Octave/Matlab Tutorial

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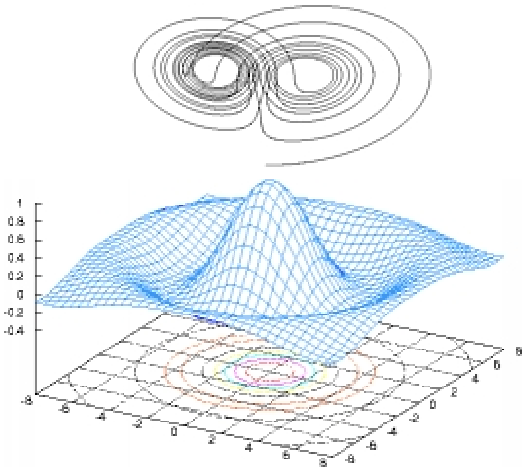
Contents



Octave

Matlab

Overview

Octave is the "open-source Matlab"

Octave is a great gnuplot wrapper

- www.octave.org
- www.mathworks.com

Octave and Matlab are both, high-level languages and mathematical programming environments for:

- Visualization
- Programming, algorithm development
- Numerical computation: linear algebra, optimization, control, statistics, signal and image processing, etc.

Overview

Matlab-Octave comparison:

- **Matlab is more flexible/advanced/powerful/costly**
- **Octave is for free (GPL license)**
- **There are minor differences in syntax**

This tutorial:

- **This tutorial applies to Octave *and* Matlab unless stated otherwise!**

Current versions (autumn 2009):

- **Octave 3.2.3**
- **Matlab 7.6**

Contents

Start, Quit, Getting Help

- **To start Octave type the shell command `octave`, double-click *Octave.app* or whatever your OS needs.**
  You should see the prompt:

  ```
  octave:1>
  ```

- **If you get into trouble, you can interrupt Octave by typing `Ctrl-C`.**

- **To exit Octave, type `quit` or `exit`.**

Start, Quit, Getting Help

- **To get help, type `help` or `doc`**

- **To get help on a specific command (=built-in function), type `help command`**

- **Examples:** `help size`, `help plot`, `help figure`, `help inv`, `...`

- **To get help on the help system, type `help help`**

- **Type `q` to exit help mode (alike man pages)**

Start, Quit, Getting Help

- **In the help text of Matlab functions, function names and variables are in capital letters.**
  ➛ Don't get confused! The (case-sensitive) naming convention specifies lowercase letters for built-in commands. It is just a way to highlight text.

- **Example:** `help round` **returns**

```
ROUND  Round towards nearest integer.

  ROUND(X) rounds the elements of X to the nearest
  integers.

  See also floor, ceil, fix.

  [...]
```

- **Octave texts are mixed, in lower- and**

Contents

Variables and Data Types

- **Matrices (real and complex)**
- **Strings (matrices of characters)**
- **Structures**

➢ **Vectors? It's a matrix with one column/row**

➢ **Scalars? It's a matrix of dimension 1x1**

➢ **Integers? It's a double (you never have to worry)**

➢ **Boolean? It's an integer (non-null=true, 0=false)**

Almost everything is a matrix!

Matlab has more types, e.g. OO classes

Variables and Data Types

Creating a Matrix

- **Simply type:**

```
octave:1> A = [8, 2, 1; 3, -1, 4; 7, 6, -5]
```

Octave will respond with a matrix in pretty-print:

```
A =

      8   2   1
      3  -1   4
      7   6  -5
```

➢ **More on matrices, further down this tutorial.**

Variables and Data Types

Creating a Character String

- **Simply type:**

```
octave:4> str = 'Hello World'
```

Opposed to Matlab, Octave can also deal with double quotes. For compatibility reasons, use single quotes.

Creating a Structure

- **Type for instance:**

```
octave:5> data.id = 3;
octave:6> data.timestamp = 1265.5983;
octave:7> data.name = 'sensor 1 front';
```

Variables and Data Types

Creating a Array of Structures

- **Oh, a new measurement arrives. Extend struct by:**

```
octave:8> data(2).id = 4;
octave:9> data(2).timestamp = 1268.9613;
octave..> data(2).name = 'sensor 1 front';
```

Octave will respond with:

```
data =
{
  1x2 struct array containing the fields:
      id
      timestamp
      name
}
```

Variables and Data Types

Display Variables

- **Simply type its name:**

```
octave:1> a
a = 4
```

Suppress Output

- **Add a semicolon:**

```
octave:2> a;
octave:3> sin(phi);
```

Applies also to function calls.

Variables and Data Types

- **Variables have no permanent type.**

  `s = 3` **followed by** `s = 'octave'` **is fine**

- **Use** `who` **(or the more detailed** `whos` **) to list the currently defined variables. Example output:**

```
Variables in the current scope:

 Attr Name        Size                     Bytes  Class
 ==== ====        ====                     =====  =====
      A           3x3                         72  double
      a           1x1                          8  double
      ans        21x1                        168  double
      s           1x5                          5  char
      v           1x21                        24  double
```

Variables and Data Types

Numerical Precision

Variables are stored as double precision numbers in IEEE floating point format.

- `realmin` **Smallest positive floating point number: 2.23e-308**
- `realmax` **Largest positive floating point number: 1.80e+308**
- `eps` **Relative precision: 2.22e-16**

Variables and Data Types

Control Display of Float Variables

- `format short` **Fixed point format with 5 digits**
- `format long` **Fixed point format with 15 digits**
- `format short e` **Floating point format, 5 digits**
- `format long e` **Floating point format, 15 digits**
- `format short g` **Best of fixed or floating point with 5 digits (good choice)**
- `format long g` **Best of fixed or floating point with 15 digits**

Variables and Data Types

Talking about Float Variables...

- `ceil(x)` **Round to smallest integer not less than x**
- `floor(x)` **Round to largest integer not greater than x**
- `round(x)` **Round towards nearest integer**
- `fix(x)` **Round towards zero**

If x is a matrix, the functions are applied to each element of x.

Contents

Matrices

Creating a Matrix

- **Simply type:**

```
octave:1> A = [8, 2, 1; 3, -1, 4; 7, 6, -5]
```

- **To delimit columns, use comma or space**
- **To delimit rows, use semicolon**

The following expressions are equivalent:

```
A = [8 2 1;3 -1 4;7 6 -5]
A = [8,2,1;3,-1,4;7,6,-5]
```

Matrices

Creating a Matrix

- **Octave will respond with a matrix in pretty-print:**

```
A =

      8   2   1
      3  -1   4
      7   6  -5
```

- **Alternative Example:**

```
octave:2> phi = pi/3;
octave:3> R = [cos(phi) -sin(phi); sin(phi) cos(phi)]
R =

      0.50000  -0.86603
      0.86603   0.50000
```

Matrices

Creating a Matrix from Matrices

```
octave:1> A = [1 1 1; 2 2 2];  B = [33; 33];
```

- **Column-wise**

```
octave:2> C = [A B]

C =

      1    1    1    33
      2    2    2    33
```

- **Row-wise:**

```
octave:3> D = [A; [44 44 44]]

D =

      1    1    1
      2    2    2
   44   44   44
```

Matrices

Indexing

Always "row before column"!

- `aij = A(i,j)` **Get an element**
- `r = A(i,:)` **Get a row**
- `c = A(:,j)` **Get a column**
- `B = A(i:k,j:l)` **Get a submatrix**

- **Useful indexing command** `end` **:**

```
octave:1> data = [4 -1 35 9 11 -2];
octave:2> v = data(3:end)
v =
    35  9  11  -2
```

Matrices

Colon '`:`', two meanings:

- **Wildcard to select entire matrix row or column**

  `A(3,:), B(:,5)`

- **Defines a *range* in expressions like**

  `indices = 1:5` **Returns row vector 1,2,3,4,5**

  `steps = 1:3:61` **Returns row vector 1,4,7,…,61**

  `t = 0:0.01:1` **Returns vector 0,0.01,0.02,…,1**

  start increment stop

- **Useful command to define ranges:** `linspace`

Matrices

Assigning a Row/Column

- **All referenced elements are set to the scalar value.**

```
octave:1> A = [1 2 3 4 5; 2 2 2 2 2; 3 3 3 3 3];
octave:2> A(3,:) = -3;
```

Adding a Row/Column

- **If the referenced row/colum doesn't exist, it's added.**

```
octave:3> A(4,:) = 4
A =
    1   2   3   4   5
    2   2   2   2   2
   -3  -3  -3  -3  -3
```

Matrices

Deleting a Row/Column

- **Assigning an empty matrix `[]` deletes the referenced rows or columns. Examples:**

```
octave:4> A(2,:) = []

A =

    1   2   3   4   5
   -3  -3  -3  -3  -3
    4   4   4   4   4

octave:4> A(:,1:2:5) = []

A =

   2   4
   2   2
  -3  -3
   4   4
```

Matrices

Get Size

- `nr = size(A,1)` **Get number of rows of A**
- `nc = size(A,2)` **Get number of columns of A**
- `[nr nc] = size(A)` **Get both (remember order)**
- `l = length(A)` **Get whatever is bigger**
- `numel(A)` **Get number of elements in A**
- `isempty(A)` **Check if A is empty matrix []**

