AE0B17MTB – Matlab

Part #10

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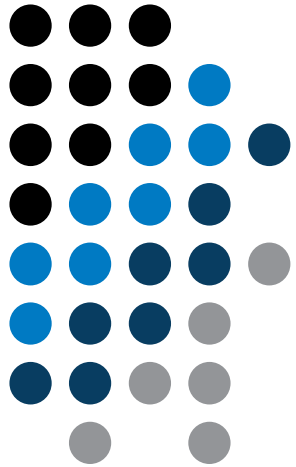
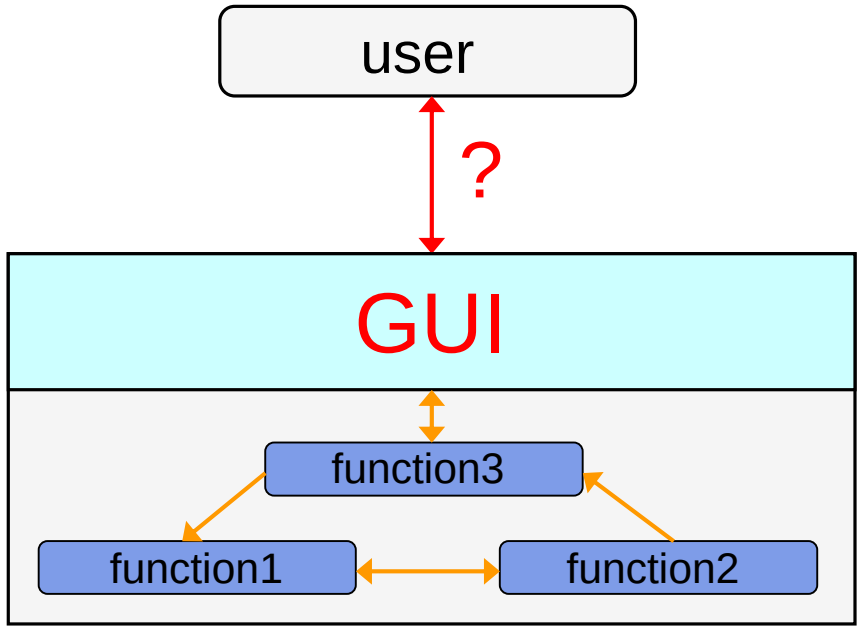


Learning how to …

GUI #2



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

Techniques of GUI design - sorting

- there exist several approaches (methodologies) to create GUI
  - design using GUIDE tool
    - not recommended

```
>> guide
```

  - design using App Designer (from R2016a)
    - new graphic objects ('old' objects are not supported)

```
>> appdesigner
```

  - switch-board technique
    - not recommended
  - utilization of side and nested functions as callback functions
    - standard
  - fully OOP approach (including functional part of the code)
    - ideal

Callback function

- there are user-evoked events defined related to each object (button click, list selection, ...)
- these events are served by so called callback functions
  - in other words, when user pushes button, callback function of this event is activated (if defined).
- when GUI is not to be static, it has to contain at least one callback function
- callback function is stored as an object property – it is possible to change it, delete it, copy it etc.

Evaluation of callback function

- callback function is evaluated as a handle function

```
hb = uicontrol('Style', 'pushbutton', 'String', 'Plot line')

% Calling function using handle function
set(hb, 'Callback', @myFunc)
```

```
function myFunc(hObject, callbackdata)
% Callback function always adds two basic inputs

hObject       % reference to the object raising the callback
callbackdata  % object describing event
```

Evaluation of callback function

- callback function is evaluated as an anonymous function

```
hb = uicontrol('Style', 'pushbutton', 'String', 'Plot line')

% TIP - anonymous function can be used in the case of
calling a function that doesn't support basic inputs of
callback function
set(hb, 'Callback', @(src, event)myFunc(inp))
```

```
function myFunc(inp)

inp % the input are only variables defined by user
```

