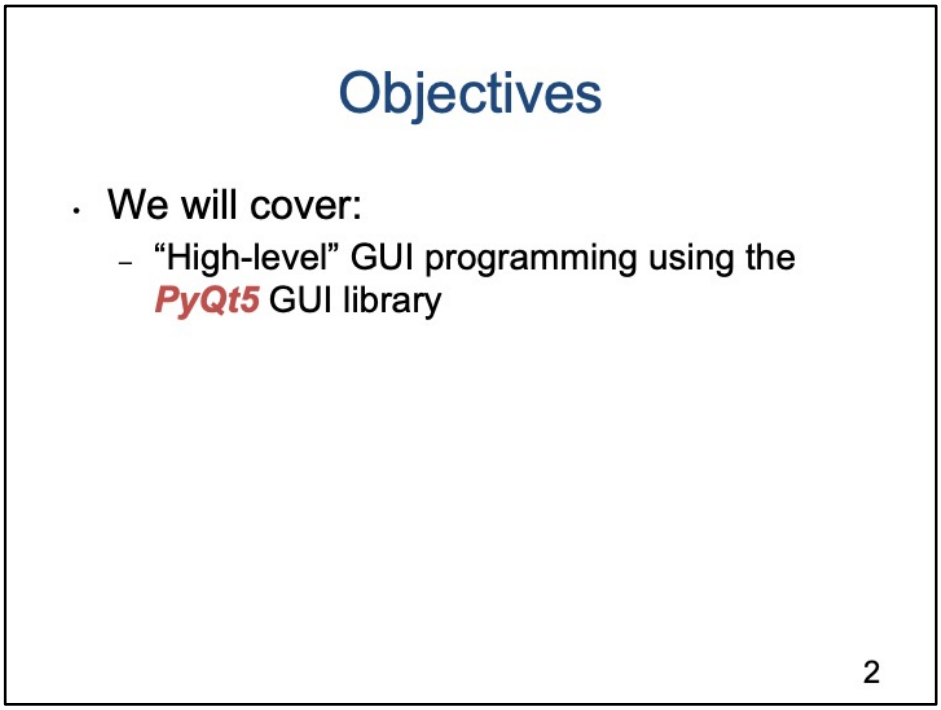
Graphical User Interface Programming (Part 2)

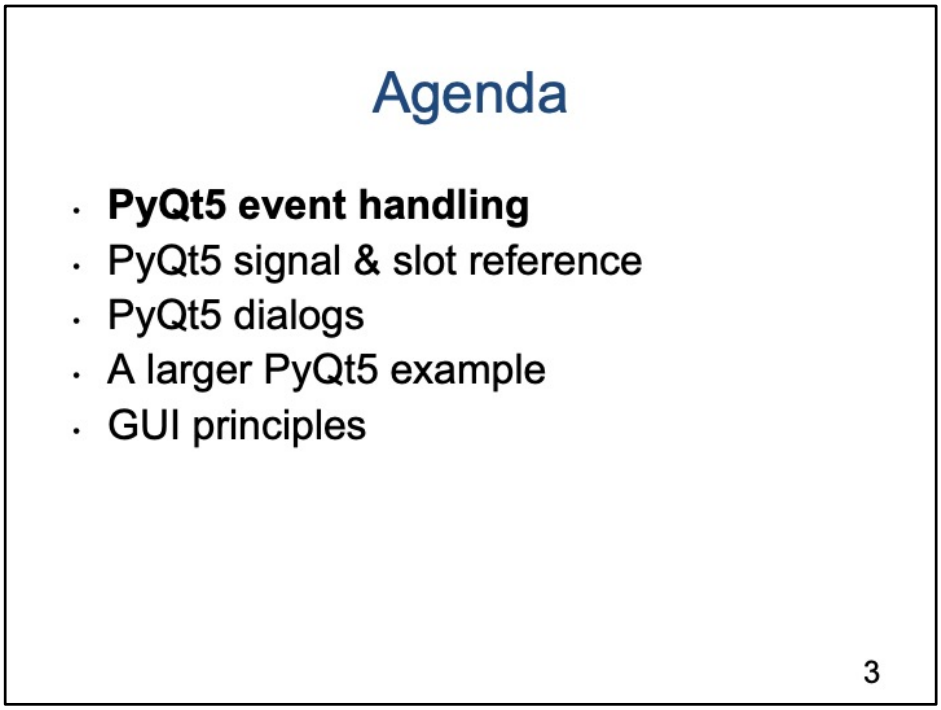
Robert M. Dondero, Ph.D.
Princeton University



Objectives

Continuing from last lecture…

[see slide]



PyQt5 Event Handling

So far we've covered:

Widgets

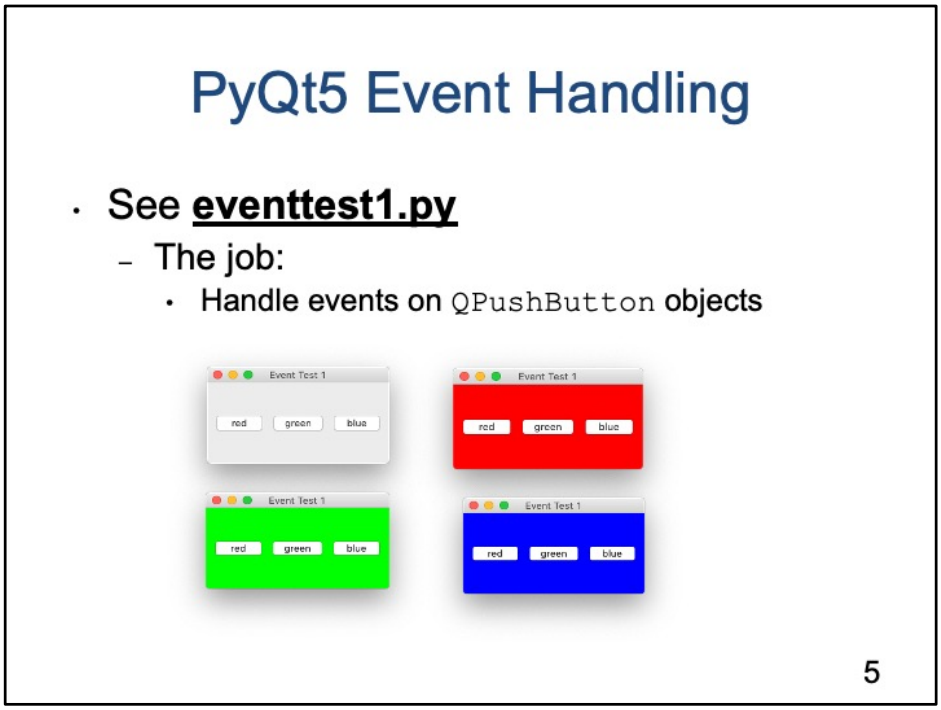
Layout management

Problem:

Widgets are inert

PyQt5 Event Handling

- PyQt5 event handling mechanism:
  - ***Signals*** & ***slots***



PyQt5 Event Handling

[see slide]

Code notes:

global window

Defines window variable to be global

Functions other than main() can access window variable

red_button.clicked.connect(red_button_slot)

Function callback mechanism

clicked is a ***signal***

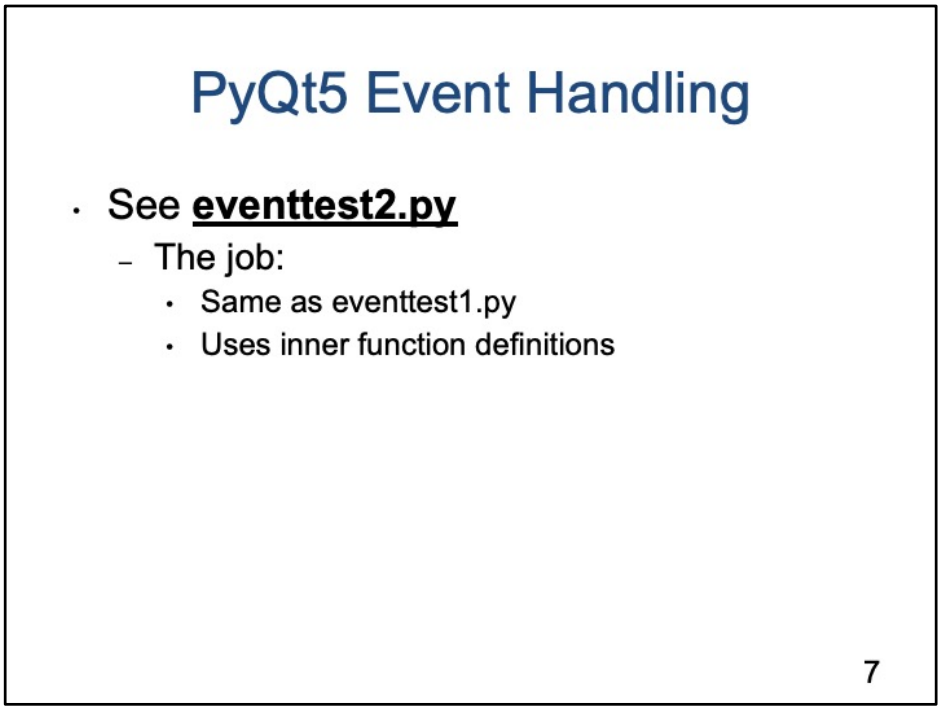
red_button is the ***receiver*** of the signal

red_button_slot is a ***slot***

red_button clicked => call red_button_slot

PyQt5 Event Handling

- **Problem**:
  - Slots often must access widgets
  - Poor style to use global variables
- **Solution**:
  - Inner function definitions…



PyQt5 Event Handling

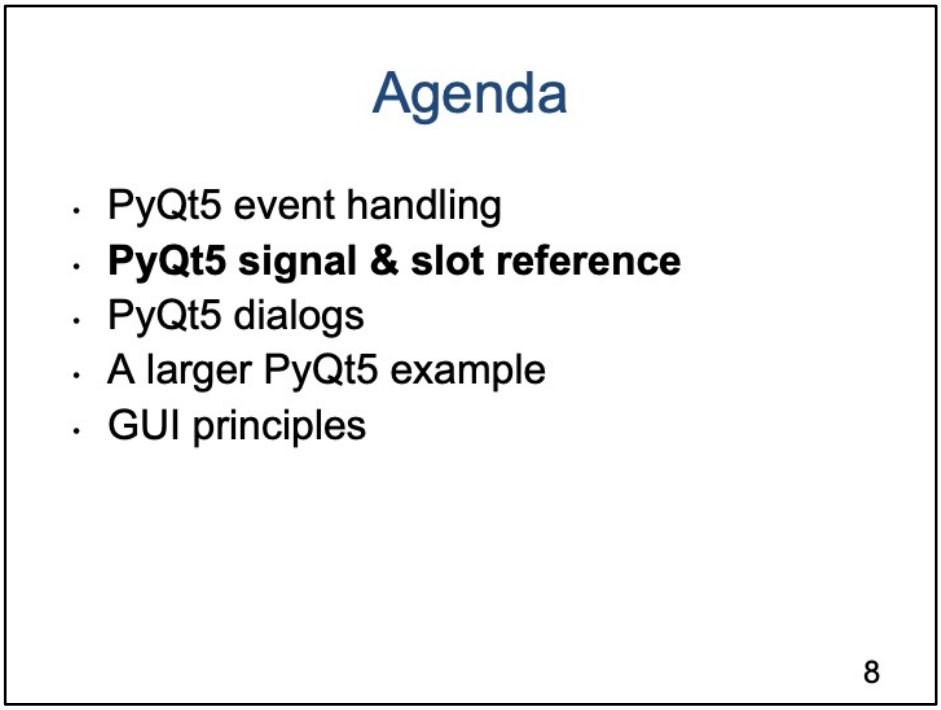
[see slide]

Code notes:

