






CS 314

IMAGE PROCESSING PRACTICAL

01 – Introduction to Python

Course Details

- **Evaluation :**

Assignments/ Quizzes	:	10%
Individual project	:	30%
Final Examination	:	60%

- **Recommended text:**
  - *Gonzalez, R. and Woods, R. (2008). Digital Image Processing, 3rd Ed., Prentice Hall.*
  - *OpenCV documentation, https://docs.opencv.org/master/*
  - *Solem, J.E. (2012). Programming Computer Vision with Python: Tools and algorithms for analyzing images, 1st Ed. O'Reilly.*

Terminology

An Image:

An image is defined as a two-dimensional function, **F(x,y)**, where x and y are spatial coordinates, and the amplitude of **F** at any pair of coordinates (x,y) is called the **intensity** of that image at that point.

Digital Image:

When (x,y) and amplitude values of F are finite, we call it a digital image.

Digital Processing:

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it.

Types of Image Processing

Analog Image Processing:

The analog image processing is applied on analog signals and it processes only two-dimensional signals. The images are manipulated by electrical signals. In analog image processing, analog signals can be periodic or non-periodic

Digital Image Processing:

A digital image processing is applied to digital images (a matrix of small pixels and elements). For manipulating the images, there is a number of software and algorithms that are applied to perform changes.