Octave only:

- `nr = rows(A)` **Get number of rows of A**
- `nc = columns(A)` **Get number of columns of A**

Matrices

Matrix Operations

- `B = 3*A` **Multiply by scalar**
- `C = A*B + X - D` **Add and multiply**
- `B = A'` **Transpose A**
- `B = inv(A)` **Invert A**
- `s = v'*Q*v` **Mix vectors and matrices**

- `d = det(A)` **Determinant of A**
- `[v lambda] = eig(A)` **Eigenvalue decomposition**
- `[U S V] = svd(A)` **Sing. value decomposition**

Matrices

Vector Operations

With `x` being a column vector

- `s = x'*x` **Inner product, result is a scalar**
- `X = x*x'` **Outer product, result is a matrix**
- `e = x*x` **Gives an error**

Element-Wise Operations (for vectors/matrices)

- `s = x.+x` **Element-wise addition**
- `p = x.*x` **Element-wise multiplication**
- `q = x./x` **Element-wise division**
- `e = x.^3` **Element-wise power operator**

Matrices

Useful Vector Functions

- `sum(v)` **Compute sum of elements of v**
- `cumsum(v)` **Compute cumulative sum of elements of v**
- `prod(v)` **Compute product of elements of v**
- `cumprod(v)` **Compute cumulative product of elements of v**
- `diff(v)` **Compute difference of subsequent elements [v(2)-v(1) v(3)-v(2) ...]**
- `mean(v)` **Mean value of elements in v**
- `std(v)` **Standard deviation of elements**

Matrices

Useful Vector Functions

- `min(v)` **Return smallest element in v**
- `max(v)` **Return largest element in v**

- `sort(v,'ascend')` **Sort in ascending order**
- `sort(v,'descend')` **Sort in descending order**

- `find(v)` **Return vector of indices of all non- zero elements in v. Great in combi- nation with vectorized conditions. Example:**
  `ivec = find(datavec == 5)`

Matrices

Special Matrices

- `A = zeros(m,n)` **Zero matrix of size m x n**
- `B = ones(m,n)` **Matrix of size m x n with all 1's**
- `I = eye(n)` **Identity matrix of size n**
- `D = diag([a b c])` **Diagonal matrix of size 3 x 3 with a,b,c in the main diagonal**

Just for fun

- `M = magic(n)` **Magic square matrix of size n x n. (All rows and columns sum up to the same number)**

Matrices

Random Matrices and Vectors

- `R = rand(m,n)` **Matrix with m x n uniformly distributed random numbers from interval [0..1]**
- `N = randn(m,n)` **Row vector with m x n normally distributed random numbers with zero mean, unit variance**
- `v = randperm(n)` **Row vector with a random permutation of the numbers 1 to n**

Matrices

Multi-Dimensional Matrices

Matrices can have more than two dimensions.

Create a 3-dimensional matrix by typing, e.g.,

```
octave:1> A = ones(2,5,2)
```

Octave will respond by

```
A =
ans(:,:,1) =
                                                  1   1
                                                 1   1
                                                1
                                                  1   1
                                                 1   1
                                                1
```

Matrices

Multi-Dimensional Matrices

- **All operations to create, index, add, assign, delete and get size apply in the same fashion**

Examples:

- `[m n l] = size(A)`
- `A = rand(m,n,l)`
- `m = min(min(min(A)))`
- `aijk = A(i,j,k)`
- `A(:,:,5) = -3`

Matrices

- `reshape(A,m,n)` **Change size of matrix A to have**
- `circshift(A,[m n])` **Shift elements of A m**
- `shiftdim(A,n)` **Shift the dimension of A by n.**

Matrices

M

Strings

Most Often Used Commands

- `strcat` **Concatenate strings**
- `int2str` **Convert integer to a string**
- `num2str` **Convert numbers to a string**
- `sprintf` **Write formatted data to a string. Same as C/C++ fprintf for strings.**

- **Example**

```
s = strcat('At step ',int2str(k),', p = ',num2str(p,4))
```

Given that strings are matrices of chars, this is also

```
s = ['At step ' int2str(k) ', p = ' num2str(p,4)]
```

Octave responds with

```
s = At step 56, p = 0.142
```

Strings

Octave/Matlab has virtually all common string and parsing functions.

- **You are encouraged to browse through the list of commands or simply type** `help command` **:**

`strcmp, strncmp, strmatch, char, ischar, findstr, strfind, str2double, str2num, num2str, strvcat, strtrim, strtok, upper, lower,`

and many more…

Contents

Plotting

Plotting in 2D

- `plot(x,cos(x))` **Display x,y-plot**

Creates automatically a figure window. Octave uses gnuplot to handle graphics.

- `figure(n)` **Create figure window 'n'**

If the figure window already exists, brings it into the foreground (= makes it the current figure)

- `figure` **Create new figure window with identifier incremented by 1.**

Plotting

Several Plots

- **Series of x,y-patterns:** `plot(x1,y1,x2,y2,...)`

  e.g. `plot(x,cos(x),x,sin(x),x,x.^2)`

- **Add legend to plot: command** `legend`

  `legend('cos(x)','sin(x)','x^2')`

- **Alternatively,** `hold on` **does the same job:**

```
octave:1> hold on; plot(x,cos(x));
octave:2> plot(x,sin(x));
octave:3> plot(x,x.^2);
```

Plotting

Frequent Commands

- `clf` **Clear figure**
- `hold on` **Hold axes. Don't replace plot with new plot, superimpose plots**
- `grid on` **Add grid lines**
- `grid off` **Remove grid lines**

- `title('Exp1')` **Set title of figure window**
- `xlabel('time')` **Set label of x-axis**
- `ylabel('prob')` **Set label of y-axis**

- `subplot` **Put several plot axes into figure**

Plotting

Controlling Axes

- `axis equal` **Set equal scales for x-/y-axes**
- `axis square` **Force a square aspect ratio**
- `axis tight` **Set axes to the limits of the data**
- `a = axis` **Return current axis limits** `[xmin xmax ymin ymax]`
- `axis([-1 1 2 5])` **Set axis limits (freeze axes)**
- `axis off` **Turn off tic marks**

- `box on` **Adds a box to the current axes**
- `box off` **Removes box**

Plotting

Choosing Symbols and Colors

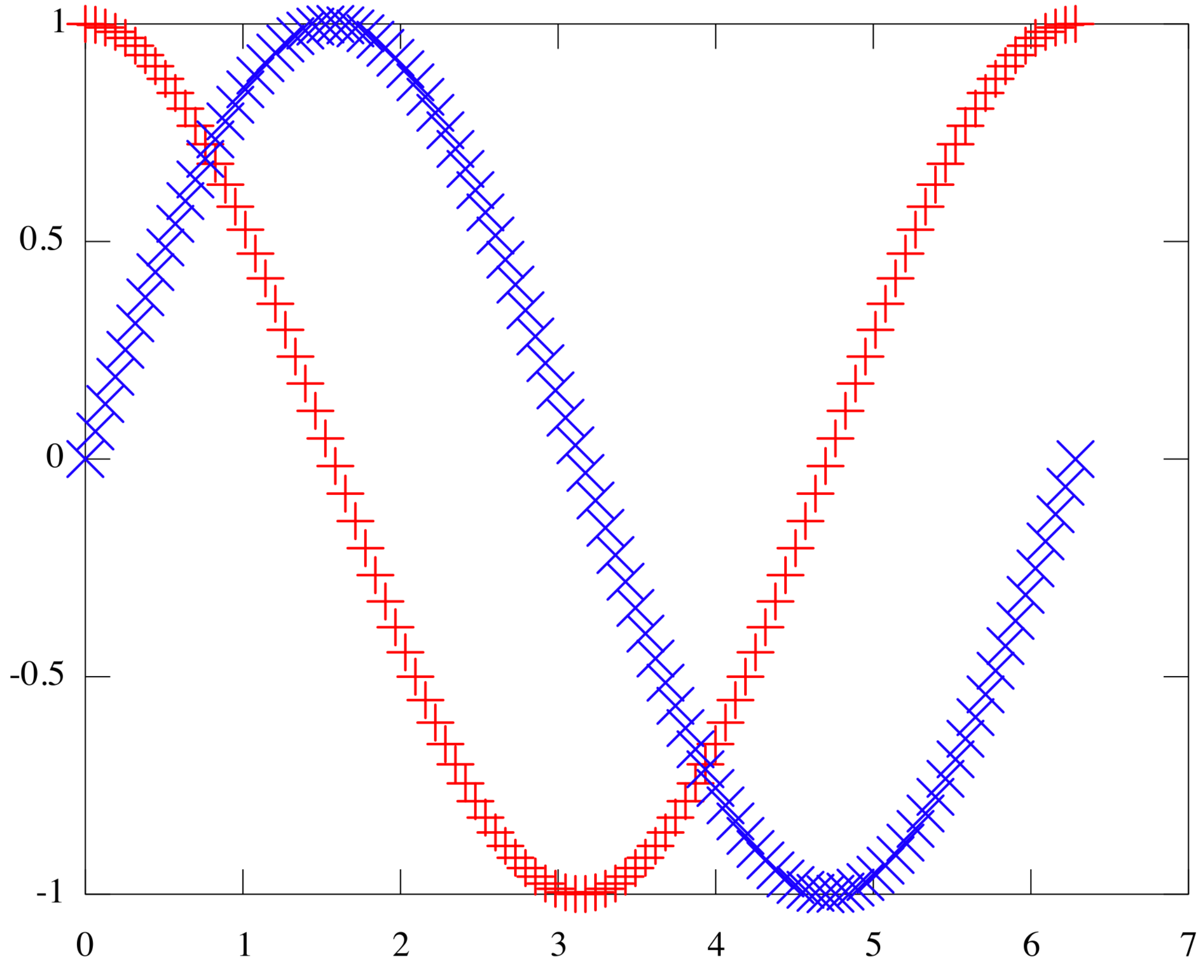
- In `plot(x,cos(x),'r+')` the format expression `'r+'` means ***red cross.***
- There are a number of line styles and colors, see `help plot`.

