Introduction to MATLAB programming

WhyNHow
Martinos Center

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Tutorial overview

- Why MATLAB? (or why not?)
- MATLAB environment
- Linear algebra in MATLAB
- General programming
- Functions
- Plotting
- Paradigm example
- Advanced topics
Why MATLAB?

- MATLAB = MATrix LABoratory
  - Data representation with matrices
  - Vectorized operations
  - User friendly (initialization)
  - Graphics
- Specialized toolboxes
  - Built-in functions
- Input/Output device interaction
- Be a knowledgeable user
MATLAB environment

This is the MATLAB default desktop/interface
Linear algebra

- Vectors, matrices, linear systems, etc…
- Matrices: \( m \) rows x \( n \) columns
  - Input into MATLAB
    - Row separator: , or <space>
    - Column separator: ; (or <return>)
  - Matrix element
    - \( A(i,j) = \text{value} \);
### In MATLAB

<table>
<thead>
<tr>
<th>Quantity</th>
<th>MATLAB syntax</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transpose $A^T$</td>
<td>$A.'$</td>
<td>Transpose only</td>
</tr>
<tr>
<td>Adjoint $A^*$</td>
<td>$A'$</td>
<td>Transpose + complex conjugate</td>
</tr>
<tr>
<td>Dot (inner) product $x^*y$</td>
<td>$x'*y$ or $\text{dot}(x,y)$</td>
<td>Assumes column vectors</td>
</tr>
<tr>
<td>Norms $|x|$ or $|A|$</td>
<td>$\sqrt{x'*x}$ or $\text{norm}(x), \text{norm}(A)$</td>
<td>L2 norm (length) Other norms too</td>
</tr>
</tbody>
</table>
More matrices in MATLAB

- **Sub-matrices**
  - Range specified by `<start>:<end>` e.g. `A(:,1:n)` where `n = 10`
  - Entire dimension is default or use :

- **Matrix operations** e.g. `* , .*, /, -, +`
  - Backslash operator: `\` (more later)
  - Match matrix dimensions
  - Reminder: `A*B ≠ B*A` (not commutative)

- **Solving systems of linear equations** `A*x = b` \(\Rightarrow\) `x = inv(A)*b` or `x = A\b`

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Introduction to MATLAB programming
Programming

- Conditional if-else statements
- Repetition: while or for loops
  - MATLAB is optimal using vectorization so avoid for loops for computational speed
- Functions
- Debugging
MATLAB functions

- `help <function>`: displays the text help file in command window
- `lookfor <keyword>`: search all m-files for keyword
- Use MATLAB help, type `doc` or use desktop
- Function declaration:
  `function [output args] = <function name>(input args)`
- Save as an m-file (.m), should use name of function
MATLAB plotting

- Basic 2-D plotting command
  > `plot(x,y,’s’)`
  > `x` and `y` must be the same size
  > `s` is a string that can be used to denote color, symbol and line-type of plot
  > See also `semilogx`, `semilogy`, `loglog`, `polar`, `fill`, `bar`, `errorbar`, `hist`, `plotyy`, `area`, `pit`, `stem`, `stairs`, etc

- Numerous plotting options e.g. `close all`, `hold`, `axis equal`
- `figure` creates a new figure
- `subplot`, `xlabel`, `ylabel`, `title`, `axis`, `strcat`, `gca`, `gcf`, etc...
Useful tips

- `meannan`, `isnan`, `stdnan`
- Keep track of NaN’s for stderr
- Imaginary numbers are represented with `i`, `j`
- Paradigm example in MATLAB
Advanced topics

- Eigenvalues
- Singular Value Decomposition (SVD)
- Rank and condition of matrices
- Structures, cells, strings, etc...
- LU decomposition, QR algorithm
References and tips

- [www.mathwork.com/matlabcentral](www.mathwork.com/matlabcentral)
  - File exchange
- MATLAB helpdesk - can’t stress how useful
- Learn from others. Everyone knows different tricks.
- MATLAB diary
- **Backslash operator**: what does it do?
- MIT OCW: 18.335 Numerical Linear Algebra