Building Engineering Applications with Python and PyQt6

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# Introduction to Python and PyQt6

# Introduction

Welcome to the world of Python and PyQt6! In this book, we will embark on an exciting journey to explore the powerful combination of Python programming and PyQt6, a set of Python bindings for the Qt application framework. Whether you're a beginner looking to dive into GUI (Graphical User Interface) development or an experienced Python developer seeking to expand your skill set, this book will provide you with the knowledge and tools you need to create dynamic and interactive applications.

The book as a journey focuses on building representative applications around various interesting topic of engineering and disciplines so as to provide a good head start. Engineering applications such as Artificial Intelligence, IOT, signal processing, embedded systems, real time communication are also covered through examples that are clearly starting from scratch taking the reader through the journey to build functional utilities for their respective use cases.

## Why Python and PyQt6?

Python has emerged as one of the most popular programming languages in recent years, known for its simplicity, readability, and versatility. Its extensive standard library and vibrant community make it an ideal choice for a wide range of applications, from web development to data analysis, and of course, GUI programming.

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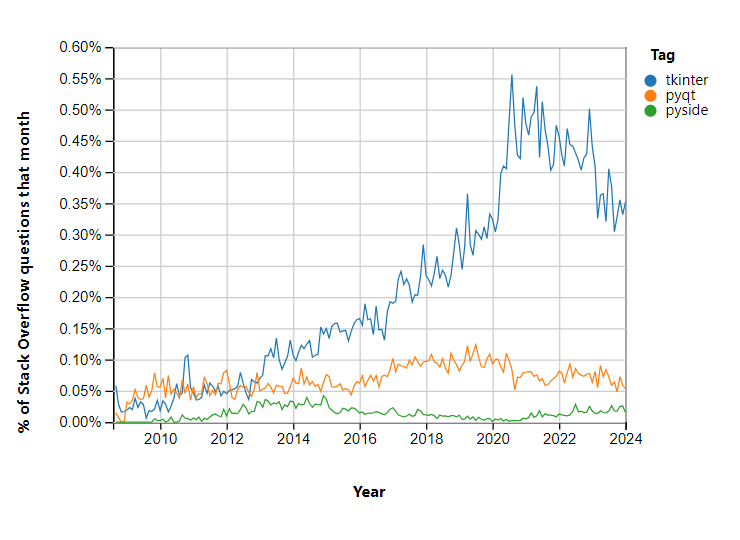
Python becomes one of the most widely used programming languages in recent times. From the stack overflow trends you can see the comparison with other languages.

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PyQt6, built on top of the Qt framework, brings the power and flexibility of Qt to Python developers. Qt is a comprehensive cross-platform toolkit used for developing applications with native-looking user interfaces. With PyQt6, developers can leverage the rich features of Qt while enjoying the simplicity and elegance of Python.

There are other GUI libraries available in python like tkinter, pyqt, pyside, etc. PyQt6is one of the famous library used for developing good looking GUI. PyQt6 provides features to create rich looking application with wide range of components. Below is the trends in using GUI library in python. When compared to other libraries PyQt6 is helpful in creating complex applications and gives more provision for customizations. Below is the current trend in market for python GUI libraries tkinter, PyQt and pySide.



## What This Book Covers

This book is designed to be a comprehensive guide to PyQt6, covering everything from the basics of Python and PyQt6 to advanced topics such as real-time data visualization and signal processing. Here's an overview of what you can expect to learn:

* **Python Fundamentals**: We'll start by covering the basics of Python programming, ensuring that you have a solid foundation before diving into PyQt6.
* **Getting Started with PyQt6**: You'll learn how to set up your development environment and create your first PyQt6 application.
* **Understanding PyQt6 Widgets**: We'll explore PyQt6's extensive collection of widgets and learn how to use them to build powerful GUIs.
* **Styling and Theming**: You'll discover how to customize the appearance of your PyQt6 applications using style sheets and themes.
* **Signals and Slots**: We'll delve into PyQt6's signal and slot mechanism, a powerful feature for handling events and communication between objects.
* **Integrating Scientific Libraries**: You'll learn how to integrate popular scientific libraries such as NumPy and Matplotlib with PyQt6 for data analysis and visualization.
* **Signal Processing**: We'll explore how to process and filter signals in real-time applications using PyQt6.
* **Real-Time Data Visualization**: You'll discover techniques for updating PyQt6 widgets dynamically to visualize real-time data.
* **Advanced Techniques**: We'll cover advanced topics such as multi-threading, internationalization, and packaging PyQt6 applications for distribution.
* **Case Studies and Practical Examples**: Throughout the book, we'll provide real-world examples and case studies to reinforce learning and demonstrate how PyQt6 can be used to solve practical problems.

