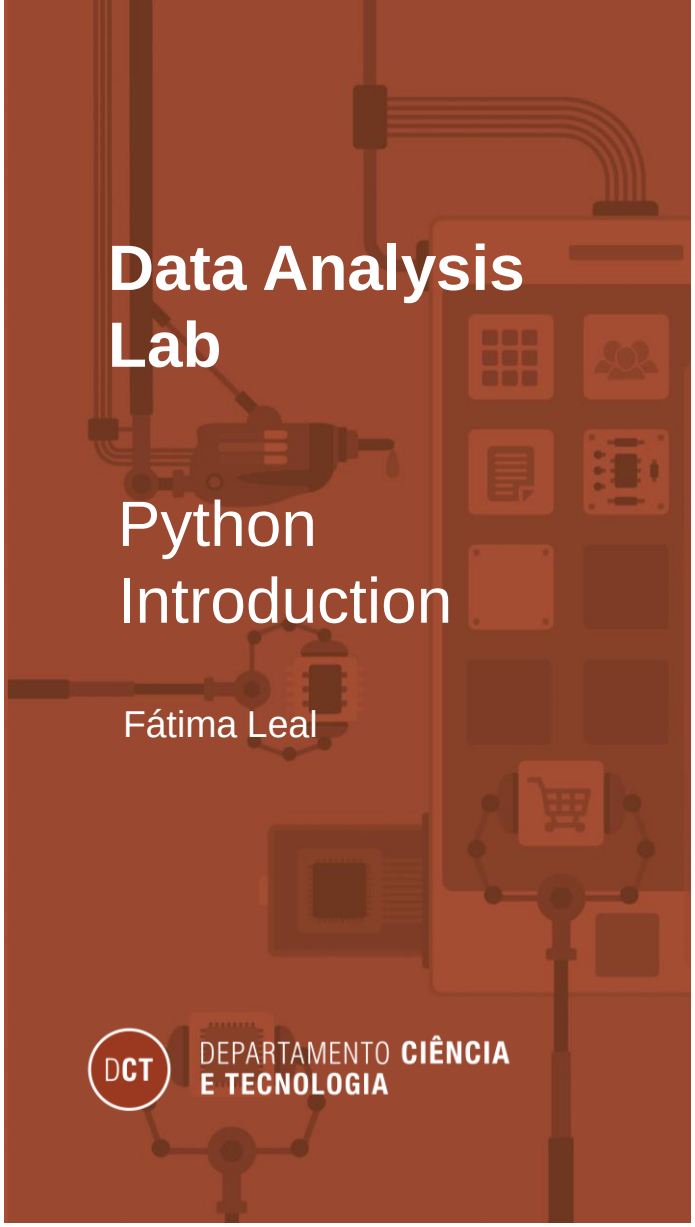

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Content

- Installation of Python Environment
- Basic Python Concepts
- Practical Examples

Installation Environment

- **Install** Python 3+
- **Install** Pycharm for Community
- Setup PyCharm with Python environment:
  - Create new project
  - Verify the existing interpreter and make it available for all projects
- Install data analysis modules
  - File -> Settings -> Project nameProject -> Python Interpreter
  - Add matplotlib
  - Add numpy
  - Add Pandas
  - Add Scikit-learn

Introduction to Python

```
a="Data Analysis Lab"
print("Welcome to {0}".format(a))
```

```
Welcome to Data Analysis Lab
```

Python: variables and data types

- **Variables**

```
>>>b = 2 # b is integer type

>>>b = b*2.0 # now b is float type
```

- **Types**: int, float, string, Boolean, etc.

