Year
2022

AI Visual Inspection system for road defection

LESSON 1

YOUTH COLLEGE (INTERNATIONAL)

Reference Websites

Python Official	
https://www.python.org/	
Google Colab	
https://colab.research.google.com/	
Python Exercises	
https://www.w3resource.com/python-exercises/ https://www.w3schools.com/python/default.asp	
GitHub	
https://github.com/garyprojects/road_detect	

1. Introduction

Examples of Road Surface Defects

Potholes



Cracking



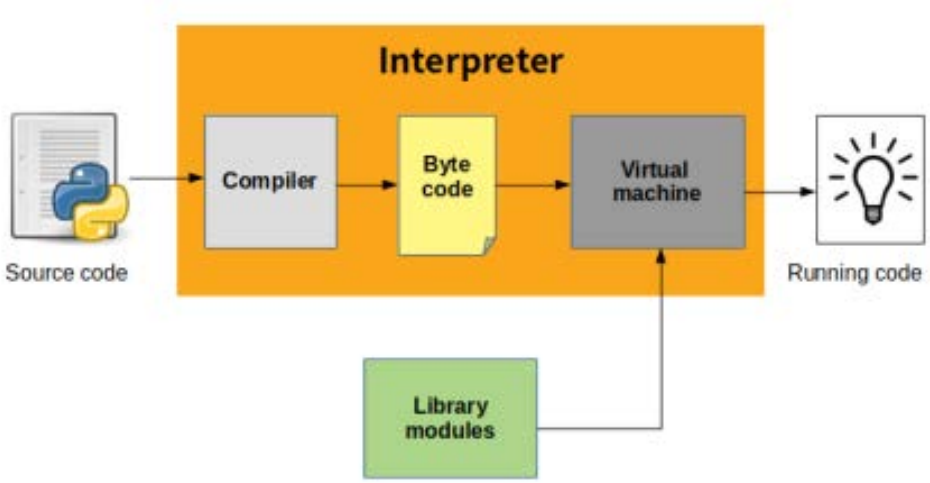
Decolored


What is Python?

Popular programming language in 2021

Jan 2021	Jan 2020	Change	Programming Language	Ratings	Change
1	2	^	C	17.38%	+1.61%
2	1	v	Java	11.96%	-4.93%
3	3		Python	11.72%	+2.01%
4	4		C++	7.56%	+1.99%
5	5		C#	3.95%	-1.40%
6	6		Visual Basic	3.84%	-1.44%
7	7		JavaScript	2.20%	-.025%
8	8		PHP	1.99%	-0.41%
9	18	^^	R	1.90%	+1.10%
10	23	^^	Groovy	1.84%	+1.23%

Interpreted language

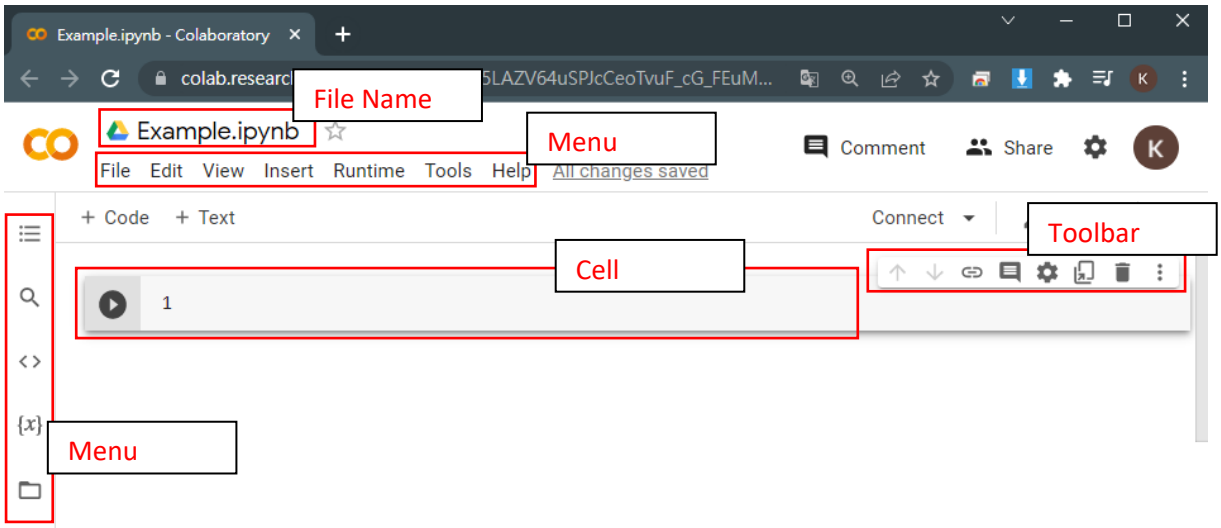


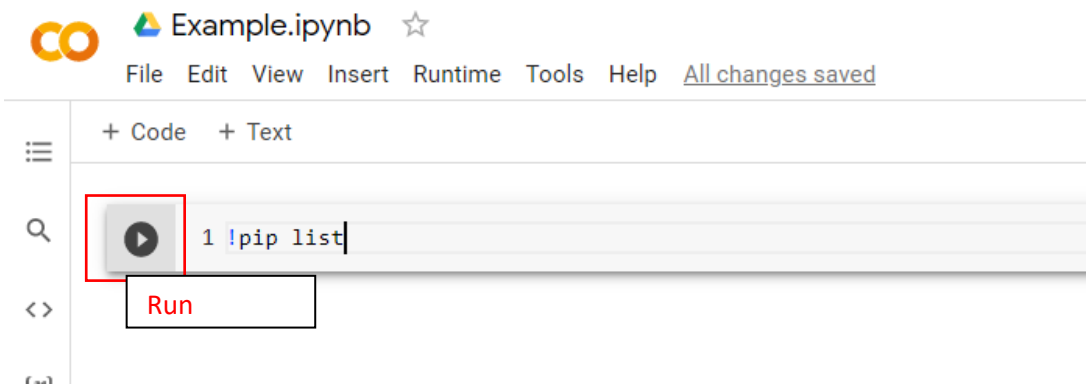
High-level programming language

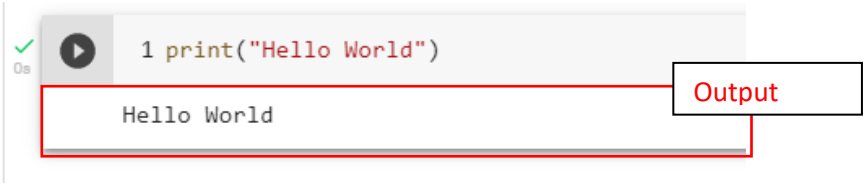
```
10101001111100
10101000001000
      .....
      .....
10101000001000
```

```
if a >b:
   print( 'a is greater than b' )
else:
   print( 'b is greater than b' )
```

