

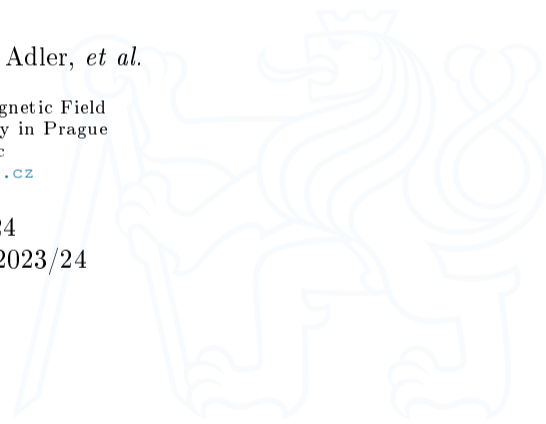
# Lecture 9: Dynamic Graphical User Interface

B0B17MTB, BE0B17MTB – MATLAB

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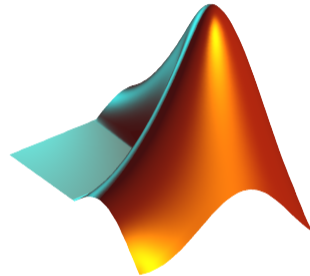
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1. Dynamic GUI
2. Exercises





# Callback Function

- ▶ There are user-evoked events related to each object (button click, list selection, slider move, ...).
- ▶ These events are served by so called callback functions.
  - ▶ In other words, when user pushes button, move slider, ..., 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.
- ▶ If a `Enable` property of an object is set to `'off'` or `false`, the callback function is not called.



# List of Callback Functions I.

---

ButtonPushedFcn	uibutton
ButtonDownFcn	uifigure
CellEditCallback	uitable
CellSelectionCallback	uitable
ClickedCallback	uipushtool, uitoggletool
ClickedFcn	uitable, uidropdown, uilistbox, uitree
CloseRequestFcn	uifigure
ContextMenuOpeningFcn	uicontextmenu
CreateFcn, DeleteFcn	all UI components and containers
DataChangedFcn	uihtml
DisplayDataChangedFcn	uitable
DoubleClickedFcn	uitable, uilistbox, uitree
ImageClickedFcn	uiimage
KeyPressFcn	uifigure
KeyReleaseFcn	uifigure
MenuSelectedFcn	uimenu

---



## List of Callback Functions II.

NodeCollapsedFcn	uitree
NodeExpandedFcn	uitree
NodeTextChangedFcn	uitree
OffCallback	uitoggletool
OnCallback	uitoggletool
SelectionChangedFcn	uibuttongroup, uitree, uitabgroup
SizeChangedFcn	uiaxes, uibuttongroup, uipanel, uitab, uitabgroup, uifigure
ValueChangedFcn	uicheckbox, uideatepicker, uidropdown, uieditfield, uilistbox, uislider, uispinner, uibutton('state'), uitextarea, uiknob, uiswitch
ValueChangingFcn	uislider, uispinner, uiknob('continuous')
WindowButtonDownFcn	uifigure
WindowButtonMotionFcn	uifigure
WindowButtonUpFcn	uifigure
WindowKeyPressFcn	uifigure
WindowKeyReleaseFcn	uifigure
WindowScrollWheelFcn	uifigure



# Evaluation of Callback Function I.

- ▶ Callback function defined as function handle without input arguments:

```
clear;
hFig = uifigure();
hButt = uibutton(hFig, 'Text', 'Plot line');
% set callback function:
hButt.ButtonPushedFcn = @plotLine;
% hButt.ButtonPushedFcn = @(a, b)plotLine(a, b);

function plotLine(hButt, eventData)
% callback function has by default two input arguments
hButt % handle to the object raising the callback
eventData % description of the event
end
```



## Evaluation of Callback Function II.

- ▶ Callback function defined as function handle with specified input arguments:

```
clear;
hFig = uifigure();
hButt = uibutton(hFig, 'Text', 'Plot line');
myVar = pi;
% set callback functions:
hButt.ButtonPushedFcn = @(src, event)plotLine(myVar);

function plotLine(myVar)
% the only input argument is the one defined by user
myVar
end
```