Inner function definitions

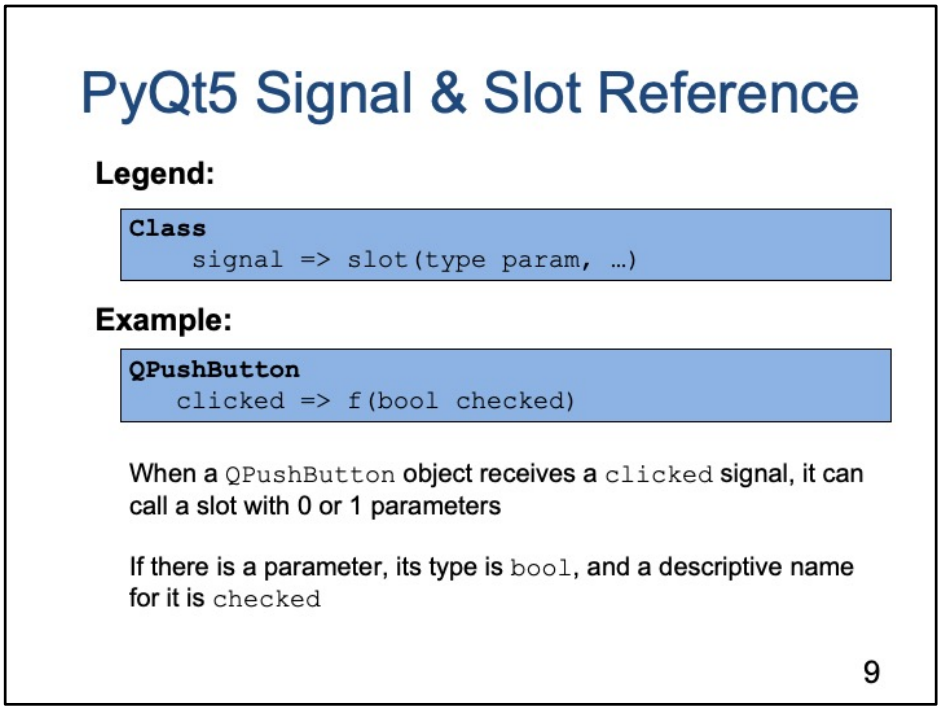
In spirit, similar to Java's inner class definition

Inner function can access variables (such as window) that are local to containing function/method



PyQt5 Signal & Slot Reference

We've seen one signal for one widget: clicked for QPushButton
There are many other signals which can be used for many other widgets



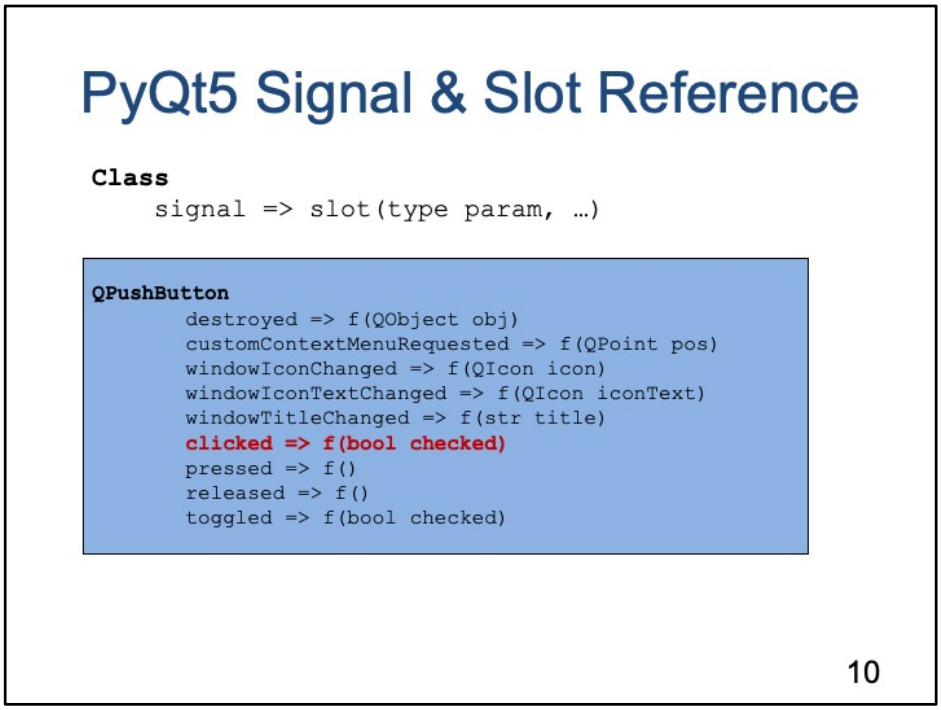
PyQt5 Signal & Slot Reference

This slide and the following multiple slides are a terse reference on the signal & slot mechanism

For each common Widget class, the slides show:

-- The signals that the widget can receive
-- The structure of the slot that you might associate with that signal

[see slide]



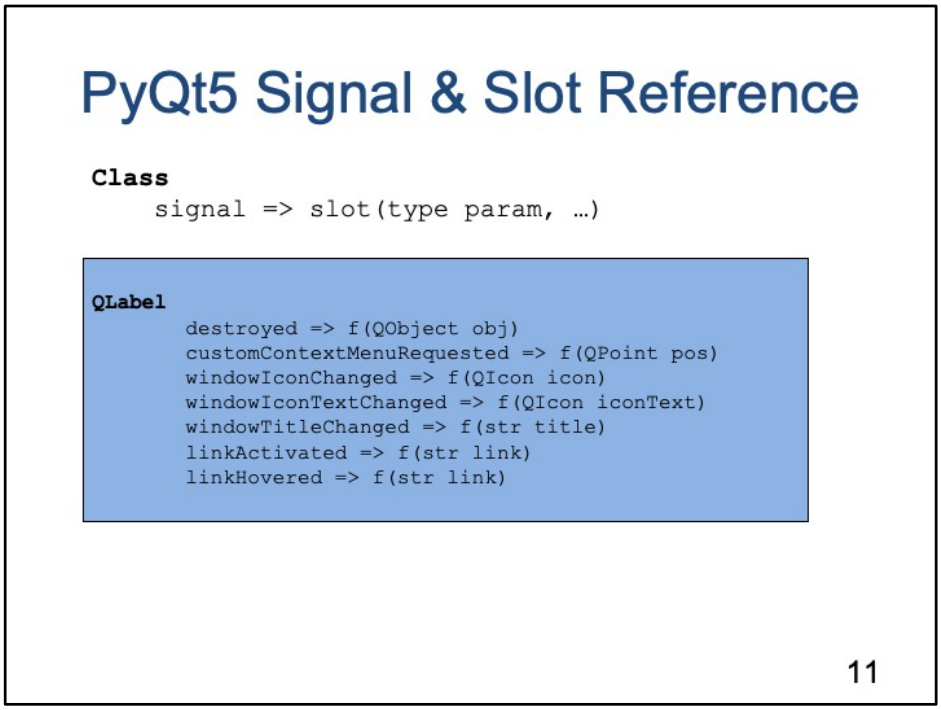
PyQt5 Event Handling

For reference

This slide shows the signals that a QPushButton object can receive.

Red indicates a signal that is often handled

A QPushButton object receives a clicked signal whenever the user clicks on the object

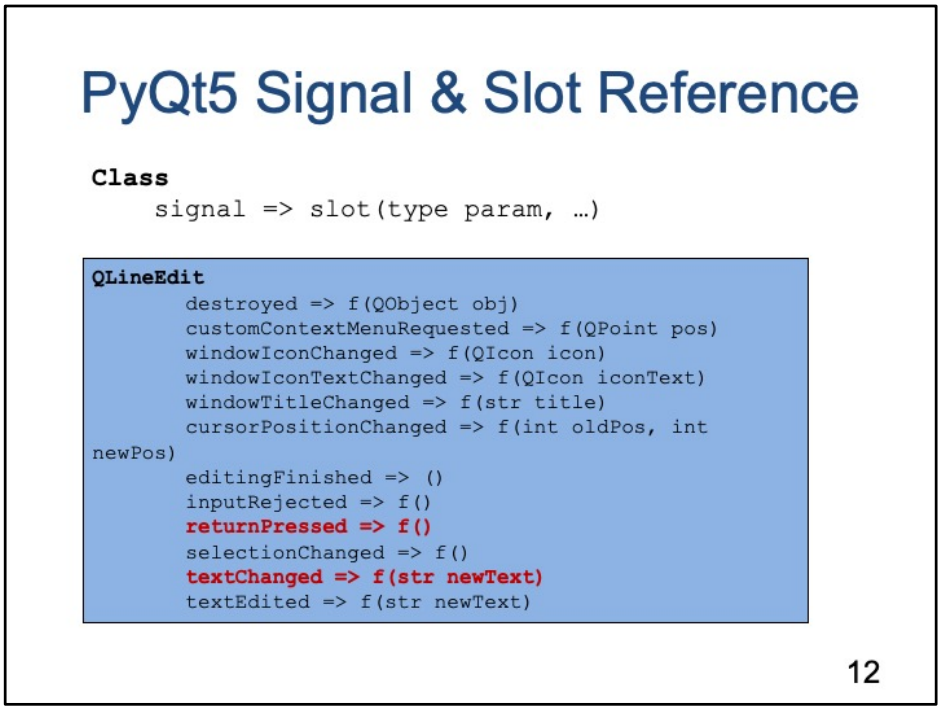


PyQt5 Event Handling

For reference

This slide shows the signals that a QLabel object can receive.

The absence of any red lines indicates that programmers rarely do signal handling for Qlabel objects



PyQt5 Event Handling

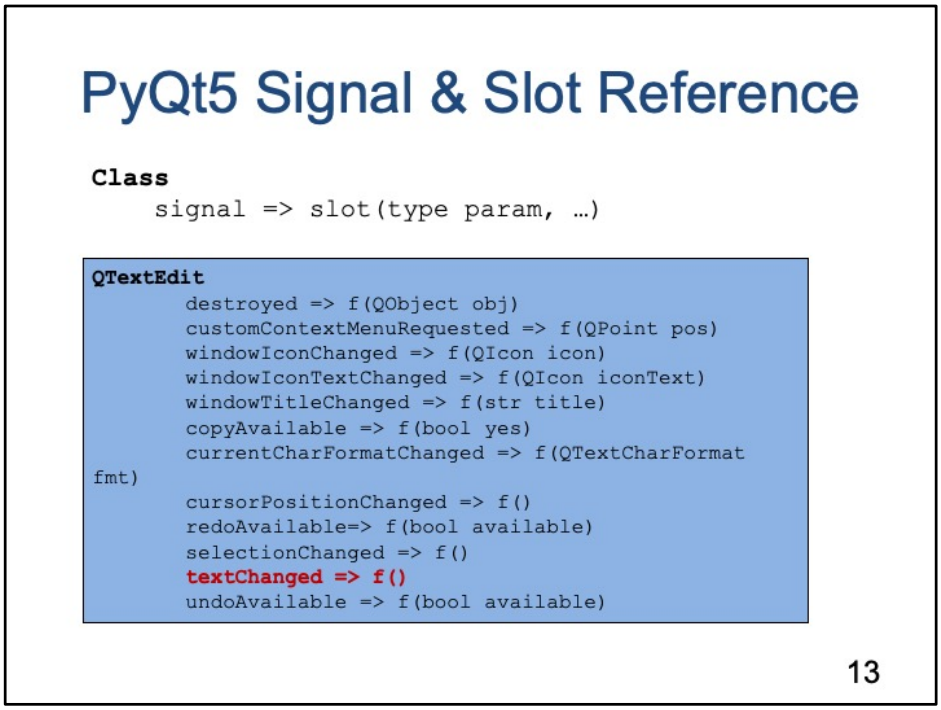
For reference

This slide shows the signals that a QLineEdit object can receive.

Red indicates signals that are often handled

A QLineEdit object receives a returnPressed signal whenever the user, having entered some text, presses the Enter key

A QLineEdit object receives a textChanged signal with each character that the user enters into the object



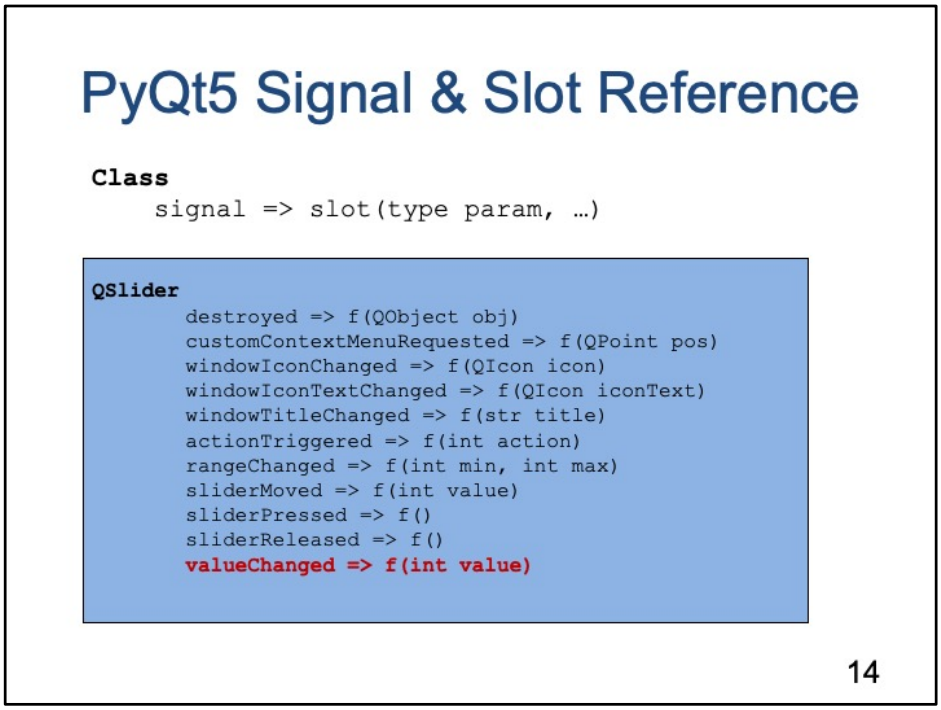
PyQt5 Event Handling

For reference

This slide shows the signals that a QTextEdit object can receive.

