12.010 Computational Methods of Scientific Programming

Lecturers
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Web page http://geoweb.mit.edu/~tah/12.010
Summary of Today’s class

- We will look at Matlab:
  - History
  - Getting help
  - Variable definitions and usage
  - Math operators
  - Control statements: Syntax is available through the online help
  - M-files: Script and function types
    - Variable number of input and output arguments
- Our approach here will be to focus on some specific problems using Matlab for analysis and for building Graphical User Interfaces (GUI) and treating graphics as objects.
MATLAB (Matrix Laboratory)

- History
  - MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects.
  - First version was released 1984.
  - Current version is version 7 (Versions come in releases; currently Release 2010a/b, 7.10). (command ver gives version)
  - Interactive system whose basic data element is an array that does not require dimensioning
  - UNIX, PC and Mac versions. Similar but differences.
MATLAB:

• All commands are executable although there is the equivalent to dimensioning. In general arrays in MATLAB are not fixed dimensions
• Syntax is flexible but there are specific set of separators
• Basic Structure:
  – MATLAB commands are executed in the command window called the base workspace (>> prompt)
  – MATLAB code can be put in M-files: Two types
    • Script type which simply executes the code in the M-file
    • Function type which executes codes in a new workspace. Generally variables in the new workspace are not available in the base workspace or other workspaces.
Getting help

- Matlab has extensive help available both locally based and through the web.
- After release 13 there is a help menu in the command window.
- Help falls into two types:
  - Help on specific commands and their usage
  - Help by topic area which is useful when looking for generic capabilities of Matlab
- Matlab also comes with guides and there are third-party books such as “Mastering Matlab X”
Basic Structure 02

- Variable types
  - Early versions of matlab had variables that are double precision, strings cells (), or structures.
  - After Version 6, other variable types introduced specifically single precision and integer forms can be used (saves memory space) (help datatypes)
  - Complex variables are used as needed (use *i or *j to set complex part)
  - Variables can be defined locally in current workspace or they can be global.
  - To be global must be defined that way in both base workspace and M-files
    - who and who are used determine current workspace variables
    - Names are case sensitive, no spaces, start with letter and may contain numbers and _
    - workspace command is GUI management tool (now built into Desktop Layout).
Basic Structure 03

- I/O: File I/O is similar to C
  - `fopen`, `fclose`, `fread` (binary), `fwrite` (binary), `fscanf` (formatted read), `fprintf` (format write), `fgets` (read line), `fgetl` (read line keep new line character), `sscanf` (string read), `sprintf` (string write)
  - `save` and `load` save and load workspace.
- Math symbols: `+`, `-`, `*`, `/`, `^` (`^` is left divide)
- When matrices are used the symbols are applied to the matrices.
- When symbol preceded by `. Array elements are operated on pair at a time.
- `*` means transpose array or matrix
- Lec01_01 and Lec01_02 are examples
Basic Structure 04

– Control
  • if statement (various forms)
  • for statement (looping control, various forms (similar to do)
  • while statement (similar to do while)
  • No goto statement!
  • break exists from for and while loops
  • switch case otherwise end combination
  • try catch end combination

– Termination
  • end is used to end control statements above
  • return is used in functions in the same way as Fortran.
M-files: Script and Function types

- Communication with functions and M-files
  - Script M-files:
    - Do not accept input or output arguments
    - Operate on data in workspace
    - Useful for automating a series of steps
  - Function M-files
    - Accept input arguments and return outputs
    - Internal variables are local to the function by default, but can be declared global
    - Useful for extending language
Syntax

- Flexible layout with certain characters have specific uses.
- % is the comment symbol. Everything after % is ignored
- \ldots (3 dots) is the line continuation symbol. Must be used at a natural break in commands
- , used to separate commands, with result printed
- ; used to separate commands with result not printed
- [] enclose arrays and matrices, {} enclose sets (difference is multi-dimensional arrays need to be all of the same type and size)
- : is the range selector for from start:increment:end, if only one: increment is 1, if no numeric values, range for matrix elements.
Multidimensional arrays

- Matlab works naturally with 1 and 2 dimensional arrays but more than 2 dimensions can be used.
- They can be constructed a number of different ways
  - By extension: \( a = [5\ 7\ 8\ ;\ 0\ 1\ 9\ ;\ 4\ 3\ 6]; \)
    \[ a(:,;2) = [1\ 0\ 4\ ;\ 3\ 5\ 6;\ 9\ 8\ 7] \]
  - Scalar extension (Set “plane” 3 to 5)
    \( a(:,;3) = 5 \)
  - Use of functions \texttt{ones}, \texttt{zeros}, \texttt{randn}
    \( b = \texttt{zeros(3,3,2)} \)
  - \texttt{cat} function, \texttt{cat(ndim, arrays, ...)} where \texttt{ndim} is the dimension to be concatenated in.
Multidimensional arrays 02

- `reshape` function allows redefinition of array shape e.g.,
  \[ a = [1:18]; \text{reshape}(a,[3 3 2]) \]
- `squeeze` removes dimensions that are only 1 element
- `permute` allows array dimensions to be re-ordered.
- Functions that operate on elements of arrays work with multidimensional arrays but matrix type functions do not work unless a suitable 2-D array is passed
- Functions that operate on vectors use the first nonsingleton index
Summary of Introduction to Matlab

• Looked at the basic features of Matlab:
  – Getting help
  – Variable definitions and usage
  – Math operators
  – Control statements: Syntax is available through the online help
  – M-files: Script and function types
    • Variable number of input and output arguments

• Class Project Descriptions and groups of 2 people due Thursday November 18.