

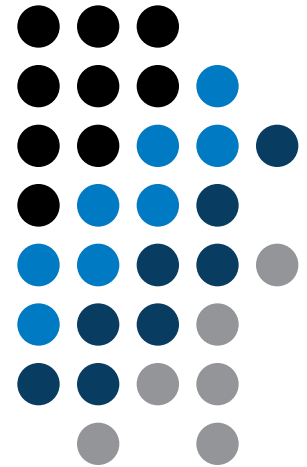
AE0B17MTB – Matlab

Part #9

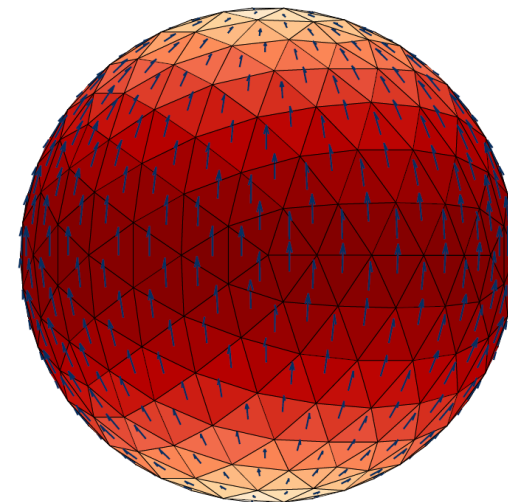


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Learning how to ...



Visualization in Matlab #2

GUI #1

!!! **Attention:** SINCE MATLAB R2014b CHANGES IN GRAPHICS !!!

Advanced visualizing in Matlab

- basic possibilities of visualizing mentioned in 6th part of the course
 - `figure` and basic plotting (`plot`, `stem`, ...)
 - setting curve options of a graph `LineStyle` (doc [LineStyle](#))
 - functions for graph description (`title`), `grid`, `legend`, etc.
- graph options
 - graph as a handle object (change since version R2014b)
 - way of setting property values of graphic "objects"
- selected advanced possibilities of visualizing
 - inserting more graphs in a single `figure`
 - tens of types of graphs (see Help)
 - projection of 3D graphs
 - `view`, `colormap`

Object identifiers (up to R2014b)

- each individual object has its own identifier ('handle' in Matlab terms)
- these handles are practically a reference to an existing object
 - handle is always created by Matlab, it is up to the user to store it
 - complex graphs (contours) may have more identifiers
- `root` has always `handle = 0` (more on `root` later), `figure` usually an integer, other objects have handle equal to positive real number (of class `double`)

handles

```
>> figHandle = figure;  
>> axHandle = axes;
```

- number stored in `figHandle` variable exists even after closing the window, but it is not a handle any more

Object identifiers (since R2014b)

- each graphic object is marked as an object in workspace
 - an object is defined by its class with its properties and methods
- `root` can still be accessed using function `get()` with parameter 0
 - `root` is newly `groot` object
 - (more in part GUI #1)
- after object destruction (closing figure)
 - the object still exists in workspace (it appears as a reference to deleted object)

Advanced visualization in Matlab

- graph as a handle number (version < R2014b)
- graph as an object (since version R2014b)
 - note: in what follows we will reference graphs as handle objects

The top screenshot shows MATLAB R2014b. The Command Window contains the following code and output:

```
>> pl = plot(0:10)

pl =

Line with properties:

    Color: [0 0.4470 0.7410]
  LineStyle: '-'
  LineWidth: 0.5000
    Marker: 'none'
  MarkerSize: 6
  MarkerFaceColor: 'none'
      XData: [1 2 3 4 5 6 7 8 9 10 11]
      YData: [0 1 2 3 4 5 6 7 8 9 10]
      ZData: [1x0 double]

Show all properties

fx >>
```

The Workspace window shows the following table:

Name	Value	Class	Bytes	Size
pl	1x1 Line	matlab.graphics.chart.primitive.Line	112	1x1

The bottom screenshot shows MATLAB R2013b. The Command Window contains the following code and output:

```
>> pl = plot(0:10)

pl =

174.0016

fx >>
```

The Workspace window shows the following table:

Name	Value	Bytes	Size	Class	Min
pl	174.0016	8	1x1	double	174.0016

Advanced visualization in Matlab

- Property editor (Inspector)

The screenshot displays the MATLAB environment with a figure window titled 'Figure 1' showing a plot of a sine wave. The plot has an x-axis from 0 to 400 and a y-axis from -1 to 1. The sine wave starts at (0,0), reaches a peak at approximately (100, 1), crosses the x-axis at approximately (200, 0), reaches a trough at approximately (300, -1), and ends at approximately (350, 0).

Surrounding the plot are several toolboxes:

- Figure Palette:** Contains options for 'New Subplots' (2D Axes, 3D Axes), 'Variables', and 'Annotations' (Line, Arrow, Double Arrow, Text Arrow, Text Box, Rectangle, Ellipse).
- Plot Browser:** Shows the current plot as 'Axes (no title)' with a blue line.
- Property Editor - Axes:** Located at the bottom, it allows editing the X Axis, Y Axis, Z Axis, and Font. The X Axis tab is active, showing 'X Label', 'X Limits: 0 to 400', and 'X Scale: linear'. A red box highlights the 'More Properties...' button.
- Inspector: matlab.graphics.axis.Axes:** Located on the right, it provides a comprehensive list of properties for the selected axes, such as 'ALim', 'Color', 'FontName', and 'FontSize'.

Advanced visualization in Matlab

- the way of setting handle object properties
 - the possibility of using functions `set` and `get` exists for both versions
 - not case sensitive

```
>> myPlotObj = plot(1:10);  
>> get(myPlotObj, 'color')
```

```
>> set(myPlotObj, 'color', 'r')  
>> get(myPlotObj, 'color')
```

- dot notation (only for versions R2014b and higher)
 - is cAsE sEnSiTiVe

```
>> myPlotObj = plot(1:10);  
>> myPlotObj.Color
```

```
>> myPlotObj.Color = 'r';  
>> myPlotObj.Color
```

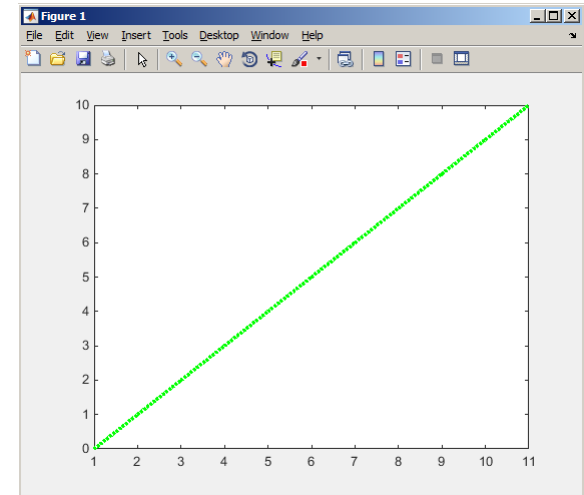

get and set functions

60 s ↑

- Create a graphic object in the way shown. Then using functions `get` and `set` perform following tasks.

```
myPlotObj = plot(0:10);
```

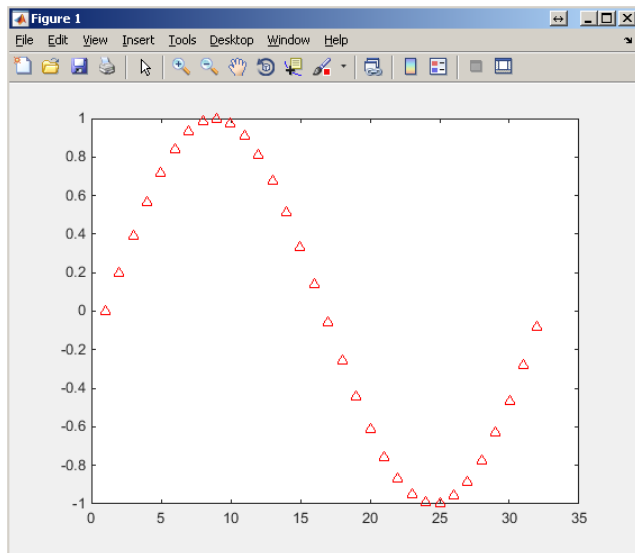
- find out the thickness of the line and increase it by 1.5
- set the line color to green
- set the line style to dotted



Dot notation application

60 s ↑

- Using dot notation change the initial setting of the function shown to get plot as in the figure.

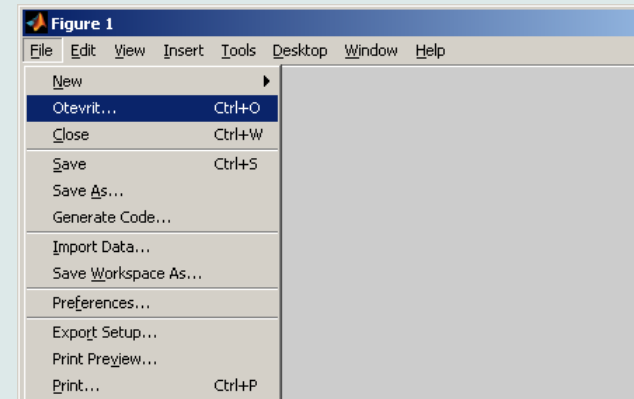
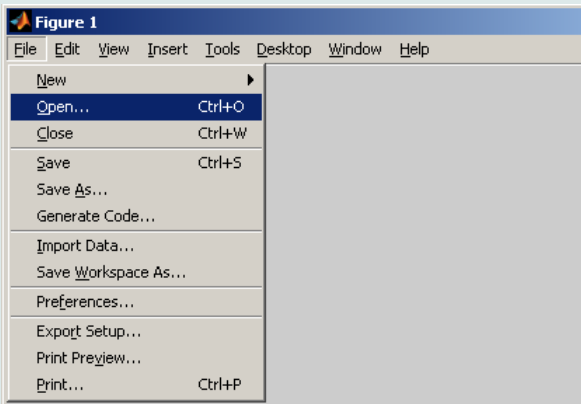


```
myPlotObj = plot(sin(0:0.2:2*pi));
```

What is handle good for?

- when having a handle, one can entirely control given object
- the example below returns all identifiers existing in window figure
- in this way we can, for instance, change item 'Open'... to 'Otevrit'...
 - or anything else (e.g. callback of file opening to callback of window closing 😊)

```
fhndl = figure('Toolbar', 'none');
allFigHndl = guihandles(fhndl);
set(allFigHndl.figMenuOpen, 'Label', 'Otevrit...')
```



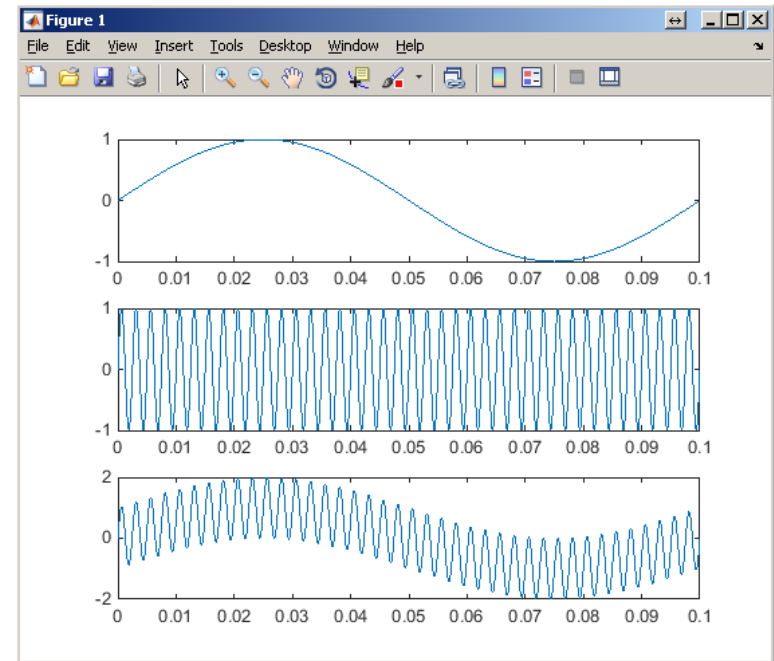
More graphs in a window – subplot

- inserting several different graphs in a single window figure
 - function `subplot(m, n, p)`
 - `m` – number of lines
 - `n` – number of columns
 - `p` – position

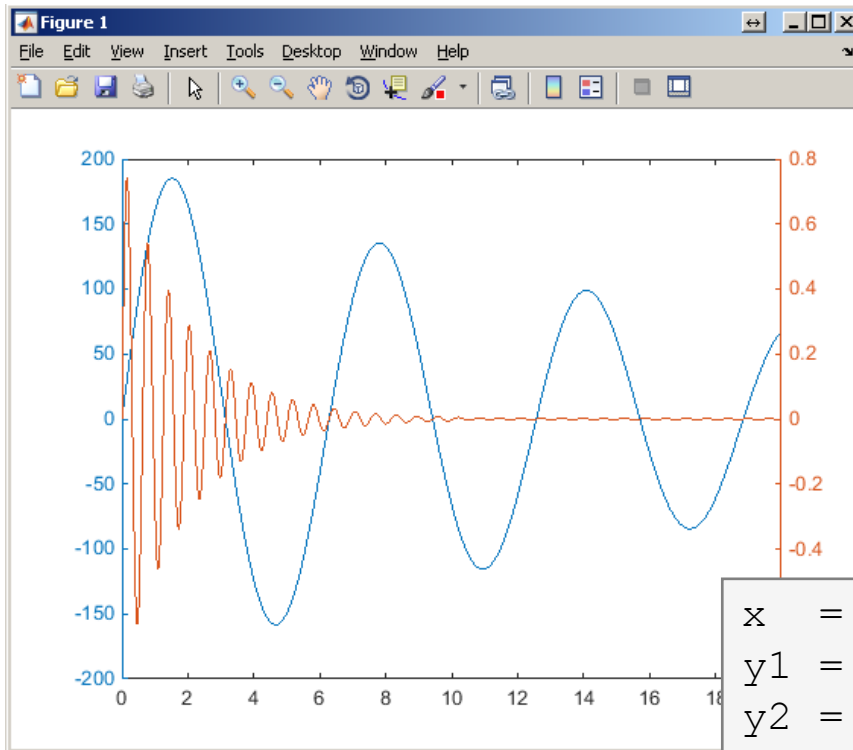
```
t = linspace(0, 0.1, 0.1*10e3);
f1 = 10;    f2 = 400;

y1 = sin(2*pi*f1*t);
y2 = sin(2*pi*f2*t);
y = sin(2*pi*f1*t) + sin(2*pi*f2*t);
```

```
figure('color', 'w')
subplot(3, 1, 1); plot(t, y1);
subplot(3, 1, 2); plot(t, y2);
subplot(3, 1, 3); plot(t, y);
```