Red indicates a signal that is often handled

A QTextEdit object receives a textChanged signal with each character that the user enters into the object



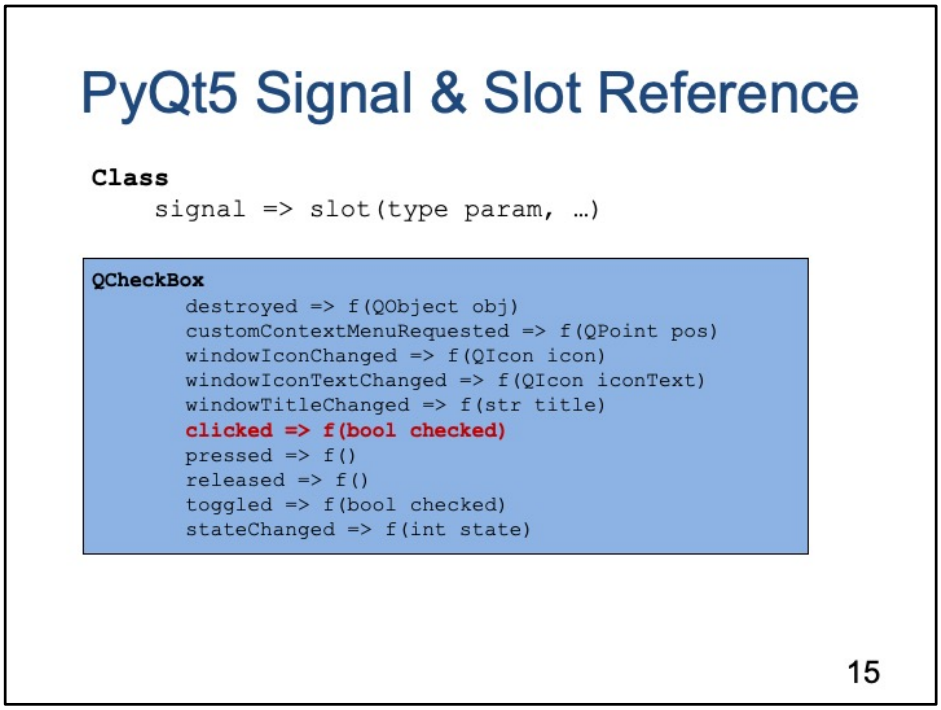
PyQt5 Event Handling

For reference

This slide shows the signals that a QSlider object can receive.

Red indicates a signal that is often handled

A QSlider object receives a valueChanged signal whenever the user moves the slider's handle



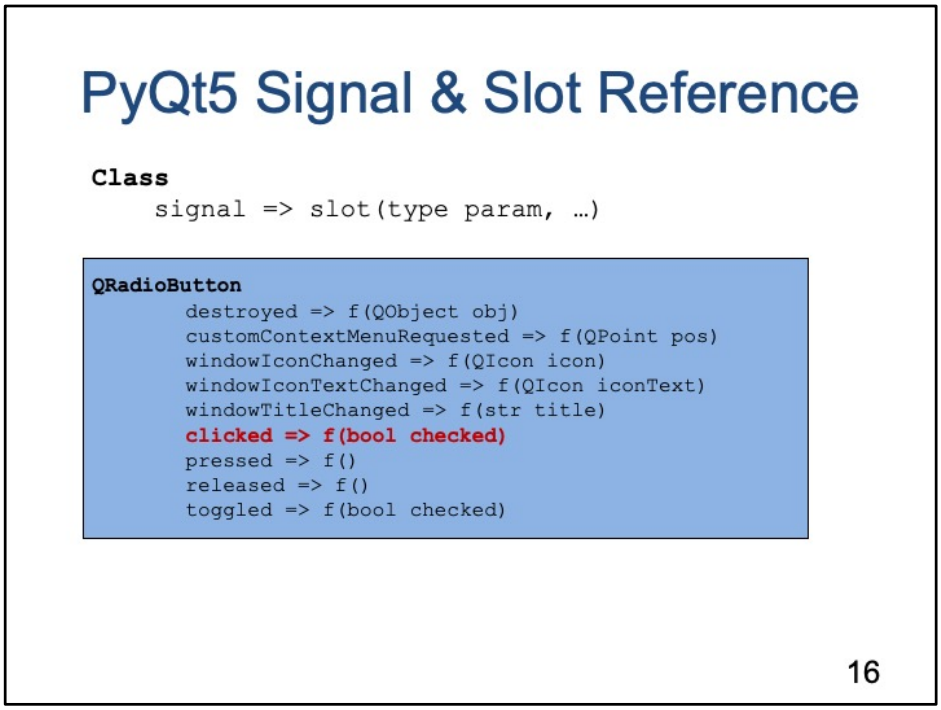
PyQt5 Event Handling

For reference

This slide shows the signals that a QCheckBox object can receive.

Red indicates a signal that is often handled

A. QCheckBox object receives a clicked signal whenever the user clicks on the object and then releases the click



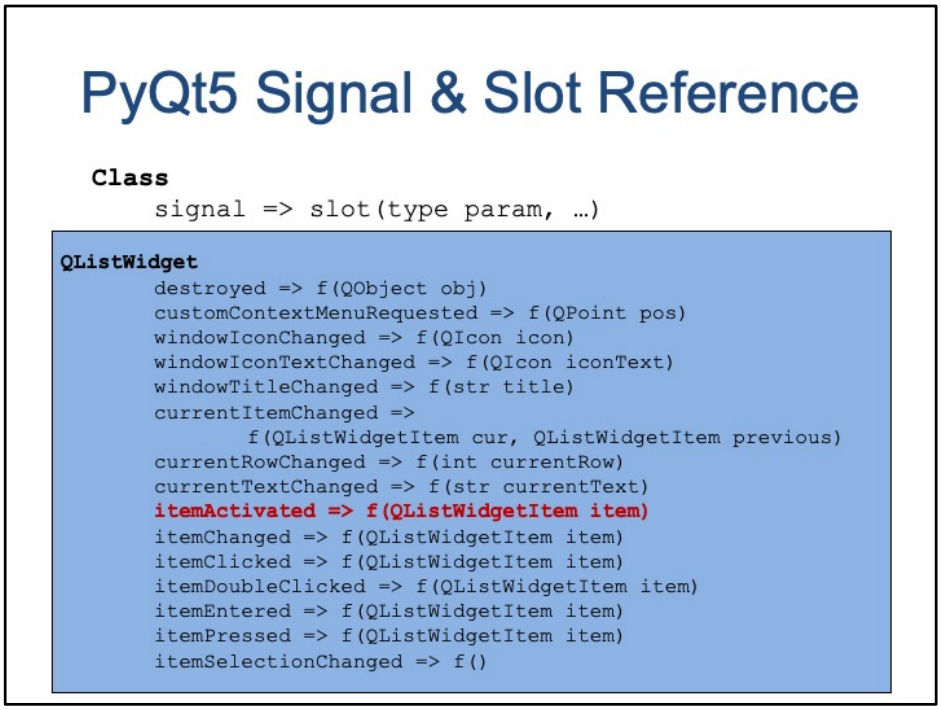
PyQt5 Event Handling

For reference

This slide shows the signals that a QRadioButton object can receive.

Red indicates a signal that is often handled

A QRadioButton object receives a clicked signal whenever the user clicks on the object and then releases the click



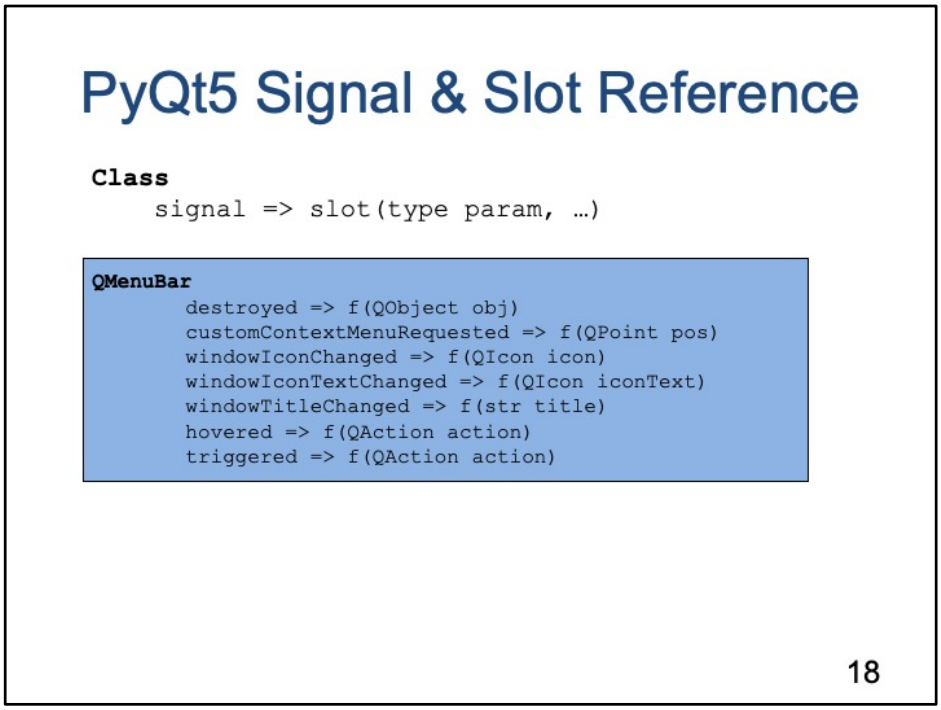
PyQt5 Event Handling

For reference

This slide shows the signals that a QListWidget object can receive.

Red indicates a signal that is often handled

A QListWidget object receives an itemActivated signal whenever the user, having selected an item, double-clicks on that item or presses the Enter key

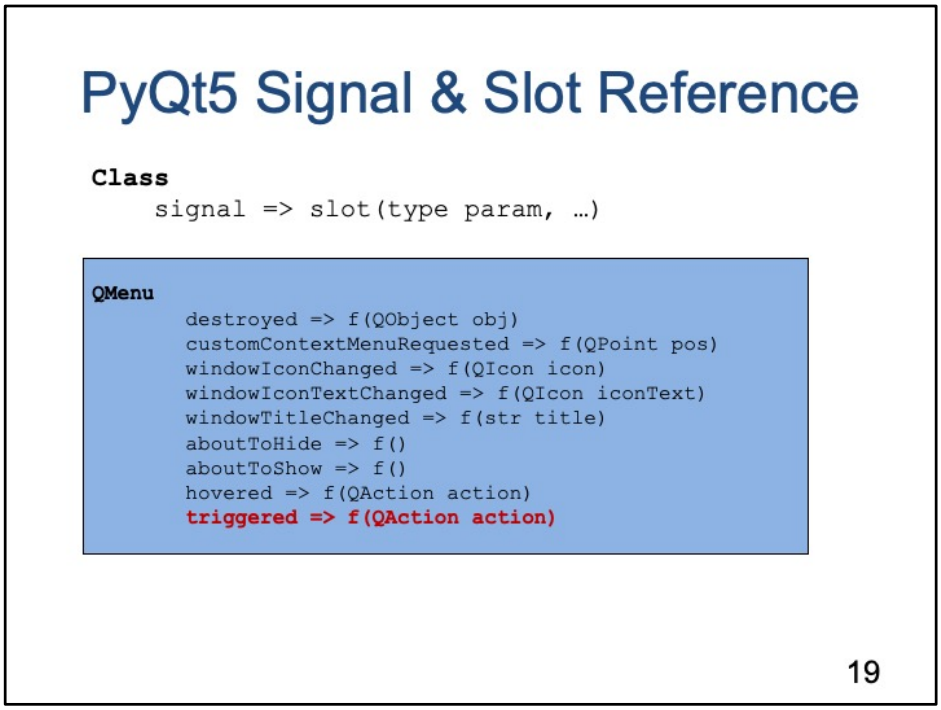


PyQt5 Event Handling

For reference

This slide shows the signals that a QMenuBar object can receive.

