Teaching program for Eigenvalues of a Symmetric Matrix

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Abstract: From the standpoint of engineering applications, eigenvalue problems are among the most important problems in connection with matrices, and there are many research papers on corresponding numerical methods for determining eigenvalues. The objective of this article is to provide software which will aid students to understand how the processes of Jacobi’s Method, Householder Method and the QL Algorithm find the eigenvalues of symmetric matrices. Definitions and theorems of relevant concepts will be available for the user to consult at all times and detailed demonstration of step by step working of the three methods will be provided. In addition, users will be able to enter their own (symmetric) matrices and see the eigenvalues being located. XView will be used to display the progress of the computing and to provide explanatory text.

Key-words: Eigenvalue problems, Symmetric Matrices, CAL, PL, Teaching Program.

1 INTRODUCTION
We are going to discuss the use of computers in teaching, and how students can become more independent in their approach and appear more willing and able to explore alternative solutions to problems. The principals of CAL were really discovered by Socrates. As a formal method of teaching, the Socrates method disappeared for over two millennia until the 1950s. It was then reviewed in the form of Programmed Learning (PL) which resulted from the researches of B.F Skinner at Harvard University [1]. The use of Computer-Assisted Learning (CAL) can provide effects of a type which are widely believed to be beneficial in terms of pupil motivation, progress and understanding(Hudson, key [1]. The focus of the Teaching Program in this article is on learning about most important ideas and numerical methods for matrix eigenvalue problems. The fundamental aim is practical work through using the software.

A Toolkit is a user interface subroutine library. Applications and window managers can be written with these toolkits. Toolkits implement a set of user interface features such as menus or buttons and allow applications to manipulate these features using Object-Oriented programming techniques. They can make programming much easier and the finished project more thorough. There are several Toolkits distributed. One of them is the XView toolkit.

2 STRUCTURE OF TEACHING PROGRAM
The following figure gives the structure of the teaching program (see Fig 1).

Fig 1
3 Main Frame
This window describes the facilities which are provided by the Teaching Program system. After invocation, the product is to display a main frame carrying the options:
- Definitions
- Theorems
- Computing Method
- Help
See following figure (fig 2).

Fig 2
Selection of each option will result in the display of a sub-frame.

3.1. The Definitions Sub-frame
The facilities of the Definitions sub-frame will permit the student to select a definition from Panel Choice and a text explanation of that definition, carried with an example (in some cases) displayed in the window. See Fig 3.

3.2 The Theorems Sub-frame
The facilities of the Theorems sub-frame will permit the student to select a theorem from the sub-menu and the contents of each theorem with examples or proof (in most cases) is displayed in the window. This sub-frame consist of a Panel, a Panel Button (Exit), a Panel Choice Stack, a Scrollbar and two canvasses. On selecting of a theorem from the Panel Choice Stack, Canvas-1, displays the contents of theorems and canvas-2, is used to displays example or a proof of related theorems at the same time. (See fig 4).

3.3 The Computing Method Sub-frame
In this Teaching Program, three computing methods were used for calculating eigenvalues of a symmetric matrix. The three methods are the Jacobi Method, the Householder, and the QL Method. Students are allowed to input an arbitrary real symmetric matrix and obtain the answers. We have also given a detailed, structured algorithm for each of the three method in which the student can repeatedly ask for the “next step” until the answer is obtained. For example:

Step 1: $s_{d} = \sum \sum e_{g} \quad \text{for } g = 1$

Step 2: $s_{d} = e_{1}^{2} + e_{2}^{2} + e_{3}^{2} \Rightarrow s_{d} = 29$

(half of sum of square of off-diagonal elements, using the fact that $A$ is symmetric)

Step 3: Find the element $e_{g}$, $e_{g} \neq 0$
of $A$, for which $|e_{g}|$ is largest

4 $e_{g} = 4$
The algorithms will have been explained in the classroom and are described in the form a student with limited practical experience can easily understand.

The facilities of the Computing Method sub-frame will permit to the identification of a method and then sequentially:

- The main concepts of the chosen computing method is displayed in Canvas_1.-The student inputs the dimension of a matrix in the Panel-Text “dimension”. Then, with clicking on return key, sequentially Panel-Text “input-element” will be displayed in the Panel-2 and panel-text “dimension“ will disappear. The Panel-Text “input-element” accepts real numbers from the keyboard and displays them in Canvas-3. Also after inputting the first element in the input-element panel-text, “input-element“ will be changed to “next element” until all matrix elements have been typed in. Then this panel-text disappears.

- The student clicks on the Panel-Button “begin” to start step-by-step computing, using the chosen method or clicks Panel-Button "all" for displaying only the final result (that is the computed eigenvalues). The Panel-Button “begin” changes to “next-step” each time after pressing the button. This step-by-step computing is continued until the result of the computation comes out. This result is displayed in Canvas-4.

- With pressing the “start again” Panel-Button all information in the Canvas-2, Canvas3, Canvas-4 is cleared and Panel-Buttons, “all” and “begin” disappear and Panel-Text “dimension” is displayed. Then the user restarts again from inputting dimension of a matrix.

- With the pressing of the “Exit” Panel Button, control returns to the main menu.

The sub-frame is shown in the following figure.

3.4 Help Sub-frame

The facilities of “Help” sub-menu will permit the student to display help text.

Conclusion

Not only is there a benefit to the student in deep understanding, it can also be used as a vital source of feedback to the lecturer in the charge it has friendly user-interface and the students can refer to relevant concepts in particular problems by means of multiple windows.

With further work in this Teaching Program it provides a software including all methods for finding eigenvalues of real and complex matrices. It is a suitable software for distance learning.

References