Double y axis – plotyy

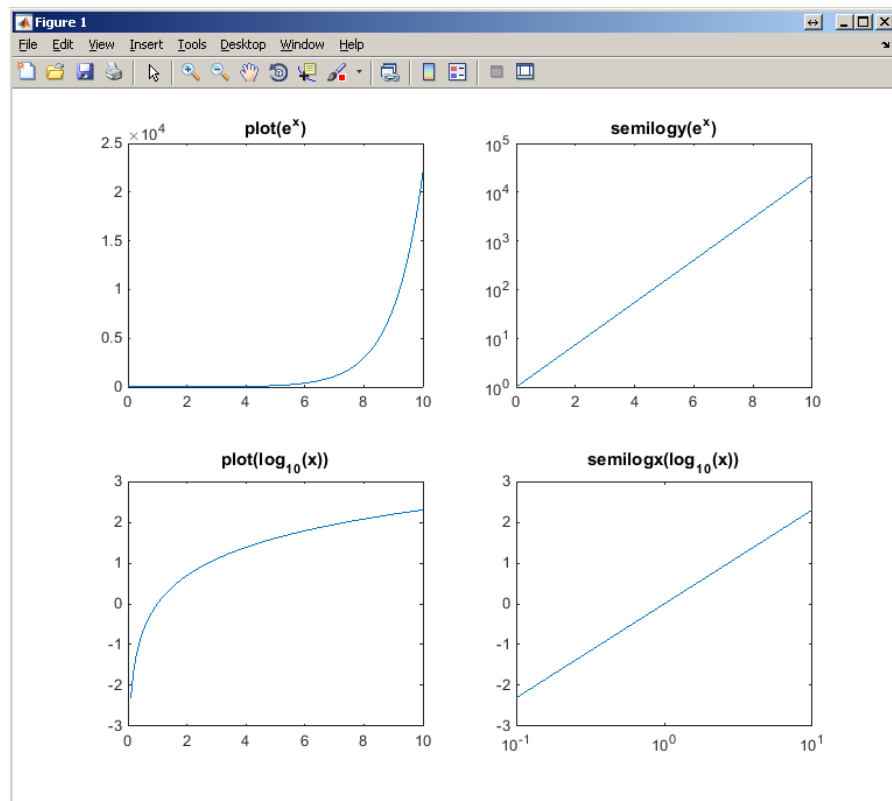


```
x = 0:0.01:20;
y1 = 200 * exp(-0.05*x) .* sin(x);
y2 = 0.8 * exp(-0.5*x) .* sin(10*x);
```

```
figure('color', 'w');
plotyy(x, y1, x, y2); % old version
% new version:
yyaxis left; plot(x, y1);
yyaxis right; plot(x, y2);
```

Logarithmic scale

- functions `semilogy`, `semilogx`, `loglog`



```
x = 0:0.1:10;
y1 = exp(x);
y2 = log(x);
```

```
figure('color', 'w')
subplot(2, 2, 1); plot(x, y1);
title('plot(e^x)');
```

```
subplot(2, 2, 2); semilogy(x, y1);
title('semilogy(e^x)')
```

```
subplot(2, 2, 3); plot(x, y2);
title('plot(log_1_0(x))')
```

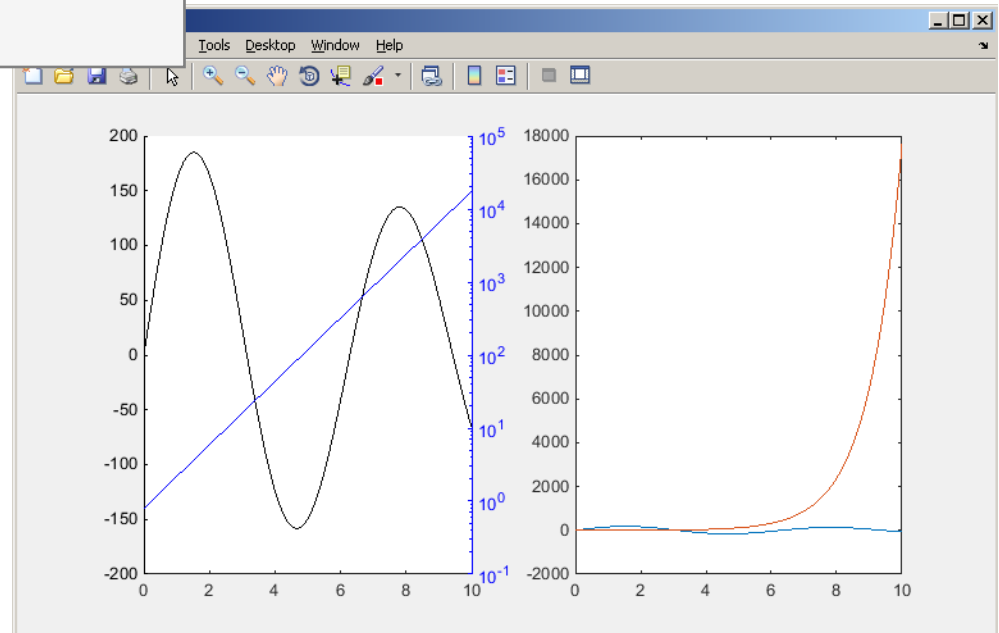
```
subplot(2, 2, 4); semilogx(x, y2);
title('semilogx(log_1_0(x))')
```

Example

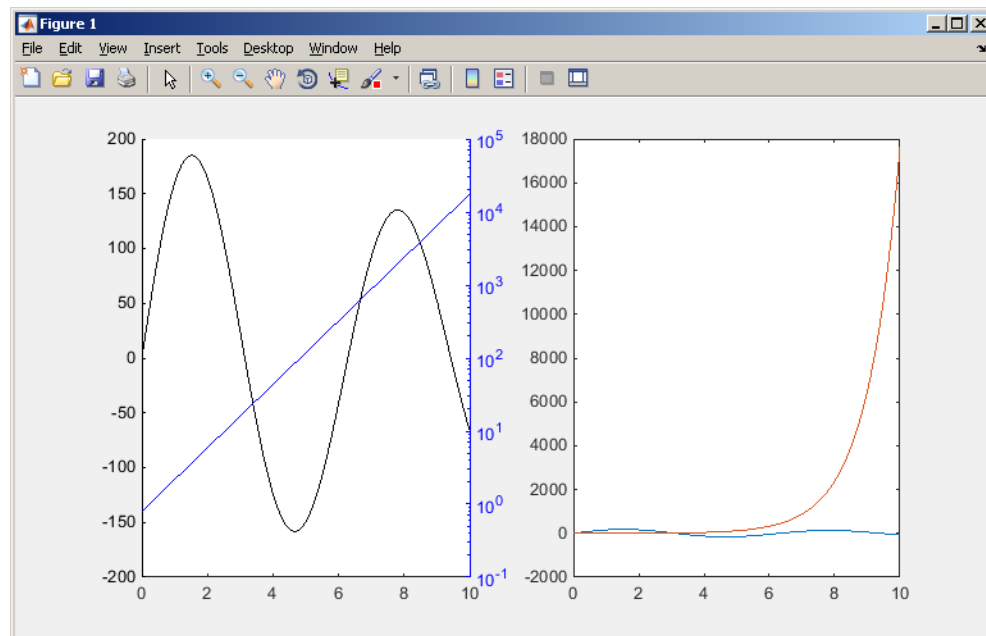
600 s ↑

- compare functions `plot` and `plotyy` in one figure object (using `subplot`) for functions shown below
 - in the object created by `plotyy` change default colors of individual lines to blue and black (don't forget about the axes)

```
x = 0:0.1:10;  
y1 = 200 * exp(-0.05*x) .* sin(x);  
y2 = 0.8 * exp(x);
```



Example - solution

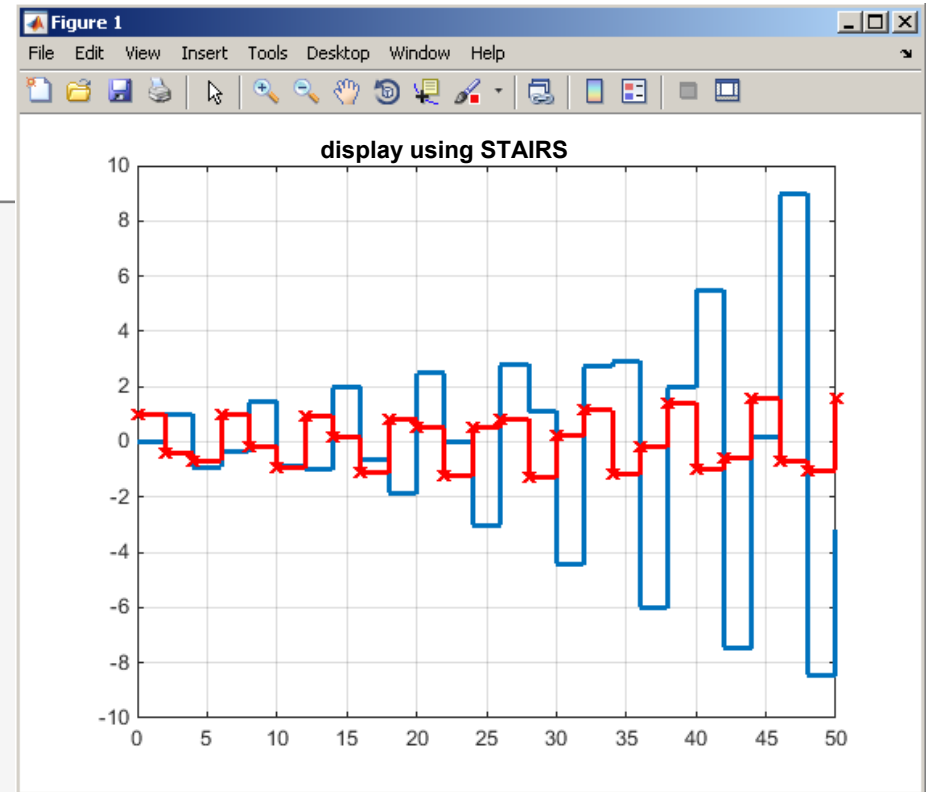


stairs

```
x = 0:2:50;
y1 = exp(0.05*x) .* sin(x);
y2 = exp(0.01*x) .* cos(x);

figure('Color', 'w');
stairs(x, y1, 'LineWidth', 2);
hold on; grid on;
stairs(x, y2, ...
      'Color', 'r', ...
      'Marker', 'x', ...
      'LineWidth', 2);

title('display using STAIRS');
```



Plotting 2-D functions

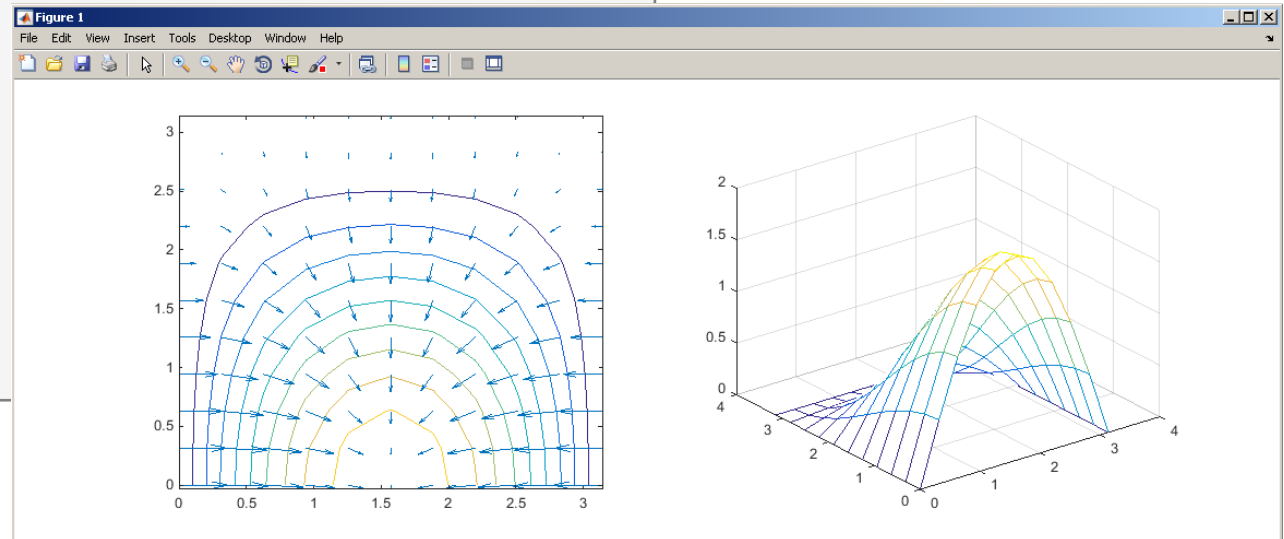
- contour, quiver, mesh

```
t = 0:pi/10:pi;
[x, y] = meshgrid(t);
z = sin(x) + cos(y) .* sin(x);
[gx, gy] = gradient(z);
```

```
figure('Color','w');
```

```
subplot(1, 2, 1);
contour(x, y, z);
hold on;
quiver(t, t, gx, gy);
```

```
subplot(1, 2, 2);
mesh(x, y, z);
```