The absence of any red lines indicates that programmers rarely do signal handling for QMenuBar objects



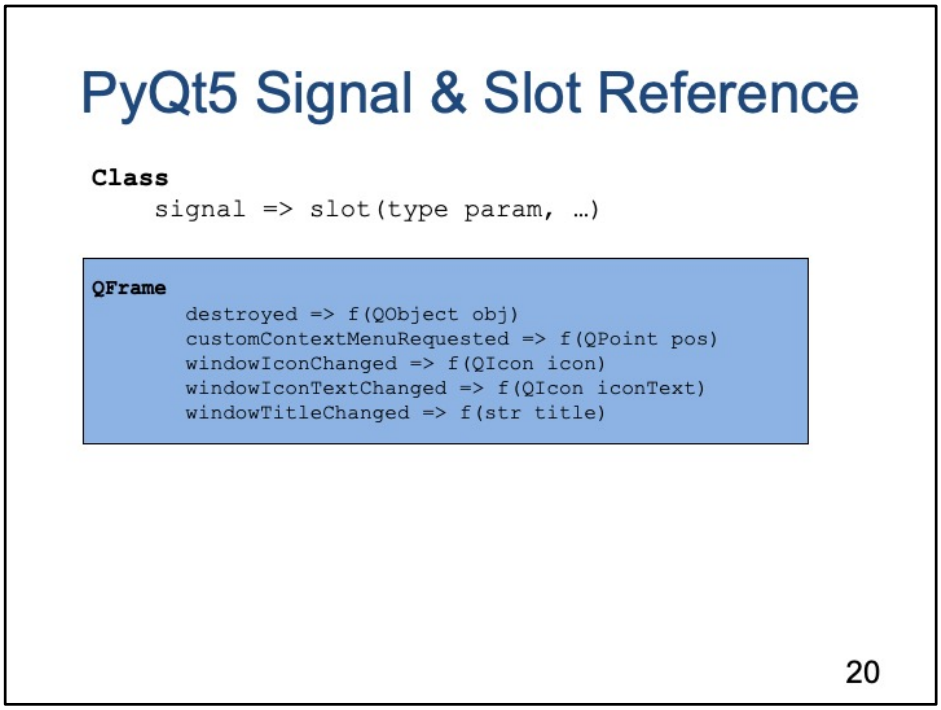
PyQt5 Event Handling

For reference

This slide shows the signals that a QMenu object can receive.

Red indicates a signal that is often handled

A QMenu object receives a triggered signal whenever the user clicks on the object and then releases the click

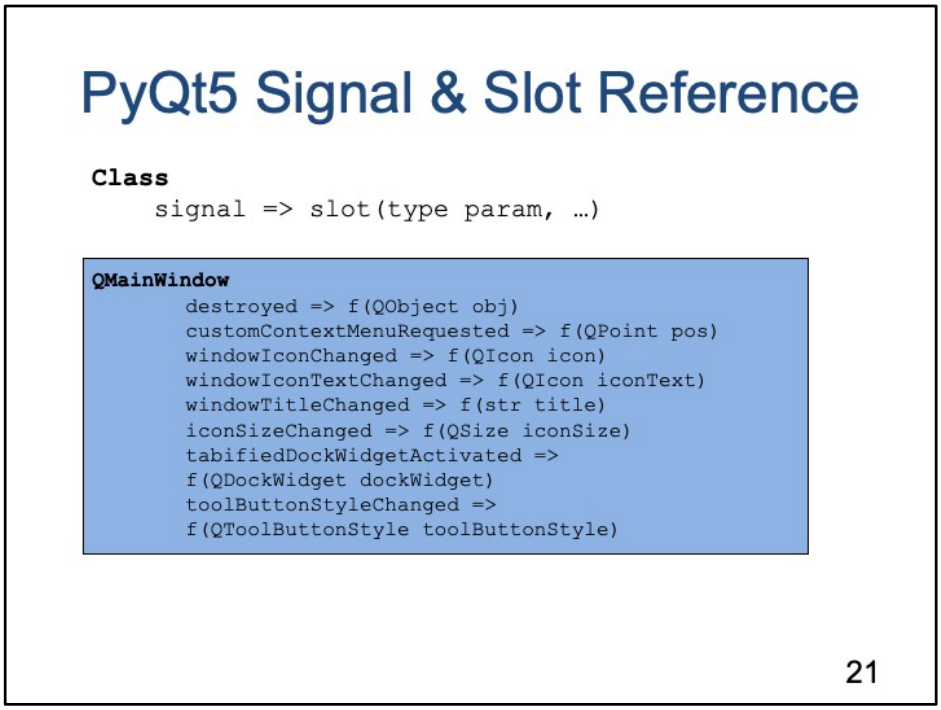


PyQt5 Event Handling

For reference

This slide shows the signals that a QFrame object can receive.

The absence of any red lines indicates that programmers rarely do signal handling for QFrame objects



PyQt5 Event Handling

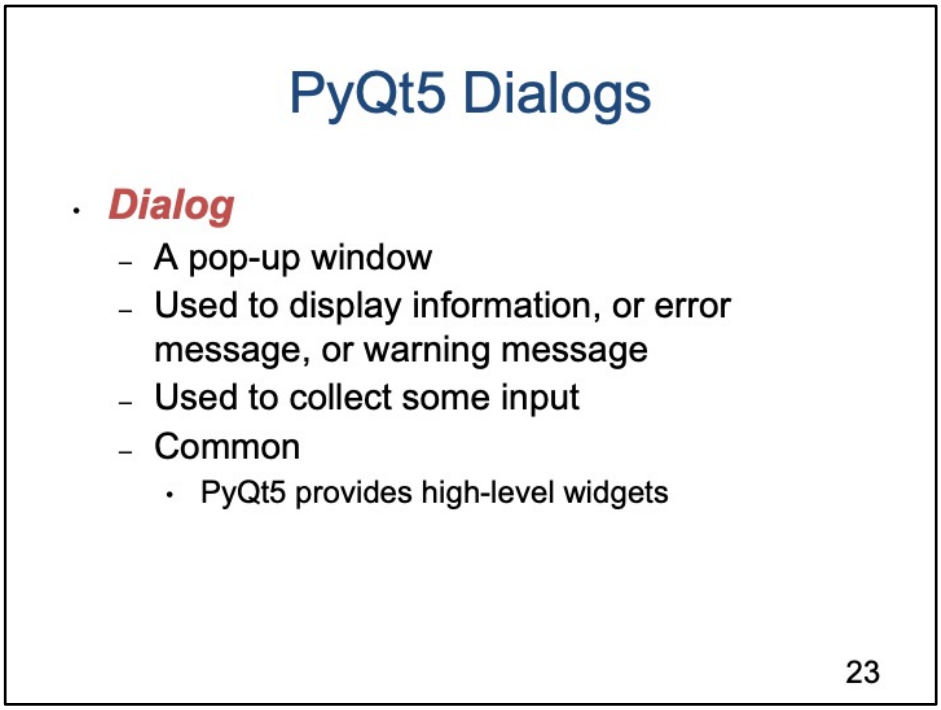
For reference

This slide shows the signals that a QMainWindow object can receive.

The absence of any red lines indicates that programmers rarely do signal handling for QMainWindow objects

Agenda

- PyQt5 event handling
- PyQt5 signal & slot reference
- **PyQt5 dialogs**
- A larger PyQt5 example
- GUI principles

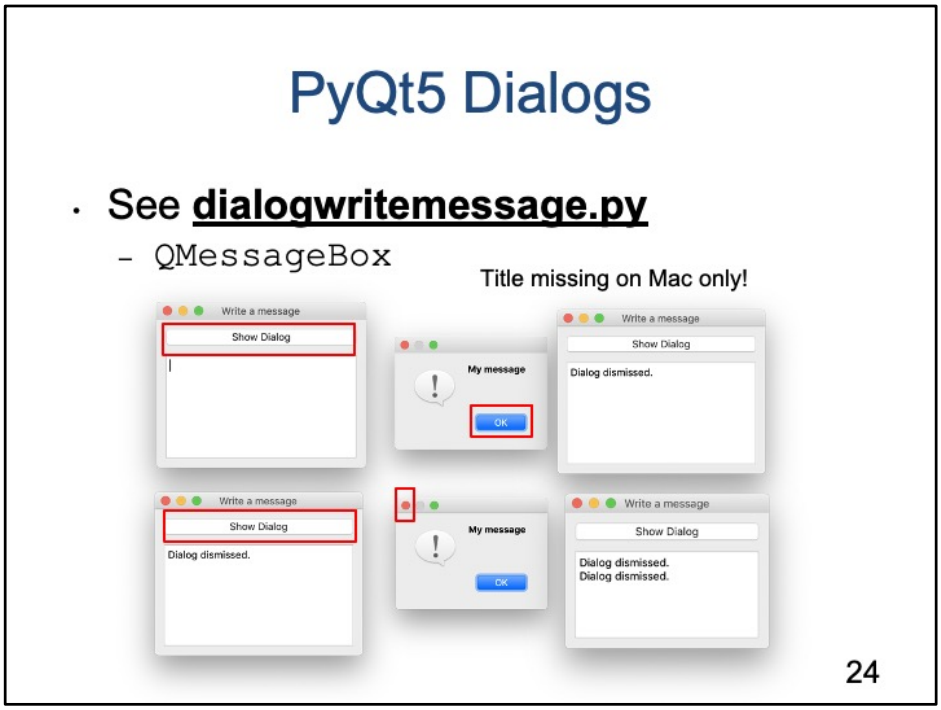


PyQt5 Dialogs

Often applications must pop up a new window to:

Temporarily display some information
Display a error/warning message
Collect some input
Etc.

That need is so common that PyQt5 provide higher level widgets specifically for such tasks



PyQt5 Dialogs

To write a message…

[see slide]

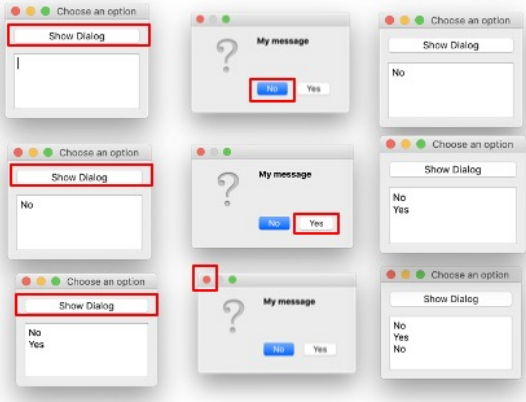
Code notes:

QMessageBox.information()

PyQt5 Dialogs

- See **dialogchooseoption.py**
  - `QMessageBox`

Title missing on Mac only!



Can't distinguish "No" vs. no response

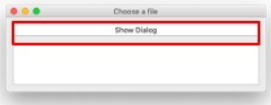
PyQt5 Dialogs

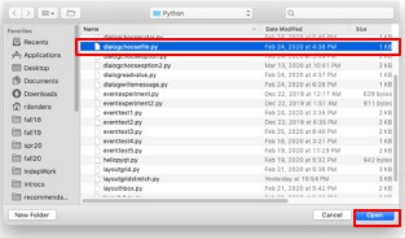
- See **dialogreadvalue.py**
  - `QInputDialog`

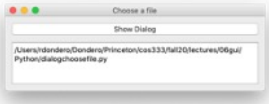
Title not missing!!!

