Applied Computational Science I
Lab 1

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September 2023

1 Programming Style

1.1 Code Formatting

Casing: Snake-Case
Indentation: 6 spaces
Line break: LF

1.2 File structure

All the routines are stored separately in files named 'Q1_A.F90', where the first two letters denote the question and the 4th letter denotes the sub-question. The same naming convention is used for the outputs where the file name ends with '_Output.txt' rather than '.F90'.

2 Execution

To compile the program you will need gfortran installed on your machine along with the lapack library. Once the dependencies are installed you can compile the code by simply using the following command.

```
gfortran Q1_A.F90 -llapack
```

After successful compilation, you should get an executable file named 'a.out' or 'a.exe' depending on your operating system.

3 Routines

3.1 Question 1 A.

Writing a Fortran program which calls `dgesv` to solve the linear system $A\overrightarrow{x} = \overrightarrow{b}$ where we compute b by multiplying A by x. With A and b, we solve x again by using `dgesv`. The output of this program which can be found in the file named 'Q1_A_output.txt' makes it clear that as we performed these operations, the values of b are inconsistent.

3.2 Question 1 B.

We have,
$A = \begin{pmatrix} 4.5 & 3.1 \\ 1.6 & 1.1 \end{pmatrix}$, $\overrightarrow{b} = \begin{pmatrix} 19.249 \\ 6.843 \end{pmatrix}$, $\overrightarrow{c} = \begin{pmatrix} 19.25 \\ 6.84 \end{pmatrix}$

and solving $A\overrightarrow{x} = \overrightarrow{b}$ and $A\overrightarrow{y} = \overrightarrow{c}$ using `dgesv` gives us the following values.
$\overrightarrow{x} = \begin{pmatrix} 3.9398 \\ 0.4901 \end{pmatrix}$ & $\overrightarrow{y} = \begin{pmatrix} 2.8999 \\ 2.0000 \end{pmatrix}$
To solve two functions that share the same A matrix, we can do that by calling the `gdesv` function only once and passing the right-hand side matrix as a combination of the $\overrightarrow{b}$ and $\overrightarrow{c}$ where the first column of the right-hand side matrix holds values of $\overrightarrow{b}$ in the first column and in second column values of $\overrightarrow{c}$. The output of this function can be found in the file 'Q1_B_output.txt'.

3.3 Question 2 A.

In this question, we are creating a banded matrix A along with a matrix B which has only one column and follows the pattern (9,10,13,13,...,13,11,12). In this function, we are using two subroutines from the lapack which are `dgbtrf` and `dgbtrs` to solve this linear system. The output of this function can be found in the file 'Q2_A_output.txt'

3.4 Question 2 B.

In this function, we are using the same routines as Question 2 A, but here we are solving multiple linear systems with the same coefficient matrix A. In every iteration, the value of the right-hand side will be b_k where $k = 1, 5$ will be the $b_k = b + x_1$. This can be seen in the Fortran code at line 91, where the value of b_k is updated for the next iteration. After successful execution, it can be seen that values ofb_k do not alter a lot more than the original value. The output of this function can be found in 'Q2_B_output.txt'