- **Strings**

```
>>>s = “3 9 81”
>>>print(s.split())
>>>s[0]='p' # error
```

Python: Strings

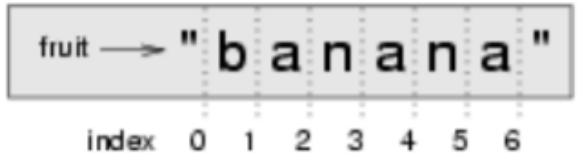
- **Strings** in Python are enclosed in either **single quotes** ’ or **double quotes** "

```
>>> type(‘This is a string.’)
<class ’str’>
>>> type(“And so is this.”)
<class ’str’>
```

- Operations with strings:
  - `len(str)` - length of a string.
  - `str[i]` the subscript operation extracts the i’th character of the string, as a new string.
  - `str[i:j]` the slice operation extracts a substring out of a string.
  - `str.find(target)` returns the index where target occurs within the string, or -1 if it is not found.

Python: Strings

- Examples




```
>>> fruit = "banana"
>>> fruit[:3]
'ban'
>>> fruit[3:]
'ana'
>>> fruit[2:5]
'nan'
```

Python: Strings

```
>>> phrase = "Pirates of the Caribbean"
>>> print(phrase[0:5])
```

What is the answer?

Python: Lists and tuples

- **Lists** and **Tuples** are **similar** data types. Both are used for **grouping data**.
- **Lists** are like **arrays** being **mutable**.
- **Tuples** are **immutable**, *i.e.,* the content cannot be changed.
- A **list** uses **[ ]** while **tuples** use **( ).**
- Like lists, tuples may contain any data type including other tuples.

Python: Lists and tuples

Method	Sintax	Description
append	`mylist.append(item)`	Adds na element in the end
insert	`mylist.insert(pos, item)`	Inserts an element in a given position
pop	`mylist.pop()`	Removes and return the last element
pop	`mylist.pop(pos)`	Removes and return the element in a given position
sort	`mylist.sort()`	Orders the list (increasing or alphabetically)
reverse	`mylist.reverse()`	Reverse ordering
index	`mylist.index(item)`	Returns the first position
count	`mylist.count(item)`	Counts the item in the list
remove	`mylist.remove(item)`	Removes the first occurrence of the item

Python: Lists and tuples

- **Tuples - Examples**

```
>>>x = ('smith','john',(6,23,68)) # this is a tuple
>>>lastname,firstname,birthname = x # unpacking the tuple
>>>print(firstname)
>>>x=(2,) # this is a tuple with a single object
>>>x[0]='p' # error. Tuples are immutable
```

- **Lists - Examples**

```
>>>a = [1.0, 2.0, 3.0] # this is a list
>>>a.append(4.0) # adding a new element to the list
>>>a[2:4] = [1.0, 1.0, 1.0] # modify selected elements
>>>b=a # create a reference to a
>>>c=a[:] # create an independent copy of a
>>>a=[[1,2,3],[4,5,6]] # create a matrix
```

Python: Lists and tuples

```
>>> beatles = [1, 2, 3]
>>> beatles[0] = "john"
>>> beatles[2] = "ringo"
>>> beatles
['john', 2, 'ringo']

>>> beatles[1:2] = ['paul', 'george']
>>> beatles
['john', 'paul', 'george', 'ringo']
```

```
>>> beatles = ['john','paul']
>>> beatles.append('george')
>>> beatles.append('ringo')
>>> beatles
['john', 'paul', 'george', 'ringo']
>>> beatles.insert(0, 'paul')
>>> beatles
['paul', 'john', 'paul', 'george', 'ringo']
>>> beatles.sort()
>>> beatles
['george', 'john', 'paul', 'paul', 'ringo']
```

Python: Dictionaries

- Dictionaries are Python's built-in mapping type.
- It maps keys (any immutable type) to values.
- One way to create a dictionary is to start with the empty dictionary and add `{key:value pairs}`.

```
>>> d = dict() # empty dictionary
>>> d = { } # empty dictionary
>>> pairs = [("cow", 5), ("dog", 98), ("cat", 1)] #dict of a list of pairs
>>> d = dict(pairs)
>>> d = { "cow":5, "dog":98, "cat":1 } # dict statically allocated
```