Advanced visualizing in Matlab

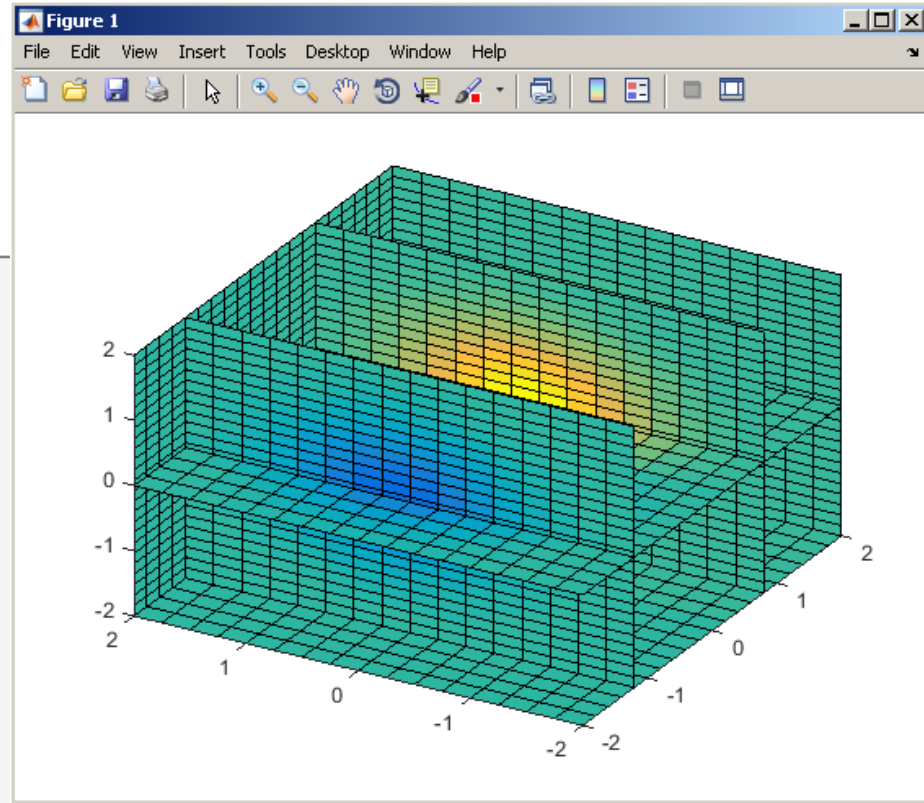
- function `slice`
- function `view`

```
[x, y, z] = meshgrid(-2:0.2:2, ...
                    -2:0.25:2, ...
                    -2:0.16:2);

v = x .* exp(-x.^2 - y.^2 - z.^2);

xslice = [-1.2, 0.8, 2];
yslice = 2;
zslice = [-2, 0];

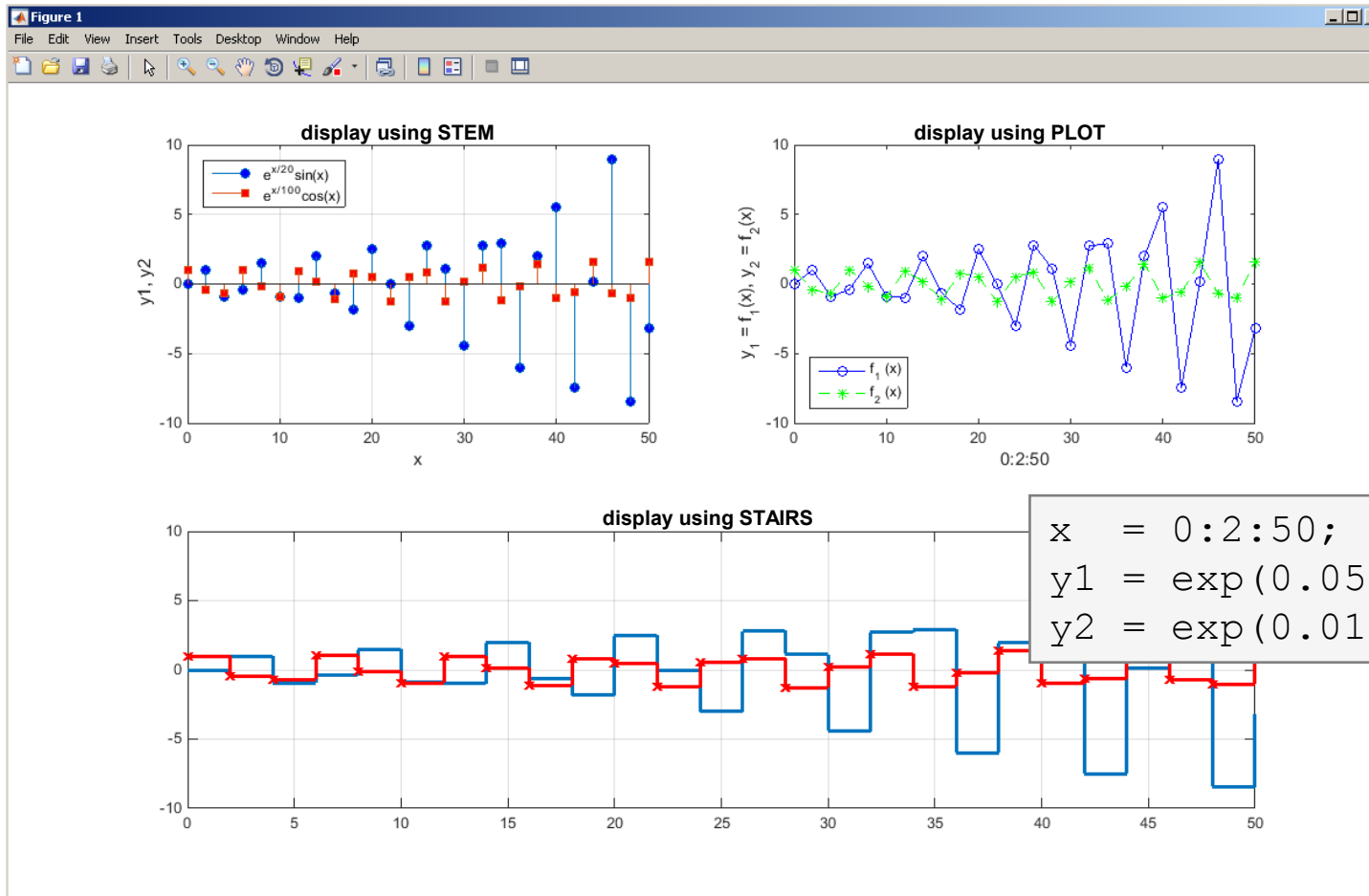
figure('Color', 'w');
slice(x, y, z, v, xslice, yslice, zslice);
% view(azimuth, elevation)
view(-60, 40);
```



Exercise #1 assignment

600 s ↑

- try to imitate the figure below where functions y_1 and y_2 are defined as:



Exercise #1 solution

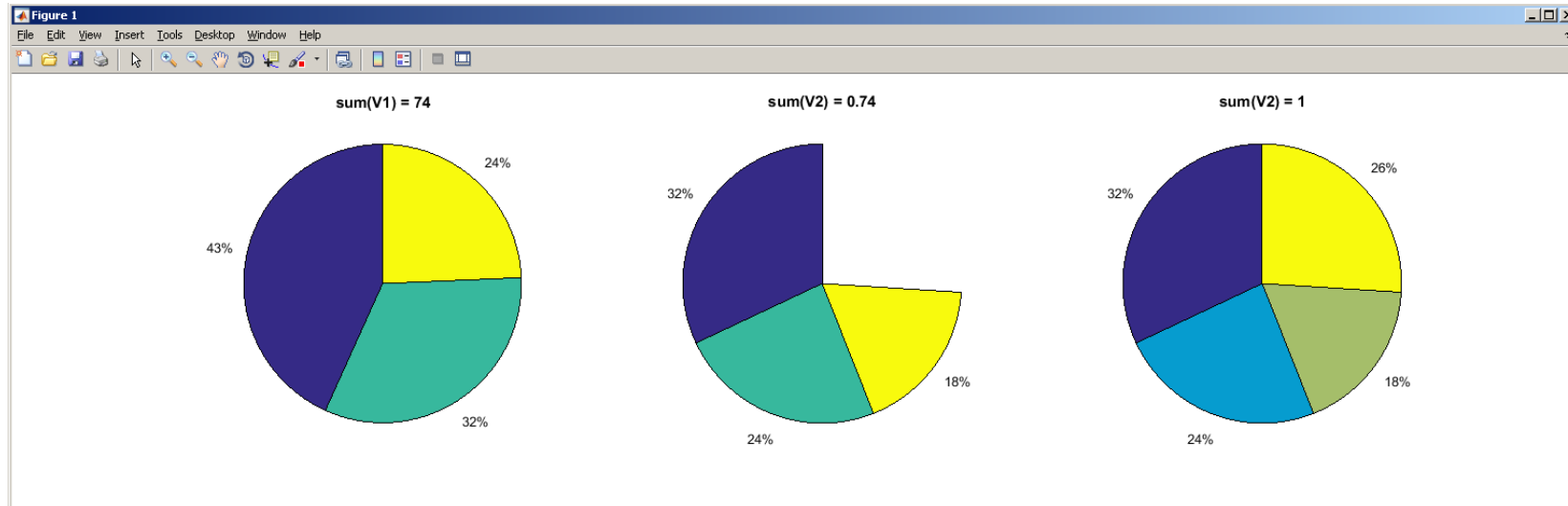
Pie plot – pie, pie3

```

V1 = [32 24 18];           % sum(V1) = 74
V2 = V1/100;              % sum(V2) = 0.74
V3 = [V2 1-sum(V2)];     % sum(V3) = 1

figure('Color', 'w');
subplot(1, 3, 1); pie(V1); title('sum(V1) = 74');
subplot(1, 3, 2); pie(V2); title('sum(V2) = 0.74');
subplot(1, 3, 3); pie(V3); title('sum(V2) = 1');

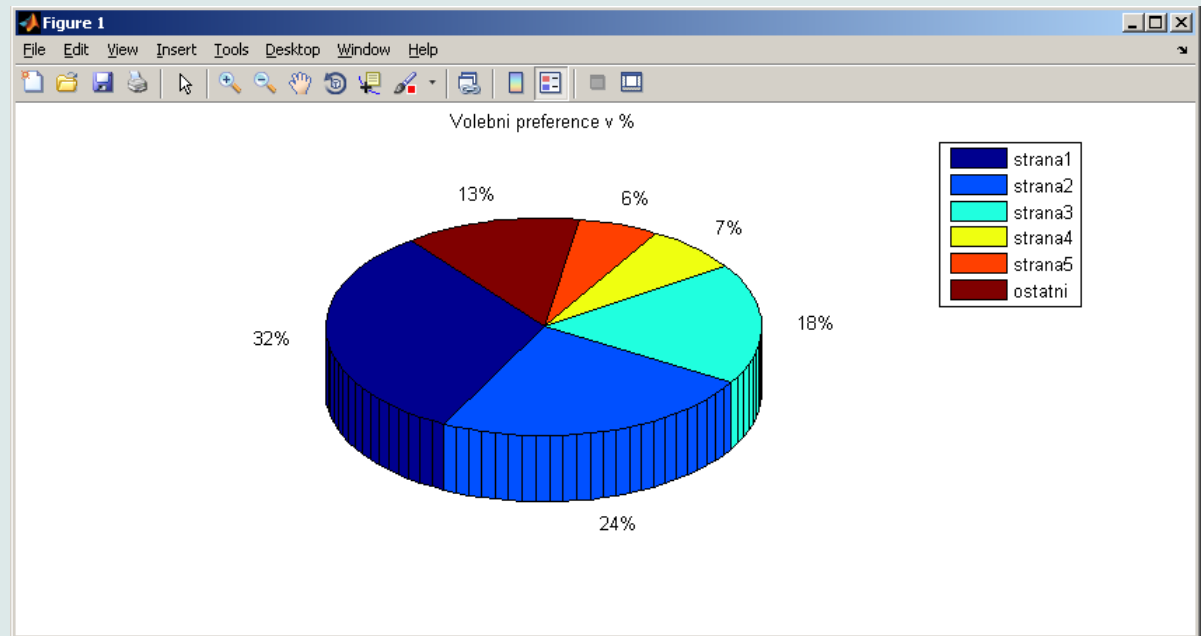
```



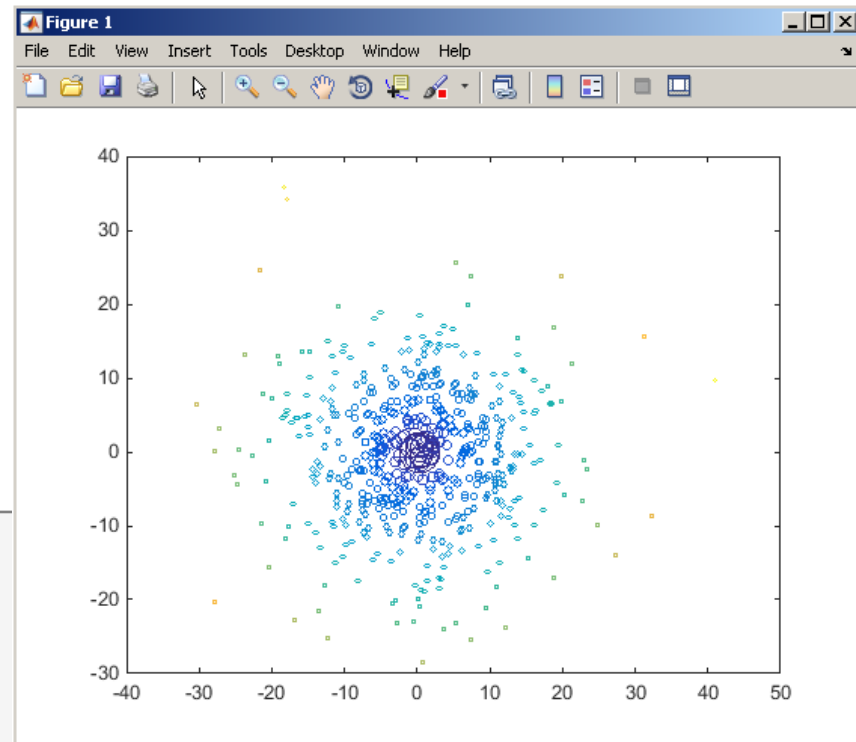
Exercise

600 s ↑

- opinion polls show parties' preference projections as follows:
- plot the poll result using pie plot including the item 'others'
 - 1st party: 32%
 - 2nd party: 24%
 - 3rd party: 18%
 - 4th party: 7%
 - 5th party: 6%