Evaluation of callback function

- callback function is evaluated as a handle function

```
hb = uicontrol('Style', 'pushbutton', 'String', 'Plot line')

% Cell array, where first element is a handle function
set(hb, 'Callback', {@myFunc, inp1, ..., inpN})
```

```
function myFunc(hObject, callbackdata, inp1, ..., inpN)
% Basic inputs added to first positions again

hObject       % reference to the object raising the callback
callbackdata  % structure of various events (can be empty)

inp1, ..., inpN % other inputs
```

Evaluation of callback function

- **Ex.:** change background color of push button and change its label to 'Done' when clicked

```
function GUI
close all
hButt = uicontrol('Units', 'normalized', 'Style', 'pushbutton', 'String', ...
    'pushbutton', 'ForegroundColor', 'white', ...
    'BackgroundColor', [0.7 0.2 0], 'FontWeight', 'bold', ...
    'FontSize', 11, 'Position', [0.1 0.65 0.15 0.1]);
hButt.Callback = @pressButton;
end

function pressButton(scr, event)
% scr and event are default parameters returned by callback functions
% scr   - callback source (button handle object in this case)
% event - info on event raised (sometimes usefull)

disp(scr);   % check list - object handle
  disp(event); % show info on raised event
  set(scr, 'String', 'Done', 'BackgroundColor', rand(1, 3));
end
```

Evaluation of callback function

- callback function is evaluated as a string

```
hb = uicontrol('Style', 'pushbutton', 'String', 'Plot line')

hb.Callback = 'plot(rand(20,3))';
```

- very limited possibilities
  - the string can contain variables as well
    - only the variables from `base Workspace` are evaluated correctly
  - GUI is usually created in functions
    - source handle object is not available
    - it is possible to call just scripts or main functions with predefined inputs

Callback functions – list

`Callback`	context menu, uiobjects
`CellEditCallback`	uitable
`CellSelectionCallback`	uitable
`ButtonDownFcn`	axes, figure, button group, panel, uiobjects
`ClickedCallback`	push tool, toggle tool
`CreateFcn, DeleteFcn`	axes, button group, context menu, figure, menu, panel, uiobjects, …
`OffCallback, OnCallback`	toggle tool
`ResizeFcn (<R2014b)`	figure, panel, button group
`SelectionChangeFcn`	button group
`KeyPressFcn`	figure, uiobjects
`KeyReleaseFcn`	figure
`WindowButtonDownFcn`	figure
`WindowButtonMotionFcn`	figure
`WindowButtonUpFcn`	figure
`WindowKeyPressFcn`	figure
`WindowKeyReleaseFcn`	figure
`WindowScrollWheelFcn`	figure
`CloseRequestFcn`	figure

Callback functions – list

`Callback`	context menu, uiobjects
`CellEditCallback`	uitable
`CellSelectionCallback`	uitable
`ButtonDownFcn`	axes, figure, button group, panel, uiobjects
`ClickedCallback`	push tool, toggle tool
`CreateFcn, DeleteFcn`	axes, button group, context menu, figure, menu, panel, uiobjects, …
`OffCallback, OnCallback`	toggle tool
`SizeChangedFcn (>=R2014b)`	figure, panel, button group
`SelectionChangeFcn`	button group
`KeyPressFcn`	figure, uiobjects
`KeyReleaseFcn`	figure
`WindowButtonDownFcn`	figure
`WindowButtonMotionFcn`	figure
`WindowButtonUpFcn`	figure
`WindowKeyPressFcn`	figure
`WindowKeyReleaseFcn`	figure
`WindowScrollWheelFcn`	figure
`CloseRequestFcn`	figure

Functions `gcf`, `gca` and `gco`

- serve to easily access identifiers of objects that are currently active, in particular:
  - `gcf` – returns identifier of current object `figure`
  - `gca` – returns identifier of current object `axes`
  - `gco` – returns identifier of the object that was last to mouse-click on (tolerance is 5 px)

```
figure
figRef = gcf
```