Python: Dictionaries

Method	Sintax	Description
keys	`mydict.keys()`	Returns the dictionary keys as a list
values	`mydict.values()`	Returns the dictionary values as a list
items	`mydict.items()`	Returns the dictionary elements as a list of tuples
get	`mydict.get(key)`	Returns the value of the indicated key

Python

- Reserved words

and	def	exec	if	not	return
assert	del	finally	import	or	try
break	elif	for	in	pass	while
class	else	from	is	print	yield
continue	except	global	lambda	raise	

Python: arithmetic operations

```
>>>s = “hello”

>>>t = “to you”

>>>print(s+t)

>>>a = [1,2,3]

>>>print(3*s)
```

+	addition
-	subtraction
*	multiplication
/	division
**	exponentiation
%	modular division

Python: arithmetic operations

- Example: Python as calculator

- Indicate the result of the following expression using $a = 1$; $b = 1$ and $c = -\frac{1}{3}$

$$\sqrt{b^2 - 4ac}$$

```
>>>a=1
>>>b=1
>>>c=-1/3
>>>math.sqrt(b**2-4*a*c)
1.5275252316519465
```

Python: other operations

<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to
==	equal to
!=	not equal to

a+=b	a=a+b
a-=b	a=a-b
a*=b	a=a*b
a/=b	a=a/b
a**=b	a=a**b
a%=b	a=%b

Python: Conditionals

- Execute a block of statements:

```
if <condition>:
    block
```

- If the condition is False the block is skipped to:

```
elif <condition>:
    block
```

- If none of previous statements are true then:

```
else:
    block
```

Python: Conditionals

- Example: Write a Python program which identifies the higher number of two values. The program should print an appropriate message.

```
if x < y:
    <STATEMENTS_A>
elif x > y:
    <STATEMENTS_B>
else:          # x == y
    <STATEMENTS_C
```

Python: Loops or cycles

- **While**: executes a block of statements **if the condition is true**.

```
while <condition>:
    block
```

- After the execution of the block the condition is evaluated again.
- If it is still true, the block is executed again.
- This process is continued until the condition becomes false.

```
n=6
current_sum = 0
i=0
while i <= n:
    current_sum += i
    i += 1
print(current_sum)
```

Python: Loops or cycles

- For cycle:

```
for <target> in <sequence>:
        block
```

```
word="Banana"
for letter in word:
    print(letter)
```

- This statement requires a target and a sequence over which the target loops.

```
for x in range(5):  # 0, 1, 2, 3, 4
    print(x)

for x in range(10): # 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
    print(x)

for x in range(3,10): # 3, 4, 5, 6, 7, 8, 9
    print(x)

for x in range(3,10,2): # 3, 5, 7, 9
    print(x)
```

Python: Loops or cycles

- Example: Consider the following list:

```
xs = [12, 10, 32, 3, 66, 17, 42, 99, 20]
```

Implement a python program which calculates the average of the list and identifies the highest number.

```
xs = [12, 10, 32, 3, 66, 17, 42, 99, 20]
sum=0
higher=0
for x in xs:
    sum += x
    if x>higher:
        higher=x
average = sum /len(xs)

print("The average of the list is: ", average)
print("The highest number is: ", higher)
```

Python: Type Conversion

```
>>>a=5
>>>b=-3.6
>>>c="4"

>>>print(a+b)
>>>print(int(b))

>>>d = a + float(d)
>>>print(d)
```

```
>>> a = "2345"
>>> type(a)
<class 'str'>
>>> a = int("2345")
>>> type(a)
<class 'int'>
```

```
>>> int("23 alunos")
Traceback (most recent call last):
  File "<pyshell#33>", line 1, in <module>
    int("23 alunos")
ValueError: invalid literal for int() with base 10: '23 alunos'
```

Python: Reading input and printing output

```
>>>age = input ("Introduce your age: ")
>>>age = int(age)
>>>print("Your age is:",age)
```

Note that all **data provided by user** comes in **string format**.