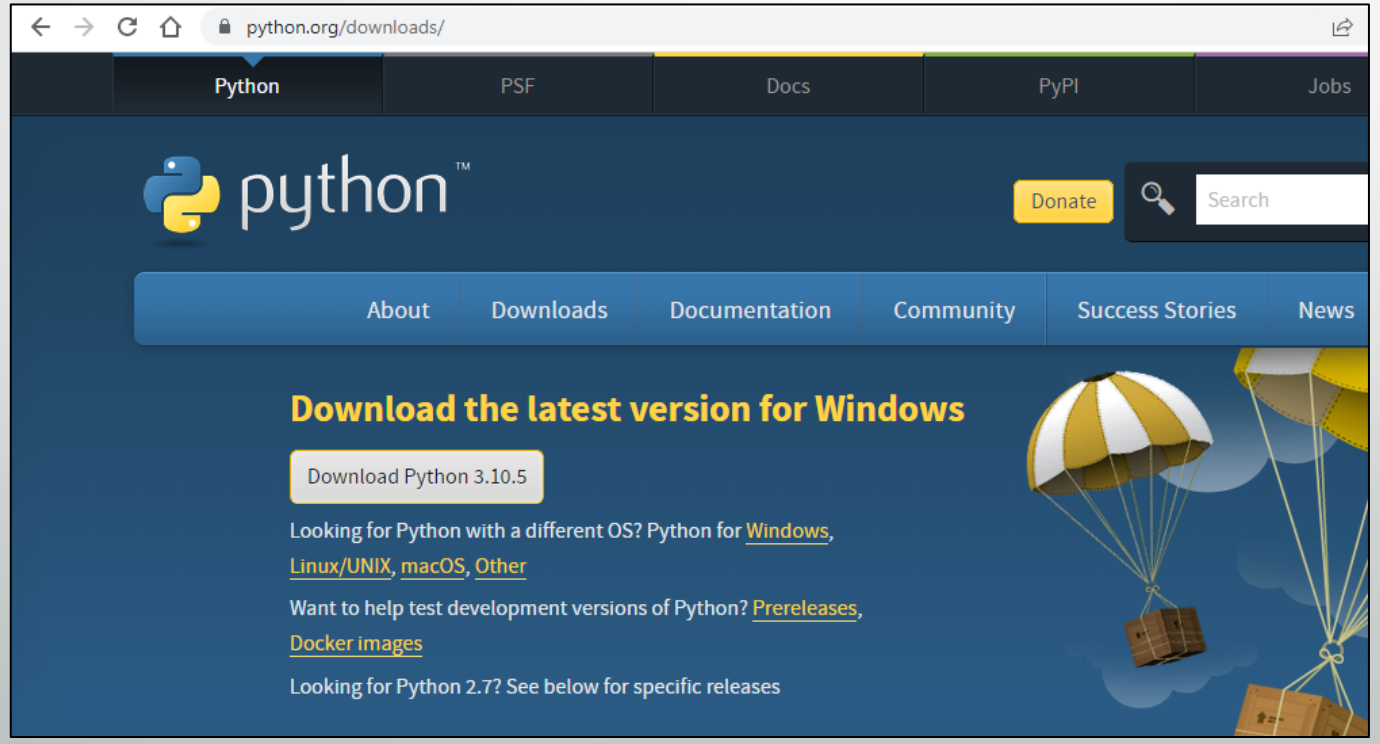
Python Basics

Introduction to Python

- Python is an interpreted, object oriented, high-level, general-purpose programming language.
- Created by Guido van Rossum in 1991
- Python is a programming language that lets you work quickly and integrate systems more efficiently.
- Loosely typed (no need to declare the type)
- Indentation based code block separation (for statement grouping)
- Open Source! Free!

Installing and setting up Python

- Download Python with the following link "https://www.python.org/downloads/" (For references)
- Choose the one appropriate for your OS and architecture(32-bit or 64-bit).



IDLE

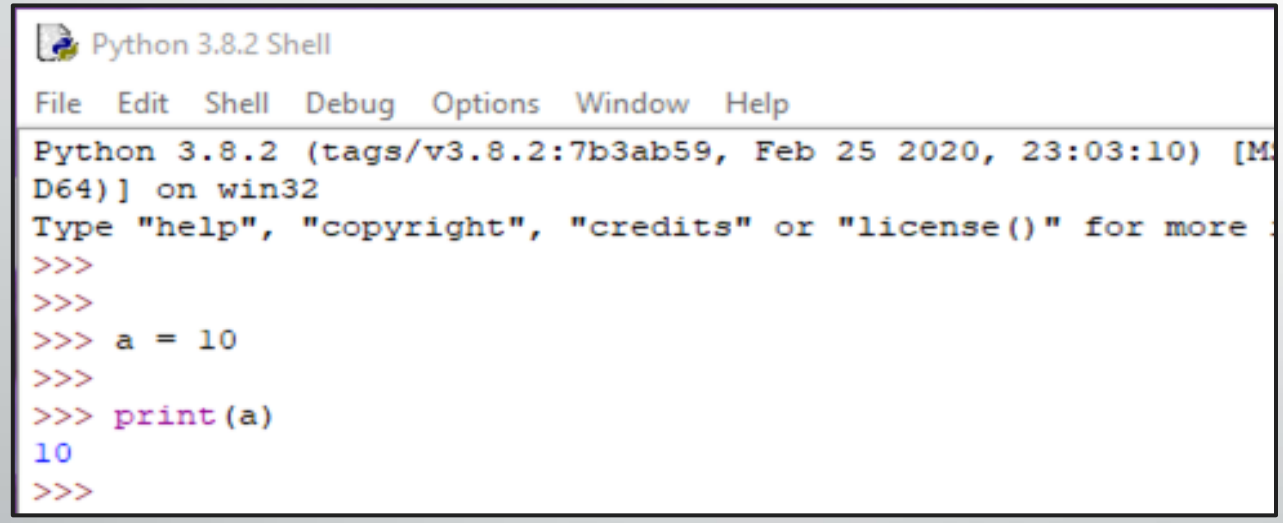
- IDLE is an Integrated Development Environment for Python.
- IDLE has two main windows type, the Shell window (interactive interpreter) and the Editor window.