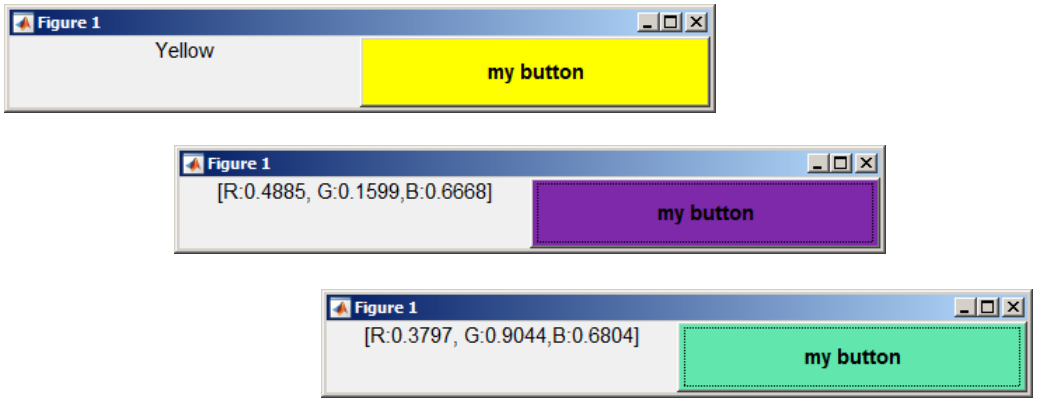
- these functions can be used as input identifiers for other functions requiring reference to object `figure` or `axes`

```
set(gcf,'color',[0 0 0])
```

Exercise – button callback

600 s ↑

- create figure with button and text box
- when clicking on button background color of button changes to random and displays individual RGB components in text box

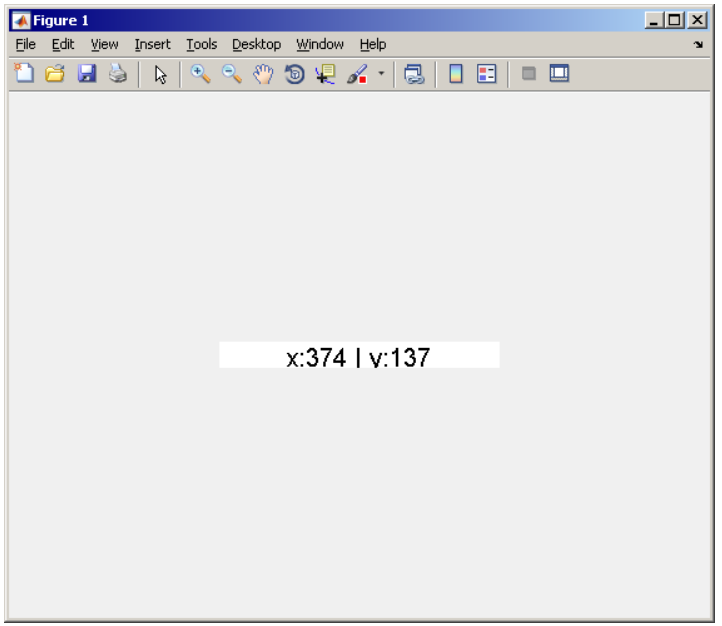


Exercise – button, solution

Exercise – mouse position

600 s ↑

- create a text array showing mouse position over `figure`.
  - figure's callback for mouse movement is `WindowButtonMotionFcn`
  - mouse position can be found in figure property `CurrentPoint`



Function `findobj`

- finds an object(s) with required property
- returns reference to the object (or an array of references)

```
>> figHndl = gcf;     % figHndl = figure;
>> axsHndl = gca;     % axsHndl = figure;
>> hTx1 = uicontrol('Style','text','String','hello','Tag','tx1');
>> hTx2 = uicontrol('Style','text','String','test1','Tag','tx2');
```