By the end of this book, you'll have the knowledge and confidence to develop your own PyQt6 applications, whether you're building scientific tools, data analysis applications, or interactive visualizations.

## How to Use This Book

This book is designed to be accessible to readers of all levels, from beginners to experienced developers. Each chapter builds upon the concepts introduced in the previous chapters, gradually increasing in complexity. If you're new to Python or PyQt6, we recommend starting from the beginning and working your way through each chapter sequentially. However, if you're already familiar with the basics, feel free to jump to the chapters that interest you the most.

Throughout the book, you'll find code examples, explanations, and exercises to help reinforce your understanding of the material. We encourage you to follow along with the examples, experiment with the code, and apply what you've learned to your own projects.

## Let's Get Started!

Are you ready to embark on this exciting journey into the world of Python and PyQt6? Let's dive in and start exploring the possibilities together!

## Python basics and syntax

Python is a powerful programming language known for its simple syntax, making it easy to read and write. Python enables developers to write programs in fewer lines of code, increasing efficiency and reducing complexity. Let’s cover some of the fundamentals of Python.

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## How Python works?

Python is an interpreted language, means the code is executed line by line by the interpreter. Python interpreter reads the source code and executes it directly. Python interpreter reads your Python code and translates it into machine-readable bytecode. This bytecode is then executed by the Python Virtual Machine (PVM).

Python interpreter supports dynamic typing. It automatically determines the type of a variable based on the value assigned to it, and it manages memory allocation and deallocation using a built-in garbage collector. You can run Python interpreter in interactive mode, using that you can enter commands and expressions directly into the shell and see the results. Python comes with lot of standard libraries that provides a wide range of modules and functions for various tasks such as file I/O, networking, multimedia, and more.

## Python Installation:

Before we start on leaning python lets get python installed in our machine. Its good to read the book but also get our hand dirty by doing some sample programs for better understanding.

To install Python, you can download from below url. You can download the latest version and for specific OS like windows, macOs, Linux/UNIX or other. In case you need different version that will be also available in the same page. You can have more the one version of python installed in your machine.

<https://www.python.org/downloads/>

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Once you download the python exe file, double click to run the installer. Before clicking **Install Now** select **Add** **python.exe to PATH.**

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Once your installation is done you can verify the installed python by using python –version command.

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To write Python program we should have your preferred text editor or integrated development environment (IDE), whether it's PyCharm, Visual Studio Code, or any other tool you prefer.

Let’s write our first program using python. We have created a Github repository for all the examples we are going to discuss in this book. You can refer in case you have doubt.

To run any program in a file, use the below command.

**python filename.py**

Create a file name FristProgram.py. Let’s print hello world! as first step.

print("Hello World!")

**Output:**

Hello World!

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Here is the link for Github repo for FirstProgram.py [FirstProgram link](https://github.com/TenetTechnetronics/Building_Engineering_Applications_With_Python/blob/main/Programs/Chapter_1/FirstProgram.py)

**Variables and Datatypes:**

Variables serve as containers to store data values in Python. You assign a value to a variable using the assignment operator “=”. Variables can be declared either globally, accessible throughout the entire program, or locally, confined to a specific scope, such as within a function.

When naming variables, it’s important to follow some basic rules:

* + Variable names can contain letters, numbers and underscores.
  + Variable names must start with a letter or an underscore.
  + Variable names never start with a number and doesn’t contain whitespace.
  + Variable names are case-sensitive.
  + Avoid using Python keywords as variable names.

Here’s a list of common data types in Python along with examples:

In Python, we don’t explicitly declare the variable type. Instead declare a variable and assign a value to it.

**Integer:**  
x = 10  
print(type(x)) # <class 'int'>

**String:**  
y = 'Hello'  
print(type(y)) # <class 'str'>

**Float:**  
z = 5.25  
print(type(z)) # <class 'float'>

**Boolean:**  
isVisible = False  
print(type(isVisible)) # <class 'bool'>

**Booleans can be either True or False**

**List:**  
myList = [1, 2, 3, 4]  
print(type(myList)) #<class 'list'>

**Tuple:**  
myTuple = (1, 2, 3, 4)  
print(type(myTuple)) #<class ' tuple'>

**Dictionary:**  
myDict = {'a': 1, 'b': 2}   
print(type(myDict)) #<class 'dict'>

You can find the sample for variable and data type in [GitHub Link](https://github.com/TenetTechnetronics/Building_Engineering_Applications_With_Python/blob/main/Programs/Chapter_1/VariableAndDatatype.py).