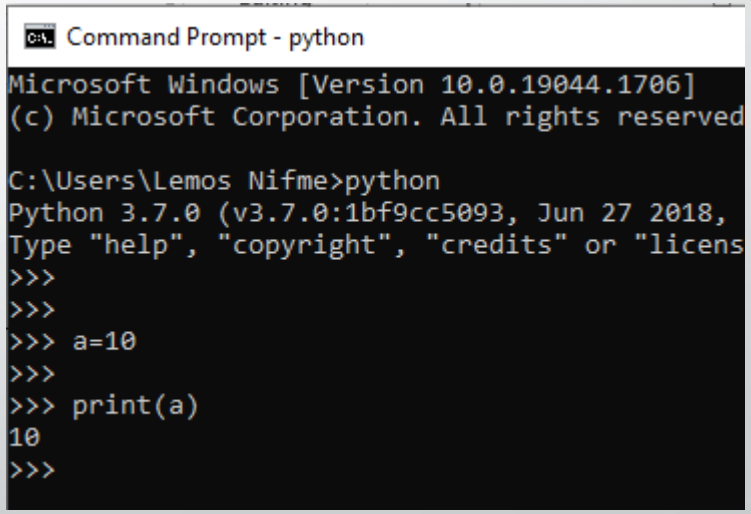
IDLE (Python 3.8 64-bit)

App

Python Shell

- Python shell which is used to execute a single python command and get the result. (*Two variations: IDLE (GUI), Python [command line]*)





print() and input()

print() : Produces text output on the console.

Syntax:

```
print("<Message>")          OR     print('<Message>')
Ex: print('Hello World')                >>> Hello World
```

Input() : Reads a value from user input (always reads as a string).

Syntax:

```
<variable> = input("<Message>")
Ex: a = input("Enter a number:")          >>> Enter a number: 6
```

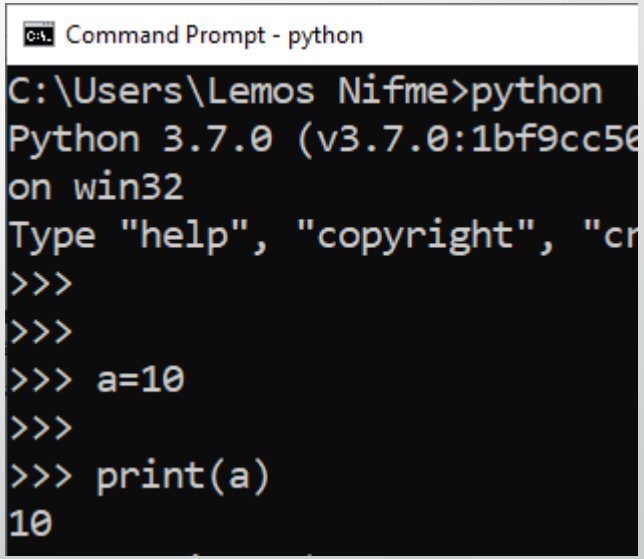
Variables

- **Variable:** A named piece of memory that can store a value.
  A variable consists of an identifier and a memory address
- **Assignment statement:** Stores a value into a variable

  Syntax:

  ```
  <name> = <value>
  ```

- An identifier must obey the following rules.
  - ✓ Must start with a letter or an underscore.
  - ✓ Can contain letters, digits, and underscores.
  - ✓ Can be of any length.
  - ✓ Cannot be a Python keyword.



Functions

Syntax:

Function Header

```
def function_name( parameters ):
    """"function_docstring"""""
    function_suite
    return [expression]
```

Function Body

Functions Examples

def keyword

function name

function parameters

```
def add(x, y):
```

Colon marks the end of the function header

function code

```
    print("Sum of number", x, "and ", y)
    sum = x + y
    return sum
```

function return statement

```
def basic_operations(a, b):
    total = a + b
    dif = a - b
    product = a * b
    div = a / b

    return total, dif, product, div
```

Data types

- *Booleans* are either True or False.
- *Numbers* can be integers (1 and 2), floats (1.1 and 1.2), fractions (1/2 and 2/3), or even complex numbers.
- *Strings* are sequences of Unicode characters, e.g. an html document.
- *Bytes* and byte arrays, e.g. a jpeg image file.
- ***Lists*** are ordered sequences of values.
- ***Tuples*** are ordered, immutable sequences of values.
- ***Sets*** are unordered bags of values.
- ***Dictionaries*** are unordered bags of key-value pairs.

