to help first time user to learn how to implement this tool. Nevertheless, several functions are still underdevelopment currently. In Sec. 2.1, an Internet user interface is set up to transform programs written by MATLAB to be executed through the Internet. In Sec. 2.2, a sample Internet calculator is introduced as a sample module for developing an advanced Internet-based module. In Sec. 2.3, the object web page is introduced, which contains different functions, their usage, and their output

format in the Internet.

2.1. An Internet User Interface

In order to install the Internet User Interface, a background of setting up a WWW Server is necessary, and this server needs to be capable of executing cgi (common gateway interface) programs. Assume that the web server is Microsoft IIS. A program MATLAB.exe is stored in the directory C:\inetroot\cgi-bin, (the purpose of this program is to enhance the connection possibility of Internet end-user and the Internal MATLAB environment). Next, we place an alias (assume it is /cgi-bin) as shown in Fig. 1 to C:\inetroot\cgi-bin and allow its cgi capability. Then we just use html “form” function to enhance its action to be /cgi-bin/matweb.exe.

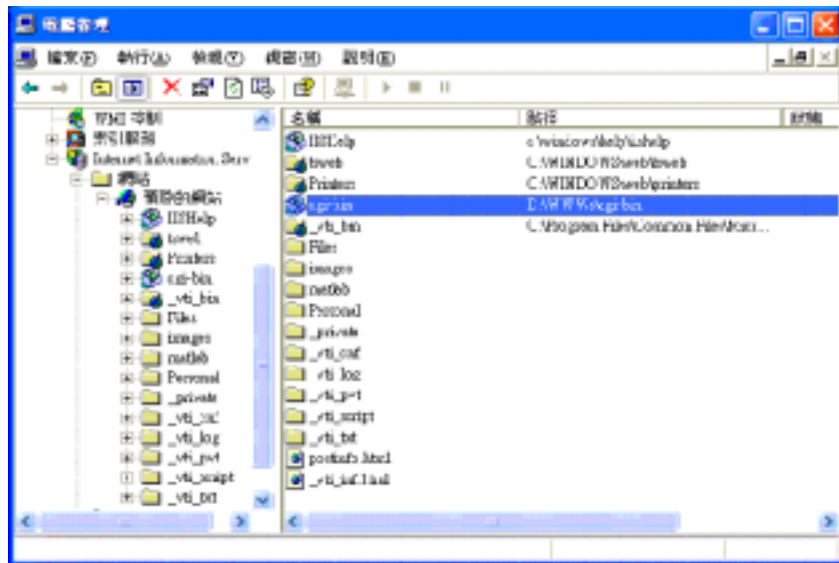


Figure 1. Definition of cgi alias



Figure 2. Definition of matweb.conf

The calculation environment in the Internet is transformed from a bunch of subprograms written in MATLAB, under this circumstance, we will recode every subprogram to MATLAB web server in the matweb.conf under /cgi-bin and open its right to execute under this environment. The definition of matweb.conf is shown in Fig. 2.

2.2 A sample Internet Calculator

A simple Internet calculator is used to demonstrate the functionality of our Internet MATLAB learning environment by giving a direct output if end-user has input a mathematical expression.

Step1. Set up an Internet web page and let end-user input a mathematical expression as shown in Fig. 3. Part of the syntax are given as the following,

```
<form method="POST" action="/cgi-bin/matweb.exe">
  <input type="text" name="strInput" size="40" value="sin(10) *
cos(10)">
  <input type="submit" value="Submit" name="B1"><input type="reset"
value="Reset" name="B2">
  <input type="hidden" name="mlmfile" value="WebEval">
</form>
```