2. Using Google Colab





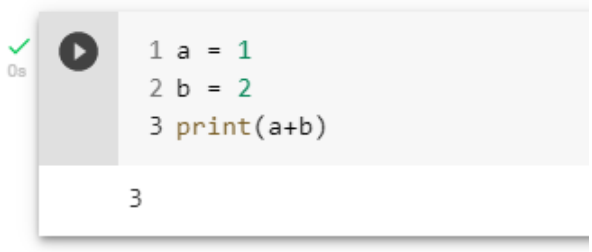


3. Variables and datatypes

Python identifier

name	valid or invalid
ab10c	valid
abc_DE	valid
_	valid
_abc	valid
99	invalid
x+y	invalid
for	invalid
a@	invalid
9abc	invalid

Statement



```
1 a = 1
2 b = 2
3 print(a+b)
```

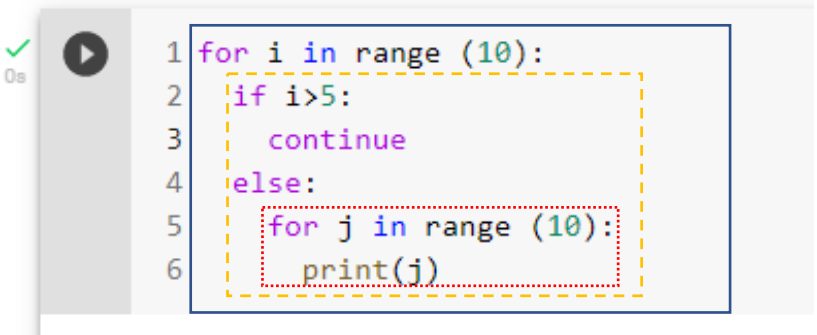
```
3
```

Comment

```
1 # This is a single line comment
2
3 '''
4 This is multiple line comment
5 This is multiple line comment
6 '''
7
8 print("Example of writing comment")
```

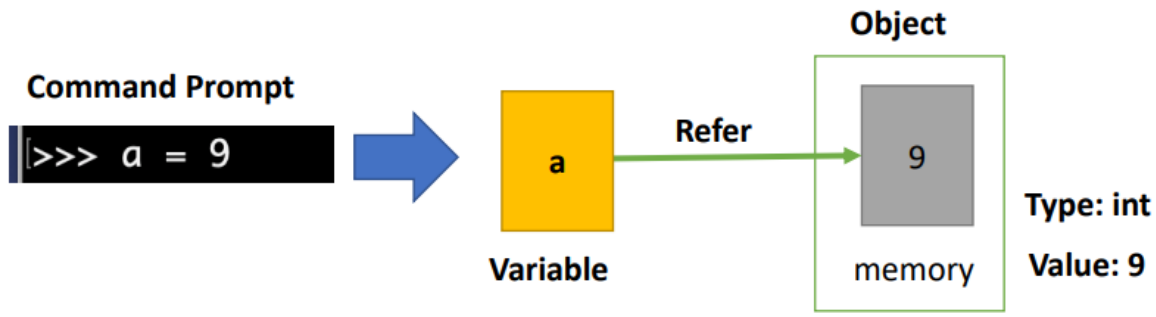
```
Example of writing comment
```

Indentation



```
1 for i in range (10):
2   if i>5:
3     continue
4   else:
5     for j in range (10):
6       print(j)
```

Datatype



identity

```
>>> a = 'Hello'
>>> b = 'Hello'
>>> id(a)
4552193072
>>> id(b)
4552193072
```

type

```
>>> type(a)
<class 'str'>
>>> c = 10
>>> type(c)
<class 'int'>
```

value

```
>>> d = 22.11
>>> print(d)
22.11
```

dynamic Data Type

```
>>> variable_A = 'Hello'
>>> type(variable_A)
<class 'str'>
>>> variable_A = 9527.87
>>> type(variable_A)
<class 'float'>
>>>
```

int	float
5	0.0
22	22.5
-3	-3.89
0b1010	-3.
-0b1011	18.3e+9
0x220	-18.3e+9
-0x220	

Arithmetic Operator

Operator	Name	Example
+	Addition	x + y
-	Subtraction	x - y
*	Multiplication	x * y
/	Division	x / y
%	Modulus	x % y
**	Exponentiation	x ** y
//	Floor division	x // y

```
1 25 + 5
30

1 5 - 10
-5

1 3 * 3
9

1 10 / 3
3.3333333333333335

1 10 % 3
1

1 3 ** 3
27

1 10 // 3
3
```

Comparison Operator

Operator	Example	Description
==	x == y	If the values of two operands are equal, then the condition becomes true
!=	x != y	If values of two operands are not equal, then condition becomes true
>	x > y	If the value of left operand is greater than the value of right operand, then condition becomes true.
<	x < y	If the value of left operand is less than the value of right operand, then condition becomes true.
>=	x >= y	If the value of left operand is greater than or equal to the value of right operand, then condition becomes true.
<=	x <= y	If the value of left operand is less than or equal to the value of right operand, then condition becomes true.

```
1 x = 10
2 y = 2

1 x != y
True
```

```
1 x = 10
2 y = 2

1 x > y
True
```

Assignment Operator

Operator	Example	Same As
=	x = 5	x = 5
+=	x += 3	x = x + 3
-=	x -= 3	x = x - 3
*=	x *= 3	x = x * 3
/=	x /= 3	x = x / 3
%=	x %= 3	x = x % 3
//=	x //= 3	x = x // 3
**=	x **= 3	x = x ** 3
&=	x &= 3	x = x & 3
|=	x |= 3	x = x | 3
^=	x ^= 3	x = x ^ 3
>>=	x >>= 3	x = x >> 3
<<=	x <<= 3	x = x << 3

Logical Operator

Operator	Description	Example
and	Returns True if both statements are true	x and y
or	Returns True if one of the statements is true	x or y
not	Reverse the result, returns False if the result is true	not(x and y)

```
1 x = True
2 y = False
```

```
1 x and y
```

```
False
```

```
1 x or y
```

```
True
```

```
1 not (x and y )
```

```
True
```

String

- Index

Example: s = 'Hello'

String	H	e	l	l	o
Index from head	0	1	2	3	4
Index from tail	-5	-4	-3	-2	-1

```
>>> s = 'Hello'
>>> s[0]
'H'
>>> s[1]
'e'
>>> s[2]
'l'
>>> s[-1]
'o'
```

- Slicing

s[start : end : interval]

```
>>> s = 'python'
>>> s[2:]
'thon'
>>> s[:-2]
'pyth'
>>> s[1:-1:2]
'yh'
```

Operation	Description
s[i]	Index i of string s
s[i:j]	Slice from index i to j
s[i:j:k]	Slice from index i to j with interval k
s + s2	Connect string s with string s2
s*n or n*s	Multiply n times of string s
len(s)	Length of string s
min(s)	The minimum value of string s
max(s)	The maximum value of string s
x not in s	If object x is not in the string s, return True.
x in s	If object x is in the string s, return True.