Numeric

- int - Integer number (28, 19, -7)
- float - Real number (0.556, -2.65)
- complex - Complex number (5 + 2j)
- bool - Boolean (True, False)

- **Typecasting numbers:**
  - *“float()” , “int()”*

Operators

Arithmetic operators:

Operators	Meaning	Example	Result
+	Addition	4 + 2	6
–	Subtraction	4 – 2	2
*	Multiplication	4 * 2	8
/	Division	4 / 2	2
%	Modulus operator to get remainder in integer division	5 % 2	1
**	Exponent	5**2 = 5^2	25
//	Integer Division/ Floor Division	5//2 -5//2	2 -3

Logical operators:

Operator	Meaning	Example	Result
and	Logical and	(5<2) and (5>3)	False
or	Logical or	(5<2) or (5>3)	True
not	Logical not	not (5<2)	True

Assignment operators:

Operator	Example	Equivalent Expression (m=15)	Result
=	y = a+b	y = 10 + 20	30
+=	m +=10	m = m+10	25
-=	m -=10	m = m-10	5
*=	m *=10	m = m*10	150
/=	m /=10	m = m/10	1.5
%=	m %=10	m = m%10	5
**=	m**=2	m = m**2 or $m = m^2$	225
//=	m//=10	m = m//10	1

Relational / comparison operators:

Operators	Meaning	Example	Result
<	Less than	5<2	False
>	Greater than	5>2	True
<=	Less than or equal to	5<=2	False
>=	Greater than or equal to	5>=2	True
==	Equal to	5==2	False
!=	Not equal to	5!=2	True

Strings

- Python has a built-in string class named "str" with many handy features.
- String literals can be enclosed by either double or single quotes.
- Python strings can be indexed and sliced in exactly the same way as lists.

Operator	Description	Example
+	Concatenation - Adds values on either side of the operator	strA + strB will give Hello World!
*	Repetition - Creates new strings, concatenating multiple copies of the same string	strA * 2 will give -Hello Hello
[]	Slice - Gives the character from the given index	strA[1] will give e
[:]	Range Slice - Gives the characters from the given range	strA[1:4] will give ell
in	Membership - Returns true if a character exists in the given string	H in strA will give 1
not in	Membership - Returns true if a character does not exist in the given string	M not in strA will give 1
r/R	Raw String - Suppresses actual meaning of Escape characters.	print r'\n' prints \n and print R'\n' prints \n
%	Format - Performs String formatting	It's the same like we used in C.

Strings Contd.

String concatenation

- The “+” operator is used to concatenate two strings.
- The *“str()”* method is used to convert values to a string.

String operations

- capitalize() - Capitalizes first letter of string
- upper() - Converts lowercase letters in string to uppercase.
- lower() - Converts all uppercase letters in string to lowercase.
- swapcase() - Inverts case for all letters in string.
- isupper() - Returns true if string has at least one cased character and all cased characters are in uppercase and false otherwise.

Python

Collection Data Types

`[], (), {}, {k:v}`

Lists

- A collection of values
- Contain any type
- Contain different types
- 0-based indexing

Syntax: `[<e1>,<el2>,…]`

```
a = []     # a is an empty list
b = ['python', 1, False]

print(a, len(a))
print(b, len(b))
```

List Indexing

- List items can be accessed using the *"list[i]"* statement where *"i"* is the index and *"list"* is the identifier of the list.
- A negative index accesses a list from the end counting backwards.

Ex:

```
list_1 = [“Kandy”,”Colombo”,”Galle”,”Jaffna”,” Ampara”]
print( list_1[1] )                    >>>” Colombo”
print( list_1[-1] )                   >>>”Ampara”
print( list_1[1:3] )                  >>>[”Colombo”,”Galle”]
```

List slicing

- Obtaining a part of a list once it has been defined is called *slicing* a list.
- A part of a list, called a “slice”, is obtained by specifying two indices. This returns a new list containing all the items of the original list, in order, starting from the first slice index, up to but not including the second slice index.

```
<list>[<>:<length_of_the_index>]
```