**Casting:**

Casting in Python is a process of converting one data type into another. Python provides built-in functions to perform these conversions, allowing you to manipulate data of different types efficiently.

Below are some of the basic examples to change datatype.

x = str('3')  
print(x) # Output: 3  
y = float(3)  
print(y) # Output: 3.0  
  
z = bool(1)  
print(z) # Output: True

You can find the sample for type casting in [GitHub Link](https://github.com/TenetTechnetronics/Building_Engineering_Applications_With_Python/blob/main/Programs/Chapter_1/TypeCasting.py).

**Comments:**

Writing comments in code is indeed a good habit. It helps not only yourself, but also other team members understand the functionality of the code. In Python, you can add comments by using the pound sign (#), and anything after the # is ignored by the interpreter. This allows you to add explanations, notes, or reminders within your code. Unlike some other programming languages, Python does not have a built-in syntax for multi-line comments using /\* … \*/.

# Comments  
X=5 # int  
Y=6 # string

**Conditional Statements:**

Condition statements are utilized for decision-making within a program. They evaluate a statement to determine whether it is true or false, and based on the result, a specific block of code is executed. In writing a conditional statement, we employ if, elif (not else if), and else. The elif and else conditional statements are optional. Furthermore, we can utilize nested if statements to construct more complex conditional statements.

age = 10  
if age > 5:  
 print("age is greater than 5")  
elif age < 5:  
 print("age is less than 5")  
else:  
 print("age is equal to 10")

You can find the sample for conditional statement in [GitHub Link](https://github.com/TenetTechnetronics/Building_Engineering_Applications_With_Python/blob/main/Programs/Chapter_1/ConditionalStatement.py).

**Loops**

Loops serve to control flow structures and repetitively execute a block of code until a specified condition is met.

You have the flexibility to use either a for loop or a while loop. Within loops, you can skip iterations using **continue** statement, exit using the **break** statement, or proceed without any action using **pass** statement.

**For Loop:**  
for i in range(3):  
 print(i)

**Output:**  
0  
1  
2

**While Loop:**   
j=0  
while j < 3:  
 print(j)  
 j = j + 1

**Output:**  
0  
1  
2

You can find the sample for loop in [GitHub Link](https://github.com/TenetTechnetronics/Building_Engineering_Applications_With_Python/blob/main/Programs/Chapter_1/Loop.py).

**Functions:**

Functions are reusable blocks of code designed to perform specific tasks. By writing functions, you can efficiently manage your codebase and easily reuse the same functionality in multiple sections of your program.

To define a function, you utilize the ‘def’ keyword followed by a unique name for the function. You can then call the function either with or without arguments, depending on its functionality.

# Without arguments

def sayHello():  
 print('Hello! ')  
sayHello() # Calling function without arguments

**Output:**  
Hello!

# With arguments  
def sayHelloByName(name):  
 print('Hello '+name +'!')  
sayHelloByName('Rob') # Calling function with arguments

**Output:**  
Hello Rob!

# Optional arguments  
def sayHelloByOptionalName(name = 'Kane'):  
 print('Hello '+name +'!')  
sayHelloByOptionalName() # Calling function by optional arguments

**Output:**  
Hello Kane!

## What is PyQt6?

PyQt6 serves as a collection of Python bindings for the Qt application framework, capable of running on all platforms supported by Qt, including Windows, macOS, Linux, and iOS. It is a powerful tool for developing graphical user interfaces (GUIs) using Python. PyQt6 mandates a minimum Python version of 3.x. Developed by Riverbank Computing, PyQt no longer supports PyQt4, with PyQt5 and PyQt6 being the current versions in use, with PyQt6 is the latest iteration.

PyQt6 is known for its ease of learning and utilization, offering a wide range of features and functionality. It helps developers to create rich user interfaces (UIs) incorporating widgets, toolbars, menus, layouts, signals, multimedia support, and beyond.

// Need to Verify

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If your use of Riverbank's software is not compatible with the GPL then you require a commercial license. There is no functional difference between the GPL versions and the commercial versions of Riverbank's software.

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## Installing PyQt6

Before proceeding with the installation of PyQt6, ensure that your system has Python version of 3.x. If you have not installed yet you can refer previous chapter Python Installation.

To install PyQt6, use below command:

**pip install PyQt6**

## Setting up your development environment

Getting Started with PyQt6

Let’s start on PyQt6, We can start from scratch for building a GUI application. Its better when we understand most of the features available in PyQt6. We have to leverage the list of features available to build a better version of application, which makes the UI look good at the same time user friendly and not make it complex. UI is always good to use when you keep it simple.