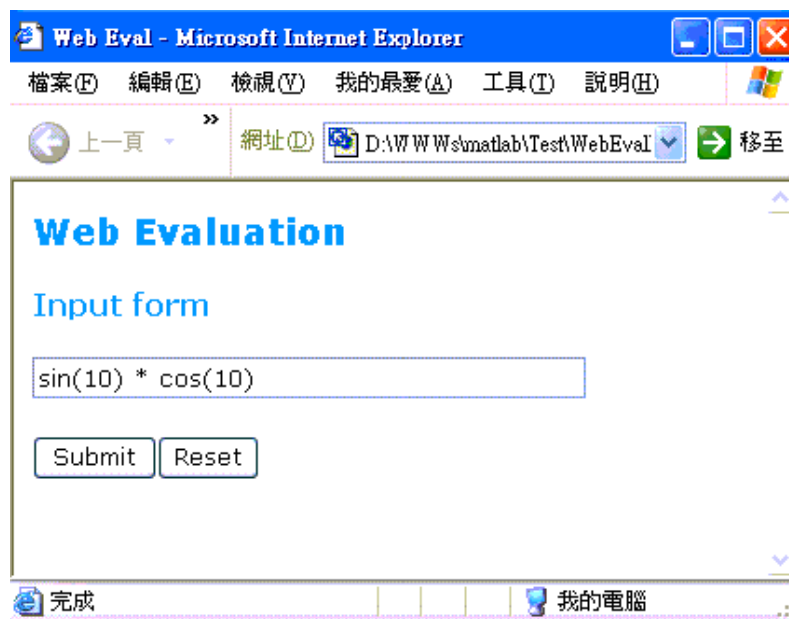


Figure 3. A sample Internet calculator

Step 2. Write a simple MATLAB .m subprogram as shown in Fig. 4 to allow Internet end-user to input mathematical expression. User can reset the input function, and if there is nothing wrong, User just pushes the Submit button to let the calculator execute, and return the result back to the

Iterative, and Condition.

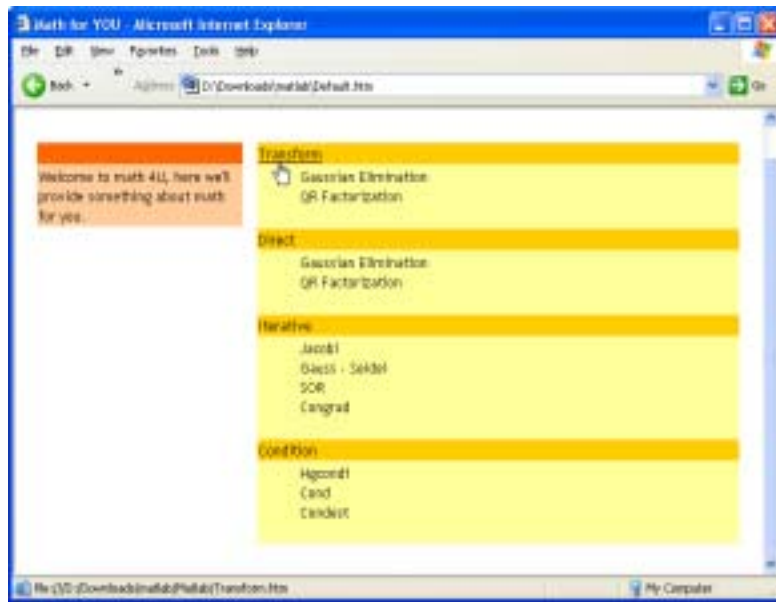


Figure 6. The MATLAB-Based web environment

The MATLAB web environment is designed as a pull bar panel, in each category, e.g., Transform, it is related to transformation of a square matrix. Two major functions are provided, one is Gaussian elimination, and the other is QR decomposition. Under Gaussian Elimination, there will be three subfunctions, there are without pivoting, with partial pivoting, and with complete pivoting. It is shown in Fig. 7.