List

Example: L = ['Hello', 'Hi', 'Hey', 'Yo', 'Sup']

List	Hello	Hi	Hey	Yo	Sup
Index from head	0	1	2	3	4
Index from tail	-5	-4	-3	-2	-1

```
# List + slicing
weekdays = ['Mon', 'Tue', 'Wed', 'Thurs', 'Fri']
weekdays[2:4]
```

```
['Wed', 'Thurs']
```

```
# List + slicing
weekdays = ['Mon', 'Tue', 'Wed', 'Thurs', 'Fri']
weekdays[1:]
```

```
['Tue', 'Wed', 'Thurs', 'Fri']
```

```
# List + slicing
weekdays = ['Mon', 'Tue', 'Wed', 'Thurs', 'Fri']
weekdays[::2]
```

```
['Mon', 'Wed', 'Fri']
```

```
# List + append
weekdays.append('SAT')
print(weekdays)
```

```
['Mon', 'Tue', 'Wed', 'Thurs', 'Fri', 'SAT']
```

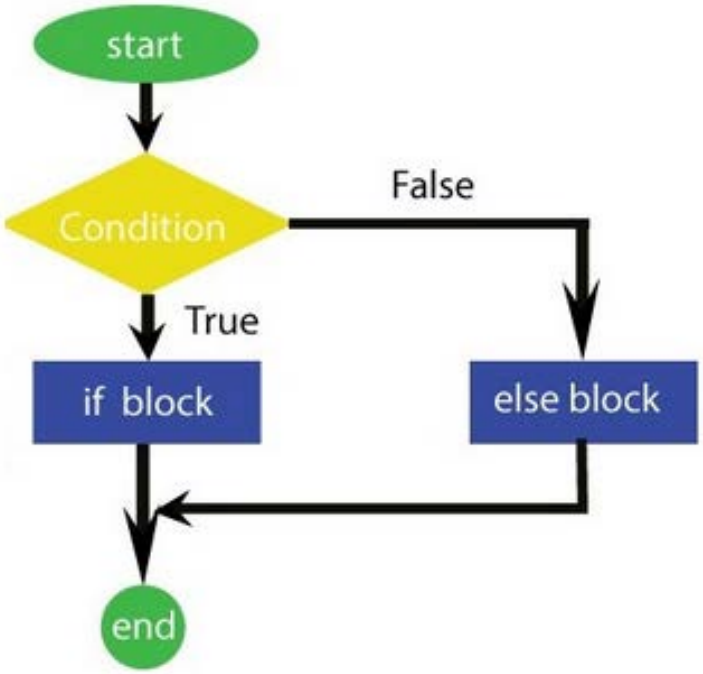
```
# List + append
weekdays = ['Mon', 'Tue', 'Wed', 'Thurs', 'Fri']
weekend = ['Sat', 'Sun']

weekdays.append(weekend)
print(weekdays)
```

```
['Mon', 'Tue', 'Wed', 'Thurs', 'Fri', ['Sat', 'Sun']]
```

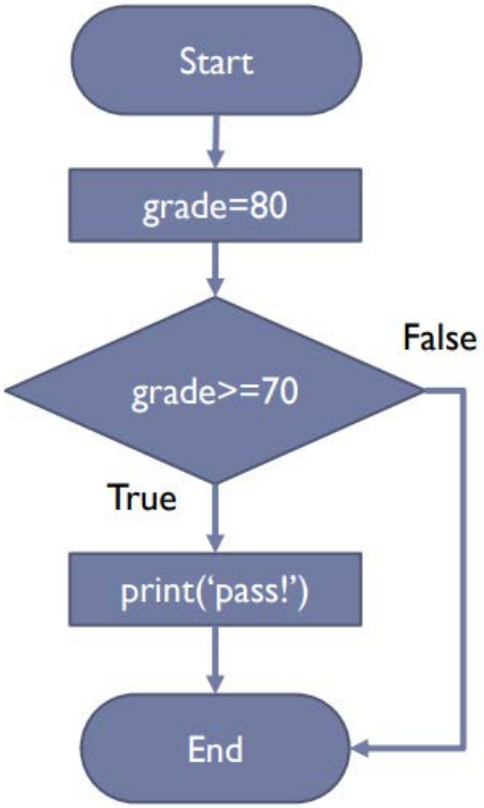
```
# List + extend
weekdays = ['Mon', 'Tue', 'Wed', 'Thurs', 'Fri']
weekend = ['Sat', 'Sun']

weekdays.extend(weekend)
print(weekdays)
```

```
['Mon', 'Tue', 'Wed', 'Thurs', 'Fri', 'Sat', 'Sun']
```

4. Decision (if/else)

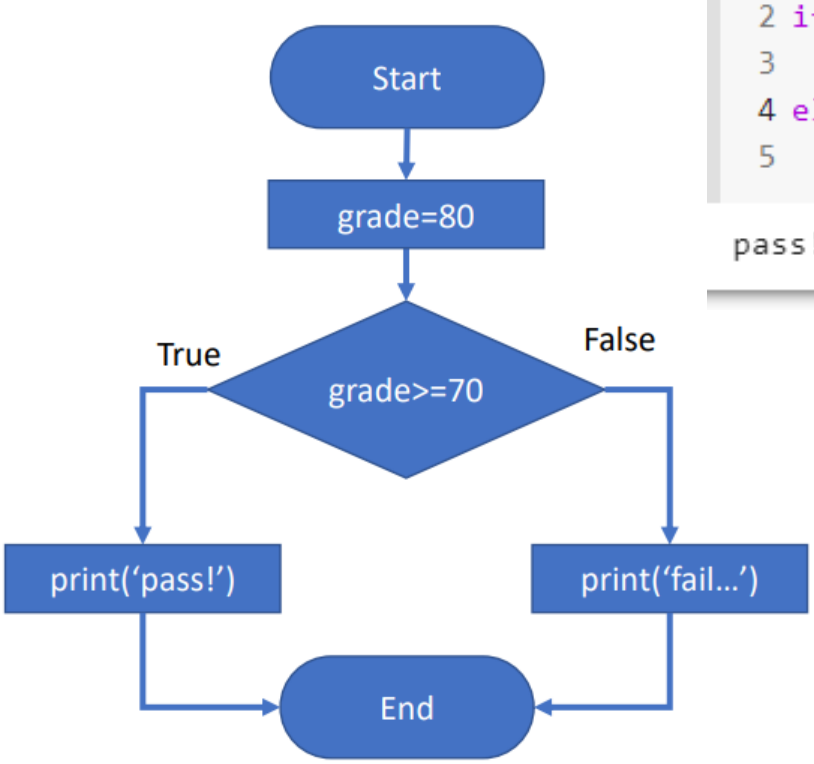



```
If (condition 1):
   if (condtion A):
      code block A
   elif (condition B):
      code block B
   else:
      code block C
else:
   code block 2
```