PyQt5 Dialogs

- See **dialogchoosefile.py**
  - `QFileDialog`

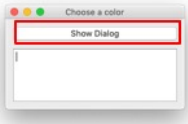


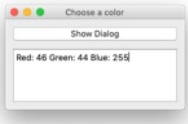




PyQt5 Dialogs

- See **dialogchoosecolor.py**
  - `QColorDialog`





PyQt5 Dialogs

PyQt5 dialog classes:

```
QWidget
   QDialog
      QMessageBox
         information()
         critical()
         warning()
         question()
      QInputDialog
         getText()
         getDouble()
         getInt()
         getItem()
         getMultiLineText()
```

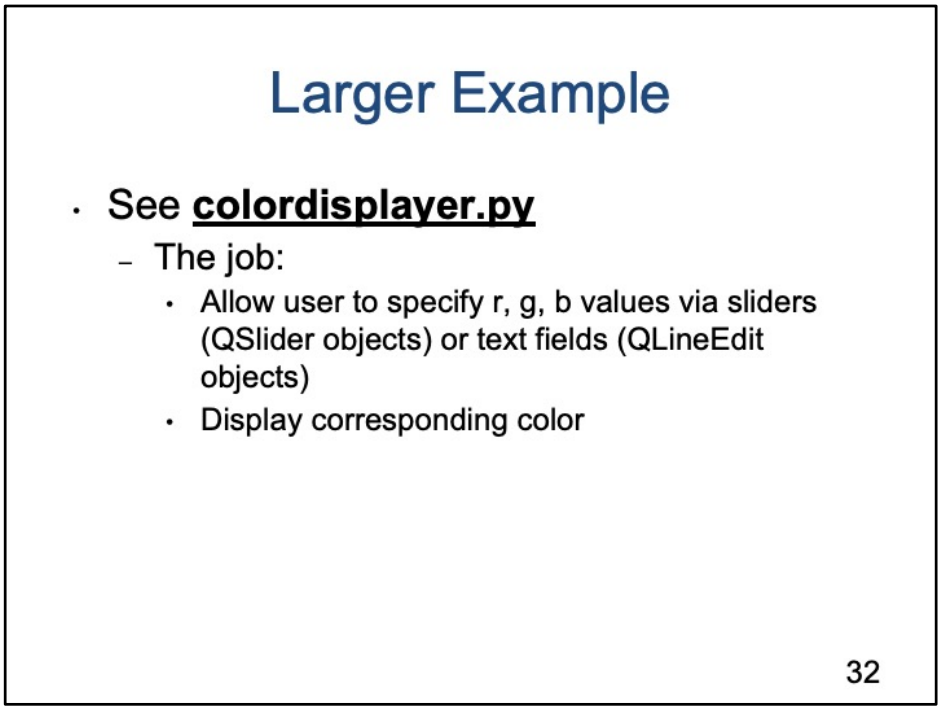
PyQt5 Dialogs

PyQt5 dialog classes:

```
QWidget
   QDialog
      QFileDialog
         getOpenFileName()
         getExistingDirectory()
         getExistingDirectoryUrl()
         getOpenFileNames()
         getOpenFileUrl()
         getOpenFileUrls()
         getSaveFileName()
         getSaveFileUrl()
         saveFileContent()
      QColorDialog
         customColor()
         customCount()
         getColor()
         setCustomColor()
         setStandardColor()
         standardColor()
```

Agenda

- PyQt5 event handling
- PyQt5 signal & slot reference
- PyQt5 dialogs
- **A larger PyQt5 example**
- GUI principles



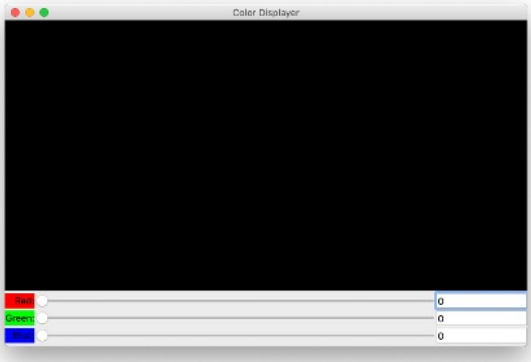
A Larger PyQt5 Example

[see slide]

Nothing new!
Slightly larger and more realistic example
Illustrates multiple interacting widgets

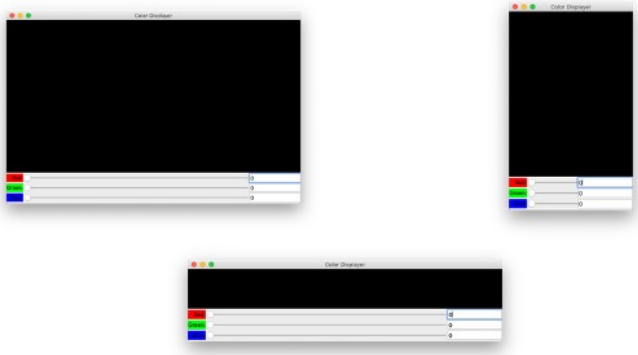
Larger Example: Behavior

- See **colordisplayer.py** (cont.)



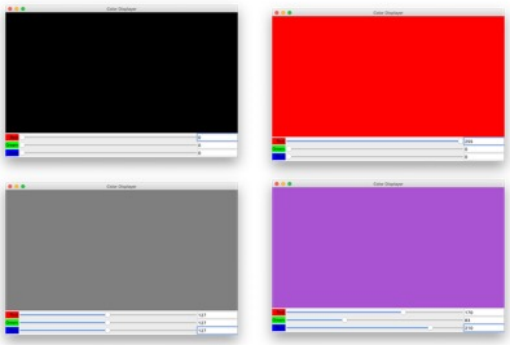
Larger Example: Behavior

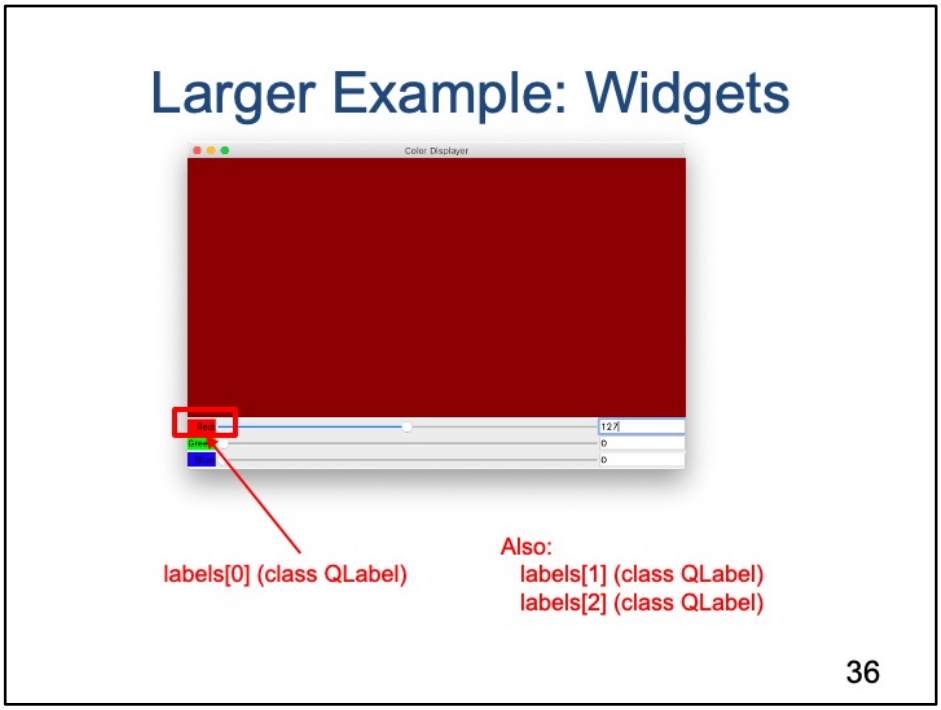
- See **colordisplayer.py** (cont.)



Larger Example: Behavior

- See **colordisplayer.py** (cont.)



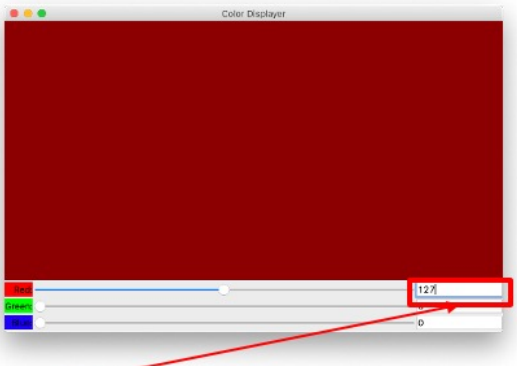


A Larger PyQt5 Example

First consider the widgets…

[see slide]

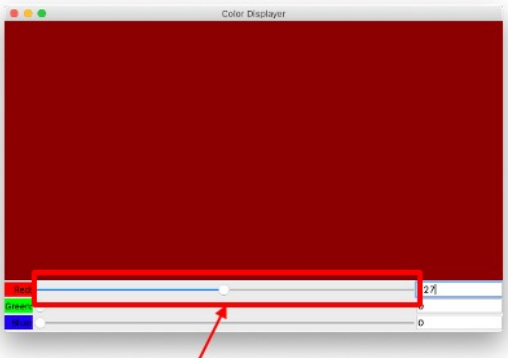
Larger Example: Widgets



lineedits[0] (class QLineEdit)

Also:
lineedits[1] (class QLineEdit)
lineedits[2] (class QLineEdit)

Larger Example: Widgets



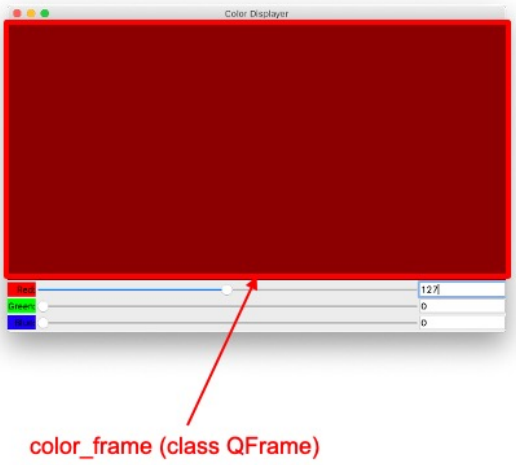
sliders[0] (class QSlider)

Also:
sliders[1] (class QSlider)
sliders[2] (class QSlider)

Larger Example: Widgets

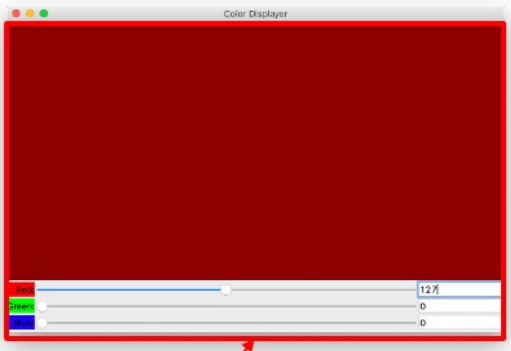
control_frame (class QFrame)

Larger Example: Widgets



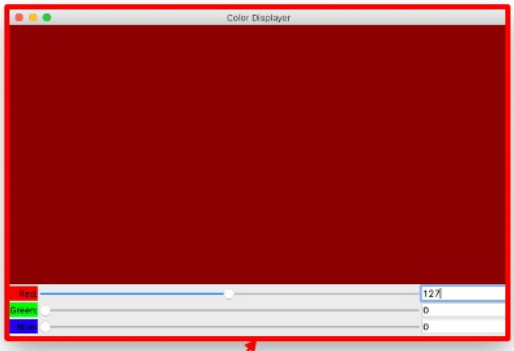
color_frame (class QFrame)

Larger Example: Widgets

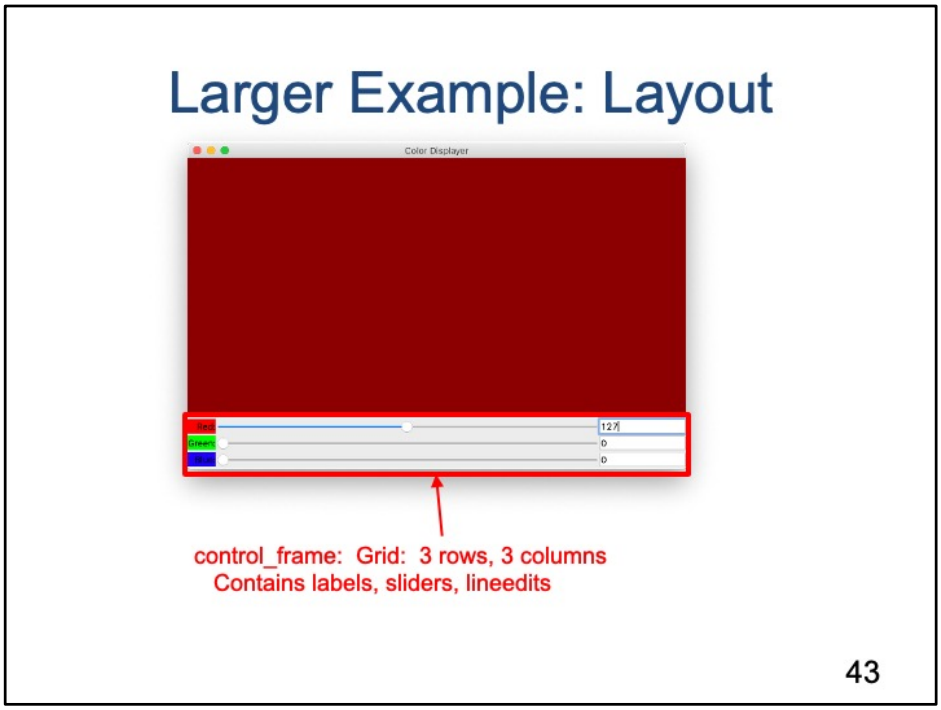


central_frame (class QFrame)