## Evaluation of Callback Function III.

- ▶ Callback function defined as cell variable.
  - ▶ First element is function handle without input arguments.
  - ▶ Next elements are additional input arguments.

```
clear;
hFig = uifigure();
hButt = uibutton(hFig, 'Text', 'Plot line');
myVar1 = pi;
myVar2 = 2*pi;
% set callback functions:
hButt.ButtonPushedFcn = {@plotLine, myVar1, myVar2};

function plotLine(hButt, eventData, myVar1, myVar2)
% Basic inputs added to first positions again
hButt % handle to the object raising the callback
eventData % description of the event
myVar1 % additional input
myVar2 % additional input
end
```





## Evaluation of Callback Function IV.

- ▶ Callback function defined as character vector.

```
clear;  
hFig = uifigure();  
hButt = uibutton(hFig, 'Text', 'Plot line');  
% set callback functions:  
hButt.ButtonPushedFcn = 'plot(rand(20, 3))';
```

- ▶ Very limited possibilities.
  - ▶ The string can contain variables as well.
  - ▶ Only the variables from base Workspace are evaluated correctly.
  - ▶ Handle of source object is not available.
  - ▶ It is possible to call just scripts or main functions with predefined inputs.
- ▶ **Not recommended!**



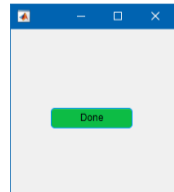
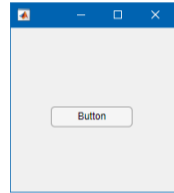
# Evaluation of Callback Function V.

- ▶ Change background color of push button and change its label to 'Done' when clicked.
- ▶ Two default input arguments of callback function utilized.

```
function GUI ()
hFig = uifigure('Position', 200*ones(1, 4));
hButt = uibutton(hFig, 'Position', [50, 50, 100, 25], ...
    'Text', 'Button');
hButt.ButtonPushedFcn = @pressButton;
end

function pressButton(src, eventData)
% src and event are default input arguments
% src - handle to the object raising the callback
% event - description of the event

set(src, 'Text', 'Done', 'BackgroundColor', rand(1, 3));
end
```



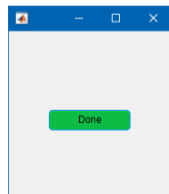
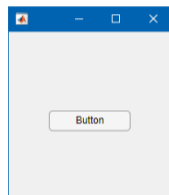
GUI



## Evaluation of Callback Function VI.

- ▶ Change background color of push button and change its label to 'Done' when clicked.
- ▶ Useless input arguments are suppressed.
  - ▶ Using `hButt` instead of `src` as the function input argument is more clear.

```
function GUI ()  
hFig = uifigure('Position', 200*ones(1, 4));  
hButt = uibutton(hFig, 'Position', [50, 50, 100, 25], ...  
    'Text', 'Button');  
hButt.ButtonPushedFcn = @(src, event)pressButton(hButt);  
end  
  
function pressButton(hButt)  
% hButt - handle to the object raising the callback  
  
set(hButt, 'Text', 'Done', 'BackgroundColor', rand(1, 3));  
end
```



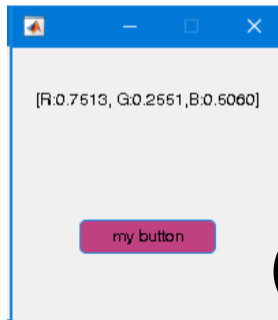
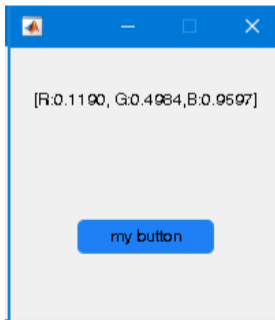
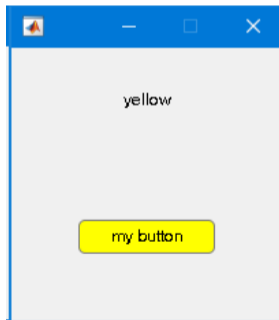
GUI