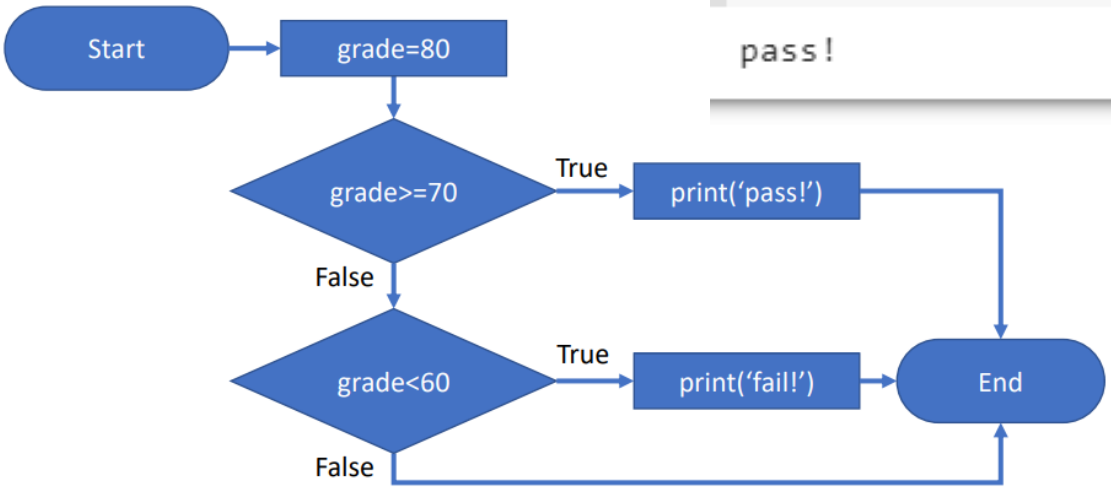

```
1 grade = 80
2 if (grade >= 70):
3   print('pass!')
```

```
pass!
```




```
1 grade = 80
2 if (grade >= 70):
3   print('pass!')
4 else:
5   print('fail...')
```

```
pass!
```




```
1 grade = 80
2 if (grade >= 70):
3   print('pass!')
4 elif(grade < 60):
5   print('fail...')
```

```
pass!
```

5. Loop (for/ while)

```
while (condition):
    code block
```

```
1  answer = 3
2  guess = 0
3
4  while guess != answer:
5      guess = int(input('Please make guess during 1~6. : '))
6      if guess > answer:
7          print('Hint: bigger than the answer.')
8      elif guess < answer:
9          print('Hint: smaller than the answer.')
10     else:
11         print('Bingo!')
```

```
Please make guess during 1~6. : 1
Hint: smaller than the answer.
Please make guess during 1~6. : 2
Hint: smaller than the answer.
Please make guess during 1~6. : 3
Bingo!
```

```
while (condition A):
    code block
    if (condition B):
        break
```

```
1  answer = 3
2  guess = 0
3
4  while True:
5      guess = int(input('Please make guess during 1~6. : '))
6      if guess > answer:
7          print('Hint: bigger than the answer.')
8      elif guess < answer:
9          print('Hint: smaller than the answer.')
10     else:
11         print('Bingo!')
12         break
```

```
Please make guess during 1~6. : 1
Hint: smaller than the answer.
Please make guess during 1~6. : 2
Hint: smaller than the answer.
Please make guess during 1~6. : 3
Bingo!
```

```
for <variable> in (sequence):
    code block
```

```
1 for c in 'Python':
2     print(f'current character:{c}')
```

```
current character:P
current character:y
current character:t
current character:h
current character:o
current character:n
```

```
1 fruits = ['watermelon', 'guava',  'strawberry']
2 for f in fruits:
3     print(f'fruits: {f}')
```

```
fruits: watermelon
fruits: guava
fruits: strawberry
```

```
for <variable> in range(number) :
    code block
```

```
1 for i in range (1,3):
2   print (i)
```

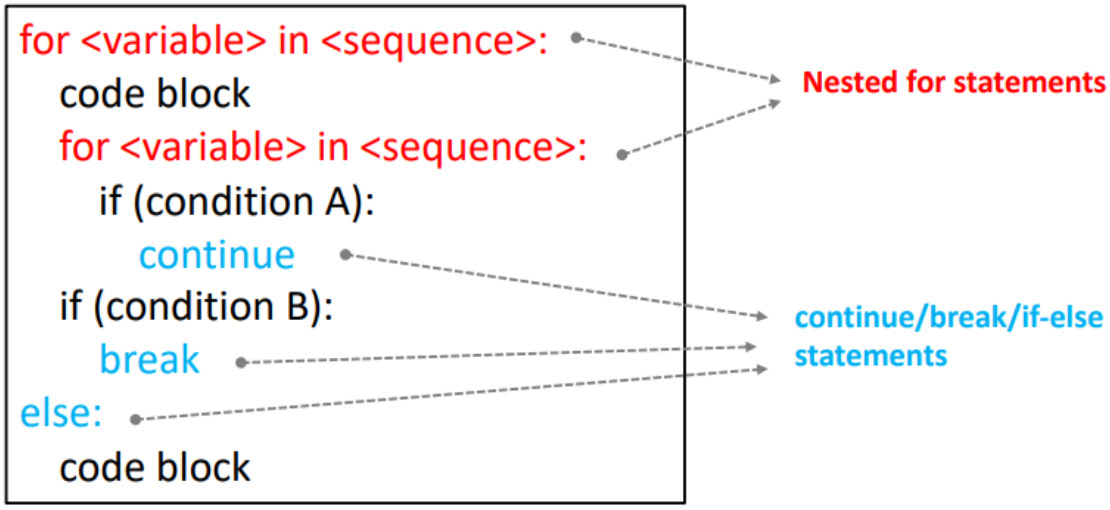
```
1
2
```

```
for <variable> in range(start, end, step) :
    code block
```

```
1 for i in range (1, 10, 2):
2   print(i)
```

```
1
3
5
7
9
```