Example:

```
octave:1> x = linspace(0,2*pi,100);
octave:2> plot(x,cos(x),'r+',x,sin(x),'bx');
```

produces this plot:

Plotting



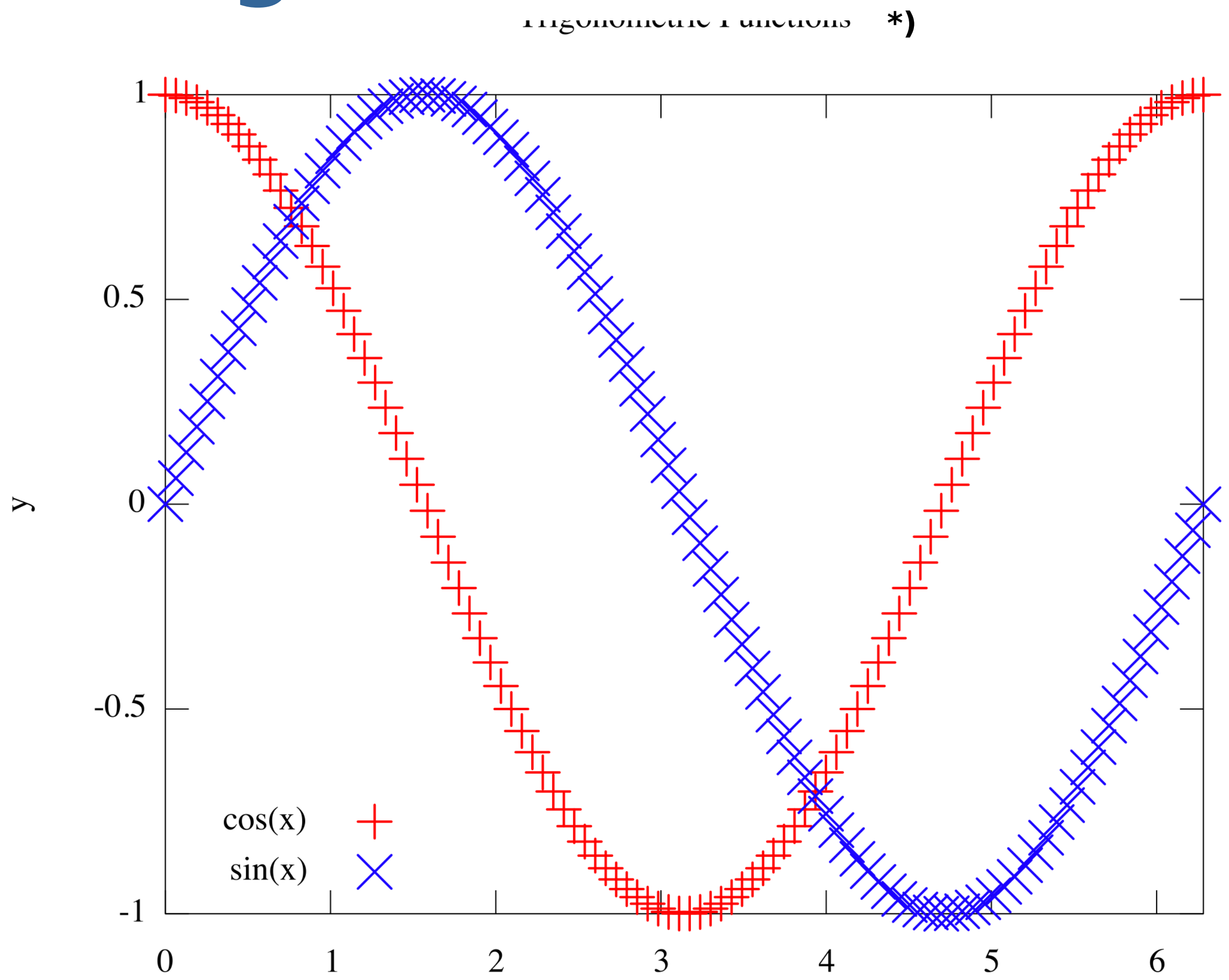

```
plot(x,cos(x),'r+',x,sin(x),'bx');
```

Plotting

- **Adjusting the axes**

```
octave:3> axis([0 2*pi
```

Plotting



***) Title and x-label wrongly cut off. This seems to be a Octave-AquaTerm on Mac problem. Should work in general.**

```
plot(x,cos(x),'r+',x,sin(x),'bx');
```

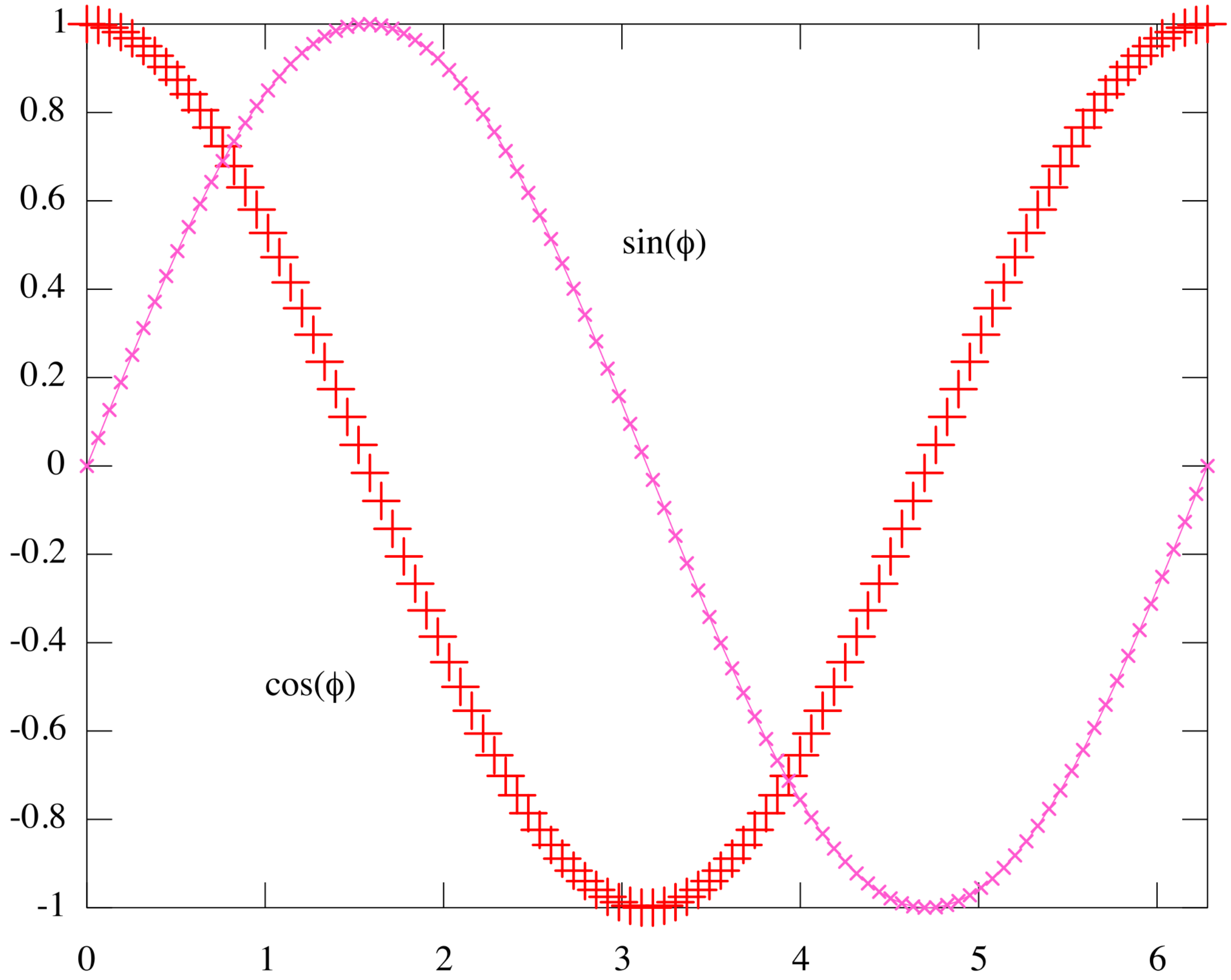
Plotting

Uhm..., don't like it. New try:

```
octave:1> clf;
```

- **Controlling Color and Ma**

Plotting




```
plot(x,cos(x),'r+',x,sin(x),'-x','Color',[1 .4 .8],'MarkerSize',2)
```

Plotting

Yepp, I like it… Get hardcopy!