# Button Callback

- ▶ Create figure with button and label box (`uicontrol`).
- ▶ When clicking on button background color of button changes to random and displays individual RGB components in text box.
- ▶ Hint:

```
sprintf('%f, %f, %f', [1 2 3])
```



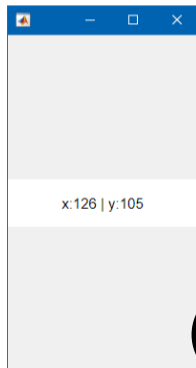
# Button Callback





# Mouse Position

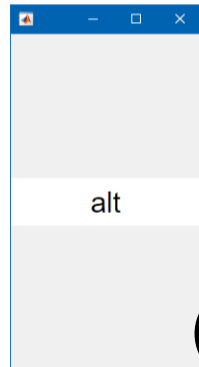
- ▶ Create a text array in a figure showing mouse position over the figure.
  - ▶ Figure's callback for mouse movement is `WindowButtonDownFcn`.
  - ▶ Mouse position can be found in figure's property `CurrentPoint`.





# Keyboard Scan

- ▶ 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`.





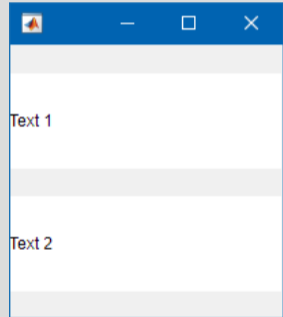
# Function findobj

- ▶ Finds an object(s) within UI container with required property.
- ▶ Returns handles of the object (or an array of handles).

```
hFig = uifigure('Position', 200*ones(1, 4));
uicontrol(hFig, 'Position', [0 110 200 70], ...
    'Text', 'Text 1', 'Tag', 'first text', ...
    'BackgroundColor', 'w');
uicontrol(hFig, 'Position', [0 20 200 70], ...
    'Text', 'Text 2', 'Tag', 'second text', ...
    'BackgroundColor', 'w');
```

```
hBothLabels = findobj(hFig, 'Type', 'uicontrol')
% or
hBothLabels = findobj(hFig, 'Tag', 'first text', ...
    '-or', 'Tag', 'second text')
```

```
hFirstLabel.HandleVisibility = false;
% first label can't be reached by findobj:
hSecondLabel = findobj(hFig, 'Type', 'uicontrol')
```





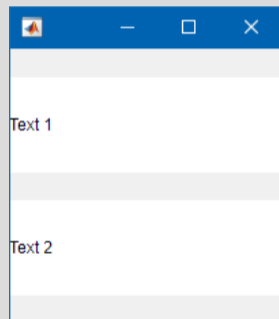


# Functions findall, allchild

- ▶ findall finds all graphic objects (including hidden).
- ▶ allchild finds all children of selected object (including hidden).

```
hFig = uifigure('Position', 200*ones(1, 4));  
uilabel(hFig, 'Position', [0 110 200 70], ...  
    'Text', 'Text 1', 'Tag', 'first text', ...  
    'BackgroundColor', 'w', ...  
    'HandleVisibility', false);  
uilabel(hFig, 'Position', [0 20 200 70], ...  
    'Text', 'Text 2', 'Tag', 'second text', ...  
    'BackgroundColor', 'w', ...  
    'HandleVisibility', false);
```

```
hAllObjs = findall(hFig)  
hBothLabels = allchild(hFig)
```



GUI

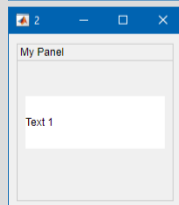
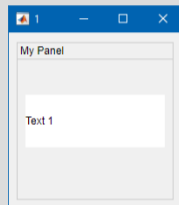