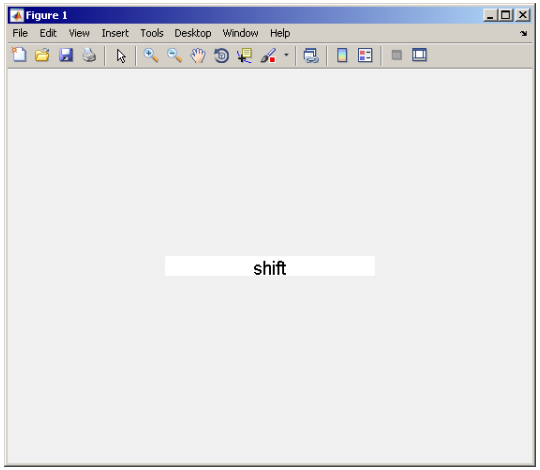
```
>> h = findobj('Style','text','-and','Tag','tx1')

h =

  UIControl (tx1) with properties:

              Style: 'text'
             String: 'hello'
    BackgroundColor: [0.9400 0.9400 0.9400]
           Callback: ''
              Value: 0
           Position: [20 20 60 20]
              Units: 'pixels'

  Show all properties
```

```
>> h = findobj('Style','text')
h =

  2x1 UIControl array:

  UIControl     (tx2)
  UIControl     (tx1)
```

Exercise – keyboard scan

600 s ↑

- create a text array that displays last key pressed
  - information on the key pressed is to be found in `event` parameter
  - figure's callback for pressing key is `WindowKeyPressFcn`
  - get the reference to the text array using `findobj`



Function `findall`, `allchild`

- `findall` finds all graphic objects (including hidden)
- `allchild` finds all children of selected object (including hidden)
  - `handle_list` can be for instance `gcf`, `gca`, ...
  - if `handle_list` is a identifier vector, Matlab returns cell array

```
clc, clear, close all
% figure with menu
hFig = figure;
% compare
hFig.Children
get(hFig, 'Children')
findobj('Parent', hFig)
allchild(hFig)
findall(hFig, 'Parent', hFig)
findall(hFig)
```

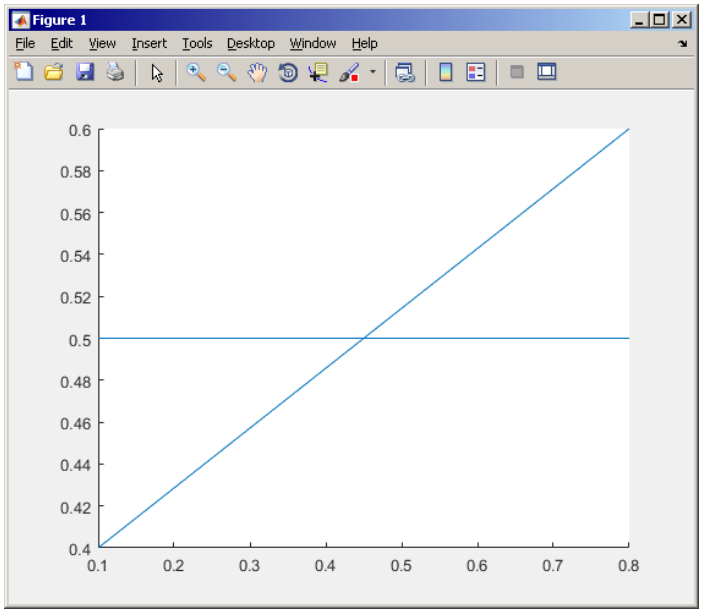
```
clc, clear, close all
% figure with menu
hFig = figure('MenuBar', 'none');
% compare
hFig.Children
get(hFig, 'Children')
findobj('Parent', hFig)
allchild(hFig)
findall(hFig, 'Parent', hFig)
findall(hFig)
```

Function copyobj

- this function enables to have an influence on lifecycle of an object
  - copies object and its descendants