Nested loop

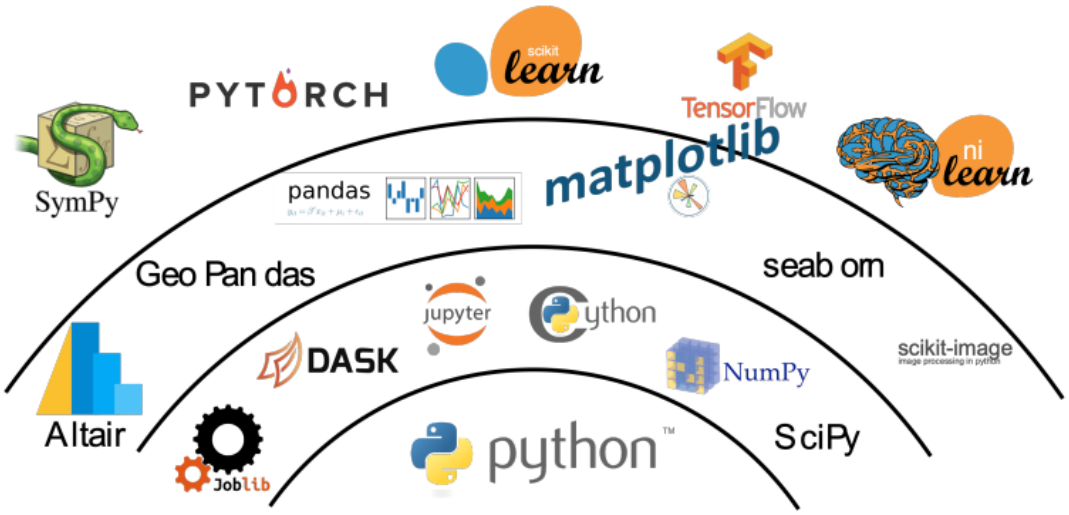



```
1 n = int (input("Enter a number n:"))
2 for j in range (0, n):
3     for i in range (0, n):
4         print("* ", end="")
5     print ("")
6
```

```
Enter a number n:5
* * * * *
* * * * *
* * * * *
* * * * *
* * * * *
```

6. Function and Library

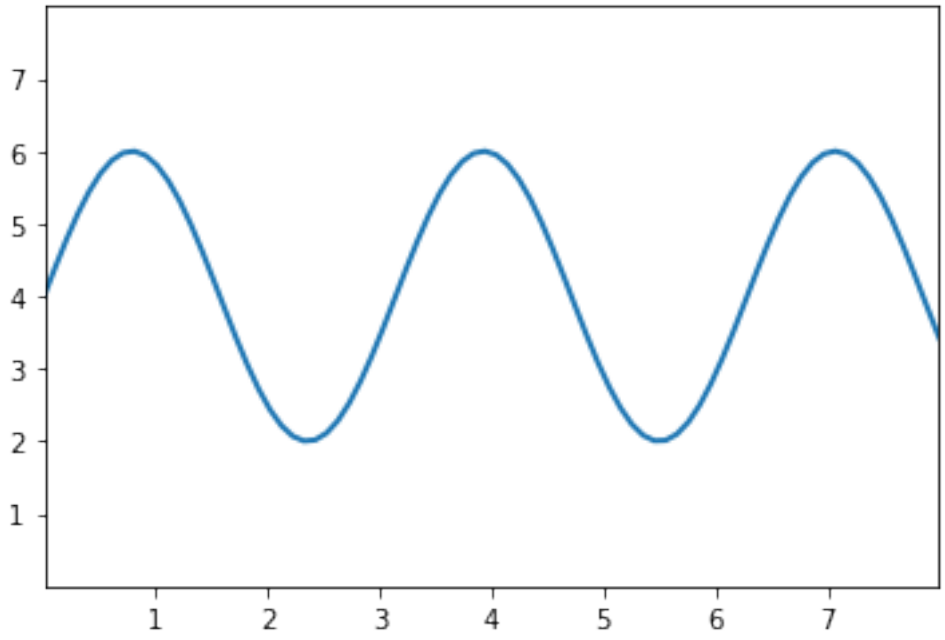
Common Libraries




```python
import math

x1 = math.ceil(1.4)
x2 = math.floor(1.4)
x3 = math.sqrt(64)
x4 = math.sin(0)
x5 = math.cos(0)

print(x1)
print(x2)
print(x3)
print(x4)
print(x5)
```

```
2
1
8.0
0.0
1.0
```

```
import matplotlib.pyplot as plt
import numpy as np

# make data
x = np.linspace(0, 10, 100)
y = 4 + 2 * np.sin(2 * x)

# plot
fig, ax = plt.subplots()

ax.plot(x, y, linewidth=2.0)

ax.set(xlim=(0, 8), xticks=np.arange(1, 8),
       ylim=(0, 8), yticks=np.arange(1, 8))

plt.show()
```



Customized Function

```
def printString( strPrint, n):
    for i in range (0, n):
        print (strPrint)

printString ("Hello World", 5)
```

Output:

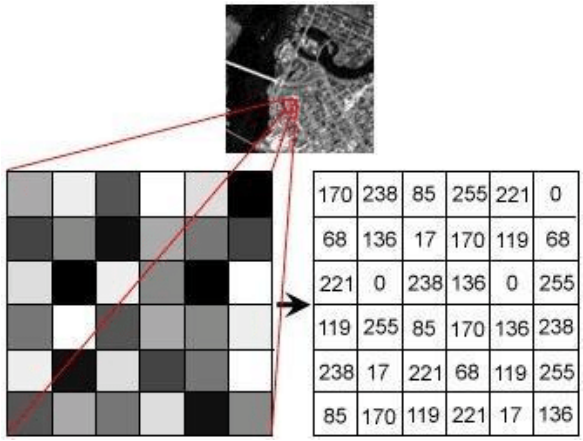
```
Hello World
Hello World
Hello World
Hello World
Hello World
```

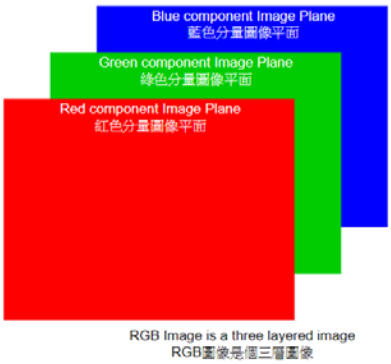
```
def addition(no1, no2):
    answer = no1 + no2
    return answer
a = float(input("a="))
b = float(input("b="))
print (a, "+", b, "= %.2f" % addition(a, b))
```

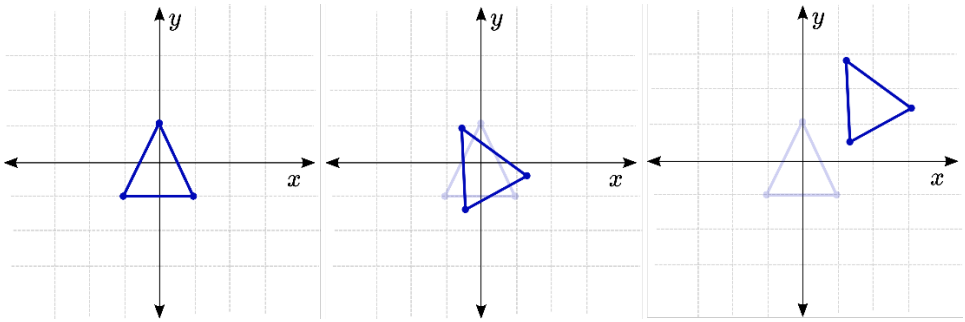
Output:

```
a=1
b=2
1.0 + 2.0 = 3.00
```

7. Image and computer vision







$$\begin{bmatrix} x' \\ y' \end{bmatrix} = A \begin{bmatrix} x \\ y \end{bmatrix} + B$$