# Function copyobj

- ▶ Creates copies of graphics objects and assigns the objects to the new parent.
  - ▶ Copies object and its descendants.

```
hFig1 = uifigure('Position', 200*ones(1, 4), 'Name', '1');  
hPanel = uipanel(hFig1, ...  
    'Position', [10, 10, 180, 180], ...  
    'Title', 'My Panel');  
hText = uilabel(hPanel, ...  
    'Position', [10, 60, 160, 60], ...  
    'Text', 'Text 1', 'Tag', 'first text', ...  
    'BackgroundColor', 'w');
```

```
hFig2 = uifigure('Position', 200*ones(1, 4), 'Name', '2');  
hPanelCopy = copyobj(hPanel, hFig2)
```





# Storing Data in GUI I.

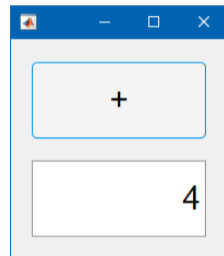
- ▶ How to store data in GUI?
  - ▶ Share variables from main function with nested functions.
    - ▶ Ideal for small applications.
  - ▶ Using property UserData.
    - ▶ Acceptable even for large applications,
    - ▶ possible to save struct with several fields.
  - ▶ Using functions `setappdata` and `getappdata`.
    - ▶ Suitable.
  - ▶ Fully OOP access (including functional part of the code).
    - ▶ Ideal, but challenging.
  - ▶ Global variables (extreme case, keyword `global`).
    - ▶ Unacceptable. **Forbidden in this course!**



## Storing Data in GUI II.

- ▶ Sharing variables between main and nested functions.
  - ▶ Shared variables must be defined within the main function!

```
function nestedGUI ()
% constants
result = 0;
% GUI building
hFig = uifigure('Position', 200*ones(1, 4));
hEdit = uieditfield(hFig, 'numeric', ...
    'Position', [20, 20 160 70], 'Value', result);
hButt = uibutton(hFig, 'Text', '+', ...
    'Position', [20, 110, 160, 70]);
set([hEdit, hButt], 'FontSize', 30);
% set callback
hButt.ButtonPushedFcn = @(src, event)increment();
function increment()
    % callback function definition
    result = result + 1;
    hEdit.Value = result;
end
end
```



GUI

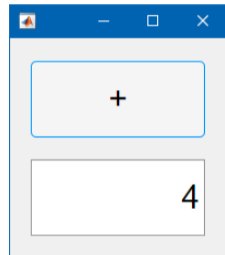


# Storing Data in GUI III.

## ► Using property UserData.

```
function userDataGUI ()
% constants
defResult = 0;
% GUI building
hFig = uifigure('Position', 200*ones(1, 4));
hEdit = uieditfield(hFig, 'numeric', ...
    'Position', [20, 20 160 70], 'Value', defResult);
hButt = uibutton(hFig, 'Text', '+', ...
    'Position', [20, 110, 160, 70]);
set([hEdit, hButt], 'FontSize', 30);
% save data
hEdit.UserData = defResult;
% set callback
hButt.ButtonPushedFcn = @(src, event)increment(hEdit);
end
```

```
function increment(hEdit)
% callback function definition
oldResult = hEdit.UserData;
newResult = oldResult + 1;
hEdit.UserData = newResult;
hEdit.Value = newResult;
end
```



GUI



## Storing Data in GUI IV.

- ▶ Functions `setappdata` and `getappdata`.
  - ▶ Enables to store or get data.
  - ▶ The graphics object must be accessible from within the functions you plan to store and retrieve the data.
  - ▶ The procedure is as follows:
    - ▶ Save the data: `setappdata(hObj, 'identifier', data)`.
    - ▶ Get data copy where needed: `data = getappdata(hObj, 'identifier')`.
    - ▶ Carry out data modification / calculation required.
    - ▶ If the data is changed, store it: `setappdata(hObj, 'identifier', data)`.
  - ▶ It is possible to save different sets of data identified by `'identifier'` argument.