We can start creating simple application and widgets before creating a full-fledged UI application.

## Creating your first PyQt6 application

We can use QApplication and Qwidget to create our first application. Lets create a simple window with title Hello world.

from PyQt6.QtWidgets import QApplication, QWidget  
#Create an application  
app = QApplication([])  
#Create a window  
window = QWidget(windowTitle="Hello World!!")  
window.show()  
app.exec()

Output:

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Will go through the code and explain what we are doing here to create our application.

**Step1:** We have to import Qpplication and Qwidget from PyQt6 QtWidgets.

**Step2:** Let’s create an application with empty array as arguments. We can use sys.args in case we provide any input.

**Step 3:** Create a window using Qwidget and set the title as Hello World!! And to show the window will call show() method.

**Step 4:** app.exec() method is called at last to execute the event loop where all the events are handled (Event loop will be taught in future chapter).

## Understanding PyQt6 widgets

PyQt6 is the basic for building GUI applications. Widget can hold other widgets together. widgets include buttons, labels, text boxes, menus, toolbars, and many others, allows to create a professional looking application. For widget you can set the height, width, styles, and more.

## Layout management in PyQt6

Layout management is most important part of creating graphical user interface because they control how widgets (such as buttons, labels, text fields, etc.) are positioned and resized within a window. When we add more widget and want to do alignment, we can use different layout to position it. You can do alignment using below four layouts, each has its unique behaviour.

* **QHBoxLayout** - Align widgets horizontally.
* **QVBoxLayout**  - Align widgets Vertically.
* **QGridLayout** - Align widgets by positioning in grid structure.
* **QStackedLayout** - Add widgets in Stack in front of one another.

**QHBoxLayout:**

## QHBoxLayout class arranges widgets horizontally. When you add new widgets, each will be placed next to each other. QHBoxLayout class inherits from QBoxLayout, which further inherits from QLayout. This inheritance allows to make effective layout management in a GUI.

## Let’s create a sample application to see how widgets are placed when we use QHBoxLayout. To use QHBoxLayout we need to import the class from PyQt6.QtWidgets.

from PyQt6.QtWidgets import QApplication, QWidget, QHBoxLayout, QPushButton  
  
# Initialize the application  
app = QApplication([])  
  
# Create the main window  
window = QWidget()  
window.setWindowTitle('QHBoxLayout')  
window. setMinimumWidth(800)  
window. setMinimumHeight(600)  
  
# Create a QHBoxLayout instance  
layout = QHBoxLayout()  
  
# Create widgets  
button1 = QPushButton('Button 1')  
button2 = QPushButton('Button 2')  
button3 = QPushButton('Button 3')  
button4 = QPushButton('Button 4')  
button5 = QPushButton('Button 5')  
button6 = QPushButton('Button 6')  
button7 = QPushButton('Button 7')  
button8 = QPushButton('Button 8')

#Add widgets to Layout  
layout.addWidget(button1)  
layout.addWidget(button2)  
layout.addWidget(button3)  
layout.addWidget(button4)  
layout.addWidget(button5)  
layout.addWidget(button6)  
layout.addWidget(button7)  
layout.addWidget(button8)  
  
# Set the layout on the main window  
window.setLayout(layout)  
# Show the window  
window.show()  
  
# Run the application's event loop  
app.exec()

**Output:**

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## In above pic you can see the buttons are arranged horizontally. First, we have to define a QHBoxLayout (layout = QHBoxLayout()) and then create more than one widgets in our case we have created widget using QPushButton. Once the widgets are created, we need add all the widgets one by one into the layout using layout.add(widgetName) method. We need to add widgets in the order that has to displayed. Finally for the window we need to set the layout using window.setLayout(layoutName) method.

## QHBoxLayout allows you to specify the spacing between adjacent widgets and the margins around the edges of the layout. This will help you in creating a polished UI. The dynamic sizing and positioning ensure that the widgets are aligned when we resize the windows. QHBoxLayout can be used with other layouts, like QVBoxLayout, QGridLayout allowing for complex UI designs. When you need to create a complex application, nesting layouts will give you more ways to align widgets and create a good-looking UI.

## **QVBoxLayout:**

## QVBoxLayout class arranges widgets vertically. When you add new widgets, each will be placed from top to bottom. Like QHBoxLayout, QVBoxLayout also inherits from QBoxLayout class, which further inherits from QLayout. This inheritance allows to make effective layout management in a GUI.