- more >> doc copyobj

```
>> hf  = figure
>> ha  = axes
>> hL1 = line([0.1 0.8], [0.5 0.5])
>> hL2 = copyobj(hL1,ha)
>> set(hL2, 'YData', [0.4 0.6])
>> ishandle(hL1) && ishandle(hL2)

ans =

     1
```



Function `delete`, `reset`

- these functions enable to have an influence on lifecycle of an object
- `delete` removes file(s) or graphic object(s) together with its descendants

```
>> delete(hf) % hf see previous example
>> ishandle(hL1) && ishandle(hL2)
ans =
     0
```

- `reset` sets all values of an object back to implicit values

```
reset(h)
```

Advanced visualizing in Matlab

- function `gobjects` predefines variables

```
% preallocation
h = gobjects(3,1);

h(1) = figure;
h(2) = plot(1:10);
h(3) = gca;
class(h)
arrayfun(@class, h, ...
'UniformOutput', false)
```

- function `isgraphics()`

```
x = 1:10; y = sin(x);

p = plot(x,y);
ax = gca;

isgraphics([p, ax])
```

- function `ishandle` finds out whether variable is a handle object

```
>> figHandle = figure;
>> ishandle(figHandle)
```

  - `>> doc Graphics Object Identification`

Storing data in GUI

- how to store data in GUI?
  - global variables (extreme case, keyword `global`)
    - unacceptable
  - using property `UserData` (depends on size of the application)
    - acceptable
  - using functions `guidata` or `setappdata` and `getappdata`
    - suitable
  - fully OOP access (including functional part of the code)
    - ideal

Function `guidata`

- enables to store or get data
- the procedure is as follows:
  - get data copy: `data = guidata(object_handle)`
  - carry out data modification / calculation required
  - if the data is changed, store `guidata(object_handle,data)`
- data is therefore related to a handle that exist during whole lifetime of GUI
  - data is saved in object's parent figure

Function `guidata`

```
>> hFig = figure('Toolbar', 'none');
>> allFigHndl = guihandles(hFig);
>> guidata(hFig, allFigHndl);
```

function `guihandles` returns references of all visible objects in `figure`

```
function myCallback()
% ...
myAllFigHndl = guidata(gcbo);
myAllFigHndl.time = clock;
guidata(gcbo, myAllFigHndl);
```

function `gcbo` returns reference of the object callback of which is being evaluated

Functions `setappdata`, `getappdata`

- `setappdata`: enables to define new data (pair name-value) for given application

```
clc, clear, close all

hFig = figure;
hButt = uicontrol('Parent', hFig);

setappdata(hButt, 'speedA', rand(1, 10));
```

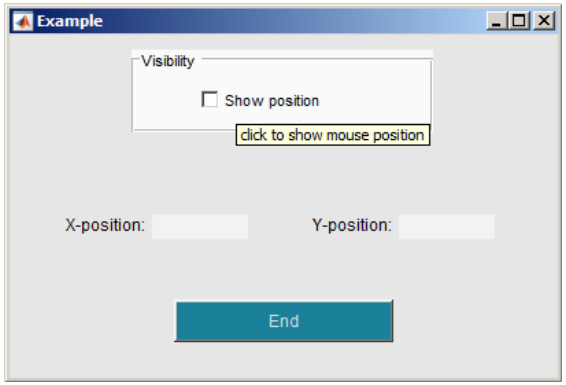
- `getappdata`: enables to get previously defined data of selected object

```
value  = getappdata(hFig, 'speedA')

% values is a structure
values = getappdata(hndl)
```

Exercise – mouse movements + buttons

600 s ↑

- create application according to picture below
  - button „End“ terminates application
    - `Callback` of `uicontrol`
  - left and right mouse button click on figure changes font type of label „X-position“ and „Y-position“ from normal to bold and vice versa
    - `WindowButtonDownFcn` of `figure` and `event` input
  - in the case checkbox is ticked, program displays cursor position
    - `Value` of `uicontrol` and `CurrentPoint` of `figure`