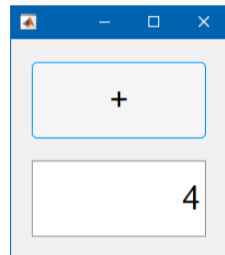


# Storing Data in GUI V.

- Functions `setappdata` and `getappdata`.

```
function setGetDataGUI()
% constants
defResult = 0;
% GUI building
hFig = uifigure('Position', 200*ones(1, 4));
hEdit = uieditfield(hFig, 'numeric', ...
    'Position', [20, 20 160 70], 'Value', defResult);
hButt = uibutton(hFig, 'Text', '+', ...
    'Position', [20, 110, 160, 70]);
set([hEdit, hButt], 'FontSize', 30);
% save data
setappdata(hEdit, 'myResult', defResult);
% set callback
hButt.ButtonPushedFcn = @(src, event)increment(hEdit);
end
```

```
function increment(hEdit)
% callback function definition
oldResult = getappdata(hEdit, 'myResult');
newResult = oldResult + 1;
setappdata(hEdit, 'myResult', newResult);
hEdit.Value = newResult;
end
```



GUI



# Storing Data in GUI VI.

- ▶ Object oriented programming.
  - ▶ Run it by `app = myApp`

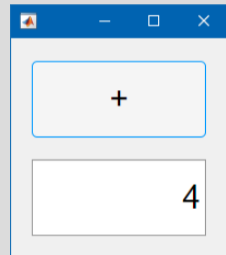
```

classdef myApp < handle
    properties (Access = private)
        hFig
        hEdit
        hButt
        result
    end

    methods
        function obj = myApp()
            obj.result = 0;
            obj.hFig = uifigure('Position', 200*ones(1, 4));
            obj.hEdit = uieditfield(obj.hFig, 'numeric', ...
                'Position', [20, 20 160 70], 'Value', obj.result);
            obj.hButt = uibutton(obj.hFig, 'Text', '+', ...
                'Position', [20, 110, 160, 70]);
            set([obj.hEdit, obj.hButt], 'FontSize', 30);
            obj.hButt.ButtonPushedFcn = @(src, event)obj.increment();
        end
    end

    methods (Access = private)
        function increment(obj)
            obj.result = obj.result + 1;
            obj.hEdit.Value = obj.result;
        end
    end
end
end

```

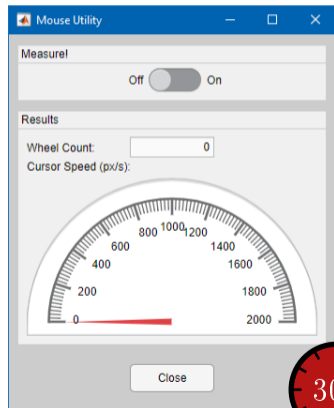






## Closing a Figure

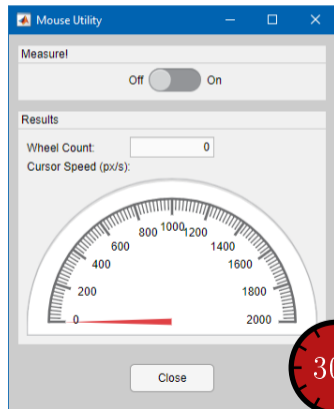
- ▶ Write callback function for Close button which closes the application figure.
  - ▶ The figure will close also when a key Esc is pushed.





# Count Wheel Steps

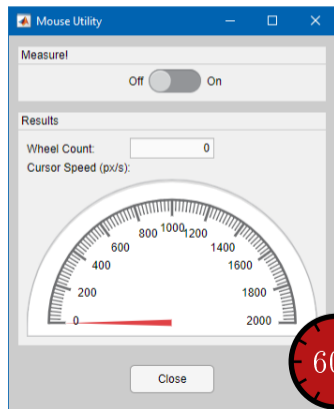
- ▶ Write a callback function for counting a number of mouse wheel steps.
- ▶ Hint: figure's callback `WindowScrollWheelFcn`, event's property `VerticalScrollCount`.