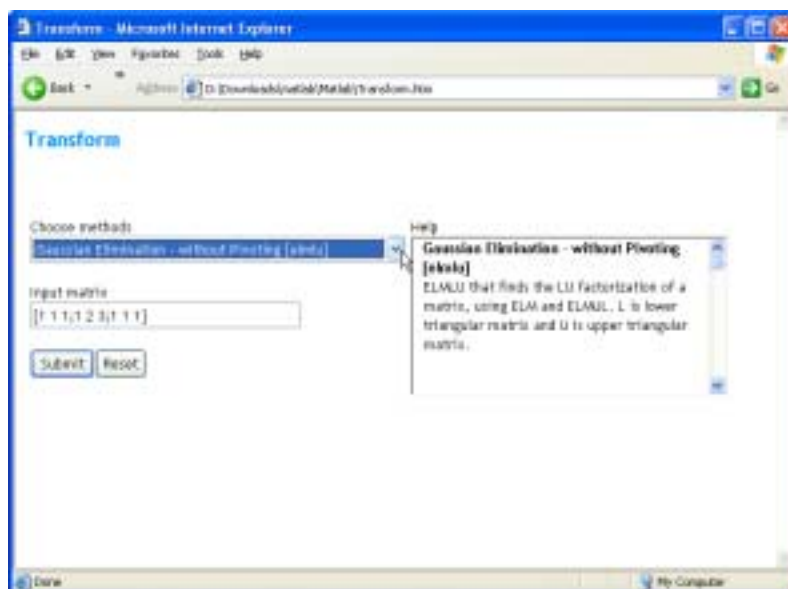


Figure 7. Option for transformations

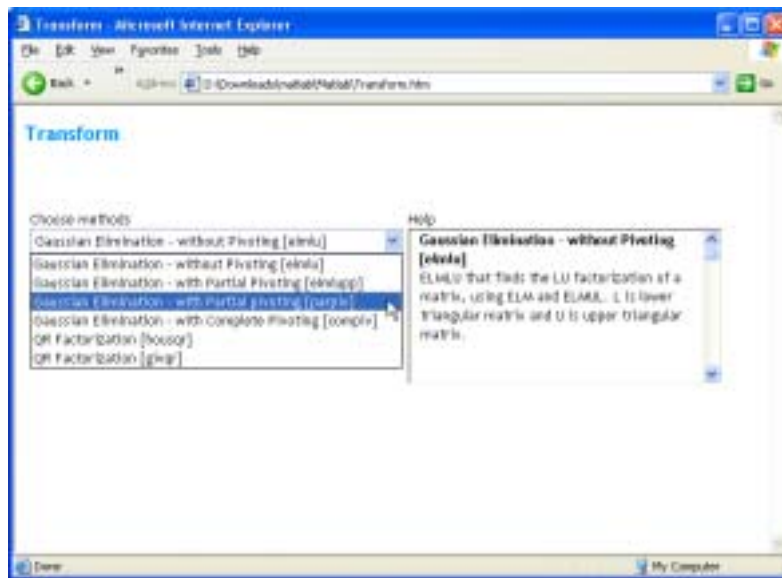


Figure 8. Help and input for the chosen function

After user decides which transformation is used for implementation, the system will provide its explanation of the function, and automatically changes its input and output conditions as shown in Fig. 8. The Help column is designed to let the first time user know how to implement the function by supplying correct information. In addition, it also informs user what will be the output. A possible output of the calculation after user has put its input matrix is given at Fig. 9. The output contains the original input matrix, the elementary matrix which is used to do transformation, and the final output, which is written as two matrices; one is a lower triangular matrix and the other is an upper triangular matrix.

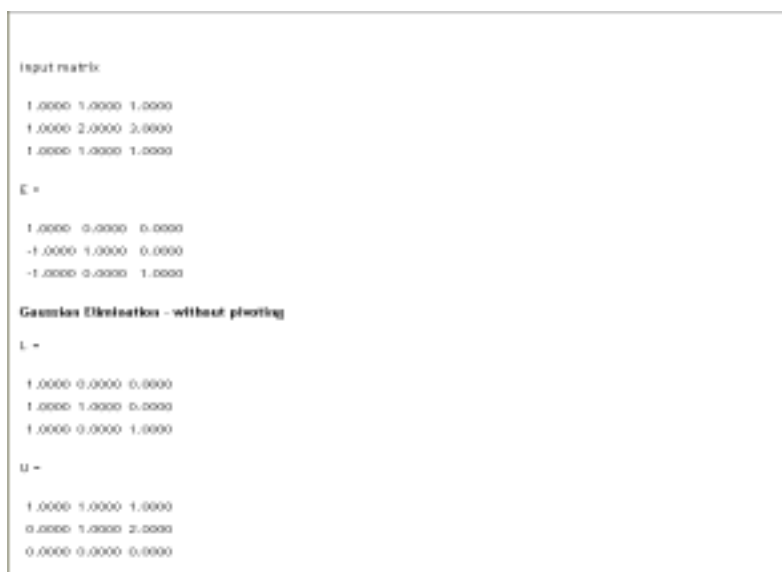


Figure 9. Output

The function of this Web MATLAB Environment can be enlarged further more [6, 8]. In addition, there are still several options can be remodeled in order to let user know better of the knowledge of matrix by reading the append document and exercises.

To learn numerical linear algebra through this Internet based MATLAB environment is still a first trial. User can only use the functions supplied in the Internet panel developed by the author; in other words, they will not have any opportunity to change these functions or to play with MATLAB themselves in the terminal. Under this circumstance, a copy right for MATLAB should have not been violated.

3. Conclusions

The advantage of this environment is that users do not have to own the software MATLAB and still be able to do calculation. User just needs to know how to connect to our web page and they can do distance calculation. The capability of this environment is able to enlarge to include most of the functions given in the course of matrix computation. The input matrix interface will be modified to be friendly for the first time MATLAB user. Description of algorithms for each subprogram will be provided in the future to let user know how to do programming. We believe this environment can provide first time user in matrix computation to know better the spirit of this course, and they will be able to develop their capability to create knowledge in this subject.

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