Exporting Figures

- `print –deps myPicBW.eps` **Export B/W .eps file**
- `print –depsc myPic.eps` **Export color .eps file**
- `print –djpeg –r80 myPic.jpg` **Export .jpg in 80 ppi**
- `print –dpng –r100 myPic.png` **Export .png in 100 ppi**

See `help print` for more devices including specialized ones for Latex.

- `print` **can also be called as a function. Then, it takes arguments and options as a comma-separa-ted list. E.g.:** `print('-dpng','-r100','myPic.png');`

Plotting

This tutorial cannot cover the huge variety of graphics commands in Octave/Matlab.

- **You are encouraged to browse through the list of commands or simply type** `help command` **:**

  `hist, bar, pie, area, fill, contour, quiver, scatter, compass, rose, semilogx, loglog, stem, stairs, image, imagesc`

  and many more...

Plotting

Plotting in 3D

- `plot3` **Plot lines and points in 3d**
- `mesh` **3D mesh surface plot**
- `surf` **3D colored surface plot**

Most 2d plot commands have a 3D sibling. Check out, for example,

`bar3, pie3, fill3, contour3, quiver3, scatter3, stem3`

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Programming

Programming in Octave/Matlab is Super Easy. However, keep the following facts in mind:

- **Indices start with 1 !!!**

```
octave:1> v = 1:10
octave:2> v(0)
error: subscript indices must be either positive integers or logicals.
```

- **Octave/Matlab is case-sensitive.**

Text Editors

- **Use an editor with m-file syntax highlighting/coloring.**

Programming

Control Structures

- **`if` Statement**

```
if condition,
  then-body;
elseif condition,
  elseif-body;
else
  else-body;
end
```

The else and elseif clauses are optional. Any number of elseif clauses may exist.

Programming

Control Structures

- `switch` **Statement**

```
switch expression
  case label
    command-list;
  case label
    command-list;
  ...
  otherwise
    command-list;
end
```

Any number of case labels are possible.

Programming

C

Programming

Interrupting and Continuing Loops

- **`break`**

Jumps out of the innermost `for` or `while` loop that encloses it.

- **`continue`**

Used only inside `for` or `while` loops. It skips over the rest of the loop body, causing the next cycle to begin. Use with care.

Programming

Programming

Comparison Operators

- **All of comparison operators return a value of 1 if the comparison is true, or 0 if it is false.**

  Examples: `i == 6, cond1 = (d > theta)`

- **For the matrix-to-matrix case, the comparison is made on an element-by-element basis. Example:**

  `[1 2; 3 4] == [1 3; 2 4]` **returns** `[1 0; 0 1]`

- **For the matrix-to-scalar case, the scalar is compared to each element in turn. Example:**

  `[1 2; 3 4] == 2` **returns** `[0 1; 0 0]`

Programming

- C

Programming

Relational Operators

- x < y True if x is less than y
- x <= y True if x is less than or equal to y
- x == y True if x is equal to y
- x >= y True if x is greater than or equal to y
- x > y True if x is greater than y
- x ~= y True if x is not equal to y

- x != y True if x is not equal to y (Octave only)
- x <> y True if x is not equal to y (Octave

Programming

Boolean Expressions

- `B1 & B2` Element-wise logical and
- `B1 | B2` Element-wise logical or
- `~B` Element-wise logical not
- `!B` Element-wise logical not (Octave only)

Short-circuit operations: evaluate expression only as long as needed (more efficient).

- `B1 && B2` Short-circuit logical and
- `B1 || B2` Short-circuit logical or

Programming

Recommended Naming Conventions

- **Underscore-separated or lowercase notation for functions**

  Examples: `intersect_line_circle.m`, `drawrobot.m`, `calcprobability.m`

- **UpperCamelCase for scripts**

  Examples: `LocalizeRobot.m`, `MatchScan.m`

- **Note: Matlab/Octave commands are all in lowercase notation (no underscores or dashes)**

  Examples: `continue`, `int2str`, `isnumeric`

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Functions and Scripts

Functions

Complicated Octave/Matlab programs can often be simplified by defining functions. Functions are typically defined in external files, and can be called just like built-in functions.

- **In its simplest form, the definition of a function named name looks like this:**

```
function name
  body
end
```

- **Get used to the principle to define one function per file (text files called m-file or .m-file)**

Functions and Scripts

Passing Parameters to/from Functions

- **Simply write**

```
function [ret-var] = name(arg-list)
  body
end
```

- `arg-list` **is a comma-separated list of input arguments arg1, arg2, ..., argn**
- `ret-var` **is a comma-separated list of output arguments. Note that** `ret-var` **is a vector enclosed in square brackets [arg1, arg2, ..., argm].**

Functions and Scripts

Example Functions:

```
      function [mu sigma] = calcmoments(data)
        mu = mean(data);
        sigma = std(data);
      end

      function [haspeaks i] = findfirstpeak(data,
thresh)
        indices = find(data > thresh);
        if isempty(indices),
          haspeaks = 0; i = [];
        else
          haspeaks = 1; i = indices(1);
        end
      end
```

Functions and Scripts

Local Variables, Variable Number of Arguments

- **Of course, all variables defined within the body of the function are local variables.**

- `varargin` **Collects all input argument in a cell array. Get them with varargin{i}**
- `varargout` **Collects all output argument in a cell array. Get them with varargout{i}**
- `nargin` **Get the number of input args.**
- `nargout` **Get the number of output args.**

See `help varargin, help varargout` **for details.**

Functions and Scripts

Functions and their m-File

- **When putting a function into its m-file, the name of that file must be the same as the function name plus the .m extension. Examples:** `calcmoments.m, findfirstpeak.m`

- **To call a function, type its name without the .m extension. Example:**

```
[bool i] = findfirstpeak(myreadings, 0.3);
```

- **Comments in Octave/Matlab start with** `%` **. Make use of them!**

Functions and Scripts

Scripts

-

Functions and Scripts

Document your Function/Script

- You can add a help text to your own functions or scripts that appears upon `help` command.
- The first block of comment lines in the beginning of an m-file is defined to be help text. Example:

help text

```
%NORMANGLE Put
```

Functions and Scripts

Setting Paths

- `path` **Print search path list**
- `addpath('dir')` **Prepend the specified directory to the path list**
- `rmpath('dir')` **Remove the specified directory from the path list**
- `savepath` **Save the current path list**

Contents

Files I/O

Save Variables

After a complex of lengthy computation, it is recom-mended to save variables on the disk.

- `save my_vars.mat`

Saves all current variables into file my_vars.mat

- `save results.mat resultdata X Y`

Saves variables resultdata, X and Y in file results.mat

- `save ... -ascii`

Saves variables in ASCII format

- `save ... -mat`

Saves variables in binary MAT format

Files I/O

Load Variables

The corresponding command is load.

- `load my_vars.mat`

Retrieves all variables from the file my_vars.mat

- `load results.mat X Y`

Retrieves only X and Y from the file results.mat

An ASCII file that contains numbers in a matrix format (columns separated by spaces, rows separated by new lines), can be simply read in by

- `A = load('data.txt')`

Files I/O

Open, Write, Close Files

- `fopen` **Open or create file for writing/reading**
- `fclose` **Close file**
- `fprintf` **Write formatted data to file. C/C++ format syntax.**

Example:

```
v = randn(1000,1);
fid = fopen('gauss.txt','w');
for i = 1:length(v),
  fprintf(fid,'%7.4f\n',v(i));
end
fclose(fid);
```

Files I/O

Attention, Popular Bug

- **If your program writes to and reads from files, floating point precision of fprintf is crucial!**

- **Be sure to always write floating point numbers into files using the appropriate precision.**

- **In the above example, with `'%7.4f\n'` as the format definition, this file is going to be poor source of Gaussian random numbers.**

Files I/O

Reading Files (more advanced stuff)

- `textread` **Read formatted data from text file**
- `fscanf` **Read formatted data from text file**
- `fgetl` **Read line from file**
- `fread` **Read binary data file**

Read/write images

- `imread` **Read image from file (many formats)**
- `imwrite` **Write image to file (many formats)**

Contents

Misc

Cleaning Up

- `clear A` **Clear variable A**
- `clear frame*` **Clear all variables whose names start with frame...**
- `clear` **Clear all variables**
- `clear all` **Clear everything: variables, globals, functions, links, etc.**

- `close` **Close foreground figure window**
- `close all` **Close all open figure windows**

- `clc` **Clear command window (shell)**

Misc

Displaying (Pretty) Messages

- `disp(A)` **Display matrix A without printing the matrix name**
- `disp(str)` **Display string str without printing the string name**

Example: when typing

```
octave:1> disp('done')
```

Octave will respond with

```
done
```

instead of

```
ans = done
```

from `sprintf('done')` **or simply** `'done'`**.**

Misc

Command History

- Navigate up and down the command history using the up/down arrow keys.
- The command history is start-letter sensitive. Type one or more letters and use the arrow keys to navigate up and down the history of commands that start with the letters you typed.