# Mouse Cursor Speed

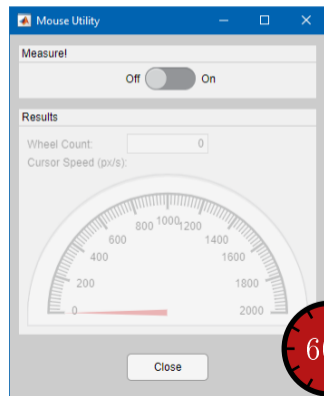
- ▶ Compute speed of a mouse cursor when moving over app figure.
  - ▶ Hints: figure's properties `CurrentPoint` and `WindowButtonMotionFcn`. Functions `clock` and `etime`.
  - ▶ Advanced: for smooth speed data compute it from several last positions and times.





## Enable Measurement with Switch

- ▶ When the switch is in Off position set property Enable of all components within Results panel to 'off'.
  - ▶ Ensure this state also when starting the application.
  - ▶ Do not call callback functions when the components are disabled.

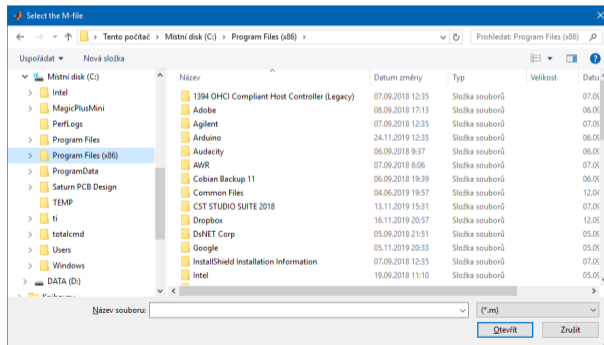




# Function uigetfile

- ▶ User can select file(s) from file dialog box.
  - ▶ Files can be filtered by their suffix.
  - ▶ It is necessary to treat the case when Cancel/Storno is pushed.

```
>> [fileName, pathName] = uigetfile('*.*', 'Select the M-file');
```

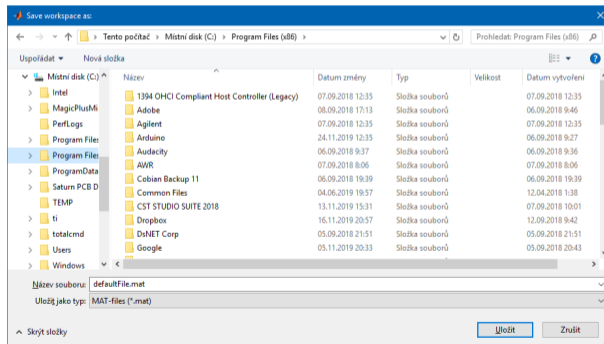




# Function uinputfile

- ▶ Opens dialog for file saving.
  - ▶ Files can be filtered by their suffix.

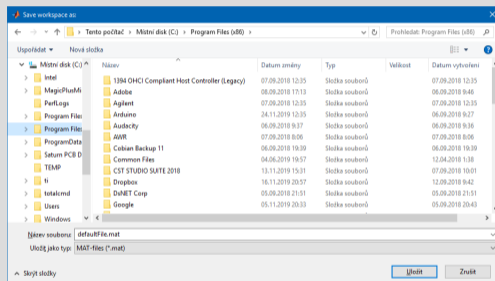
```
>> [fileName, pathName] = uinputfile('*.*mat', 'Save workspace as:', ...
    'defaultFile.mat')
```










# Saving into File

- ▶ Save variable data from Workspace in a file using dialog box.
  - ▶ Treat the case when Cancel/Storno is pushed.