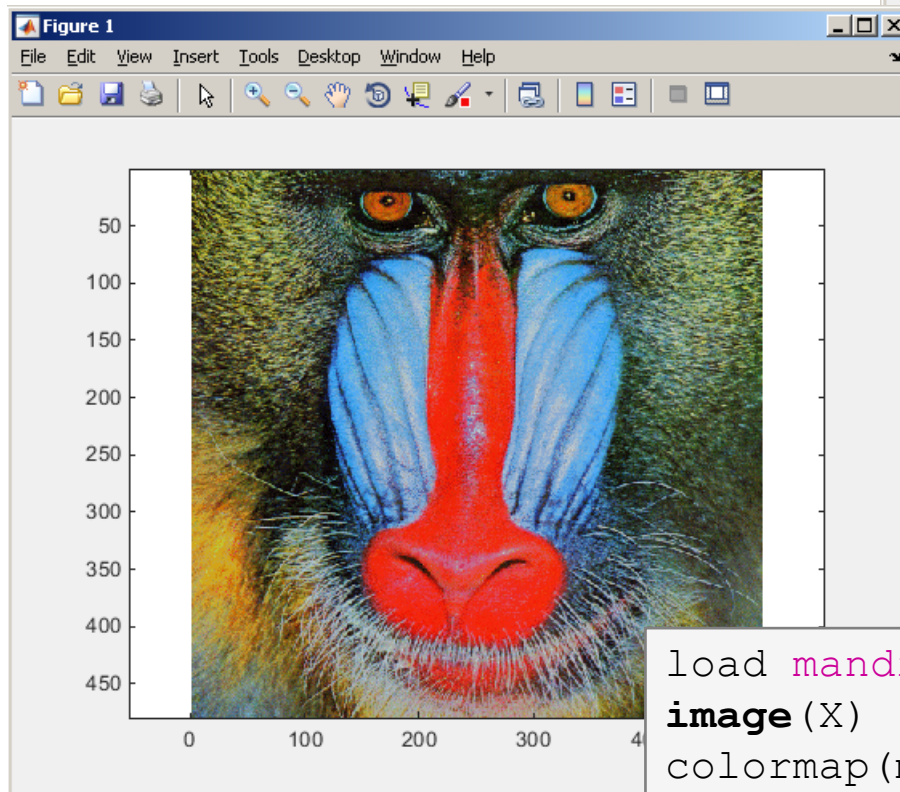


```
x = 10 * randn(500, 1);  
y = 10 * randn(500, 1);  
c = hypot(x, y);  
  
figure('color', 'w');  
scatter(x, y, 100./c, c);  
box on;
```

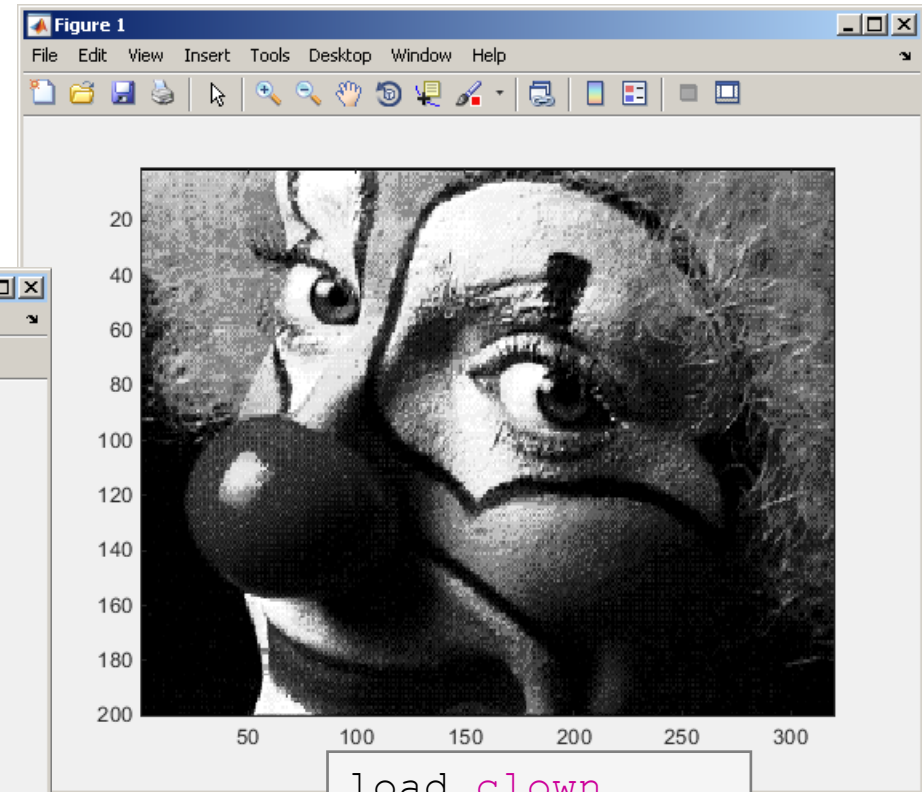


Picture depiction

- functions `image`, `imagesc`
- function `colormap`



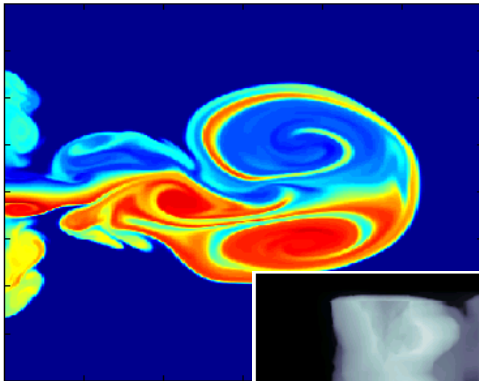
```
load mandrill
image(X)
colormap(map)
axis equal
```



```
load clown
imagesc(X)
colormap(gray)
```

colormap

- determines the scale used in picture color mapping
- it is possible to create / apply an own one: `colormapeditor`

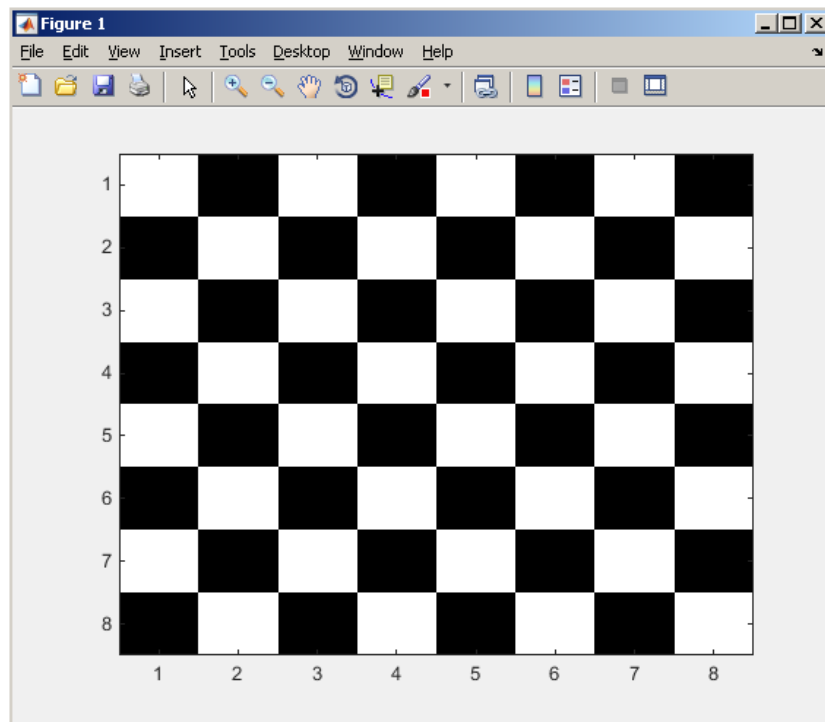


Colormap Name	Color Scale
parula	
jet	
hsv	
hot	
cool	
spring	
summer	
autumn	
winter	
gray	
bone	
copper	
pink	
lines	
colorcube	
prism	
flag	
white	

Exercise

600 s ↑

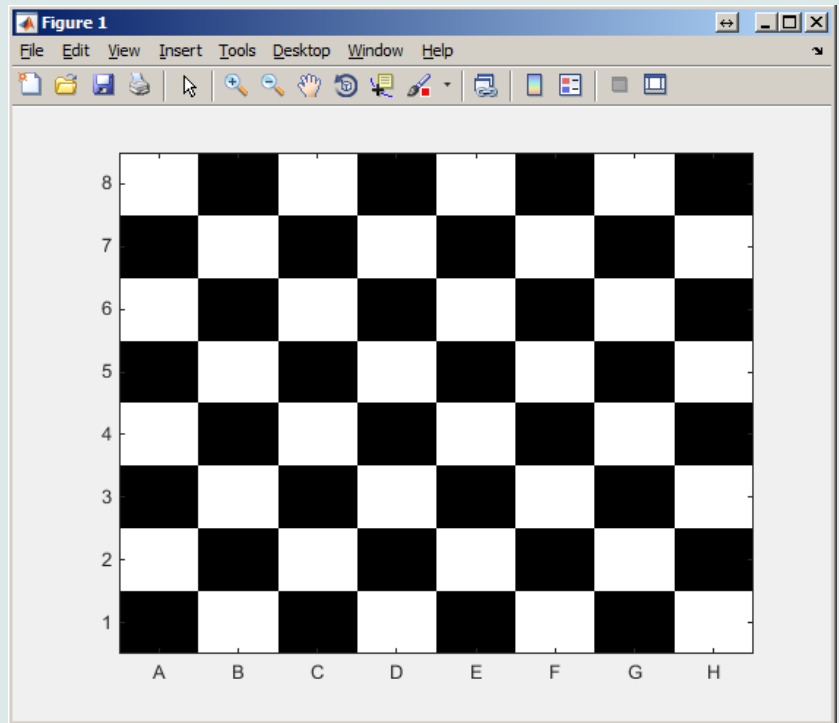
- create a chessboard as shown in the figure:
 - the picture can be drawn using the function `imagesc`
 - consider `colormap` setting



Exercise

600 s ↑

- Modify the axes of the chessboard so that it corresponded to reality :



Structure of GUI #1

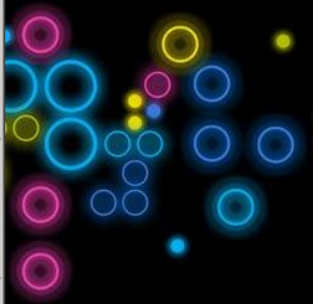
screen ~ groot

application window ~ figure

The screenshot shows the IFSMaker application window. The main drawing space contains a fractal composed of blue and light green rectangles. The drawing space is bounded by axes with coordinates ranging from -60 to 60. The interface includes a menu bar (File, Tools, Points, Lines, Selection, Modification, Polygons, Transformations, IFS fractal, Parameter sweep), a toolbar with various drawing tools, and a right-hand panel with several sub-sections: a coordinate table, 'New point' and 'Delete point' buttons, 'Snap' options, a table of existing points, 'New polyg.', 'Del. polyg.', 'Add node', and 'Retire node' buttons, 'Selection' and 'Modification' options, 'IFS generation' settings (Iteration, Apply to, Display), and 'Show' options for Points, Lines, Polygon, Transf., and IFS. At the bottom of the right panel are buttons for 'Load FRC', 'Help', 'Quick save', 'Clear all', and 'Exit'.

drawing space ~ axes

graphical objects ~ uiobjects



Structure of GUI #2

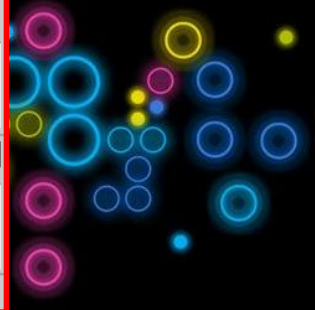
The screenshot displays the IFSMaker application window. The main canvas shows a fractal structure composed of blue and green polygons. Several GUI components are highlighted with red boxes and labels:

- uitoolbar**: Located at the top left of the main window.
- uimenu**: Located at the top center of the main window.
- uitable**: A table listing points and their coordinates, located in the upper right control panel.
- uicontextmenu**: A menu for selecting and modifying objects, located in the middle right control panel.
- uipanel**: A container for various controls, located in the lower right control panel.
- uibuttongroup**: A group of buttons for IFS generation, located at the bottom right of the control panel.
- uicontrol**: A group of text and checkbox controls, located at the bottom of the control panel.