Transformed points — Input points

Here, $A = \begin{bmatrix} a_{00} & a_{01} \\ a_{10} & a_{11} \end{bmatrix}$; $B = \begin{bmatrix} b_{00} \\ b_{10} \end{bmatrix}$

Combining A and B we can write,

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a_{00} & a_{01} & b_{00} \\ a_{10} & a_{11} & b_{10} \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Transformation Matrix (M)

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a_{00}x + a_{01}y + b_{00} \\ a_{10}x + a_{11}y + b_{10} \end{bmatrix}$$

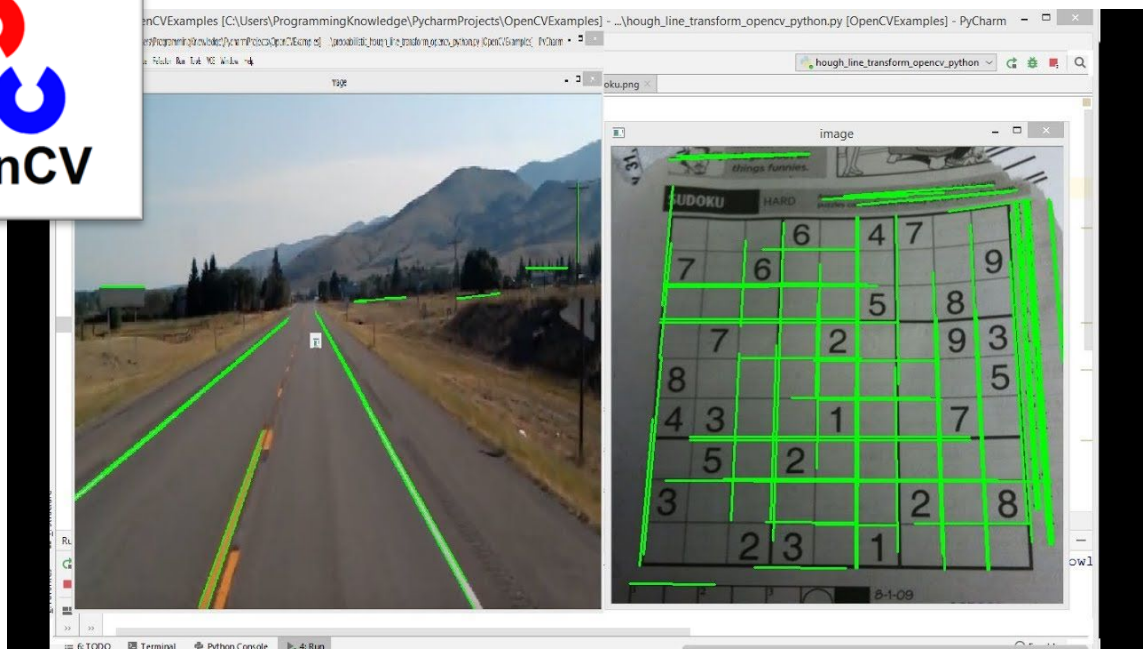
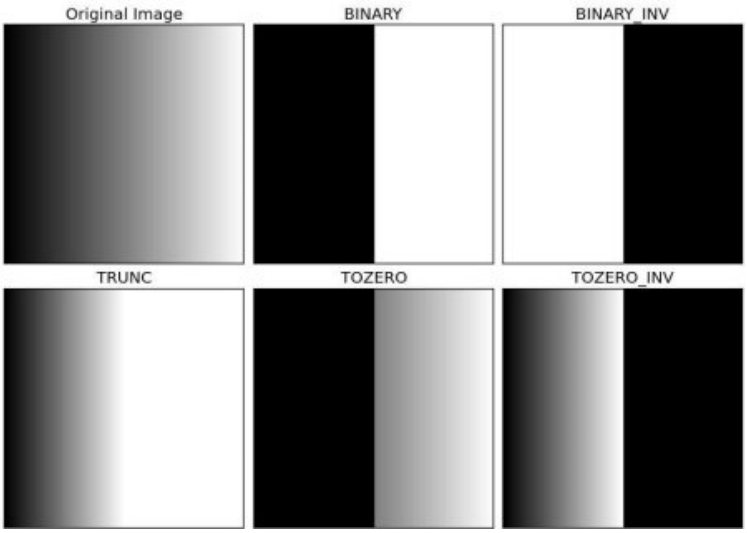


image
SUDOKU
HARD


traffic light
person
car
backpack
handbag
traffic light
person
car
handbag

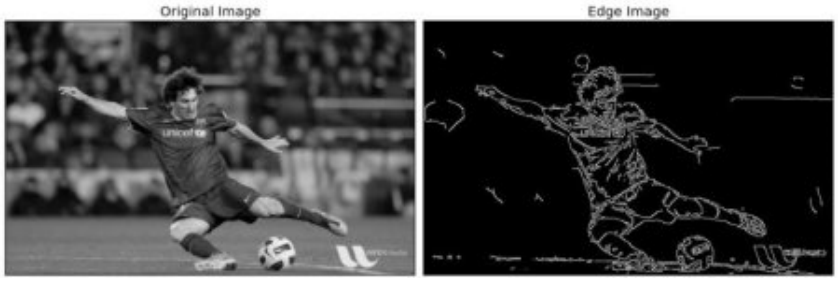
8. Feature extraction

Binary image



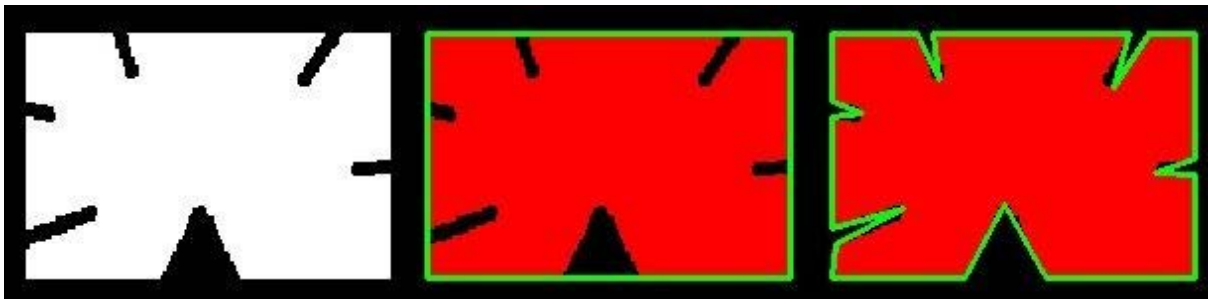
https://docs.opencv.org/3.4/d7/d4d/tutorial_py_thresholding.html