## Let’s create a sample application to see how widgets are placed when we use QVBoxLayout. To use QVBoxLayout we need to import the class from PyQt6.QtWidgets.

from PyQt6.QtWidgets import QApplication, QWidget, QVBoxLayout, QPushButton  
  
# Initialize the PyQt application  
app = QApplication([])  
  
# Create the main window  
mainWindow = QWidget()  
mainWindow.setWindowTitle("QVBoxLayout")  
mainWindow.setMinimumWidth(400)  
mainWindow.setMinimumHeight(500)  
# Create a QVBoxLayout instance  
layout = QVBoxLayout()  
  
# Create and add widgets to the layout in one line  
layout.addWidget(QPushButton("Button 1"))  
layout.addWidget(QPushButton("Button 2"))  
layout.addWidget(QPushButton("Button 3"))  
layout.addWidget(QPushButton("Button 4"))  
layout.addWidget(QPushButton("Button 5"))  
  
# Set the layout for the mainWindow  
mainWindow.setLayout(layout)  
  
# Display the main window  
mainWindow.show()   
  
# Start the event loop  
app.exec()

**Output:**

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## In above pic you can see the buttons are arranged vertically one by one. First, we need to define a QVBoxLayout (layout = QVBoxLayout()) and then create QPushButton and add it to layout widget using layout using layout.add(widgetName) method. We need to add widgets in the order that must be displayed. Finally for the window we need to set the layout using window.setLayout(layoutName) method.

## QVBoxLayout allows you to specify the spacing between adjacent widgets and the margins around the edges of the layout. The dynamic sizing and positioning ensure that the widgets are aligned when we resize the windows. QVBoxLayout can be used with other layouts, like QHBoxLayout, QGridLayout allowing for complex UI designs. When you need to create a complex application, nesting layouts will give you more ways to align widgets and create a good-looking UI.

## **QGridLayout:**

## QGridLayout is little bit different than both QHBoxLayout and QVBoxLayout. QGridLayout allows widgets to be arranged in a grid format. QGridLayout organizes widgets in a two-dimensional grid, where each cell in the grid can contain one widget. The grid layout can be used for creating forms or any application requiring a structured layout. QGridLayout inherits from QLayout.

## Let’s create a sample application to see how widgets can be placed using QGridLayout. To use QGridLayout we need to import the class from PyQt6.QtWidgets.

from PyQt6.QtWidgets import QApplication, QWidget, QGridLayout, QPushButton  
  
# Initialize the application  
app = QApplication([])  
  
# Create a window  
window = QWidget()  
window.setWindowTitle('QGridLayout')  
window.setMinimumWidth(600)  
window.setMinimumHeight(600)  
  
# Create a QGridLayout  
layout = QGridLayout()  
  
# Create widgets   
button1 = QPushButton('Button 1')  
button2 = QPushButton('Button 2')  
button3 = QPushButton('Button 3')  
button4 = QPushButton('Button 4')  
button5 = QPushButton('Button 5')  
button6 = QPushButton('Button 6')  
button7 = QPushButton('Button 7')  
  
  
# Add widgets to the layout at specified positions  
layout.addWidget(button1, 0, 0) # Arguments row, column  
layout.addWidget(button2, 0, 1, 1, 2) # Arguments row, column, rowSpan, columnSpan  
layout.addWidget(button3, 0, 3) # Arguments row, column  
layout.addWidget(button4, 1, 0, 1, 2) # Arguments row, column, rowSpan, columnSpan  
layout.addWidget(button5, 1, 2) # Arguments row, column  
layout.addWidget(button6, 1, 3) # Arguments row, column  
layout.addWidget(button7, 2, 0, 1, 4) # Arguments row, column, rowSpan, columnSpan  
  
# Apply the layout to the window  
window.setLayout(layout)  
  
# Display the window  
window.show()  
  
# Start the application's event loop  
app.exec()

## **Output:**

## 

## In above pic you can see the buttons are positioned in Grid layout. First, we have to define a QGridLayout (layout = QGridLayout()) and then create widgets in our case we have created widget using QPushButton. Once the widgets are created, we need add all the widgets one by one into the layout using layout.add(widgetName, row, column) or layout.add(widgetName, row, column, rowSpan, columnSpan) method. We need to add widgets based on row and column and also, we can specify the row span and column span to make widget size to multiple cell. Finally for the window we need to set the layout using window.setLayout(layoutName) method.

## QGridLayout allows you to specify the spacing between rows and columns and aligns within grid cells. The lauout dynamicaly adjust the size of cells when we resize the windows so that the widgets are aligned properly. Like other layouts QGridLayout can be used with other layouts like QHBoxLayout, QGridLayout allowing for complex UI designs.

**QStackedLayout:**

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