Exercise – mouse movements + buttons

Exercise – mouse movements + buttons

Predefined dialog windows

- The most common operations used ↔ GUI are predefined
- the most common ones are displayed below (most of them):

Function msgbox

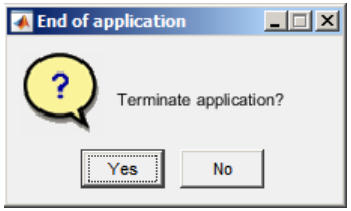
- displays message for the user

```
>> h = msgbox({'This is a message for Matlab students.', ...
               'Predefined functions save time', ...
               'Demonstration of msgbox usage.'})
```

Function `questdlg`

- displays a question, returns answer

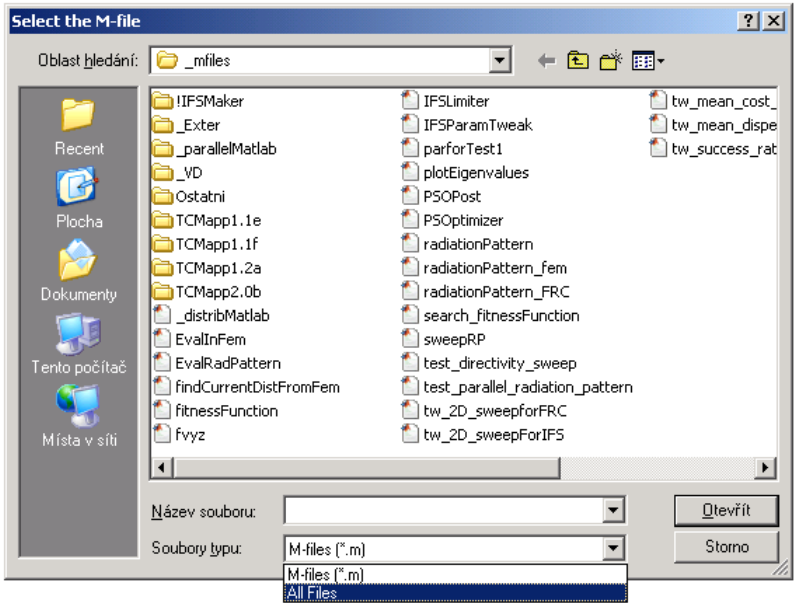
```
>> query = questdlg('Terminate application?', ...
                 'End of application','Yes','No','Yes')
```



Function `uigetfile`

- user can select file(s) from file dialog box
  - files can be filtered by their suffix

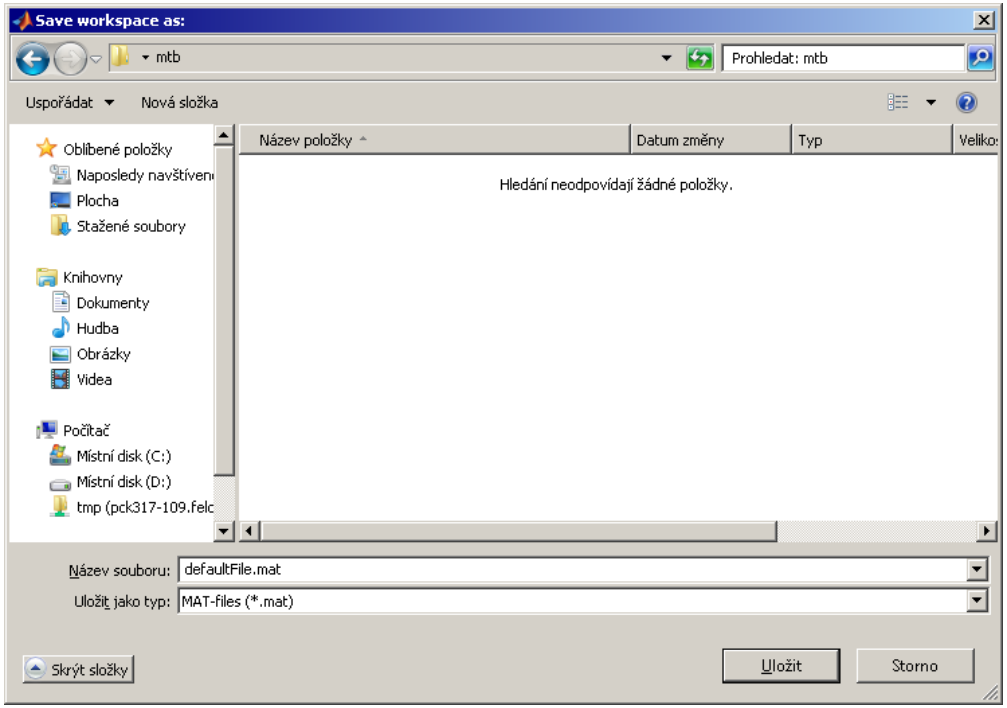
```
>> [FileName,PathName] = uigetfile('*.m', 'Select the M-file');
```