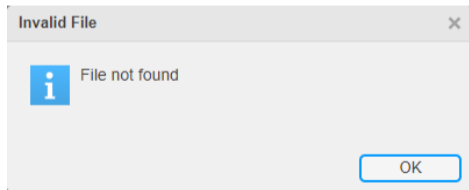




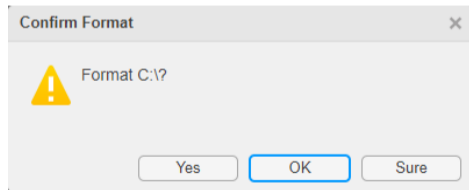
# Predefined Dialog Windows – uialert, uiconfirm

- ▶ Useful for common alerts and confirmations in application.
- ▶ Predefined icons settable via Icon property:
  - ▶ 'error' – , 'warning' – , 'info' – , 'success' – , 'question' – 

```
hFig = uifigure();
uialert(hFig, 'File not found', ...
'Invalid File', 'icon', 'info');
```



```
hFig = uifigure();
sel = uiconfirm(hFig, 'Format C:\?', ...
'Confirm Format', ...
'Options', {'Yes', 'OK', 'Sure'}, ...
'Icon', 'warning', 'DefaultOption', 2);
```





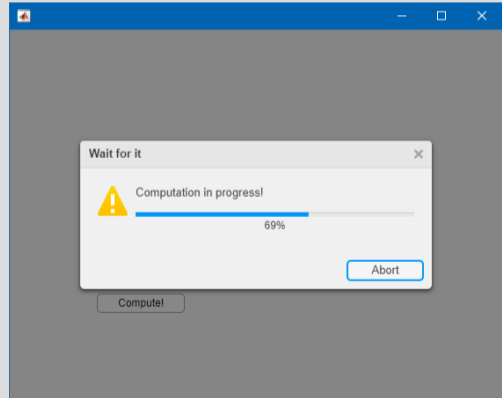


# Function uiprogressdlg

- ▶ Displays a determinate progress dialog box in figure.
- ▶ Aborting the process is possible via CancelRequested property.

```
function compWithProgress()
hFig = uifigure();
uibutton(hFig, 'Text', 'Compute!', ...
    'ButtonPushedFcn', @(a, b) compute);

function compute()
    hDiag = uiprogressdlg(hFig, ...
        'Message', 'Computation in progress!', ...
        'Title', 'Wait for it', 'ShowPercentage', true, ...
        'Cancelable', true, ...
        'CancelText', 'Abort');
    nSteps = 1e2;
    for iStep = 1:nSteps
        hDiag.Value = iStep/nSteps;
        pause(0.02);
        if hDiag.CancelRequested
            pause(1);
            hDiag.close();
            break;
        end
    end
    hDiag.close();
end
end
```





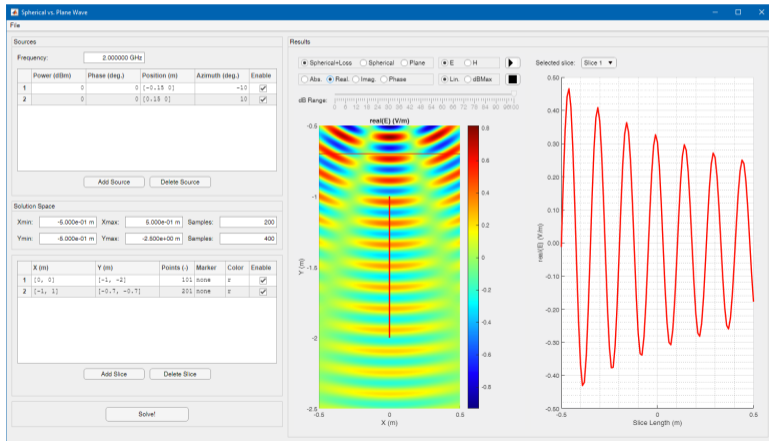
# Design of a Simple GUI – Recommended Procedure

- ▶ Consider:
  - ▶ what the GUI should do (detailed description of functionality),
  - ▶ what are the user inputs,
  - ▶ required outputs,
  - ▶ objects used (scheme of GUI, list of elements, available properties),
  - ▶ callback functions, dynamic elements,
  - ▶ saving of handles and data in GUI,
  - ▶ programming style,
  - ▶ implementation of individual parts.
- ▶ Getting it to work, testing, debugging, ...
- ▶ Proceed in small steps.