Ex:

```
list_1[:3] returns 0,1,2 indexed elements from list_1
```

Adding items to a list

- The “+” operator concatenates two lists to make a new one.

```
a = ['red', 'green']
b = [1, 2]

a = a + b    # The "+" operator creates a new list and assigns it to a.
print(a)
```

- The *“append()”* method adds a single item to the end of a list

```
a = ['red', 'green']

a.append('blue')
print(a)
```

Adding items to a list

- The "*extend()*" method takes one list or a single value as an argument and appends each item of this list to the original list.

```
a = ['red', 'green']
a.extend([1, 2, 3])     # Adds all the elements in the argument list
                        # to original list.
print(a)

b = ['cat', 'dog']
a.extend(b)             # This works the same.

print(a)
```

Adding items to a list (continued)

- The *"insert()"* method inserts a single item to the list at the given index. The first argument is the index to be inserted at, and the second argument is the item to be inserted.

```
a = ['red', 'green', 'blue']
a.insert(1, 'black')    # Inserts the string "black" at index 1.

# The value "green" which was at index 1 gets bumped to index 2, and
# "black" is inserted at index 1.
print(a)
```

Tuple

- Immutable/unchangeable
  (cannot add or remove items after tuple is created)
- Use full for fixed data
- Faster than list lists (accessing items and iteration)

  Syntax: <identifier> = (<el1>, <el2>, …..)

  Ex:

  - `tuple1 = (1,2,3,4,5)`
  - `tuple2 = (‘a’, ‘b’, ’c’)`
  - `tuple3 = (‘a’, 3, 45.9, ‘Hello’)`

Set

- Store non duplicate items
- unindexed
- Very fast access compared to Lists
- Math set operations(union, intersect)
- Unordered

Syntax: <identifier> = {<el1>, <el2>, …..}

Dictionaries

- A dictionary , or a “dict”, is an efficient key/value hash table structure Python.
- The contents of a dictionary is a series of ordered key/value pairs. **from python version 3.7, dictionaries are ordered**
- Dictionaries are changeable (can change, add or remove items after creation)
- Dictionaries do not allow duplicates (do not allow duplicated keys)

Dictionaries (Cont…)

Syntax:

```
<dict name> = {<key>:<value>}
```

- dict is listed in curly brackets.
- Inside the curly brackets, keys and values are declared.
- Each key is separated from its value by a colon(:) while each element is separated by commas.

Dictionaries (Contd.)

- **Key** –
  - No duplicate key is allowed.
  - Immutable data type such as string, numbers, or tuples.
  - Case sensitive.

```
>>> new_dict1 = {1:"First year", 2:"Second Year", 3:"Third Year", 4:"Fourth Year"}
>>>
>>> print(new_dict1)
{1: 'First year', 2: 'Second Year', 3: 'Third Year', 4: 'Fourth Year'}
```

Dictionaries (Cont…)

```
>>> dict_course = {"CS100":553, "CS104":349, "CS202":294, "CS314":13}
>>> dict_student = {"First year":('Praveen','Ruwandi','Salith'),"Second year":('Anushka','Chanaka','Hi
mansi'),"Third Year-SP":('Gunasekara','Edirisinghe','Madugalla')}
>>>
```

```
>>> dict_student["First year"]
('Praveen', 'Ruwandi', 'Salith')
>>>
>>>
>>> dict_student["First Year"]
Traceback (most recent call last):
  File "<pyshell#21>", line 1, in <module>
    dict_student["First Year"]
KeyError: 'First Year'
>>> |
```

Dictionary in-built methods

- keys() - Retrieve the list of keys in the dictionary.
- values() - Retrieve the list of values in the dictionary.
- items() - Retrieve the list of keys and their vales as tuples in the dictionary.
- copy() - Copy the entire dictionary to new dictionary.
- update() - Update a dictionary by adding a new entry or a key:value pair to an existing entry.

Python

Repetition and Selection

The For loop

- **for loop**: Repeats a set of statements over a group of values.