The right-hand control panel includes the following elements:

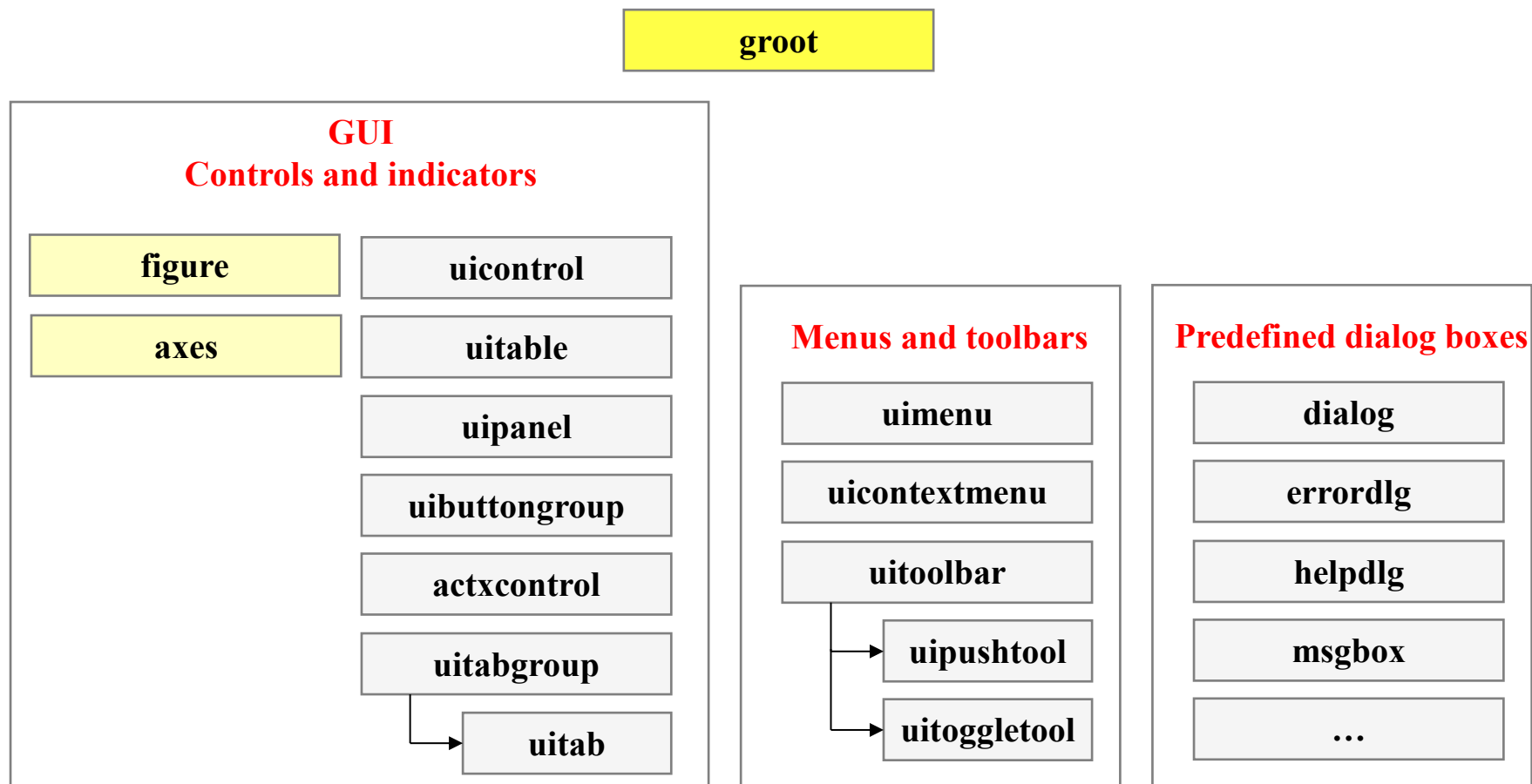
- Points Table:**

Name	Tag	X coord	Y coord	Show	pt:R	pt:G	pt:B	pSize
1 Point1	FRC1	-50	-30	<input checked="" type="checkbox"/>	0	0	1	medium
2 Point2	FRC2	50	-30	<input checked="" type="checkbox"/>	0	0	1	medium
3 Point3	FRC3	50	30	<input checked="" type="checkbox"/>	0	0	1	medium
4 Point4	FRC4	-50	30	<input checked="" type="checkbox"/>	0	0	1	medium
- Selection Tools:** Select, Unselect, Clear all, All points, List.
- Modification Tools:** Invisible, Modify, Options, @Move.
- IFS generation:** Iteration (1-3), Generate, Refresh, Advanced, Dark, Points: 4, Nodes: 100, Display, Trans: 5, Polvos: 25.
- Show:** Points, Lines, Polygon, Transf., IFS.
- Subdomains:** - ready -
- Fractal dimension:** actual
- Optimization:** Sweep
- Buttons:** Load FRC, Help, Quick save, Clear all, Exit.



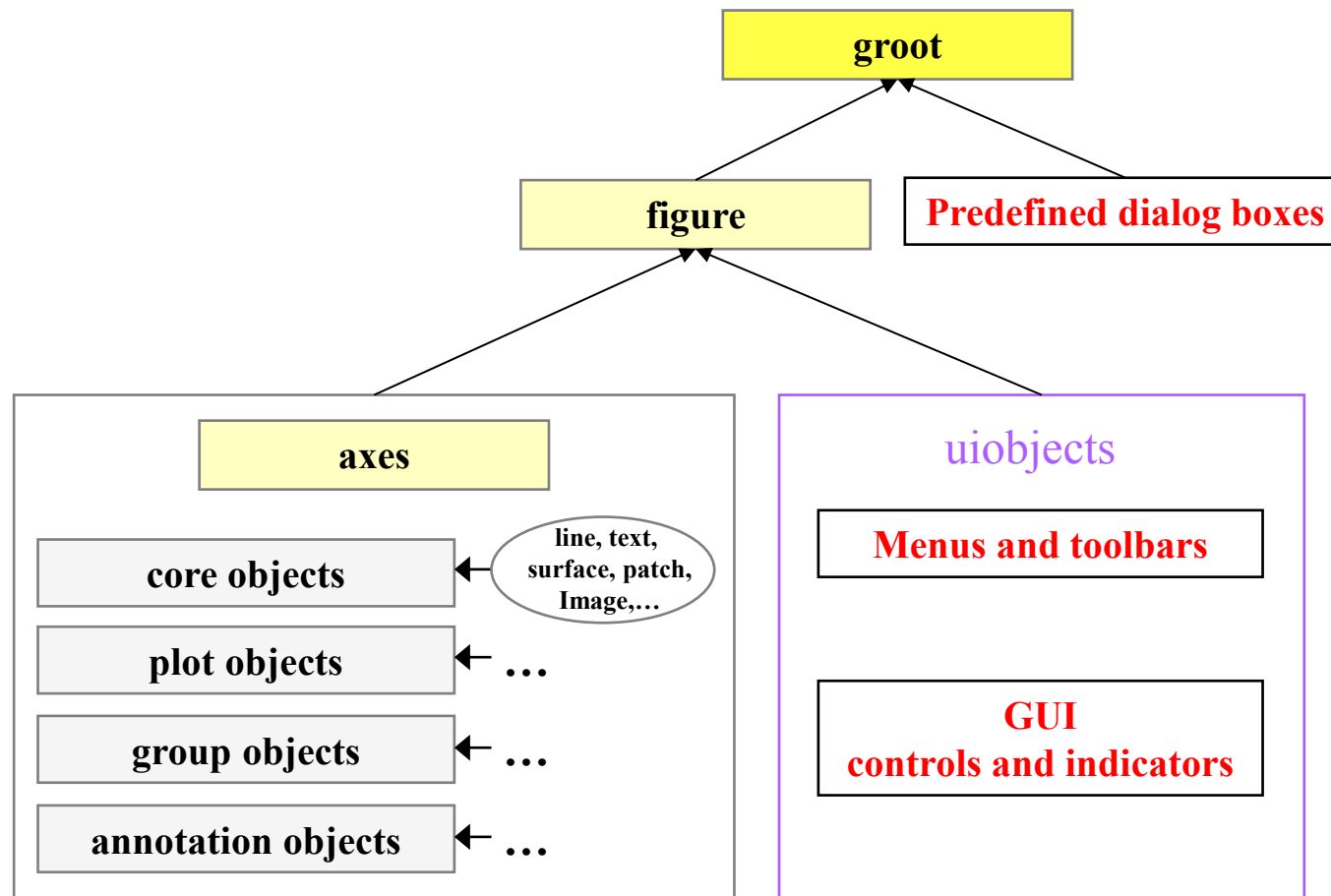
Structure of GUI

- objects are sorted in a logical way

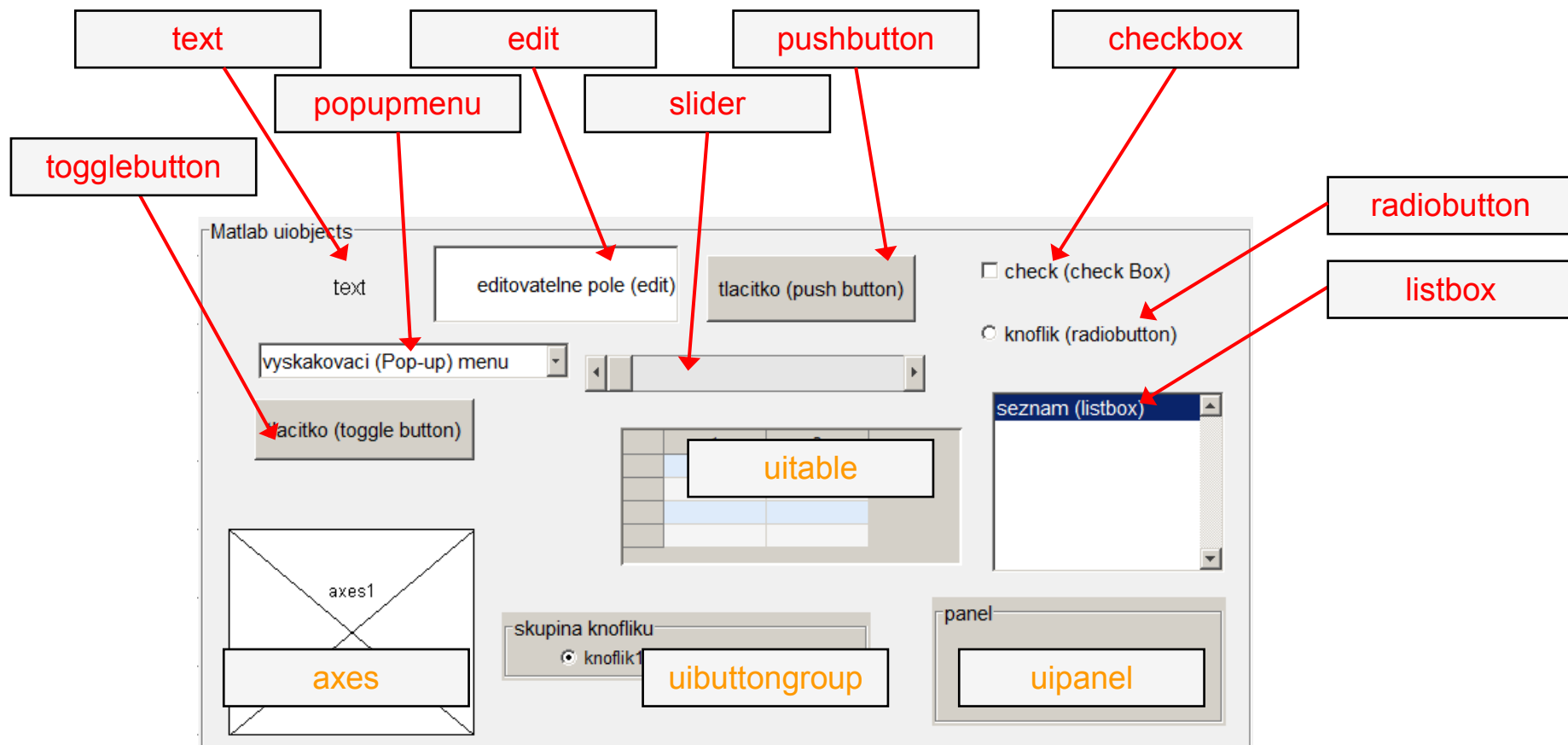


Structure of GUI

- object hierarchy



Structure of GUI #3



Screen properties, `groot`

- corresponds to computer screen in Matlab
- is unique and callable using function
 - `get(0)`
 - in workspace – data structure
 - `groot`
 - in workspace – handle object
- all other objects are children (descendants)

```
>> groot
```

```
ans =
```

```
Graphics Root with properties:
```

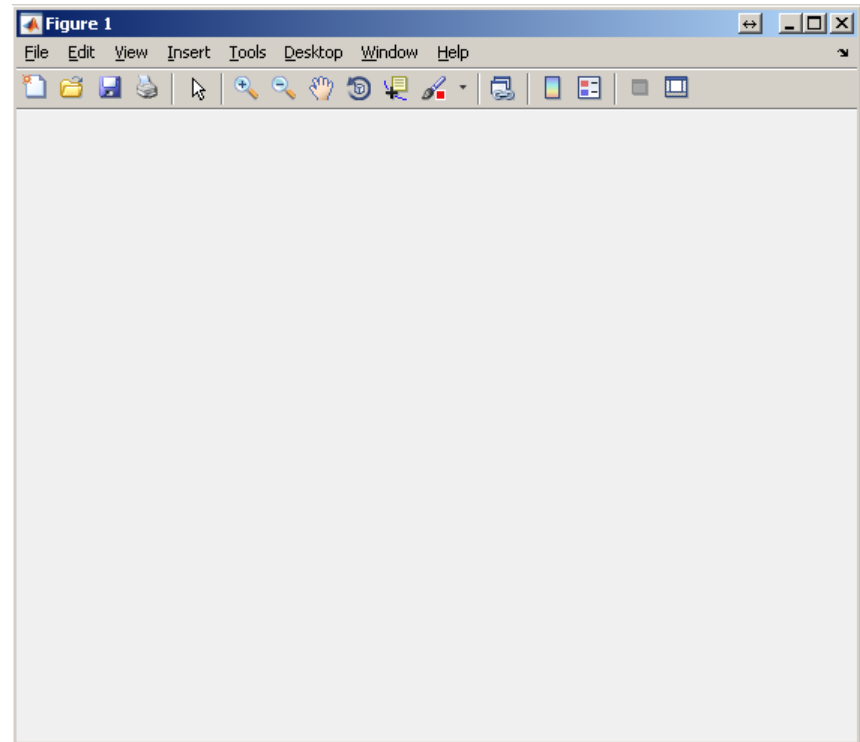
```
    CurrentFigure: [0x0 GraphicsPlaceholder]
  ScreenPixelsPerInch: 96
           ScreenSize: [1 1 1920 1200]
    MonitorPositions: [2x4 double]
                Units: 'pixels'
```

```
Show all properties
```

```
    CallbackObject: [0x0 GraphicsPlaceholder]
           Children: [0x0 GraphicsPlaceholder]
    CurrentFigure: [0x0 GraphicsPlaceholder]
  FixedWidthFontName: 'Courier New'
    HandleVisibility: 'on'
    MonitorPositions: [2x4 double]
           Parent: [0x0 GraphicsPlaceholder]
    PointerLocation: [2401 787]
           ScreenDepth: 32
  ScreenPixelsPerInch: 96
           ScreenSize: [1 1 1920 1200]
    ShowHiddenHandles: 'off'
           Tag: ''
           Type: 'root'
           Units: 'pixels'
           UserData: []
```