Tab completion

- Octave/Matlab have tab completion. Type some letters followed by tab to get a list of all commands that start with the letters you typed.

Misc

Built-in Unix Commands

- `pwd` **Display current working directory**
- `ls` **List directory. See also** `dir` **.**
- `cd` **Change directory**
- `mkdir` **Make new directory**
- `rmdir` **Delete directory**

Related Commands

- `movefile` **Move file**
- `copyfile` **Copy file**

Misc

Random Seeds

- `rand` **and** `randn` **obtain their initial seeds from the system clock.**
- **To generate identical/repeatable sequences, set the random generator seeds manually.**

To set the random seeds:

- `rand('seed',value)` **Set seed to scalar integer value** `value`**.**
- `randn('seed',value)` **Set seed to scalar integer value** `value`**.**

Contents

Octave/Matlab in Practice

Useful Stuff in Practice

- Generating output from a C/C++/Python/Java/... program in Octave syntax
- Making animations
- Calling unix/dos functions from within Octave programs
- Increasing speed

Octave/Matlab in Practice

Output Files in Octave Syntax

- **Data written in a matrix format. Example:**

`filtered_readings.txt`

```
0.792258   0.325823   0.957683   0.647680   0.498282
0.328679   0.414615   0.270472   0.975753   0.043852
0.601800   0.062914   0.837494   0.621332   0.870605
0.940364   0.036513   0.843801   0.806506   0.804710
0.937506   0.872248   0.134889   0.042745   0.228380
```

- **Read in using the command `load`.**
  Example: `A = load('filtered_readings.txt');`

Octave/Matlab in Practice

Output Files in Octave Syntax

- File contains code snippets. Example:

PlotFilteredReadings.m

```
A = [
0.792258   0.325823
0.957683   0.647680   0.498282
0.328679   0.414615
0.270472   0.975753   0.043852
0.601800   0.062914
0.837494   0.621332   0.870605
0.940364   0.036513
0.843801   0.806506   0.804710
];
figure(1); clf; hold on;
plot(1:size(A,1),A(:,1));
```

Octave/Matlab in Practice

Making Animations

- **Matlab has commands such as `getframe` and `movie` to make animated movies from plots.**
- **Octave, being free of charge, does not (yet) support these commands.**
- **Never mind! Here is a pretty obvious way to make movies:**

Octave/Matlab in Practice

Making Animations. Example:

- **Let `data.txt` contain data in matrix format, we want to plot each column and save it as a frame.**

```
A = load('data.txt');
[m n] = size(A);
figure(1);
for i = 1:n,
  plot(1:m,A(:,i));
  fname = sprintf('frames/frame%04d.png',i);
  print('-dpng','-r100',fname);
end
```

- **Problem: axis limits change for each plot/frame.**

Octave/Matlab in Practice

Making Animations. Example:

- **To freeze the axes over the entire animation, use the command** `axis([xmin xmax ymin ymax])` **after the plot command.**

```
A = load('data.txt');
[m n] = size(A);
figure(1);
for i = 1:n,
  plot(1:m,A(:,i));
  axis([1 m min(min(A)) max(max(A))]);
  fname = sprintf('frames/frame%04d.png',i);
  print('-dpng','-r100',fname);
end
```

Octave/Matlab in Practice

Calling unix/dos Functions

- **For Unix/Linux/MacOSX systems, there is the command `unix` to execute system commands and return the result. Examples:**

```
unix('ls -al')
unix('ftp < ftp_script')
unix('./myprogram')
```

- **For PCs, there is the equivalent command `dos` .**

- **These commands allow for powerful and handy combinations with other programs or system commands.**

Octave/Matlab in Practice

Speed!

- **The lack of speed of Octave/Matlab programs is widely recognized to be their biggest drawback.**
- **Mostly it's your program that is slow, not the built-in functions!**
- **This brings us to the following guidelines:**
  - **For-loops are evil**
  - **Vectorization is good**
  - **Preallocation is good**
  - **Prefer struct of arrays over arrays of struct**

Octave/Matlab in Practice

Speed: Vectorization

- **Given** `phi = linspace(0,2*pi,100000);`

  The code

  ```
  for i = 1:length(phi),
    sinphi(i) = sin(phi(i));
  end;
  ```

  is significantly slower than simply

  ```
  sinphi = sin(phi);
  ```

- **Nearly all built-in commands are vectorized. Think vectorized!**

Octave/Matlab in Practice

Speed: Preallocation

- If a for- or while-loop cannot be avoided, do not grow data structures in the loop, preallocate them if you can. Instead of, e.g.,

```
for i = 1:100,
  A(i,:) = rand(1,50);
end;
```

Write:

```
A = zeros(100,50);   % preallocate matrix
for i = 1:100,
  A(i,:) = rand(1,50);
end;
```

Octave/Matlab in Practice

Speed: Structure of Arrays

- **Always prefer a struct of arrays over a array of structs. It requires significantly less memory and has a corresponding speed benefit.**

- **Structure of arrays**

```
data.x = linspace(0,2*pi,100);
data.y = sin(data.x);
```

- **Array of structure**

```
people(1).name = 'Polly J Harvey';
people(1).age = 32;

people(2).name = 'Monica Lebowski';
people(2).age = 27;
```

Contents

- Overview
- Start, quit, getting help
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- Octave and Matlab in practice
- **librobotics**

librobotics

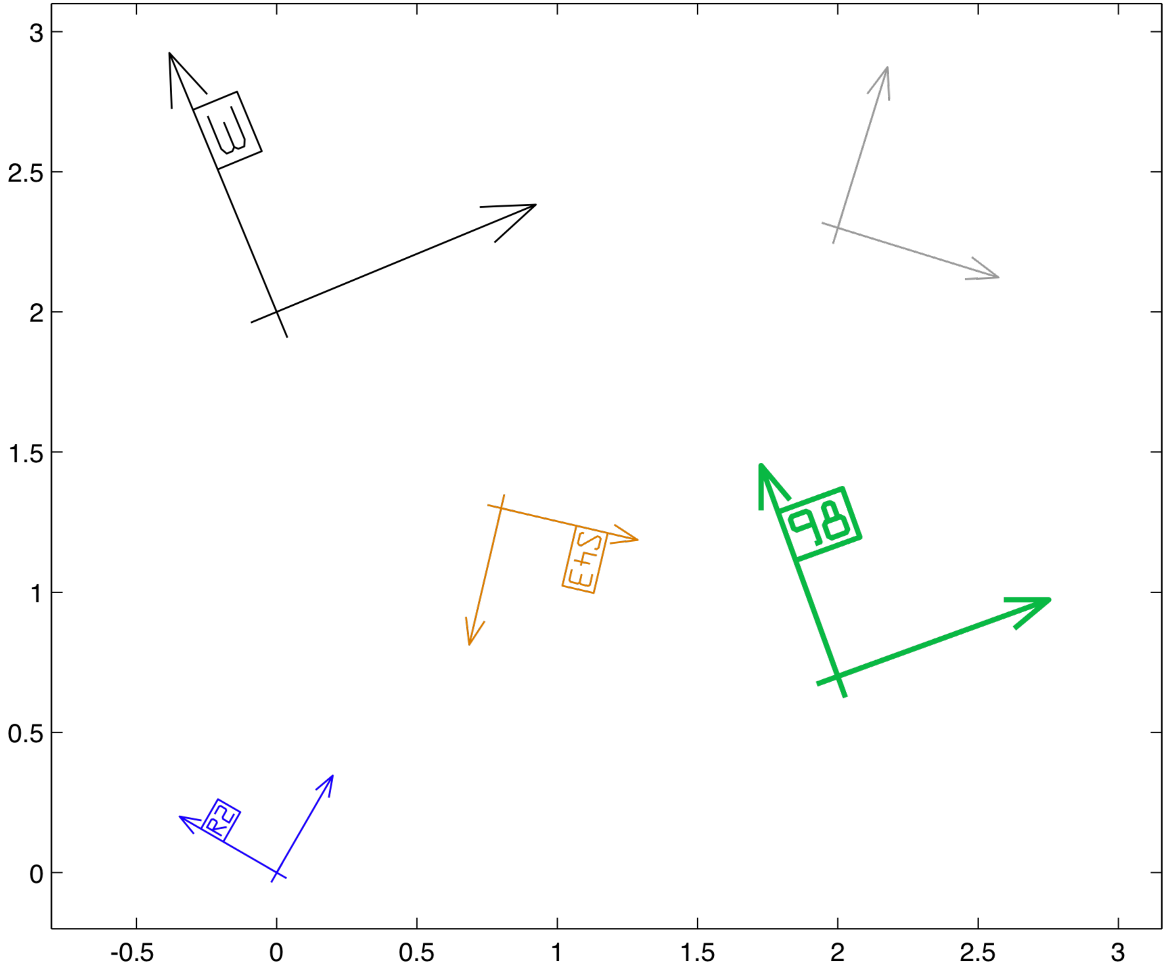
- **librobotics is a small library with frequently used Octave/Matlab functions in Robotics, especially for visualization.**

```
chi2invtable.m    drawrawdata.m j2comp.m
compound.mdrawreference.m     jinv.m
diffangle.m       drawrobot.m   mahalanobis.m
drawarrow.m       drawrect.m    meanwm.m
drawellipse.m     drawtransform.m      normangle.m
drawlabel.m       icompound.m
drawprobellipse.mj1comp.m
```