Larger Example: Widgets



window (class QMainWindow)



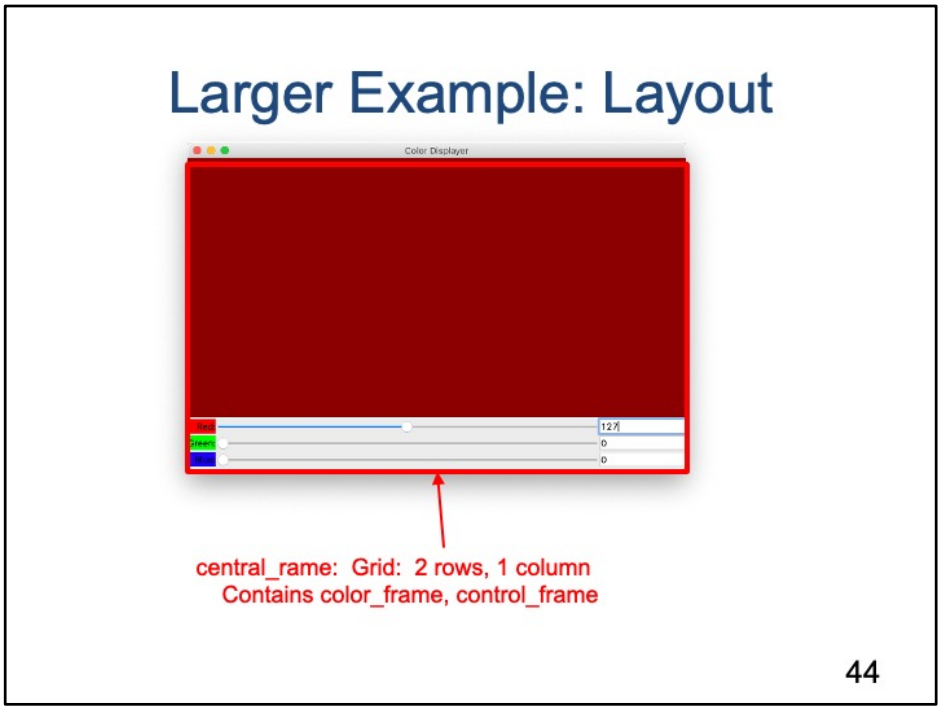
A Larger PyQt5 Example

Now consider the layout

[see slide]

Row 0 stretch: 0
Row 1 stretch: 0
Row 2 stretch: 0

Col 0 stretch: 0
Col 1 stretch: 1
Col 2 stretch: 0

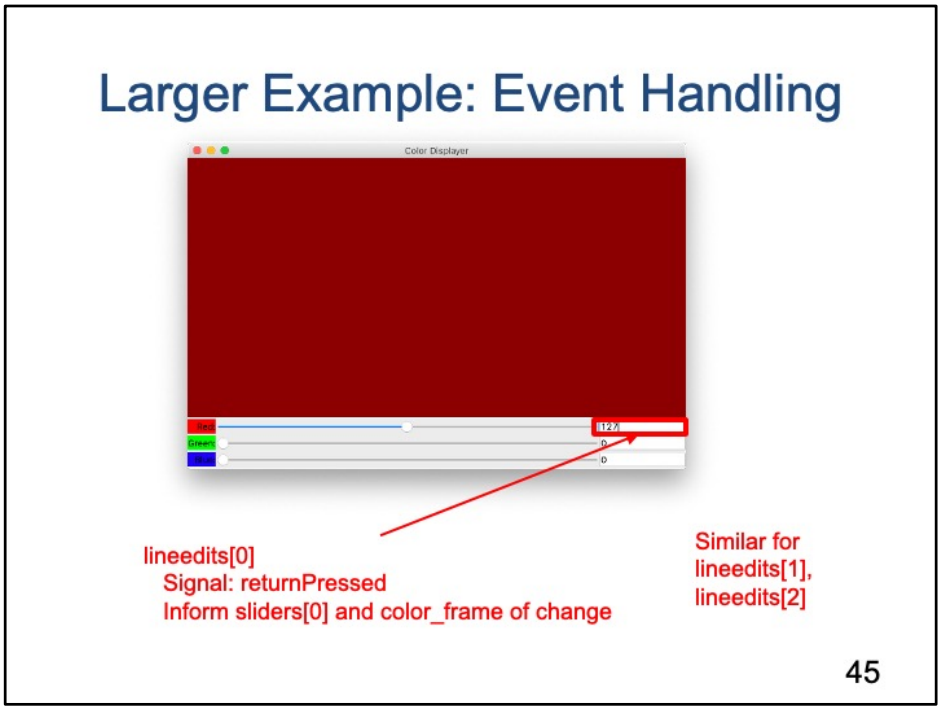


A Larger PyQt5 Example

[see slide]

Row 0 stretch: 1
Row 1 stretch: 0

Col 0 stretch: 1

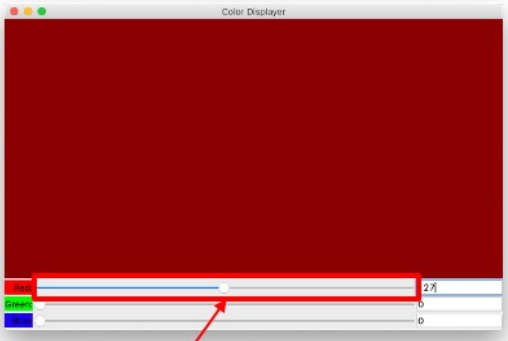


A Larger PyQt5 Example

Now consider event handling…

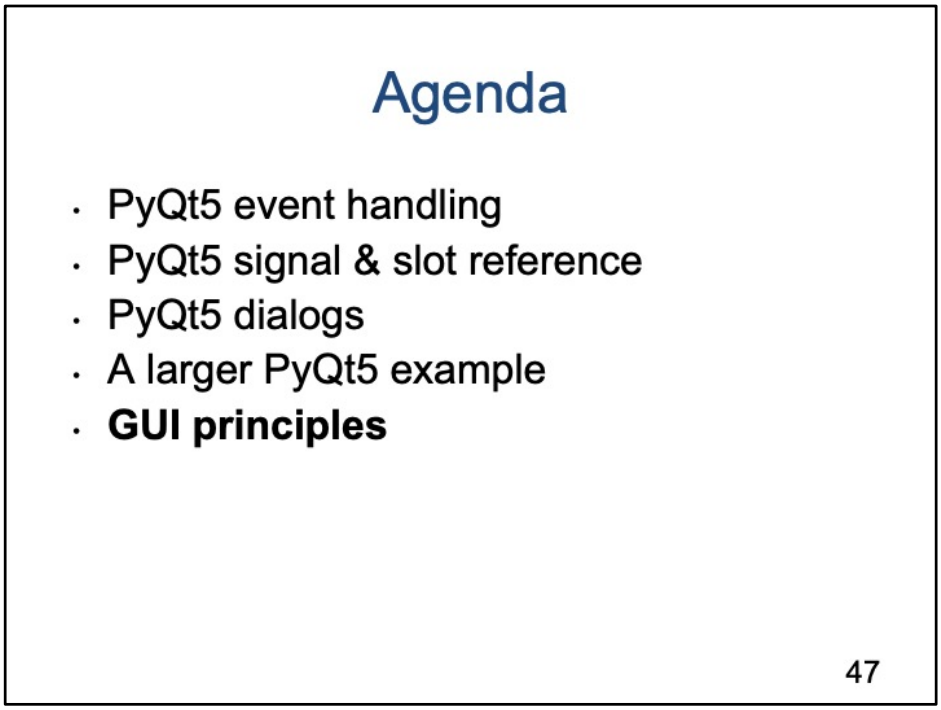
[see slide]

Larger Example: Event Handling



sliders[0]
Signal: valueChanged
Inform lineedits[0] and colorFrame of change

Similar for
sliders[1],
sliders[2]

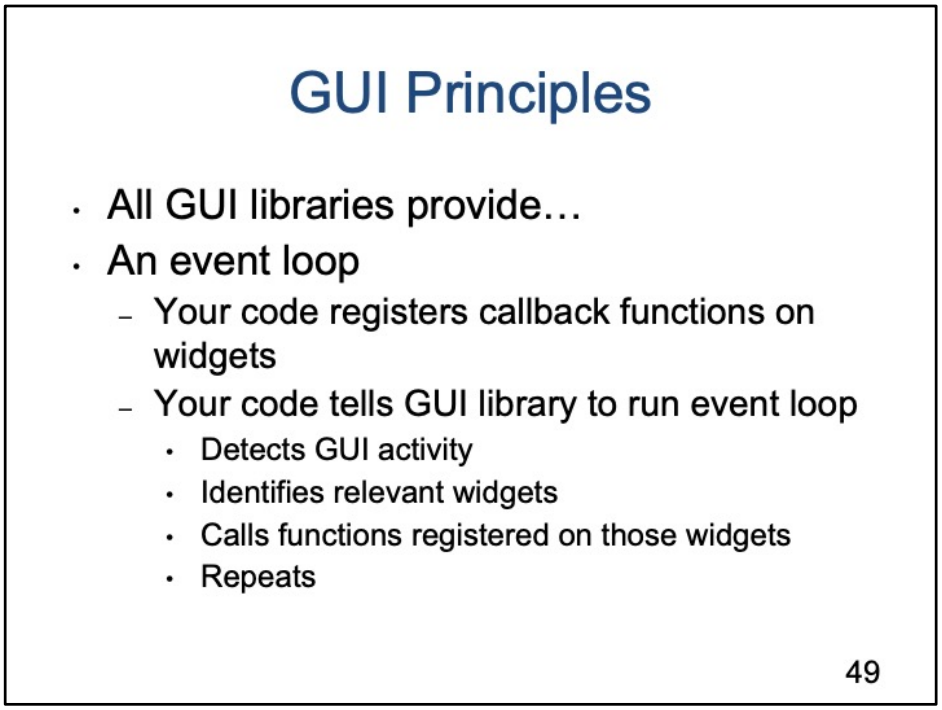


GUI Principles

There are some principles that apply to not only PyQt5, but also to (almost?) all GUI libraries

GUI Principles

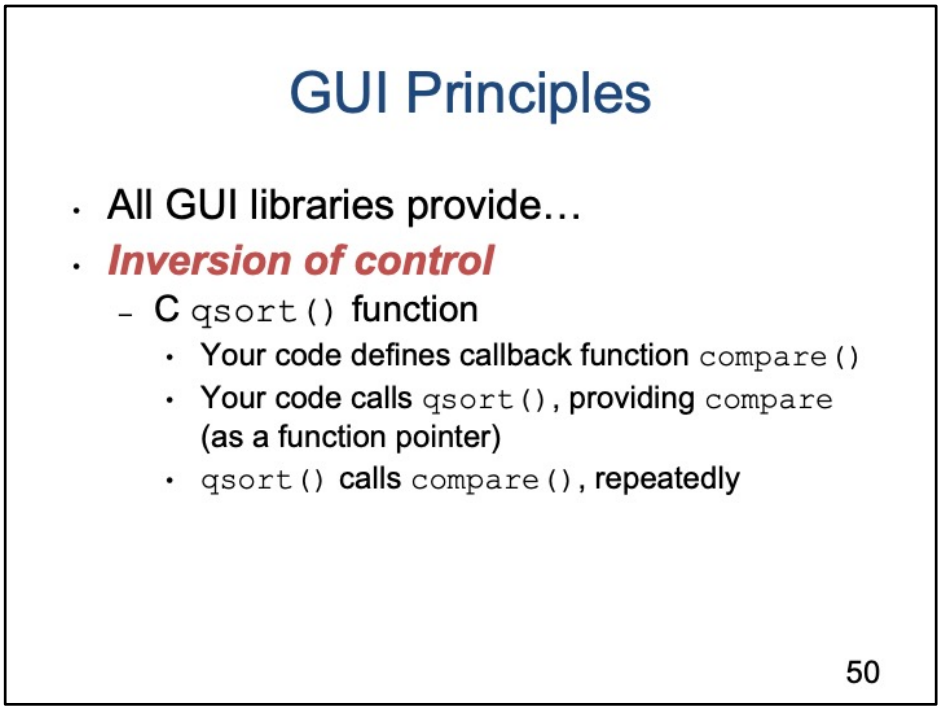
- All GUI libraries provide:
  - Widgets
  - Containers
  - Layout managers
  - Event handling mechanism(s)
  - Dialogs