Graphical window, figure

- `object figure` creates standalone graphical window
 - a new window is created on calling the function when the window doesn't exist
 - all windows are descendants of the object `groot`
 - all secondary graphic objects are descendants of the object `figure` and are drawn in the window
 - `figure` has many properties
 - see `get(figure)`
 - `hFig = figure`



Position **property**

- Matlab combines size of an object and its position in one matrix
- two ways of entering exist
 - (A) absolute position in pixels
 - (B) normalized position related to the size of parent object

`[left bottom width height]`

```
%% A)
uicontrol('Units','pixels',...
         'Style','pushbutton',...
         'Position',[50 150 75 25]);

%% B)
uicontrol('Units','normalized',...
         'Style','pushbutton ',...
         'Position',[0.05 0.12 0.1 0.05]);
```

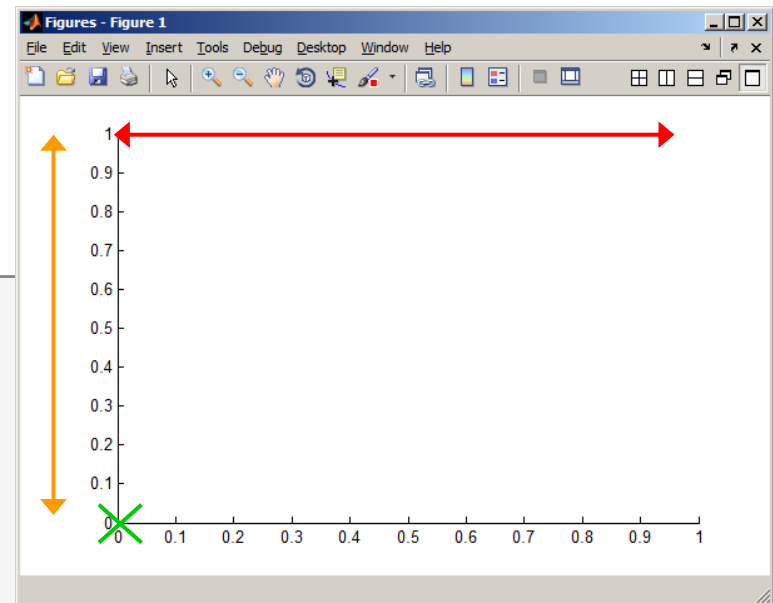
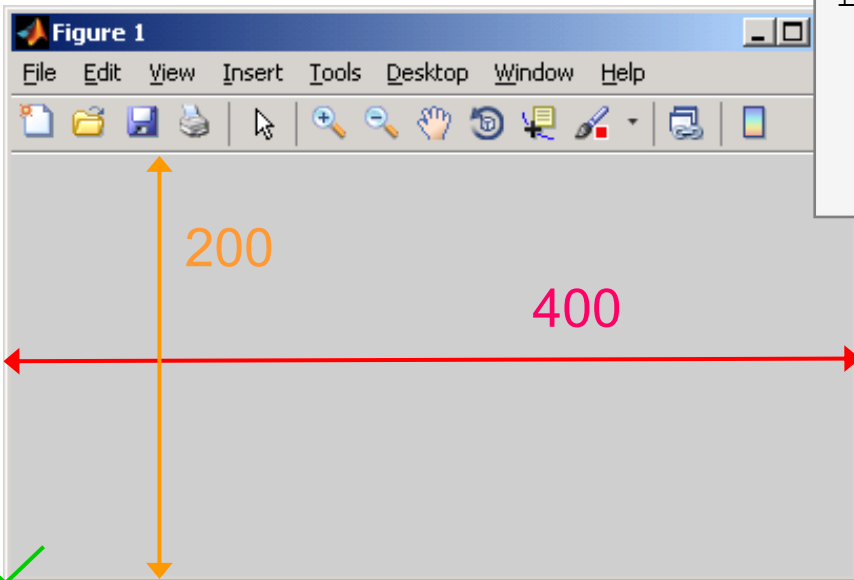


Figure creation

- used when we want, for instance, to put figure in the center of the screen
 - window width: 400px, window height: 200px



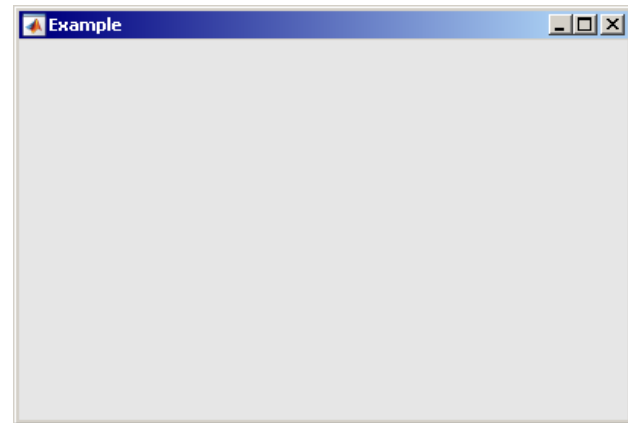
```
dispSize = get(0, 'ScreenSize');
figSize = [400 200];
figHndl = figure('pos', ...
    [(dispSize(3)-figSize(1))/2 ...
    (dispSize(4)-figSize(2))/2 ...
    figSize(1) figSize(2)]);
```

[760 500]

Exercise – GUI window creation

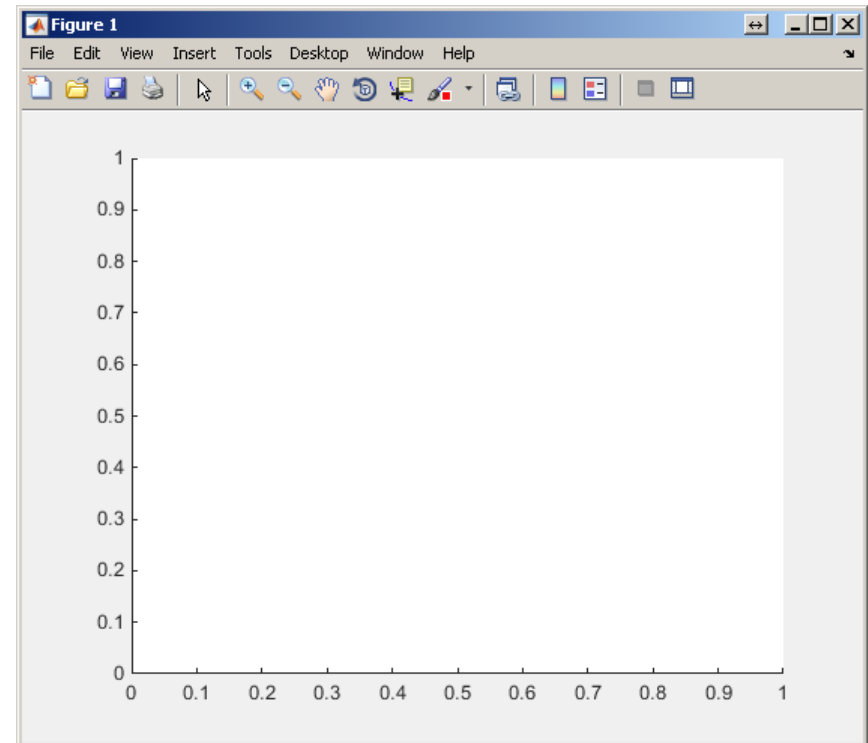
400 s ↑

- in a new script that we will be extending throughout today's lecture create a `figure` window that opens in the center of the screen having width of 400 pixels and height of 250 pixels
 - make sure the figure's name is „Example“ and the title `figure 1` doesn't display
 - use `Tag` property for naming (e.g. `'figExample'`)
 - change window's color (up to you)



Graph area, axes

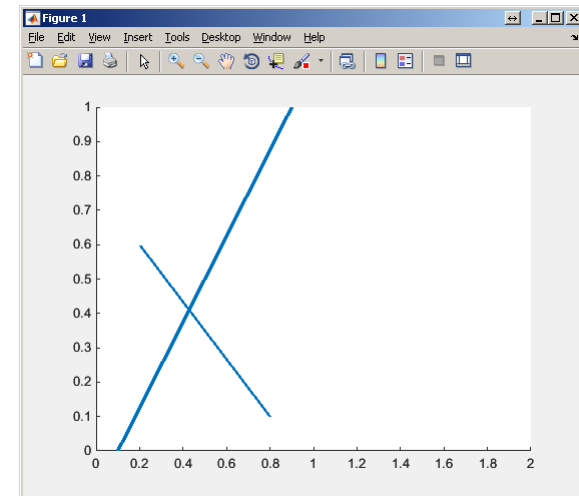
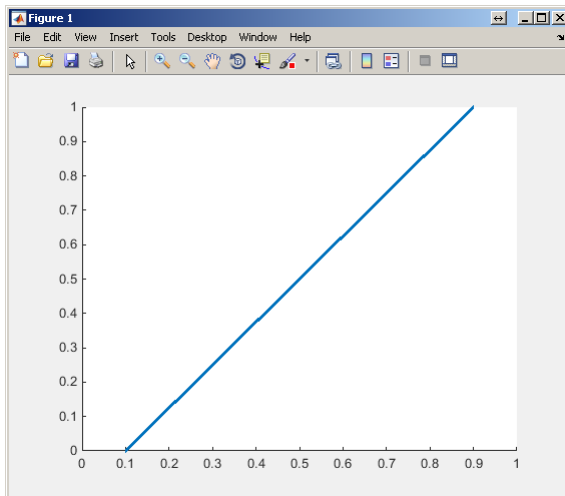
- defines area where descendants of object `axes` are placed
 - all objects related to `axes` object generate axes even when not yet exist (similarly to `figure`)
 - `axes` has many properties
 - see `get (axes)`
- or
- `properties (axes)`



Function axis

- axis scales axes
 - format (2D): [x_min x_max y_min y_max]
 - format (3D): [x_min x_max y_min y_max z_min z_max]

```
line([0.1 0.9], [0 1], 'LineWidth', 3)
axis([0 1 0 1])
```

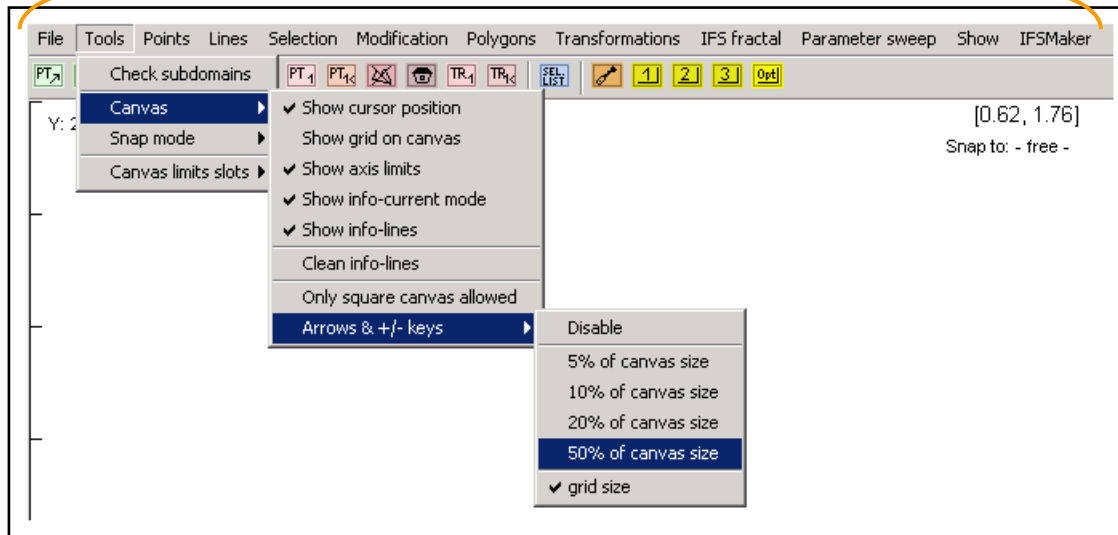


```
line([0.8 0.2], [0.1 0.6], 'LineWidth', 2)
axis([0 2 0 1])
```


Group uiobjects: uimenu

- it is possible to define keyboard shortcuts (e.g. CTRL+L)
- it is possible to move in the menu using ALT+character
- callback function can be assigned

490 lines of code



- for more see `help uimenu`

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

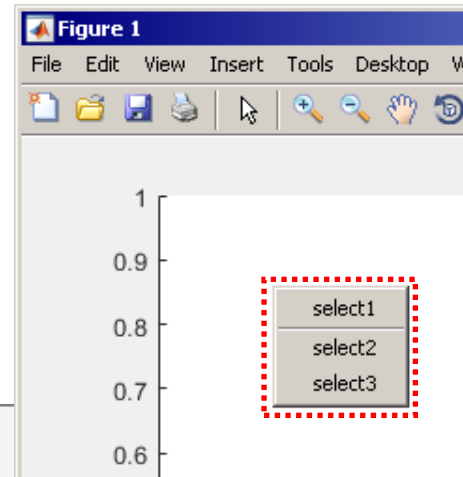
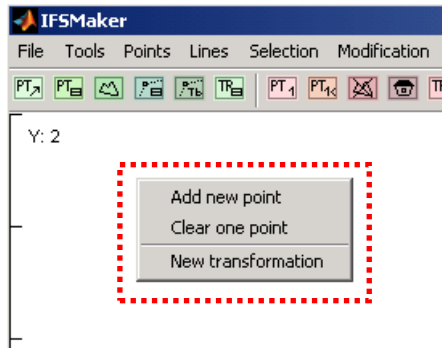
uibuttongroup

actxcontrol

uicontrol

Group uiobjects: uicontextmenu

- creates context menu
 - appears upon mouse right-click
 - menu item selection activates related callback



```

figHndl = figure;
cMenu   = uicontextmenu;
axsHndl = axes('Parent', figHndl, 'UIContextMenu', cMenu);
uimenu(cMenu, 'Label', 'select1', 'Callback', @callbackFcn1);
uimenu(cMenu, 'Label', 'select2', 'Callback', @callbackFcn2, ...
        'Separator', 'on');
uimenu(cMenu, 'Label', 'select3', 'Callback', @callbackFcn3);
  