# Medium Application - Animation of Electromagnetic Field

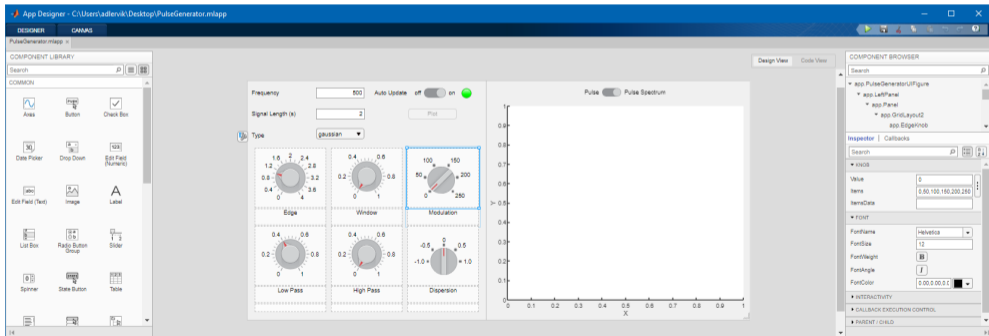
- ▶ Code is available in section “List of projects” on <https://cw.fel.cvut.cz/wiki/courses/b0b17mtb/start>.





# App Designer

- ▶ App Designer is a development environment that provides an interactive design of applications using UI components.
  - ▶ appdesigner
  - ▶ Designed application using object-oriented programming (OOP).
  - ▶ It is possible to use App Designer for semester projects.

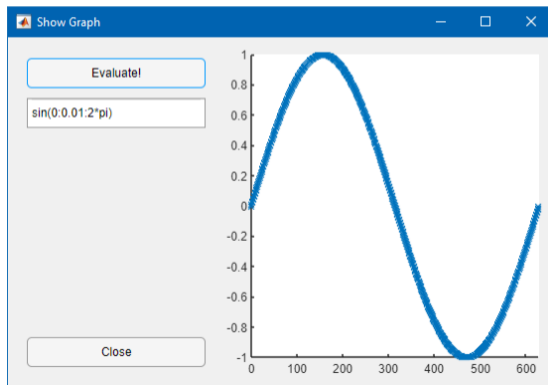


# Exercises



## Exercise I.a Displaying Graph of a Function

- ▶ Create a GUI which shows a graph of a function defined by a user.
  - ▶ Use `try-catch` to eliminate erroneous inputs.
  - ▶ Indicate somehow the erroneous input (color of edit field, `uialert`, ...)
  - ▶ What function do you use to evaluate the text input?



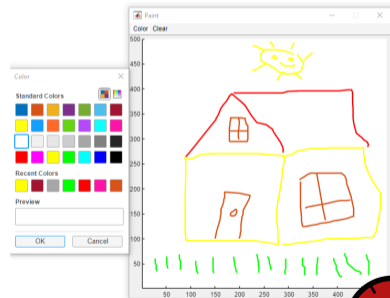
# Exercise I.b Displaying Graph of a Function





## Exercise II.a Paint

- ▶ Create an application allowing simple drawing by a mouse movements over a figure (axes).
  - ▶ Allow change of drawing color and clearing of the canvas.
  - ▶ Adding other functionality is up to you.
- ▶ Hints:
  - ▶ draw individual lines as line objects in `uiaxes` object,
  - ▶ `TightInset` property of `uiaxes` object specify border size around `uiaxes`,
  - ▶ it is necessary to transform `CurrentPoint` value of the `uifigure` to coordinates of the `uiaxes`,
  - ▶ color picker is `uisetcolor` (treat Cancel button),
  - ▶ read `CurrentPoint` property of the `uifigure` just after pushing the mouse left button.



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# Exercise II.b Paint



# Questions?

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