GUI Principles

All GUI libraries provide an event loop

Your code tells GUI library to run event loop
Event loop:
Detects GUI activity
Keystrokes, pointing device clicks, pointing device movement, …
Identifies relevant widgets
Calls functions registered on those widgets
Repeats



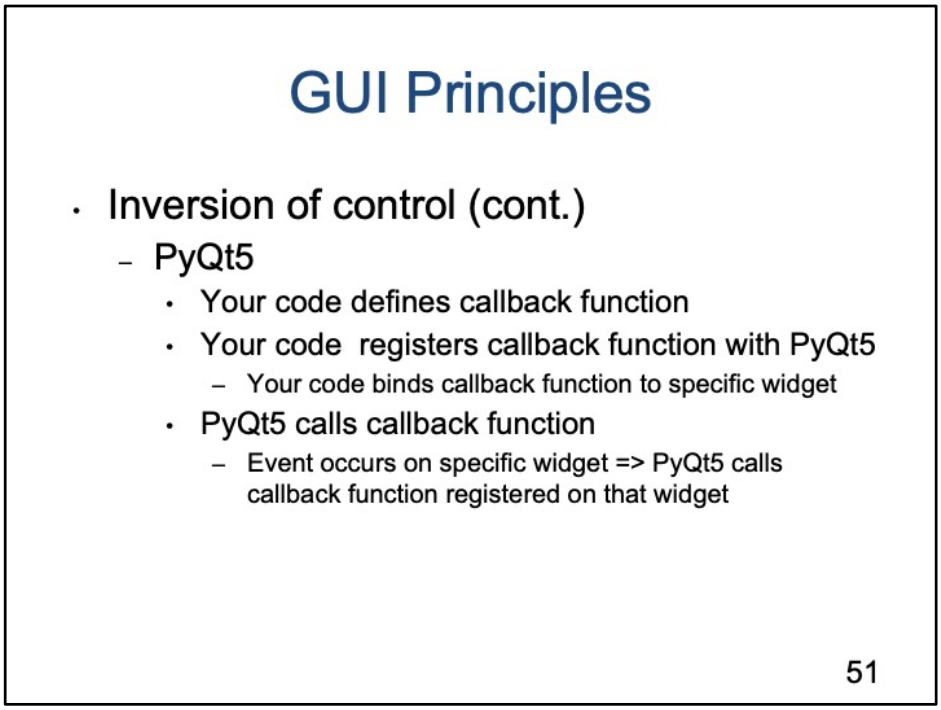
GUI Principles

All GUI libraries provide ***inversion of control***

Example (covered in COS 217)

[see slide]

Normally, your code is in control and requests services of the standard library
In this situation, the standard library qsort() is in control, and requests services of your code
The control is inverted



GUI Principles

[see slide]

Normally, your code is in control and requests services of other modules
In this situation, the PyQt5 module is in control, and requests services of your code
The control is inverted

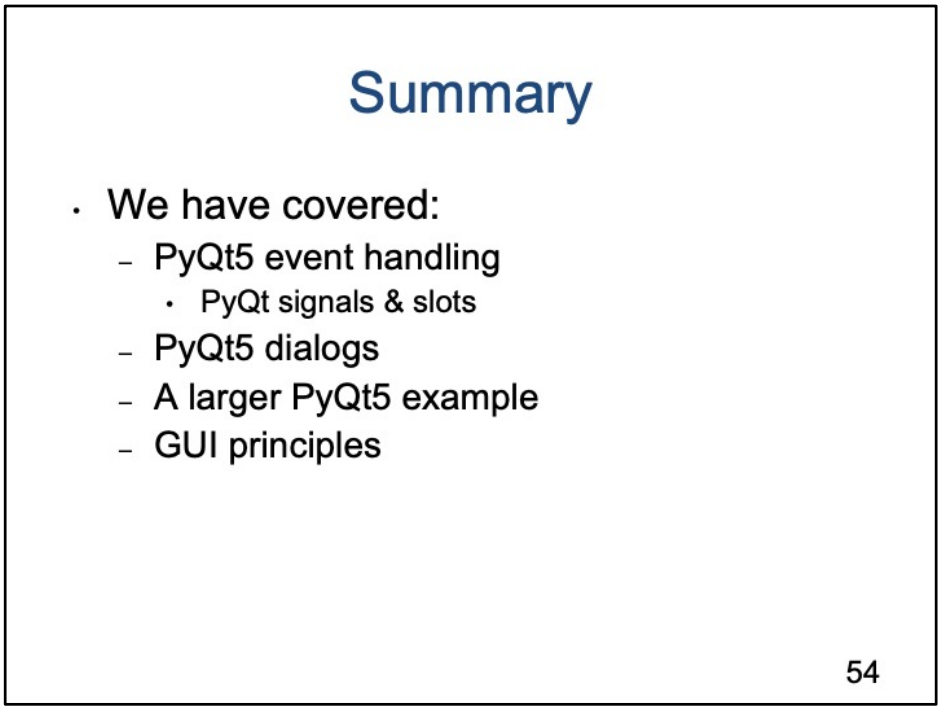
GUI Principles

- Inversion of control (cont.)
  - Normally
    - Your code calls library code to request services
    - Your code is in control
  - Inversion of control
    - Library code calls your code to request services
    - Library code is in control

Getting More Info

- PyQt5 reference guide
  - https://doc.bccnsoft.com/docs/PyQt5/
- PySide2 reference guide
  - https://doc.qt.io/qtforpython/#documentation

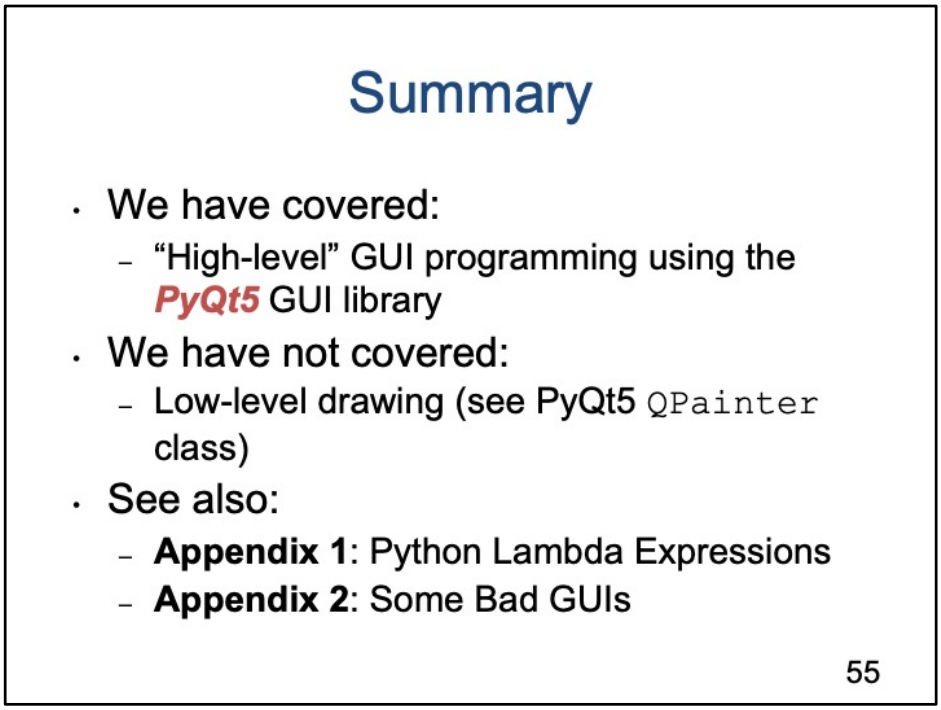
```
$ python
>>> from PyQt5.QtWidgets import *
>>> help(QApplication)
>>> help(QMainWindow)
>>> help(QBoxLayout)
>>> help(QFrame)
>>> help(QPushButton)
...
```



Summary

Summary of this lecture

[see slide]



Summary

Summary of the 2 GUI Programming lecture slide decks

[see slide]

Appendix 1:
Python Lambda Expressions

Lambda Expressions

- ***Lambda expression***
  - From Alonzo Church
  - 1930s
  - A nameless function

57

Lambda Expressions

Lambda expression
A nameless function
From Alonzo Church
Alumnus of Princeton
Prof of philosophy and mathematics at Princeton for many years
Contemporary of Alan Turing
1930s
Developed some important theoretical results independent of and working with Turing

Lambda Expressions

- In Python:
  - The keyword `lambda`
  - (optionally) Parameters separated by commas
  - A colon
  - A single expression that uses the parameters

Lambda Expressions

Without using a lambda expression:

```
def mult(x, y):
   return x * y
…
prod = mult(5, 6)
print(prod)   # prints 30
```

Using a lambda expression:

```
mult = lambda x, y: x * y
…
prod = mult(5, 6)
print(prod)   # prints 30
```

Using a lambda expression:

```
print( (lambda x, y: x * y)(5, 6) )   # prints 30
```

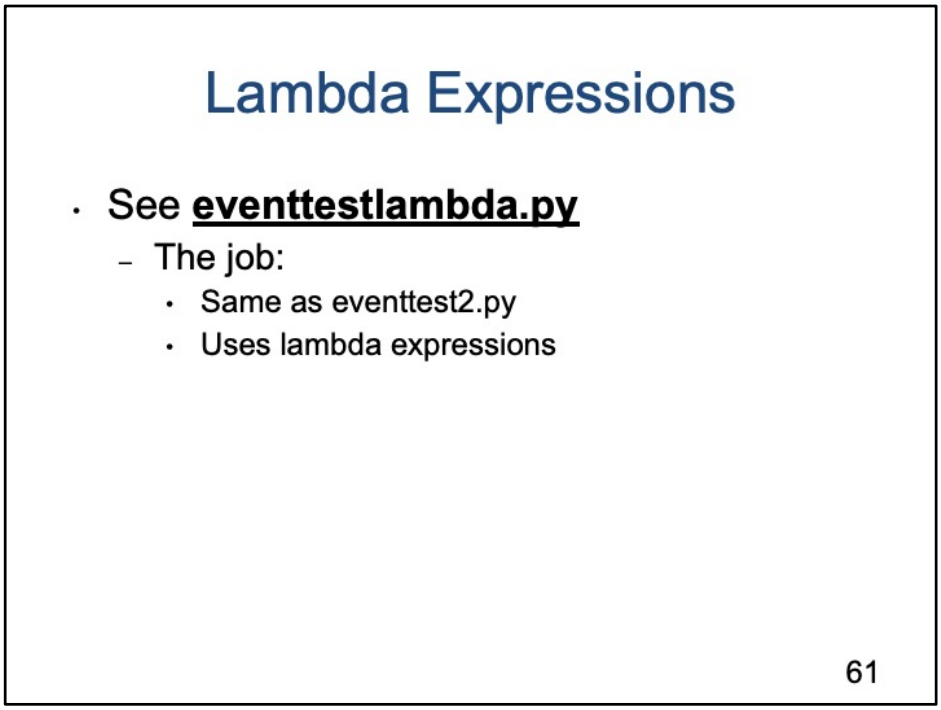
Lambda Expressions

Without lambda expression:

```
def compareLengths(word1, word2):
    return len(word1)-len(word2)
…
words.sort(compareLengths)
…
```

With lambda expression:

```
…
words.sort(
    lambda word1,word2: len(word1)-len(word2) )
…
```



Lambda Expressions

[see slide]

Code notes:

An (arguably) nicer approach

Use ***lambda expressions***

Appendix 2:
Bad GUIs

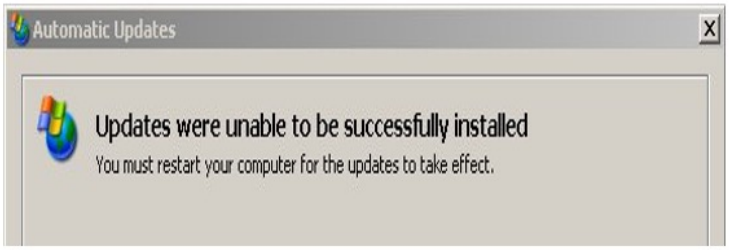
Bad GUIs

- For your amusement…
- Some bad GUIs
  - Mostly some bad dialog boxes

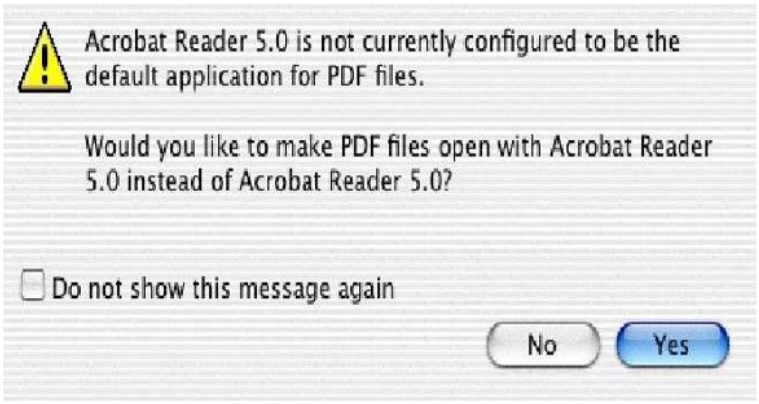
Bad GUIs

- Collected by Prof. Kernighan:

Bad GUIs


Automatic Updates
Updates were unable to be successfully installed
You must restart your computer for the updates to take effect.

