

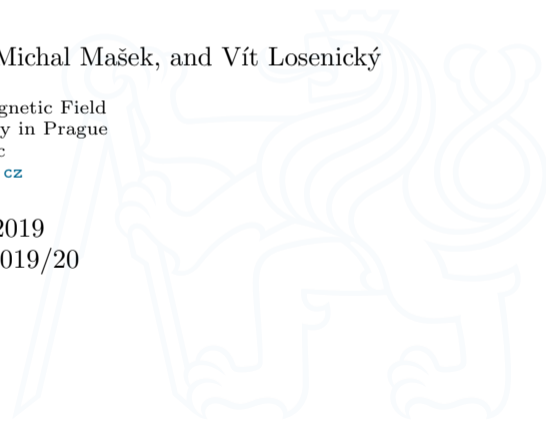
Lecture 9: Dynamic Graphical User Interface

BE0B17MTB – Matlab

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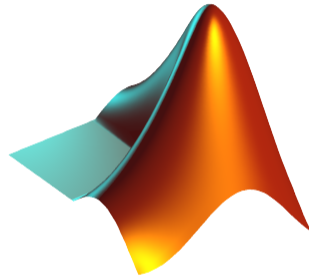
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1. Dynamic GUI
2. Exercises





Callback Function

- ▶ There are user-evoked events defined 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'**, the callback function is not called.



List of Callback Functions I.

ButtonPushedFcn	uibutton
ButtonDownFcn	uifigure
CellEditCallback	uitable
CellSelectionCallback	uitable
CloseRequestFcn	uifigure
CreateFcn	all UI components and containers
DeleteFcn	all UI components and containers
DisplayDataChangedFcn	uitable
ImageClickedFcn	uiimage
KeyPressFcn	uifigure
KeyReleaseFcn	uifigure
MenuSelectedFcn	uimenu
NodeCollapsedFcn	uitree
NodeExpandedFcn	uitree
NodeTextChangedFcn	uitree



List of Callback Functions II.

SelectionChangedFcn	uibuttongroup, uitree, uitabgroup
SizeChangedFcn	uiaxes, uibuttongroup, uipanel, uitab, uitabgroup, uifigure
ValueChangedFcn	uicheckbox, uidepicker, 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 anonymous function without input arguments:

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

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 anonymous function 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 anonymous function 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!**



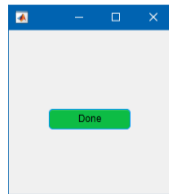
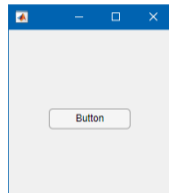
Evaluation of Callback Function V.

- ▶ 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
```





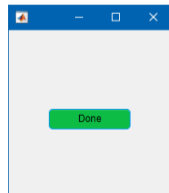
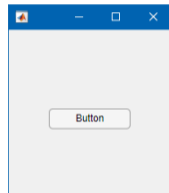
Evaluation of Callback Function VI.

- ▶ Change background color of push button and change its label to 'Done' when clicked.
- ▶ The useless input argument suppressed.

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

function pressButton(src)
% src - handle to the object raising the callback

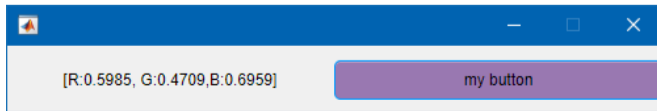
set(src, 'Text', 'Done', 'BackgroundColor', rand(1, 3));
end
```





Button Callback

- ▶ Create figure with button and label box.
- ▶ 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])`



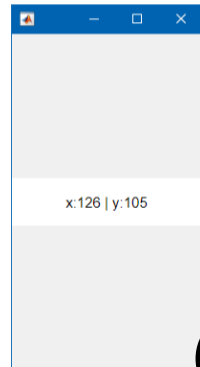
Button Callback





Mouse Position

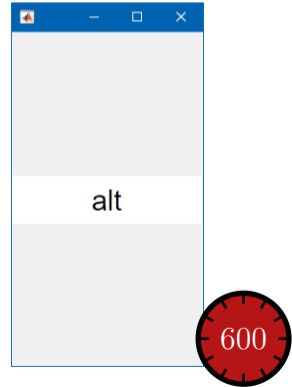
- ▶ Create a text array in a figure showing mouse position over the figure.
 - ▶ Figure's callback for mouse movement is `WindowButtonDownFcn`.
 - ▶ Mouse position can be found in figure's property `CurrentPoint`.





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`.