Function `uiputfile`

- opens dialog for file saving
  - files can be filtered by their suffix

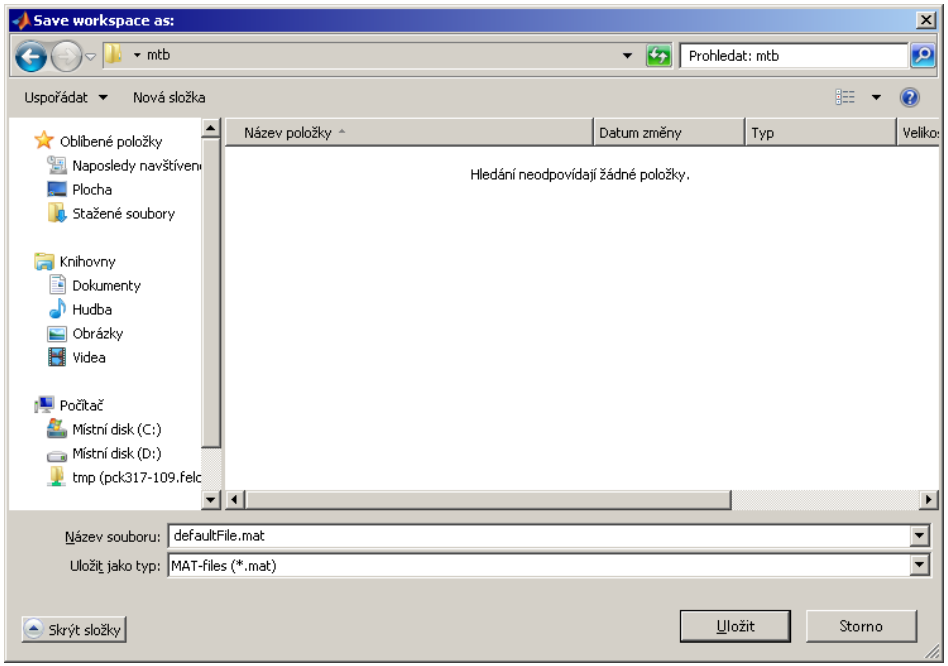
```
>> [file,path] = uiputfile('*.mat', 'Save workspace as:', ...
    'defaultFile.mat')
```



Exercise – saving into file

400 s ↑

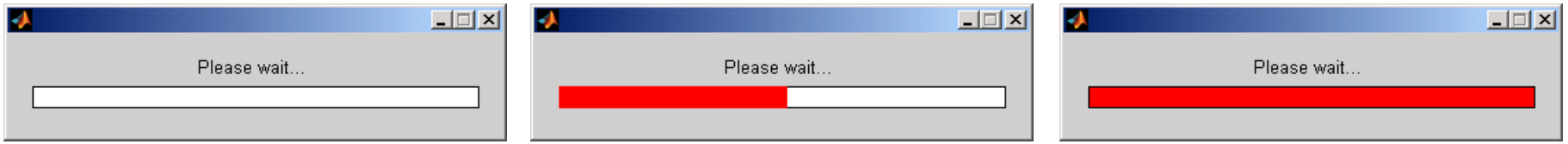
- save variable `data` from Workspace in a file using dialog box