- **Download from SRL Homepage: srl.informatik.uni-freiburg.de/downloads**

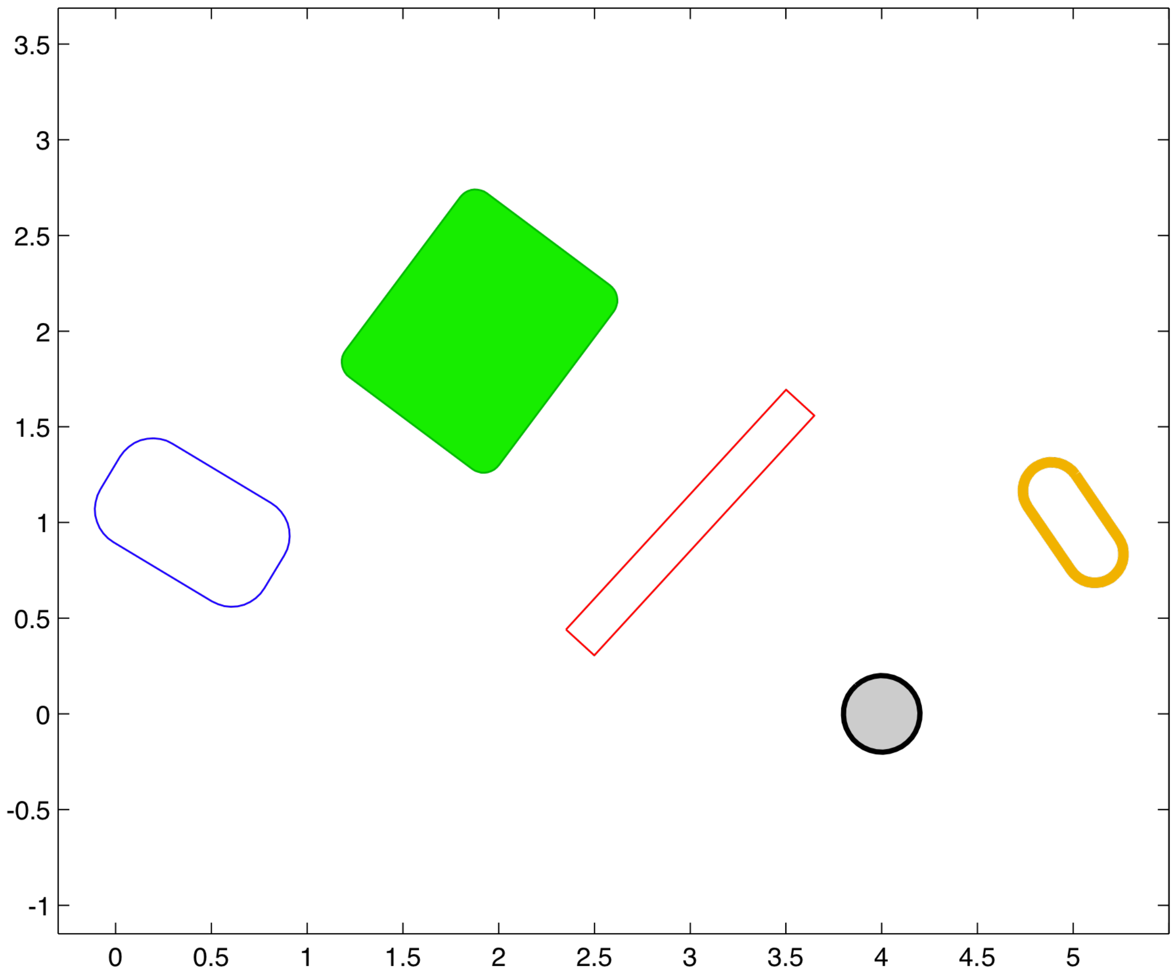
librobotics

Command `drawreference.m`



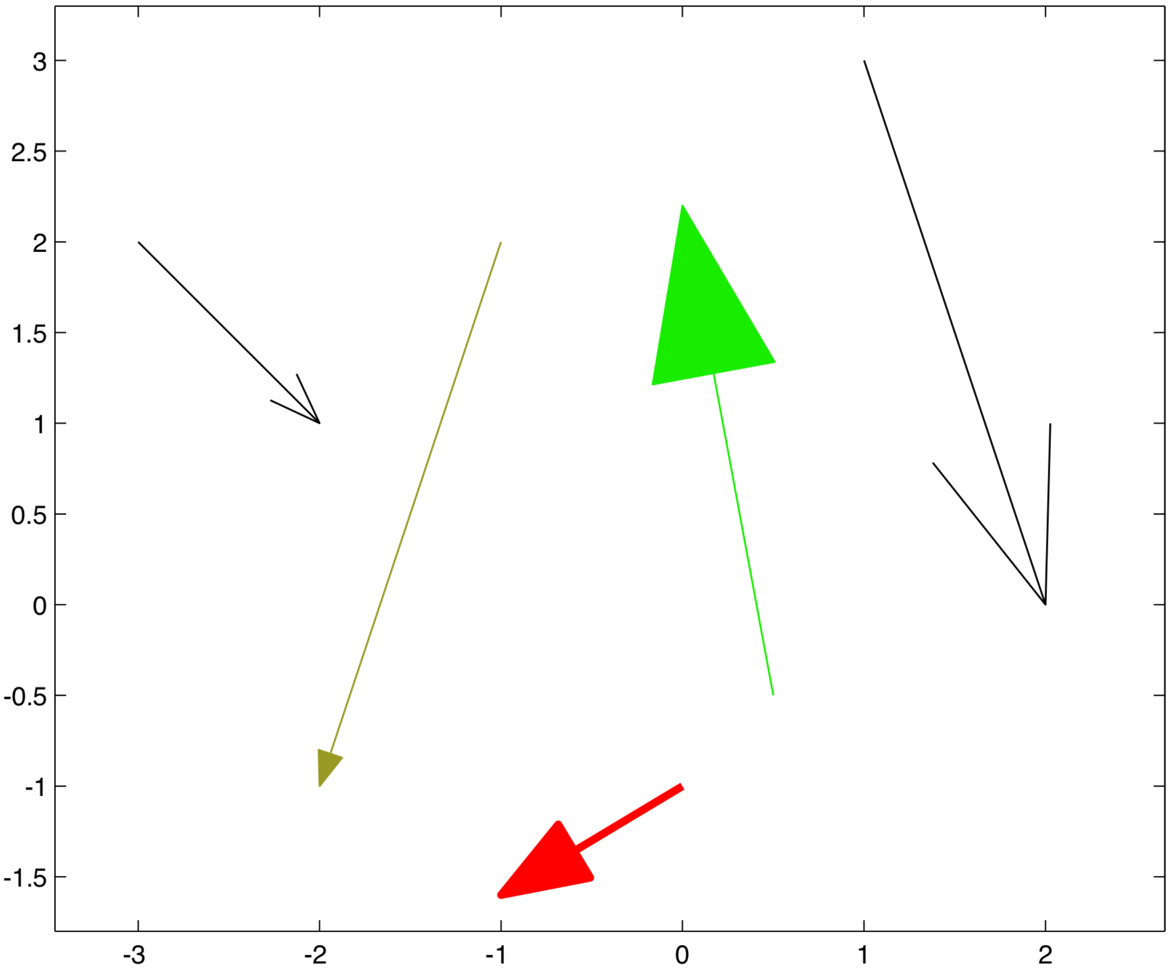
librobotics

Command `drawrect.m`



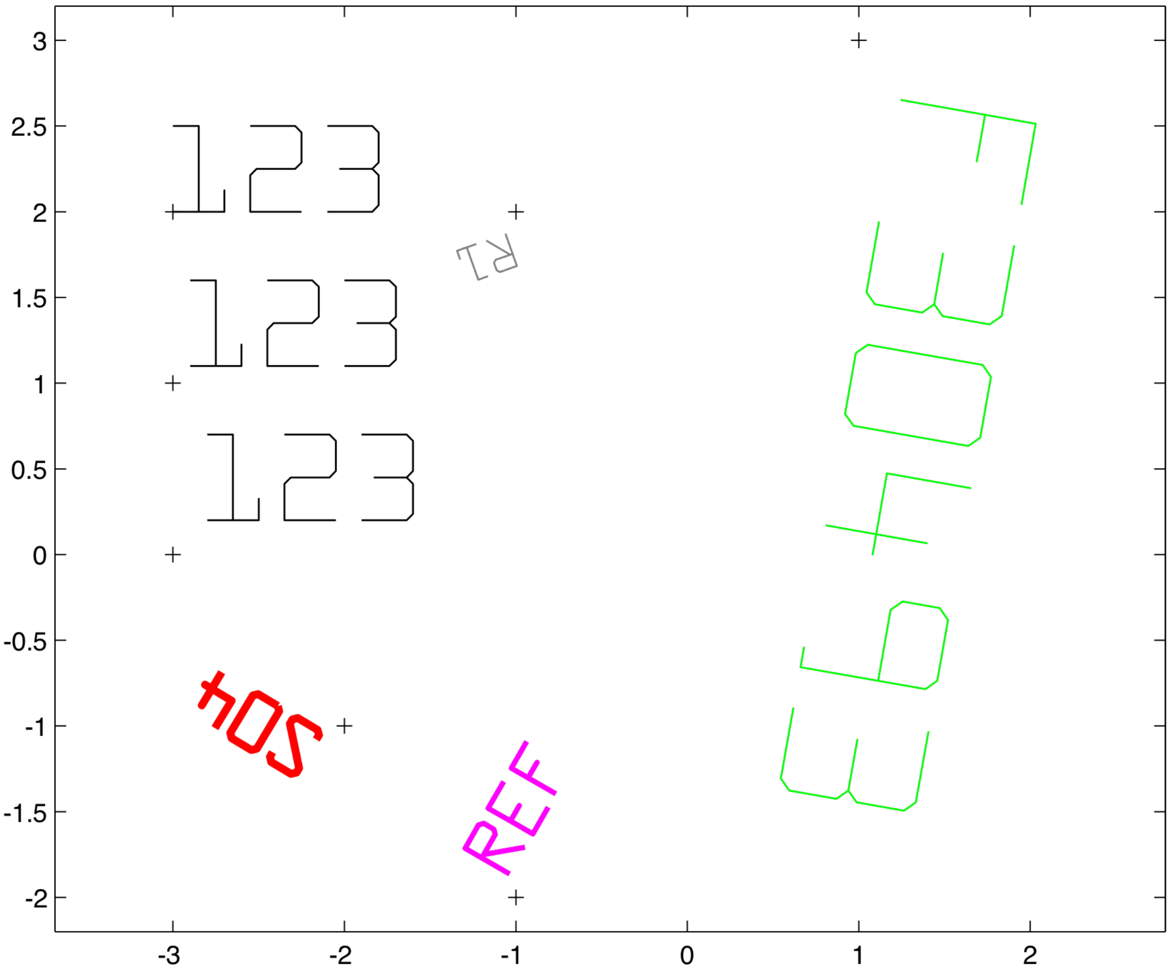
librobotics

Command `drawarrow.m`



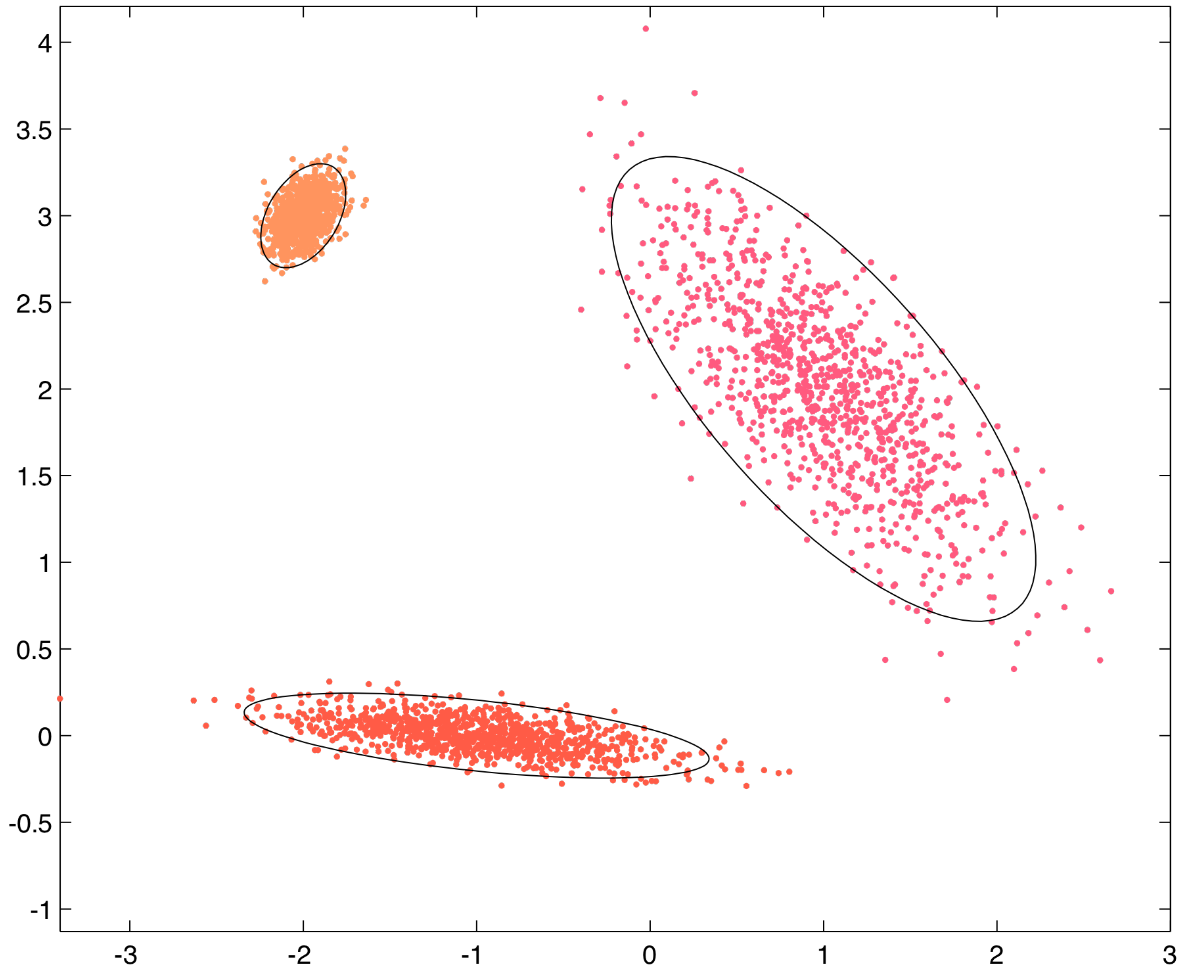
librobotics

Command `drawlabel.m`



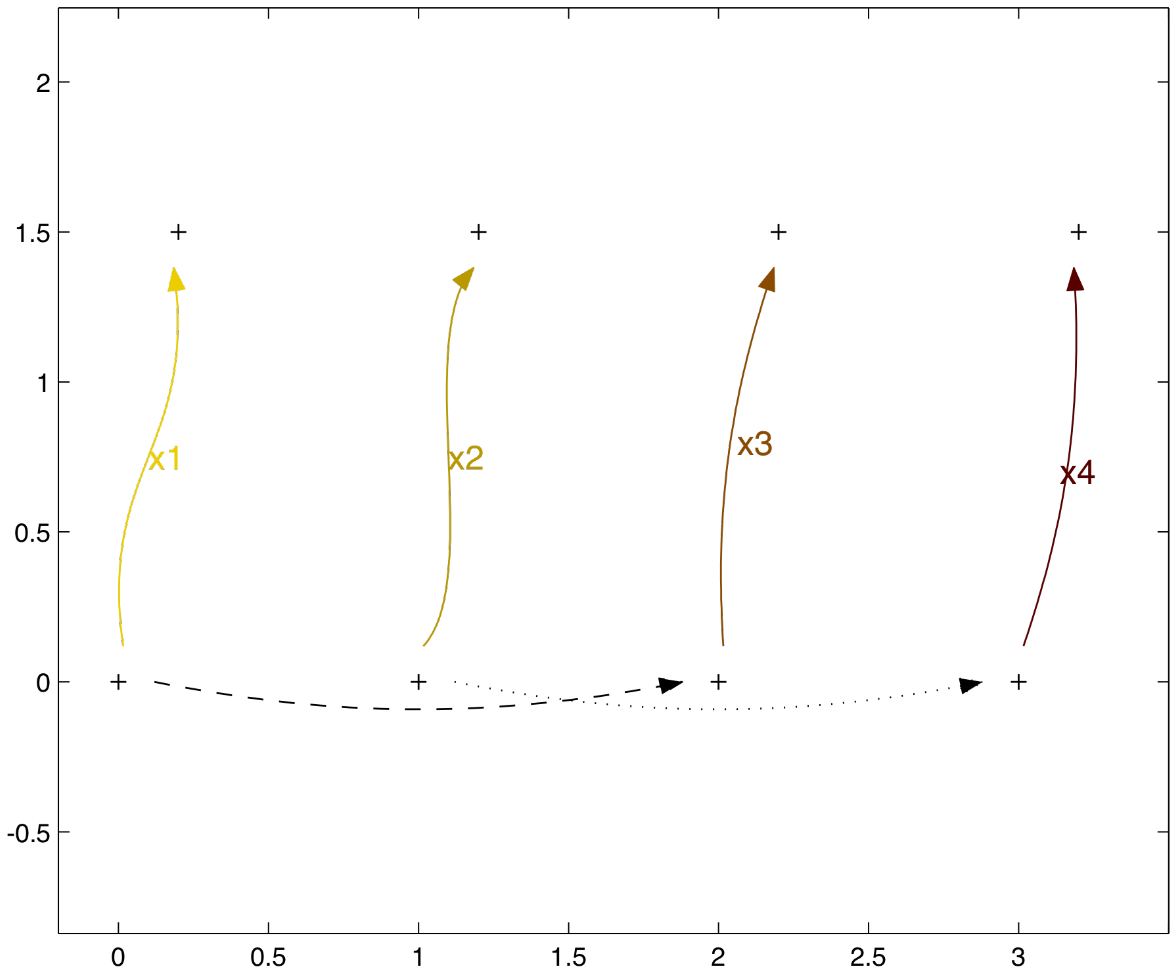
librobotics

Command `drawprobellipse.m`



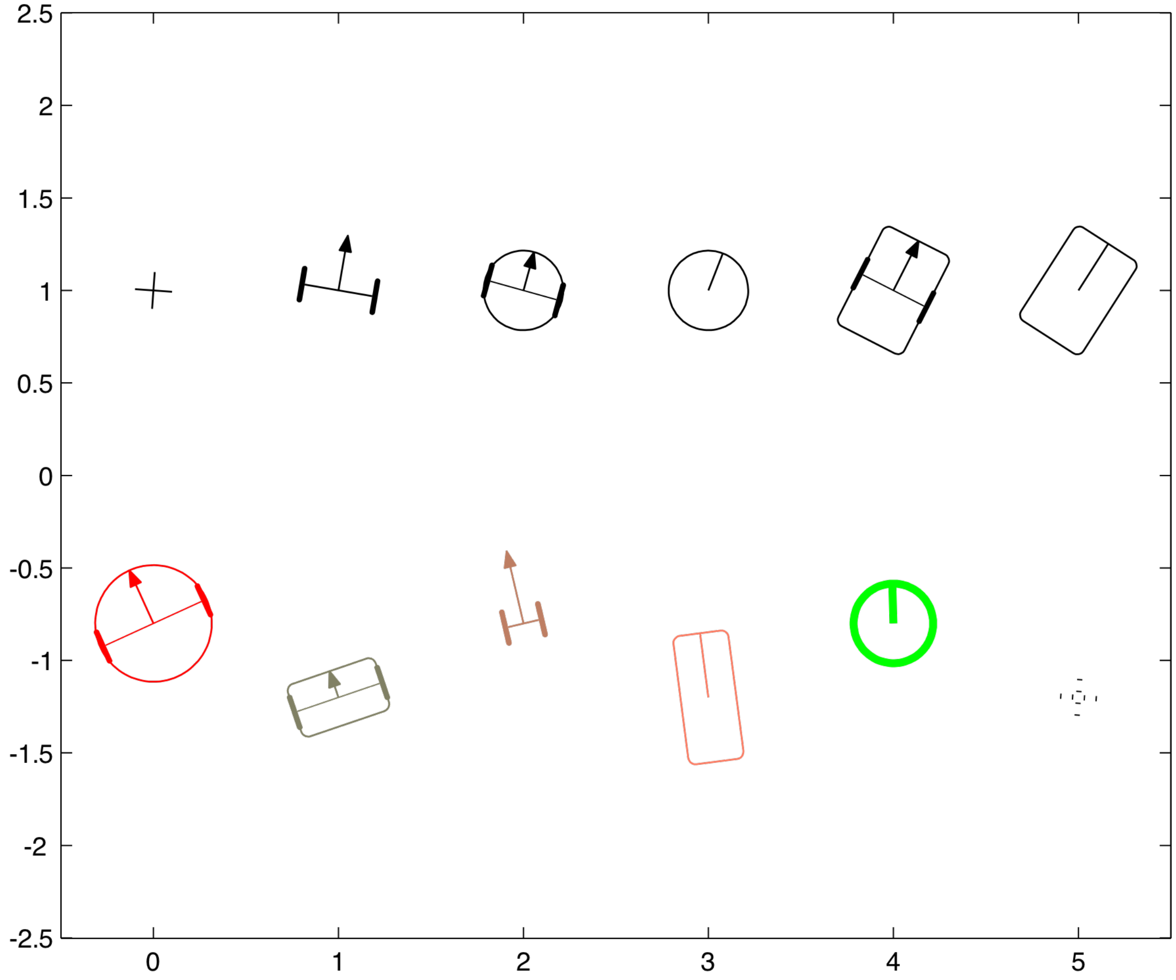