Canny Edge detection



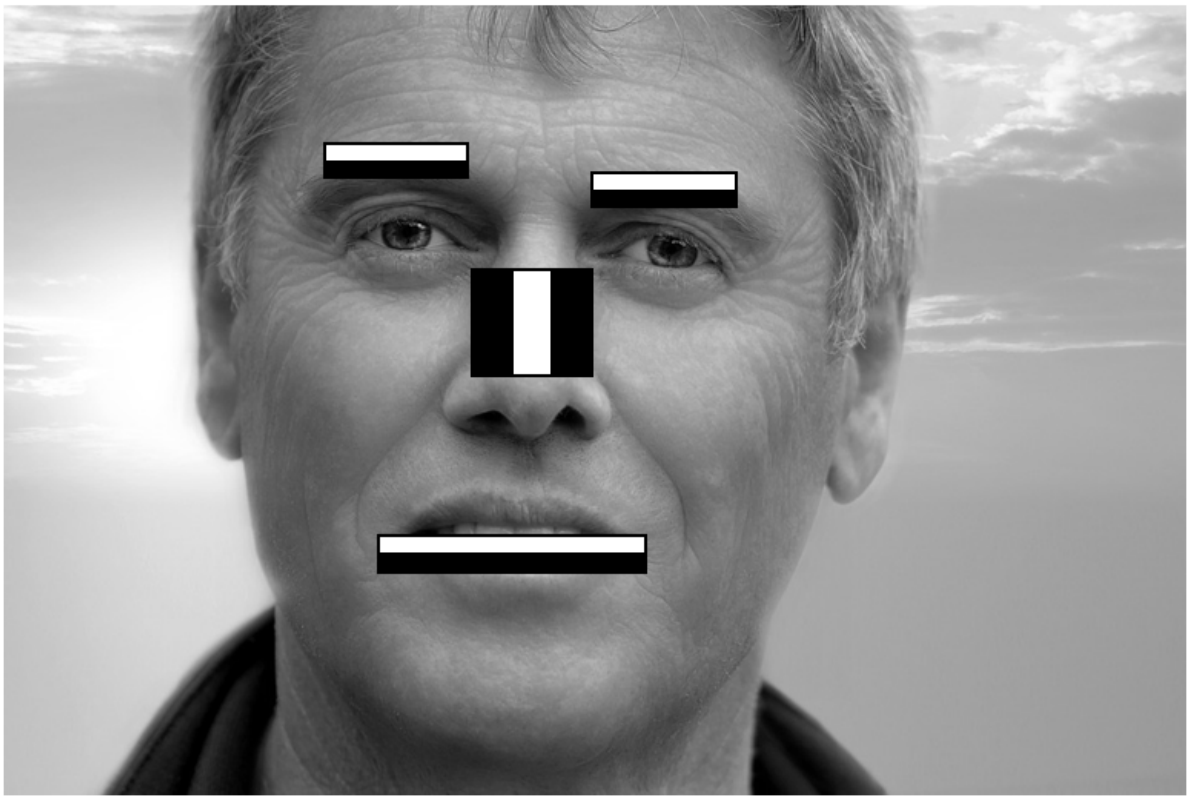
https://docs.opencv.org/3.4/da/d22/tutorial_py_canny.html

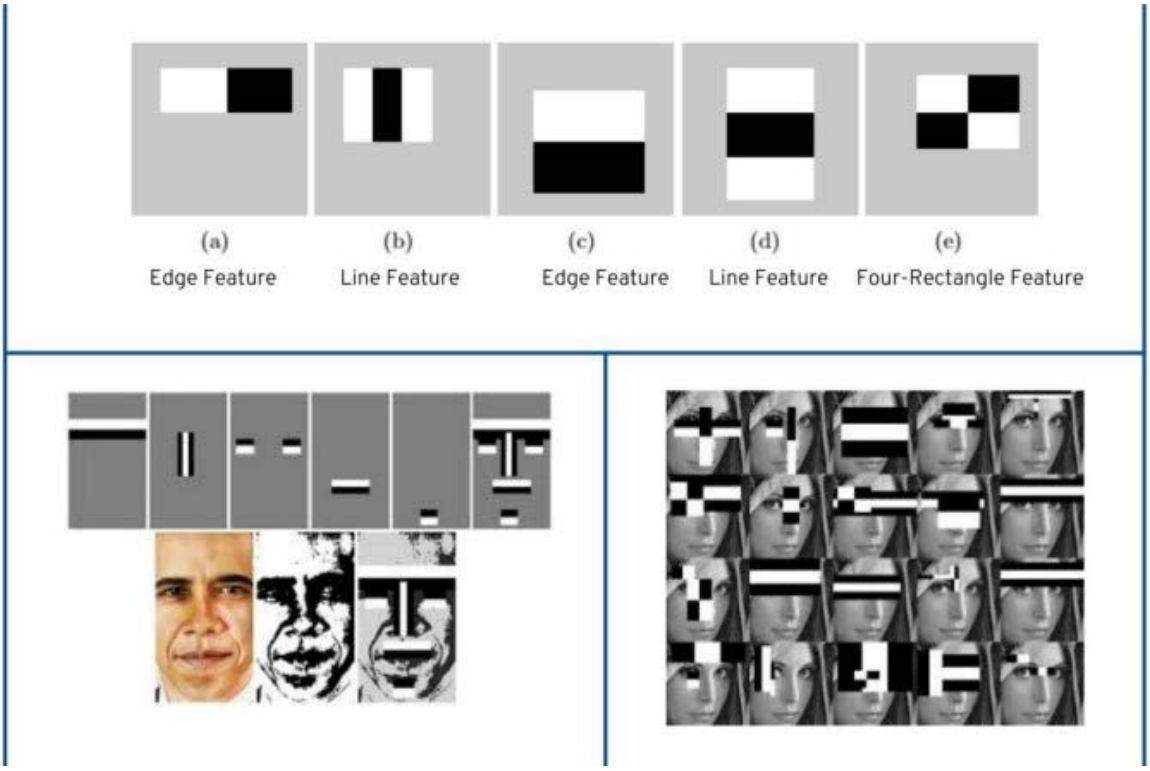
Contour



https://docs.opencv.org/4.x/dd/d49/tutorial_py_contour_features.html

Haar-Like Features





https://www.youtube.com/watch?v=RPoUdDGonWc

Exercise 0 – Warm up

File: basicPython.ipynb

Task1:

Test scores	Grades
>=80	A
60 - <80	B
40 - <60	C
< 40	F

```
Your test mark:85
Your grade is A
>>>
```

```
Your test mark:76
Your grade is B
>>>
```

```
Your test mark:40
Your grade is C
>>>
```

```
Your test mark:37
Your grade is D
>>>
```

Task2:

```
Enter a number n:5
*
* *
* * *
* * * *
* * * * *
>>>
```

```
Enter a number n:5
* * * * *
* * * *
* * *
* *
*
>>>
```

Task3:

```
Please enter a number: 4
4 != 24
```

```
Please enter a number: 9
9 != 362880
>>>
```