Function `waitbar`

- displays state of a process

```
h = waitbar(0, 'Please wait...');
nsteps = 1000;
for k = 1:nsteps
    waitbar(k/nsteps);
end
close(h);
```



Design of a simple GUI #1

- what the GUI should do (detailed description of functionality)
- what are the user inputs
- required outputs

- objects used (scheme of GUI, list of elements, design of tags and properties)
- callback functions, dynamic elements

- saving of identifiers and data in GUI
- programming style

- implementation of individual parts

- getting it to work, testing...

Discussed functions

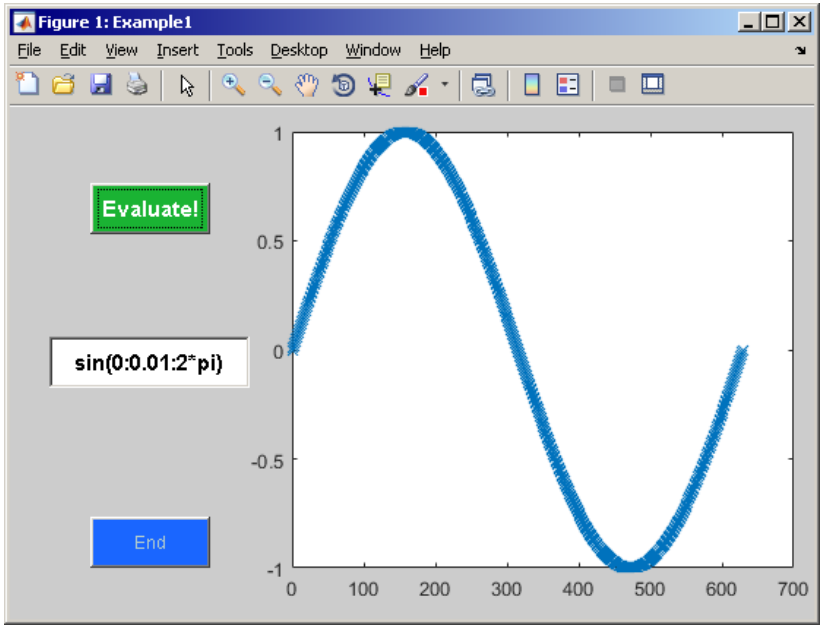
`gcf, gca, gco`	
`findobj, findall, allchild`	
`copyobj`	
`delete, reset`	
`gobjects, ishandle, isgraphics`	
`helpdlg, msgbox, warndlg, errordlg`	•
`inputdlg, listdlg, questdlg`	•
`uigetdir, uigetfile, uiopen`	•
`uiputfile, uisave`	•
`waitbar`	
`guide`	
`guidata, setappdata, getappdata`	

Exercise – displaying graph of a function

600 s ↑

- expand previous function so that it enabled to draw graph of a function defined by user
  - use `try`—`catch` to eliminate erroneous inputs
  - use function `reset` to clear graph before another drawing
  - what function do you use to evaluate the text input?

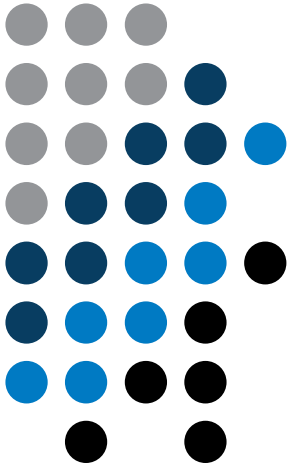
```
>> MTB_GUI1edit
```



Exercise – displaying graph of a function

Exercise – displaying graph of a function

Thank you!



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