```

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

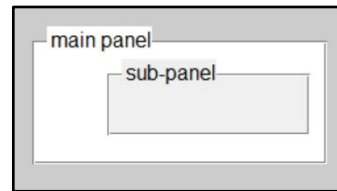
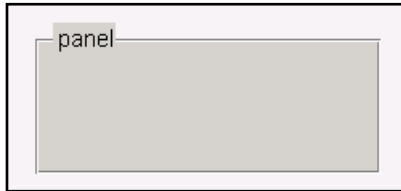
uibuttongroup

actxcontrol

uicontrol

Group uiobjects: uipanel

- create panel as a parent to other objects
- objects inside are oriented related to the panel
- many features available (see >> doc `uipanel`)



```
fgHnd = figure;
h1p   = uipanel('Title', 'main panel', ...
               'FontSize', 12, 'BackgroundColor', ...
               'white', 'Position', [0.25 0.25 0.4 0.25]);
h2p   = uipanel('Parent', h1p, ...
               'Title', 'sub-panel', 'FontSize', 12, ...
               'Position', [0.25 0.25 0.7 0.7]);
```

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

uibuttongroup

actxcontrol

uicontrol

Exercise – panel

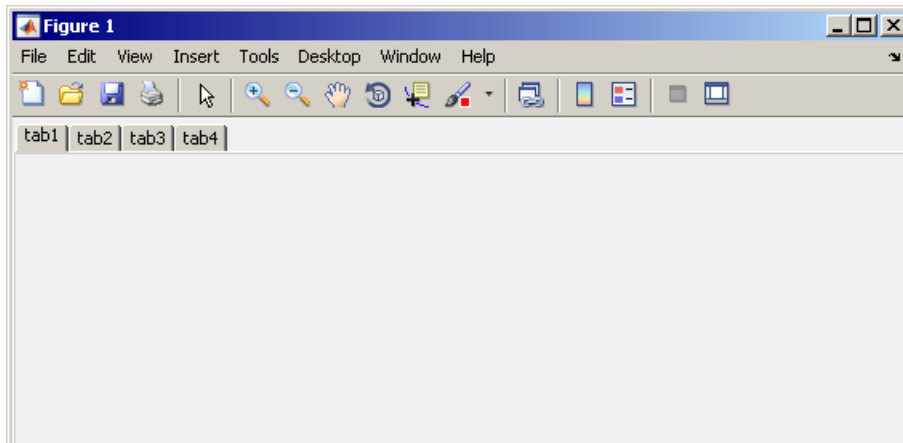
400 s ↑

- create panel and place it to position [90 180 220 60] px
- call the panel „Visibility“, set Tag to „panelVisibility“
- find out its color and store it in a variable which we will be later using to unify colors of other objects within the panel



Group uiobjects: uitab

- creates a tab that will be parent for other object (same as with panel)
- for more see >> doc `uitabgroup`



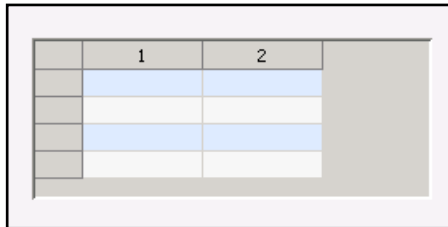
```
tabs_gp = uitabgroup();  
tabs_1  = uitab(tabs_gp, 'Title', 'tab1');  
tabs_2  = uitab(tabs_gp, 'Title', 'tab2');  
tabs_3  = uitab(tabs_gp, 'Title', 'tab3');  
tabs_4  = uitab(tabs_gp, 'Title', 'tab4');
```

uiobjects

`uimenu``uicontextmenu``uitoolbar``uipanel``uitabgroup``uitable``uibuttongroup``actxcontrol``uicontrol`

Group uiobjects: uitable

- creates a 2D table
 - can be placed anywhere in the figure window
 - has a wide range of properties and items (check, popup)
- see >> doc `uitable`



	1	2	3	4	5	6	7	8
1	92	99	1	8	15	67	74	
2	98	80	7	14	16	73	55	
3	4	81	88	20	22	54	56	
4	85	87	19	21	3	60	62	
5	86	93	25	2	9	61	68	
6	17	24	76	83	90	42	49	
7	23	5	82	89	91	48	30	
8	79	6	13	95	97	29	31	
9	10	12	94	96	78	35	37	
10	11	18	100	77	84	36	43	

```
>> figure
>> t = uitable;
>> set(t, 'Data', magic(10));
>> set(t, 'ColumnWidth', {35})
```

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

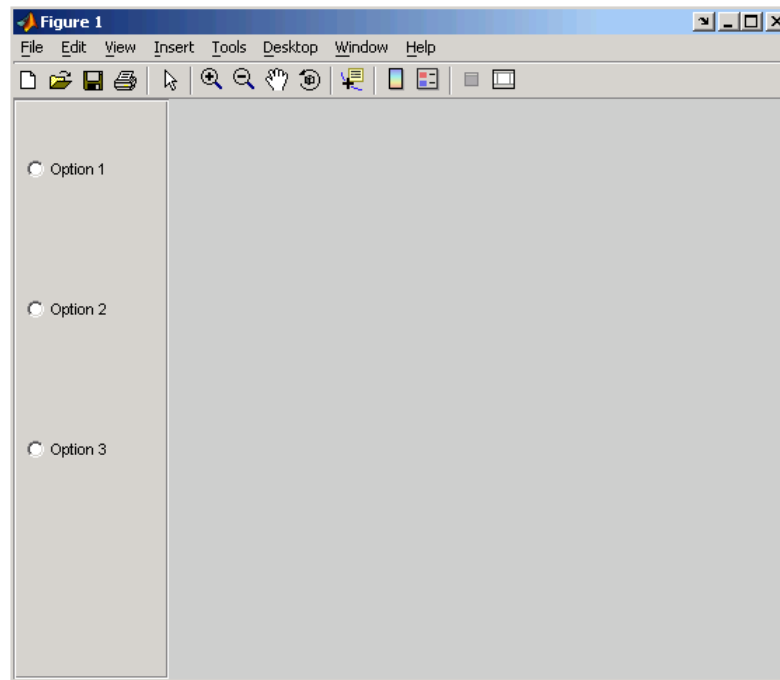
uibuttongroup

actxcontrol

uicontrol

Group uiobjects: uibuttongroup

- block with a group of buttons
- for more see >> doc `uibuttongroup`



uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

uibuttongroup

actxcontrol

uicontrol

Group uiobjects: actxcontrol

- enables to create Microsoft ActiveX control in the figure window

- seznam podporovaných Microsoft ActiveX control

```
>> list = actxcontrollist
>> h     = actxcontrolselect
```

- examples

- web browser

```
>> h = actxcontrol('AcroPDF.PDF.1', ...
```

- PDF reader

```
>> h = actxcontrol('Shell.Explorer.2', ...
```

- for more information see

```
>> docsearch getting started with COM
```

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

uibuttongroup

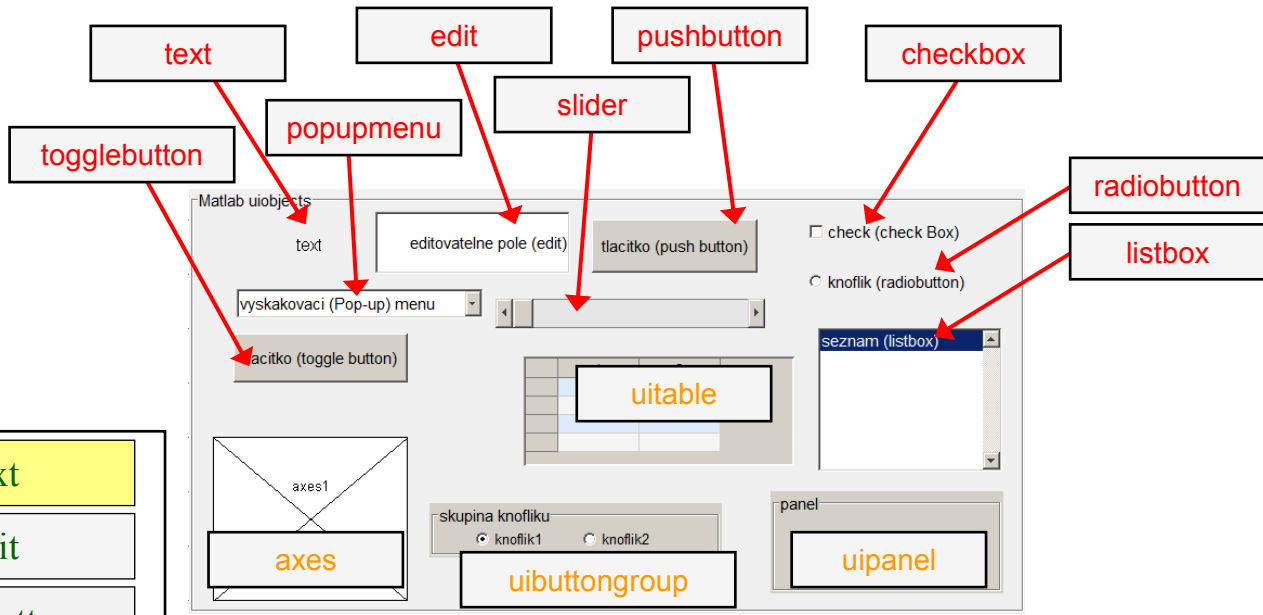
actxcontrol

uicontrol

Group uiobjects: uicontrol

- uiobjects
 - uimenu
 - uicontextmenu
 - uitoolbar
 - uipanel
 - uitabgroup
 - uitable
 - uibuttongroup
 - actxcontrol
 - uicontrol**

- text**
- edit**
- pushbutton**
- radiobutton**
- checkbox**
- listbox**
- slider**
- popupmenu**
- togglebutton**



Group uiobjects: uicontrol

- `uicontrol` creates basic functional elements of GUI
- to change style of `uicontrol` use property `style`

```
>> t = uicontrol;  
>> set(t, 'Style', 'text');
```

- to get properties of `uicontrol` use

```
>> get(t);
```

- for more see `>> doc uicontrol`

uiobjects

uimenu

uicontextmenu

uitoolbar

uipanel

uitabgroup

uitable

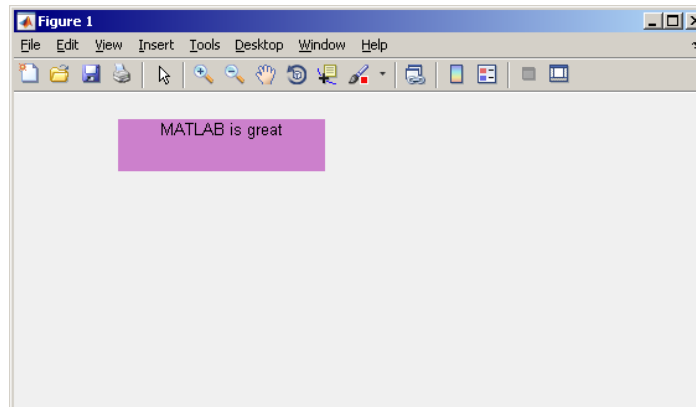
uibuttongroup

actxcontrol

uicontrol

Group uicontrol: text

- place text at a given spot
- usually used to
 - as a label for other items
 - information text for user



```
>> figure
>> text1 = uicontrol(...
    'Units', 'Normalized', ...
    'Style', 'Text', ...
    'Position', [0.15 0.85 0.3 0.1], ...
    'Tag', 'MTB', ...
    'FontSize', 10, ...
    'BackgroundColor', [0.8 0.5 0.8], ...
    'HorizontalAlignment', 'center', ...
    'String', 'MATLAB is great');
```

uicontrol

text

edit

pushbutton

radiobutton

checkbox

listbox

slider

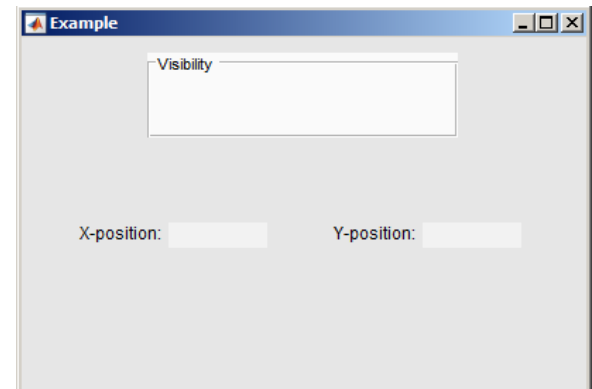
popupmenu

togglebutton

Exercise – text

400 s ↑

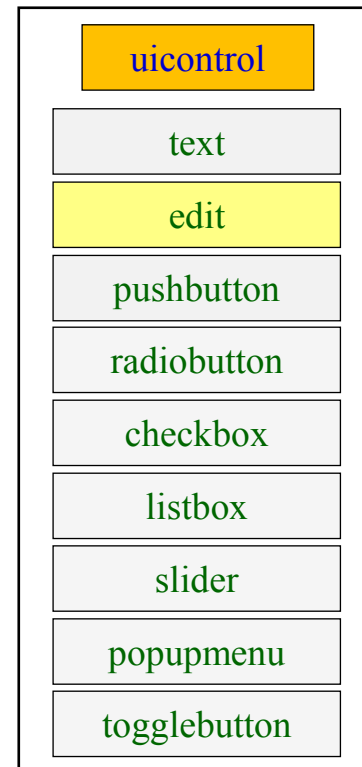
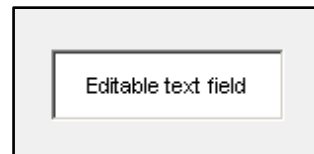
- create four text arrays having following properties that will be placed to following positions (normalized values)
 - [0.1 0.4 0.15 0.075] font 9 figureColor
 - [0.26 0.4 0.175 0.075] font 10 textColor
 - [0.55 0.4 0.15 0.075] font 9 figureColor
 - [0.71 0.4 0.175 0.075] font 10 textColor
- assign labels X-position/Y-position to the arrays with figureColor, others leave without labels
- assign its own handle to each text array