Exercise 1 – Data visualization

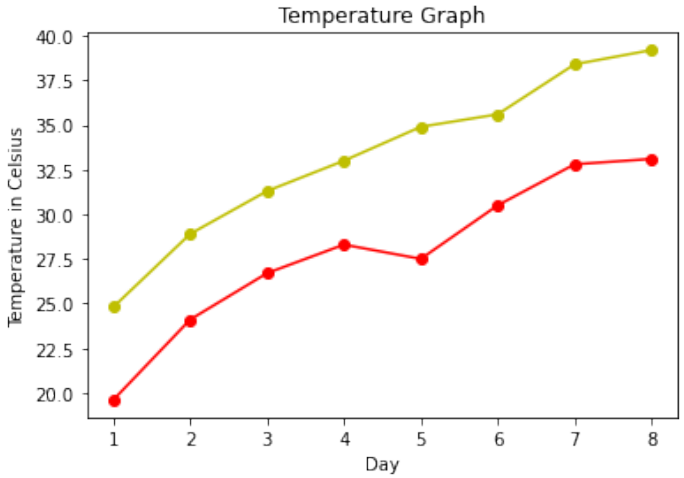
File: dataVisualization.ipynb

Reference: https://matplotlib.org/stable/api/_as_gen/matplotlib.pyplot.plot.html

Visualize the data below with the given graph.

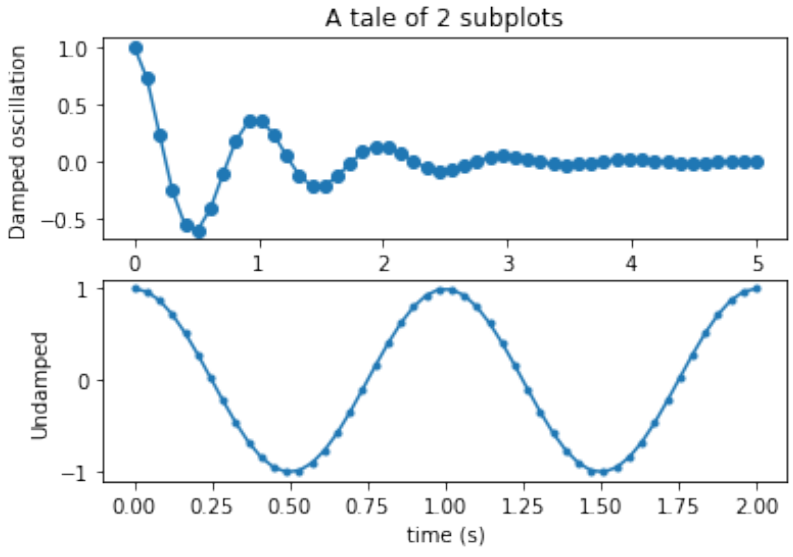
Task1:

```
celsius_min = [19.6, 24.1, 26.7, 28.3, 27.5, 30.5, 32.8, 33.1]
celsius_max = [24.8, 28.9, 31.3, 33.0, 34.9, 35.6, 38.4, 39.2]
```



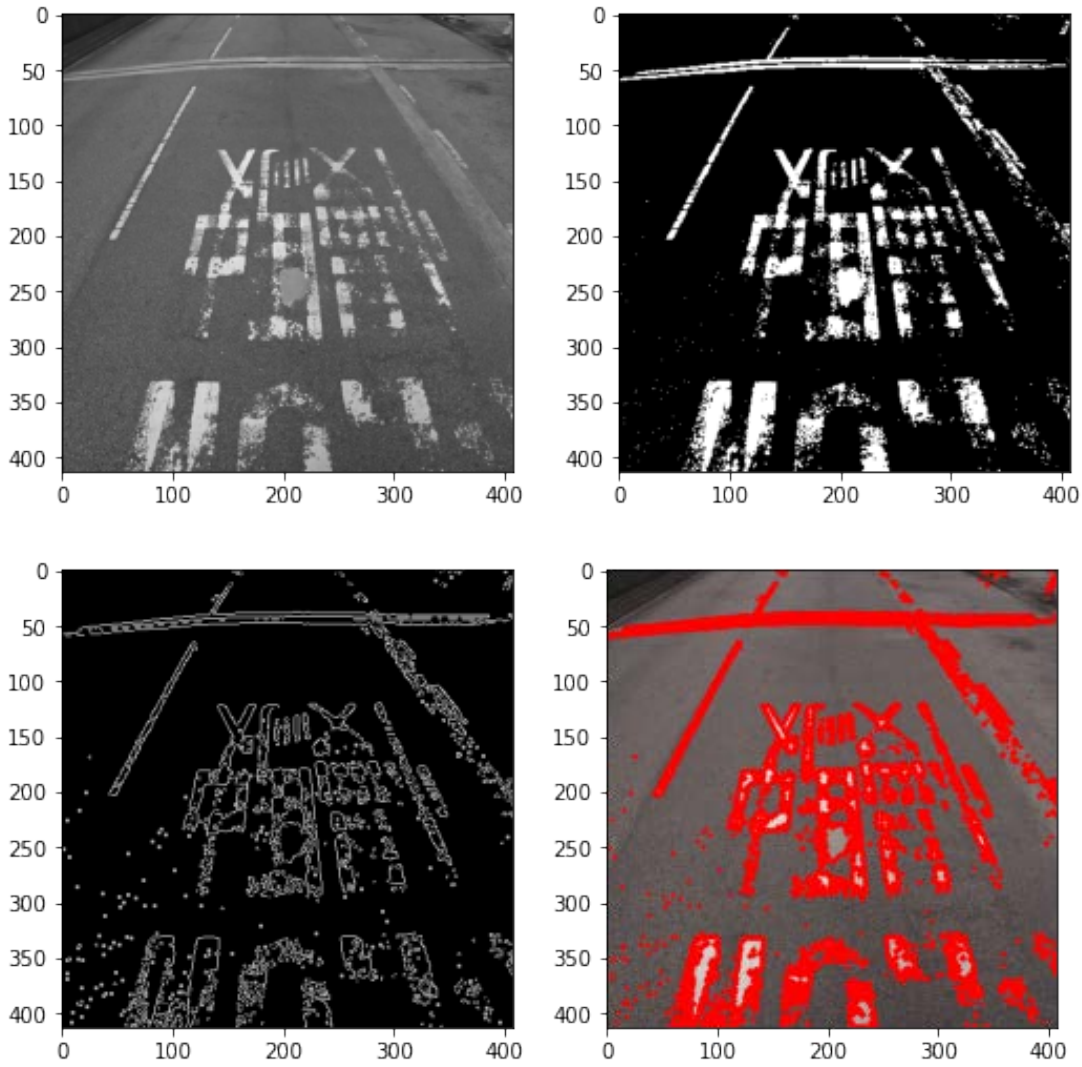
Task2:

```
x1 = np.linspace(0.0, 5.0)
y1 = np.cos(2 * np.pi * x1) * np.exp(-x1)
x2 = np.linspace(0.0, 2.0)
y2 = np.cos(2 * np.pi * x2)
```



Exercise 2a – Features extraction

File: openCV.ipynb



Exercise 2b – Face detection

File: openCV.ipynb