Bad GUIs


Acrobat Reader 5.0 is not currently configured to be the default application for PDF files.
Would you like to make PDF files open with Acrobat Reader 5.0 instead of Acrobat Reader 5.0?
Do not show this message again
No
Yes

Bad GUIs

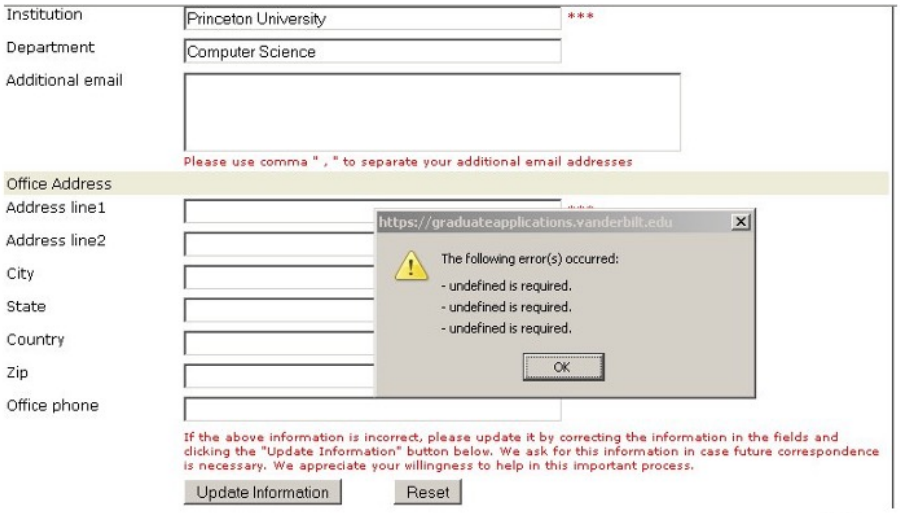
Step 2: Inspector

You must answer all required questions before you submit your recommendation.

→ indicates a required question.

Question	Original Answer	New Answer	Hint
TO BE COMPLETED BY THE RECOMMENDER:	(empty)	→ Go to Page 2	Required Item

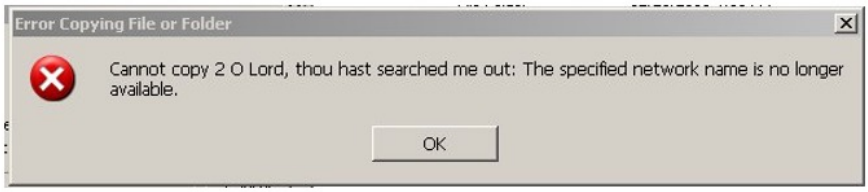
Bad GUIs


Institution
Princeton University
***
Department
Computer Science
Additional email
Please use comma " , " to separate your additional email addresses
Office Address
Address line1
Address line2
City
State
Country
Zip
Office phone
https://graduateapplications.vanderbilt.edu
The following error(s) occurred:
- undefined is required.
- undefined is required.
- undefined is required.
OK
If the above information is incorrect, please update it by correcting the information in the fields and clicking the "Update Information" button below. We ask for this information in case future correspondence is necessary. We appreciate your willingness to help in this important process.
Update Information
Reset

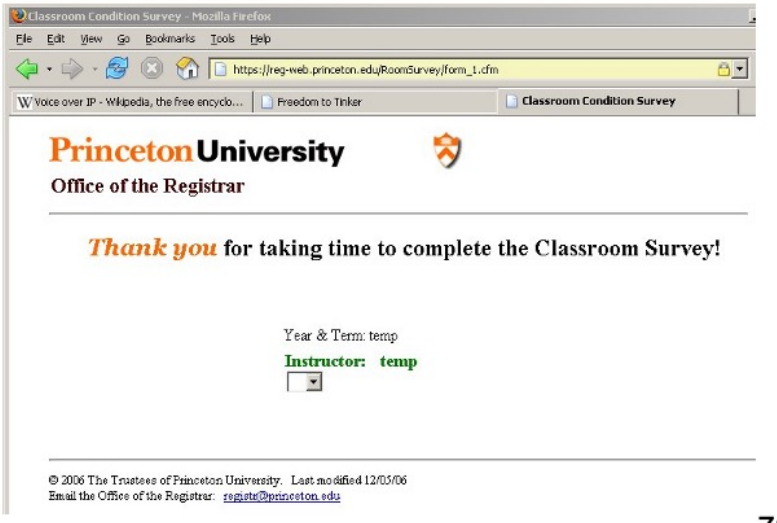
Bad GUIs

UNIVERSITY OF WASHINGTON

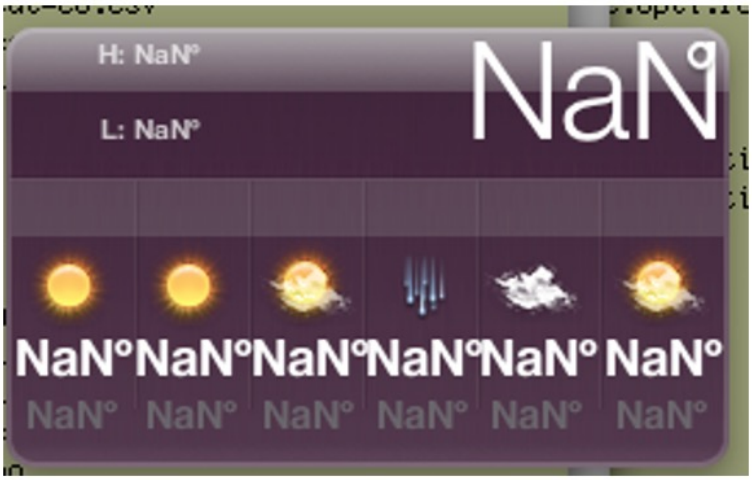
You have been redirected to this page for the following reason:



Bad GUIs


Classroom Condition Survey - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
https://reg-web.princeton.edu/RoomSurvey/form_1.cfm
Voice over IP - Wikipedia, the free encyclo...
Freedom to Tinker
Classroom Condition Survey
Princeton University
Office of the Registrar
Thank you for taking time to complete the Classroom Survey!
Year & Term: temp
Instructor: temp
© 2006 The Trustees of Princeton University. Last modified 12/05/06
Email the Office of the Registrar: regists@princeton.edu

Bad GUIs



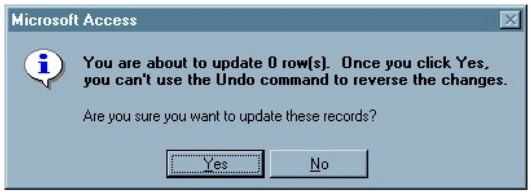
Bad GUIs

- From the *Interface Hall of Shame at* http://hallofshame.gp.co.at/index.php?mode=original:

Bad GUIs

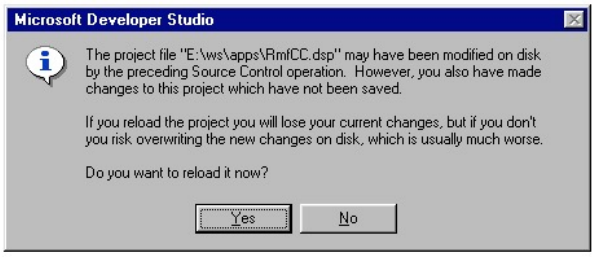

FreeJava
Unholy Error
OK


RealPlayer
Unable to contact Technical Support for further information.
More information is available at the RealNetworks Technical Support Website.
More Info
OK


Microsoft Access
You are about to update 0 row(s). Once you click Yes, you can't use the Undo command to reverse the changes.
Are you sure you want to update these records?
Yes
No

Bad GUIs


Outlook Express
There was an error opening this message.
An error has occurred.
OK

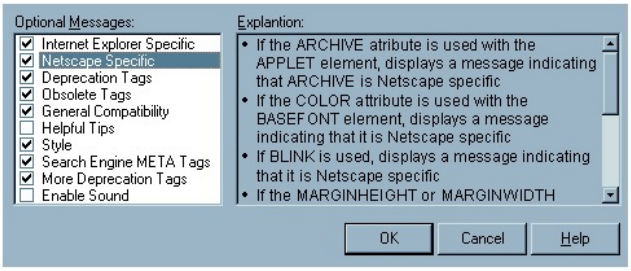

Microsoft Developer Studio
The project file "E:\ws\apps\RmfCC.dsp" may have been modified on disk by the preceding Source Control operation. However, you also have made changes to this project which have not been saved.
If you reload the project you will lose your current changes, but if you don't you risk overwriting the new changes on disk, which is usually much worse.
Do you want to reload it now?
Yes
No

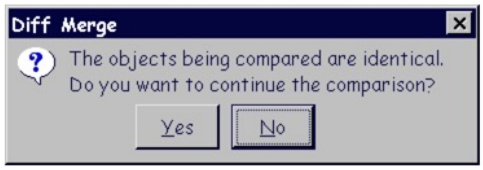
Bad GUIs


Microsoft Access
Wrong button!
This button doesn't work.
Solution
Try another.
OK

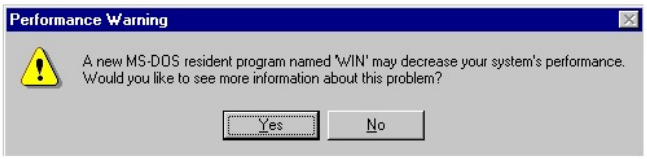

Send Mail
When you send an e-mail message, it will be placed in your 'Outbox' folder ready to be sent the next time you choose the 'Send and Receive' command.
Don't ask me this again
OK

Bad GUIs


Optional Messages:
Internet Explorer Specific
Netscape Specific
Deprecation Tags
Obsolete Tags
General Compatibility
Helpful Tips
Style
Search Engine META Tags
More Deprecation Tags
Enable Sound
Explantion:
If the ARCHIVE atribute is used with the APPLET element, displays a message indicating that ARCHIVE is Netscape specific
If the COLOR attribute is used with the BASEFONT element, displays a message indicating that it is Netscape specific
If BLINK is used, displays a message indicating that it is Netscape specific
If the MARGINHEIGHT or MARGINWIDTH
OK
Cancel
Help


Diff Merge
The objects being compared are identical.
Do you want to continue the comparison?
Yes
No

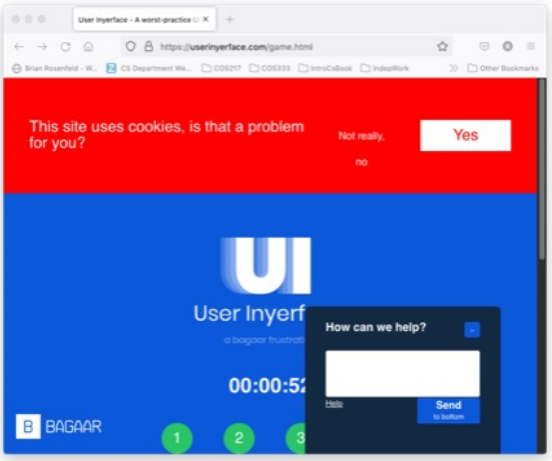
Bad GUIs


Performance Warning
A new MS-DOS resident program named 'WIN' may decrease your system's performance. Would you like to see more information about this problem?
Yes
No

Bad GUIs

- User Inyerface
  - https://userinyerface.com/game.html
  - Brought to my attention by COS 333 alumnus Joseph Kim…
  - Intention: The most horrible user interface imaginable…

Bad GUIs


This site uses cookies, is that a problem for you?
Not really,
no
Yes
How can we help?
Help
Send
BAGAAR