Syntax:

```
for variable_name in collection:
    statements
```

- If the index is required, we can use the ***"enumerate()"*** function.

```
numbers = [1, 2, 3, 4, 5]
total = 0

for number in numbers:
    total += number

print(total)
```

```
numbers = [10,20,30,40,50]
total = 0

for index,number in enumerate(numbers):
    total += number
    print(index)

print("\n",total)
```

Range

- The **range** function specifies a range of integers:
  - range(***start***, ***stop***) - the integers between ***start*** (inclusive) and ***stop*** (exclusive)
  - range(***start***, ***stop, step***) - the integers between ***start*** (inclusive) and ***stop*** (exclusive) by ***step***

Example :

```
for x in range(5, 0, -1):
    print (x)
```

If, If-else, else-if statements

1. **if --- Syntax:**

```
if condition:
        #statements
```

The statements are executed if condition is evaluated to True.

2. **if-else --- Syntax:**

```
if condition:
        #statements
else:
        #statements
```

Executes one block of statements if a certain condition is True, and a second block of statements if it is False

3. **else-if --- Syntax:**

```
if condition:
        #statements
elif condition:
        #statements
else:
        #statements
```

Multiple conditions can be chained with **elif** ("else if")

While-loop

- Python also has the standard while-loop.
- The while loop provides total control over the index numbers.

Syntax:

```
while condition:
        #statements
```

```
a = [0, 1, 2, 3, 4, 5, 6, 7, 8]
i = 0

while i < len(a):
    print(a[i])
    i += 2
```

Python

File Handling

File Handling

- The key function : **open()**

  Syntax : `<file_object> = open(<filename> , <mode>)`

- modes:
  - **"r"** - Read mode which is used when the file is only being read
  - **"w"** - Write mode which is used to edit and write new information to the file (any existing files with the same name will be erased when this mode is activated)
  - **"a"** - Appending mode, which is used to add new data to the end of the file; that is new information is automatically amended to the end
  - **"r+"** - Special read and write mode, which is used to handle both actions when working with a file
  - **"b"** - Open in binary mode

Example:

(Constant file name)

```
inputFile = open("data.txt", "r")
```

or

(Variable file name: entered by user at runtime)

```
fname = input("Enter name of input file: ")
inputFile = open(fname, "w")
```

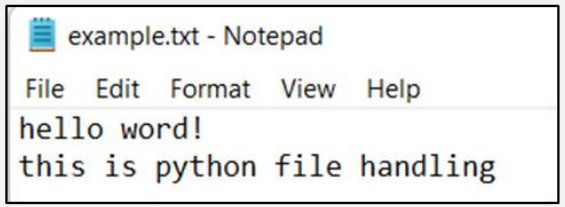
Read file

- **“ r ”** – opens a file for reading
- **read()** – Reading the content of the file
- **read([size])** – Reading the content of the file for a specified size
- **readline()** – Read one line of the file
- **readlines()** – Read lines to a list

```
f= open("example.txt","r+")

print( f.read(10) ) # size=10 → 10 bytes/ 10
                      characters
f.close()

#output
hello word
```



Write file

- **“w”** – Write : will overwrite any existing content
- **“a”** – Append : will append to the end of the file

```
f= open("example.txt","a") #append

f.write("New content is written here!")

f.close()
```

example.txt - Notepad

File Edit Format View Help

```
hello word!
this is python file handling
New content is written here!
```

```
f= open("example.txt",“w") #overwrite

f.write("New content is written here!")

f.close()
```

example.txt - Notepad

File Edit Format View Help

```
New content is written here!
```

Writing multiple lines

```
f= open("example.txt","w")

for i in range(5):
     f.write("This is line %d\n" % (i+1))

f.close()
```

example.txt - Notep

File Edit Format Vi

```
This is line 1
This is line 2
This is line 3
This is line 4
This is line 5
```

Note: You should always close your files at the end. In some cases, due to buffering, changes made to a file may not visible until you close the file.

Delete file & Rename file

Syntax (Delete):

```
import os
os.remove(<file name>)
```

Syntax (Rename):

```
import os
os.rename(<file name>, <new file name>)
```

– END –

[redacted]