Exercise – text, solution

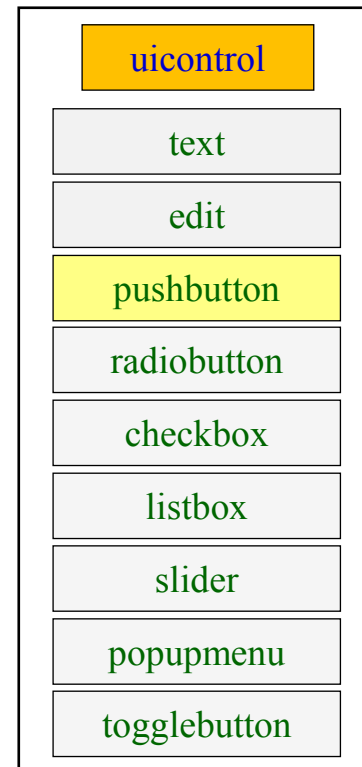
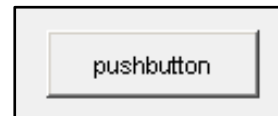
Group uicontrol: `edit`

- enables to read an array of characters
 - the array of characters is of type `char`
 - the string has to be processed (`str2num`, `str2double`,...)
- CTRL+C,+V,+X,+A,+H shortcuts are available to user
- a console can be created using `edit` in Matlab



Group uicontrol: pushbutton

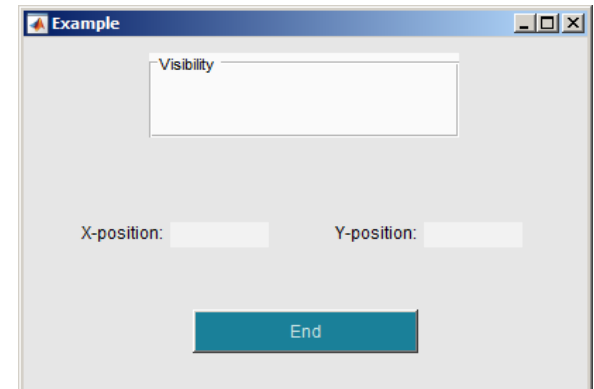
- one-state button
- callback function is called on push
- appearance setting is similar to object text



Exercise – pushbutton

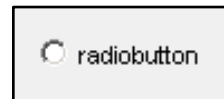
400 s ↑

- create a button with label „End“
 - place it at (normalized) position [0.3 0.1 0.4 0.125]
 - font size set to 9
 - background color: [0.1 0.5 0.6]
 - text color: [0.8 0.9 0.9]

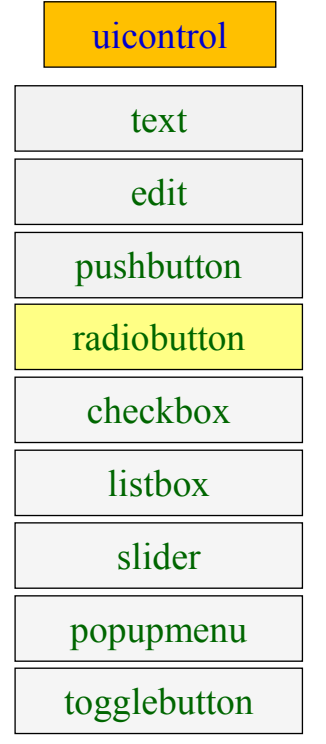
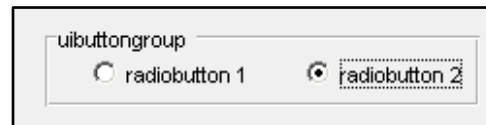


Group uicontrol: radiobutton

- two-state (on/off)

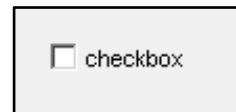


- these elements can be grouped
 - button group (object `uibuttongroup`)
- callback function can detect switching from one radiobutton to other

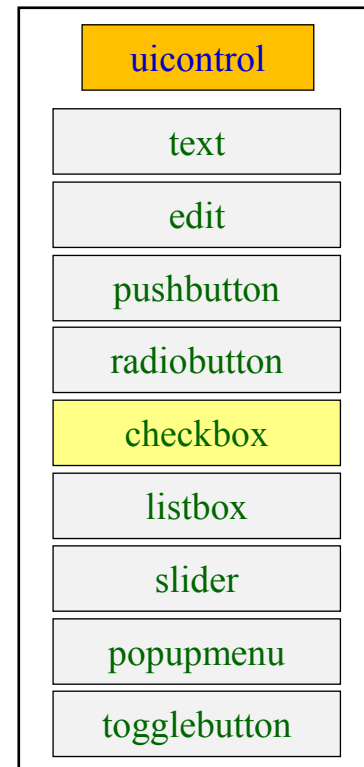


Group uicontrol: checkbox

- similar to radiobutton
- tick box (with a text attached)
- callback called on state change



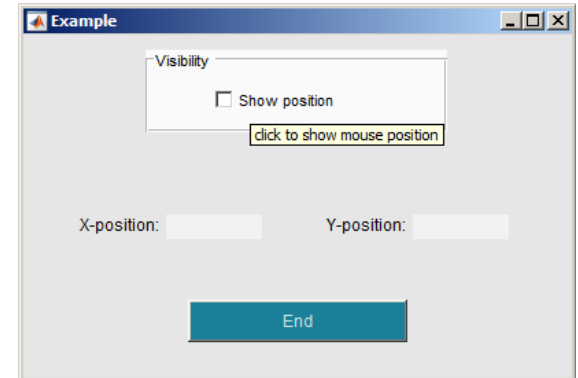
```
function checkboxFcn(hObject) % treated
%% to find out, whether the box is ticked
if hObject.Value % ticked
    % ...
else % not ticked
    % ...
end
```



Exercise – checkbox

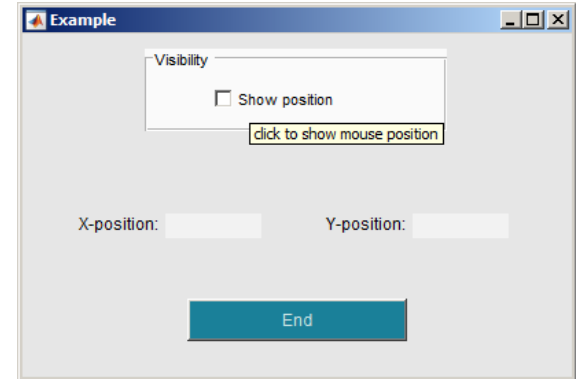
400 s ↑

- create a checkbox placed inside panel `panel1`
- the label is „Show position“
 - make sure to show hint help on mouse cursor close to the checkbox
- assign its own tag to the checkbox
- set the same background color as that of panel



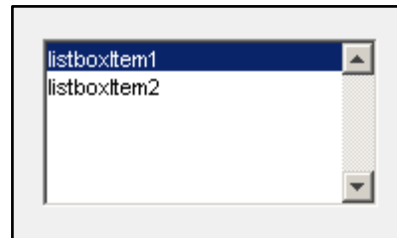
Exercise

- Save your GUI file for later use (during next lecture)



Group uicontrol: listbox

- list of items, it is possible to choose one or more items
- property `string` contains list of strings (items)
- property `value` contains matrix of selected items
- values `max` and `min` have impact on selection

**uicontrol**

text

edit

pushbutton

radiobutton

checkbox

listbox

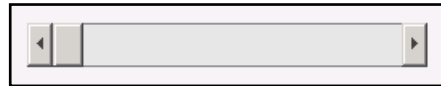
slider

popupmenu

togglebutton

Group uicontrol: slider

- input value is a numerical range (min and max)
- user moves slider by steps (sliderstep)
- requires
 - range
 - slider step
 - initial value



```

maxVal = 10;
minVal = 2;
slider_step(1) = 0.4/(maxVal-minVal);
slider_step(2) = 1/(maxVal-minVal);
set(sliderHndl, 'SliderStep', ...
    slider_step, 'Max', maxVal, ...
    'Min', minVal, 'Value', 6.5);
  
```

uicontrol

text

edit

pushbutton

radiobutton

checkbox

listbox

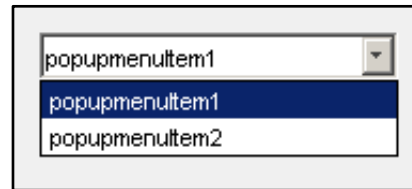
slider

popupmenu

togglebutton

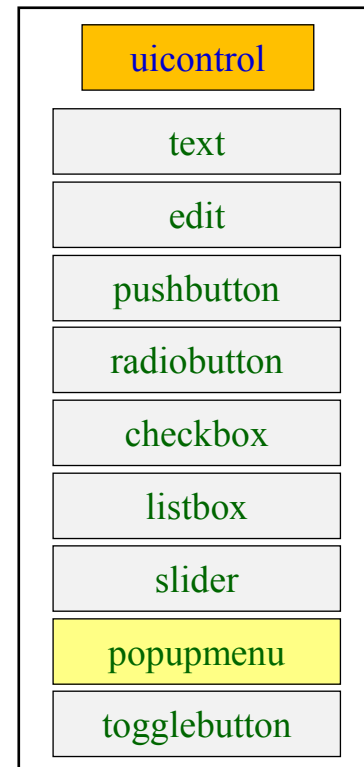
Group uicontrol: popupmenu

- clicking on arrow displays item list and enables to choose one item
 - string contains list of strings
 - value contains index of the selected item
- more info >> doc `uicontrol`



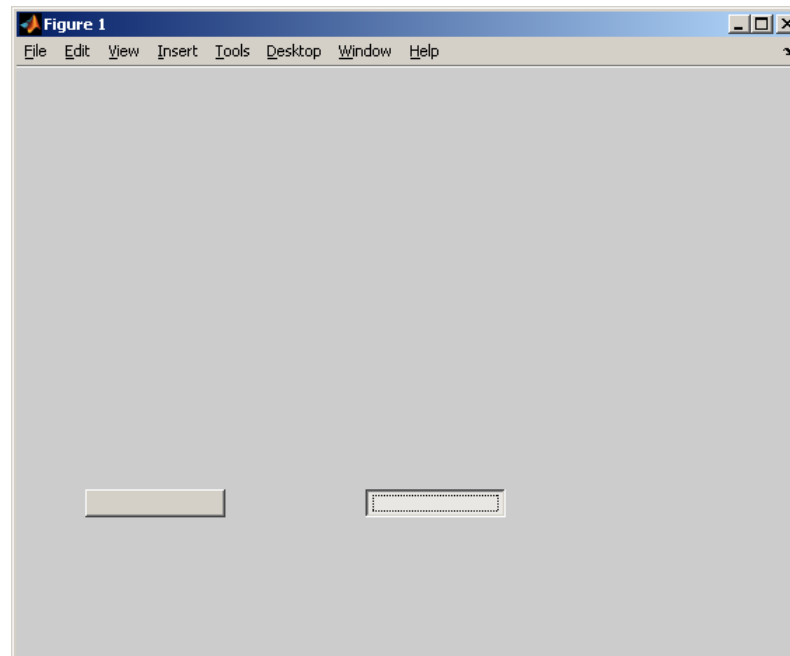
```
function popupFcn(hObject) % treated
val = get(hObject, 'Value');

string_list      = get(hObject, 'String');
selected_string = string_list{val};
% ...
```



Group uicontrol: togglebutton

- toggle button
 - stays turned on after clicking
- more info >> doc `uicontrol`

`uicontrol``text``edit``pushbutton``radiobutton``checkbox``listbox``slider``popupmenu``togglebutton`

Discussed functions

<code>get, set</code>	get or set object's property	•
<code>subplot</code>	placing more graphs in one figure	•
<code>plotyy, semilogy, semilogx, loglog,</code>	2D graphs with modified axis/axes	•
<code>pie, stairs, contour, quiver</code>	2D graphs	•
<code>image, imagesc</code>	draw matrix as a picture	•
<code>pie3, mesh, slice, scatter</code>	3D graphs	•
<code>colormap</code>	change colormap of a plot	•
<code>view</code>	defines view of 3D graph	•
<code>axis</code>	sets axis range	•

Exercise #1

600 s ↑

- create function with two inputs and one output

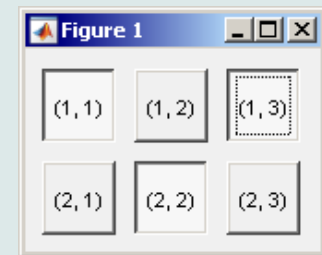
```
function logicState = createToggles(nRows, nColumns)
% function generating GUI with toggle buttons
```

- function creates figure with toggle buttons arranged in matrix nRows x nColumns
- after clicking on toggle buttons and close window function returns matrix of logical values representing state of toggle buttons

```
>> logicState = createToggles(2, 3)

logicState =

     1     0     1
     0     1     0
```



Exercise #1 - solution

Thank you!



ver. 8.1 (12/11/2017)

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Document created as part of A0B17MTB course.