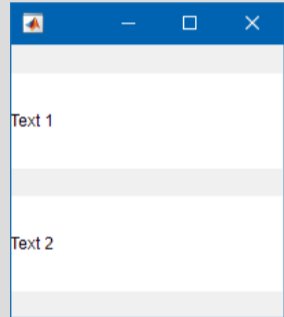
Function findobj

- ▶ 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));
xlabel(hFig, 'Position', [0 110 200 70], ...
    'Text', 'Text 1', 'Tag', 'first text', ...
    'BackgroundColor', 'w');
ylabel(hFig, 'Position', [0 20 200 70], ...
    'Text', 'Text 2', 'Tag', 'second text', ...
    'BackgroundColor', 'w');
```

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

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



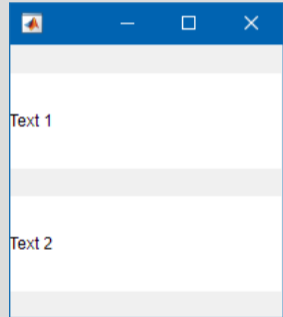


Functions findall, allchild

- ▶ 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', 'off');  
uilabel(hFig, 'Position', [0 20 200 70], ...  
    'Text', 'Text 2', 'Tag', 'second text', ...  
    'BackgroundColor', 'w', ...  
    'HandleVisibility', 'off');
```

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



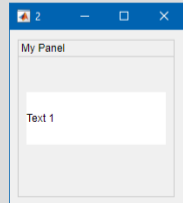
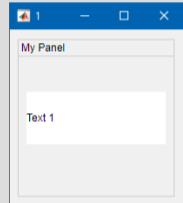


Function copyobj

- ▶ 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.

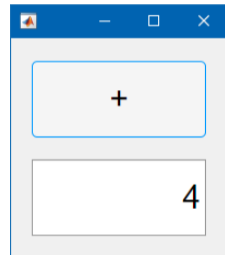
- ▶ How to store data in GUI?
 - ▶ Share variables from main function with nested functions.
 - ▶ Ideal for small applications.
 - ▶ Using property `UserData`.
 - ▶ Acceptable even for large applications.
 - ▶ Using functions `setappdata` and `getappdata` (or `guidata`).
 - ▶ Suitable.
 - ▶ Fully OOP 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
```



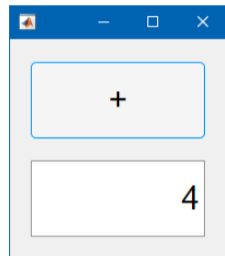


Storing Data in GUI III.

► 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
```





Storing Data in GUI IV.

- ▶ Functions `setappdata` and `getappdata`.
 - ▶ Enables to store or get data.
 - ▶ Data is related to a handle that exist during whole lifetime of GUI.
 - ▶ Data is actually saved in object's parent figure!
 - ▶ Arbitrary descendant of the figure object can be used to retrieve the data.
 - ▶ The procedure is as follows:
 - ▶ Save the data: `setappdata(hObject, 'identifier', data)`.
 - ▶ Get data copy where needed: `data = getappdata(hObject, 'identifier')`.
 - ▶ Carry out data modification / calculation required.
 - ▶ If the data is changed, store it: `setappdata(hObject, 'identifier', data)`.
 - ▶ It is possible to save different sets of data identified by `'identifier'` argument.

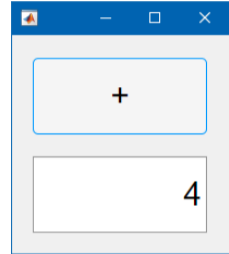


Storing Data in GUI V.

► 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
```



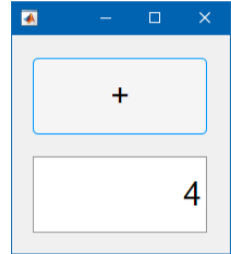


Storing Data in GUI VI.

► Function guidata.

```
function guidataGUI
% 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
guidata(hEdit, defResult);
% set callback
hButt.ButtonPushedFcn = @(src, event)increment(hEdit);
end
```

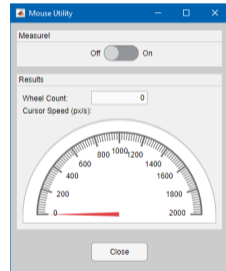
```
function increment(hEdit)
% callback function definition
oldResult = guidata(hEdit);
newResult = oldResult + 1;
guidata(hEdit, newResult);
hEdit.Value = newResult;
end
```





Closing a Figure

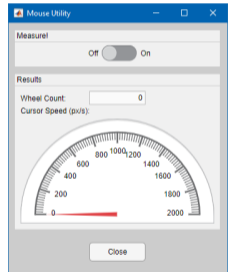
- ▶ Write callback function for Close button which close the application figure.
 - ▶ The figure will close also when a key Esc is pushed.





Count Wheel Steps

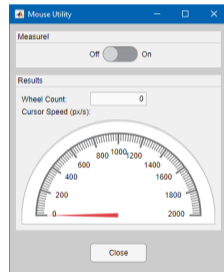
- ▶ Write a callback function for counting a number of mouse wheel steps.
- ▶ Hint: figure's callback `WindowScrollWheelFcn`, event's property `VerticalScrollCount`.





Mouse Cursor Speed

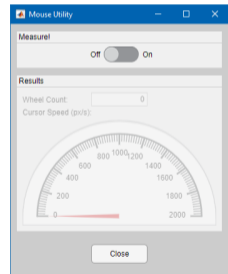
- ▶ Compute speed of a mouse cursor when moving over app figure.
 - ▶ Hints: figure's properties `CurrentPoint` and `WindowButtonMotionFcn`. Functions `clock` and `etime`.
 - ▶ Advanced: for smooth speed data compute it from several last positions and times.





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.

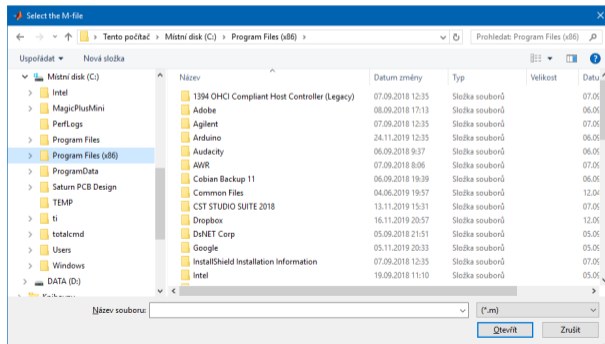




Function uigetfile

- ▶ 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('*.m', 'Select the M-file');
```