librobotics

Command `drawtransform.m`



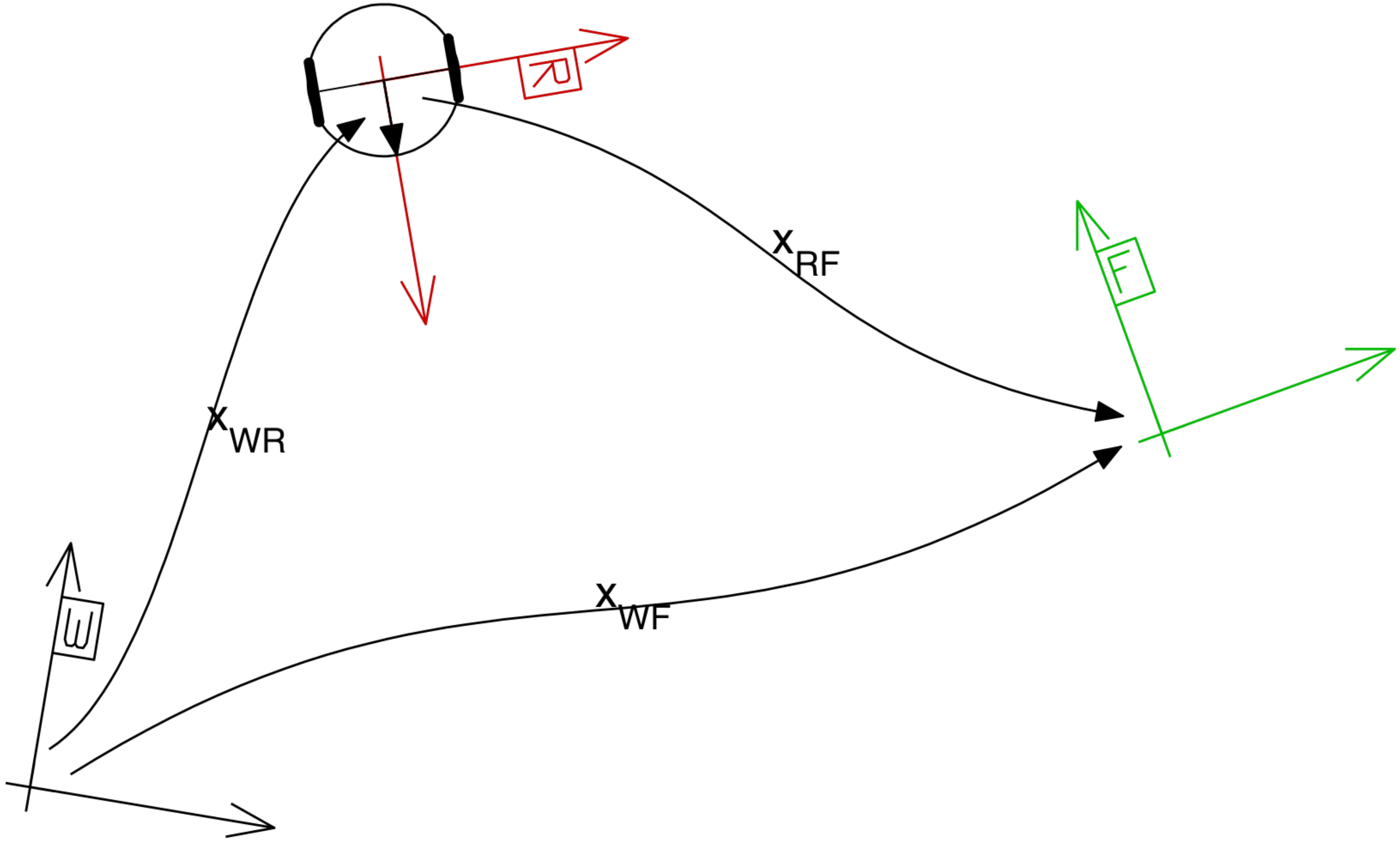
librobotics

Command `drawrobot.m`



librobotics

Example Figure



librobotics

- **All commands are fully documented, just type `help command`.**
- **Note the command `chi2invtable.m`. It returns values of the cumulative chi square distri-bution, typically used for gating and hypothesis testing. It replaces the `chi2inv` function from the Matlab statistics toolbox (which is a costly addition to Matlab) while being much faster, too.**
- **librobotics is compatible with both, Matlab and Octave.**
- **It's open source, feel free to distribute and extend.**

More Information

Full Octave online documentation:

http://www.octave.org

- ➢ **Docs**
- ➢ **575 page manual**

(directly:
www.gnu.org/software/octave/doc/interpreter)

Full Matlab online documentation:

http://www.mathworks.com

- ➢ **Products & Services**
- ➢ **Product List**
- ➢ **MATLAB**
- ➢ **Documentation**

Thanks and Enjoy!

Kai Arras

Social Robotics Lab