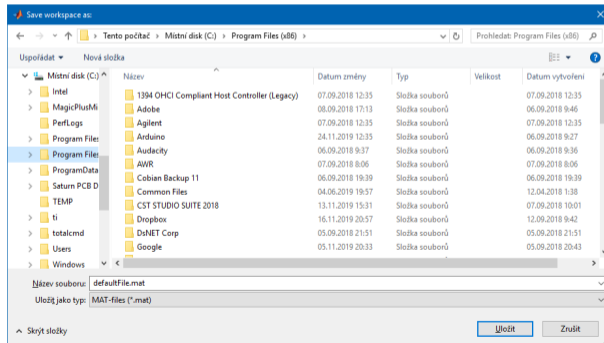




Function uiputfile

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

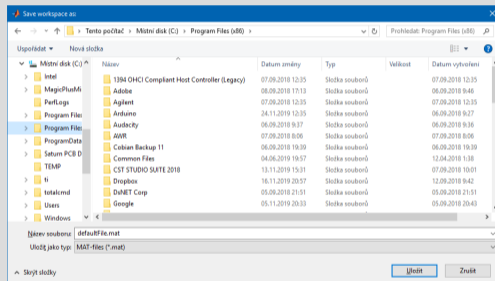
```
>> [FileName, PathName] = uiputfile('*.mat', 'Save workspace as:', ...
  'defaultFile.mat')
```










Saving into File

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

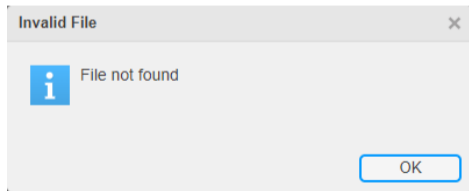




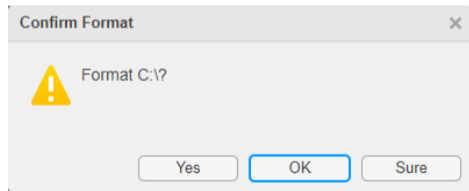
Predefined Dialog Windows – uialert, uiconfirm

- ▶ 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);
```



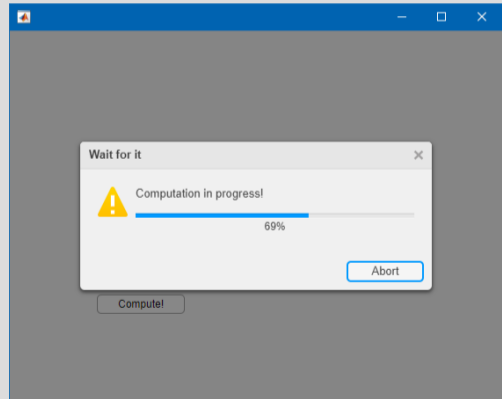


Function uiprogressdlg

- ▶ 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', 'on', ...
        'Cancelable', 'on', ...
        '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
```





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,
 - ▶ required outputs,

 - ▶ saving of handles and data in GUI,
 - ▶ programming style,

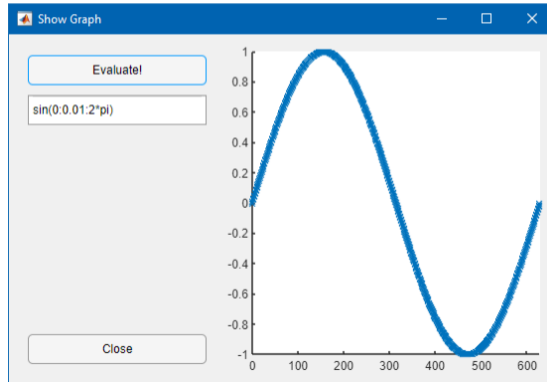
 - ▶ implementation of individual parts.
- ▶ Getting it to work, testing, debugging, ...
- ▶ Proceed in small steps.

Exercises



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?



Displaying Graph of a Function



Questions?

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