Python: Reading input and printing output

- Format method:
- The **format method** substitutes its arguments into the **place holders**.
- The numbers in the **place holders** are **indexes**
- It is possible **to define** the **data type**

```
>>> phrase = "His name is {0}! ". format("Arthur")
>>> print(phrase)
His name is Arthur!
```

Python: Reading input and printing output

```
>>> name = "Alice"
>>> age = 10
>>> phrase = "I am {1} and I am {0} years old. ". format(age, name)
>>> print(phrase)
I am Alice and I am 10 years old.
```

```
>>> x = 4
>>> y = 5
>>> phrase = "2**10 = {0} and {1} * {2} = {3:f}". format(2**10, x, y, x * y)
>>> print(phrase)
2**10 = 1024 and 4 * 5 = 20.000000
```

Python: Opening and Closing a File

```
file = open(filename,action) #open a file
```

where action is one of the following strings:

'r'	read from an existing file
'w'	write to a file. if the filename does not exist it is created
'a'	append to the end of the file
'r+'	read to and write from an existing file
'w+'	same as 'r+', but filename is created if it does not exist
'a+'	same as 'w+', but data is appended to the end of the file

```
file.close() # close a file
```

Python: Functions

```
def func_name(param1,param2,...):
        statements
        return return_values
```

- A **function** is a piece of code which **executes specific tasks**
- It has a **name** and may have **parameters**
- A **parameter** can be **any python object**, including another function.
- A **parameter can have default** values.
- If the **return statement is omitted** the function returns the **null object**.

Python: Functions

- **Exercise**: Define a function which calculates the circumference area. The function should receive as parameter the circumference radius and return the corresponding area.

```
import math
def area(radius)
        res = math.pi*radius**2
        return res
```

Note that `res` is a local variable.

Python: Modules

- **A module** is a file containing **Python definitions and statements** intended for use in **other Python programs**.

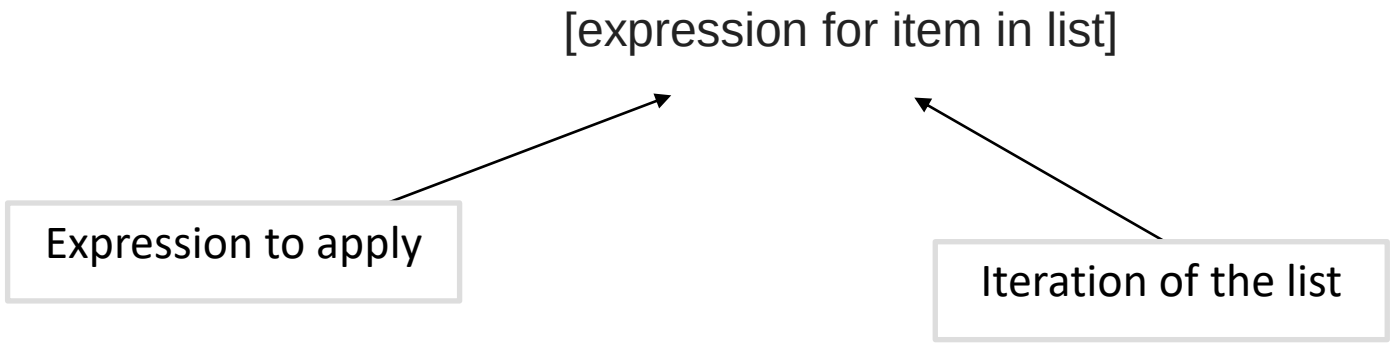
- There are many Python modules that come with Python as part of the standard library.

```
import <module>
```

- math, numpy, pandas, matplotlib

Python: List Comprehension

- The comprehension of lists is another solution for creating lists through the result of operations on lists.

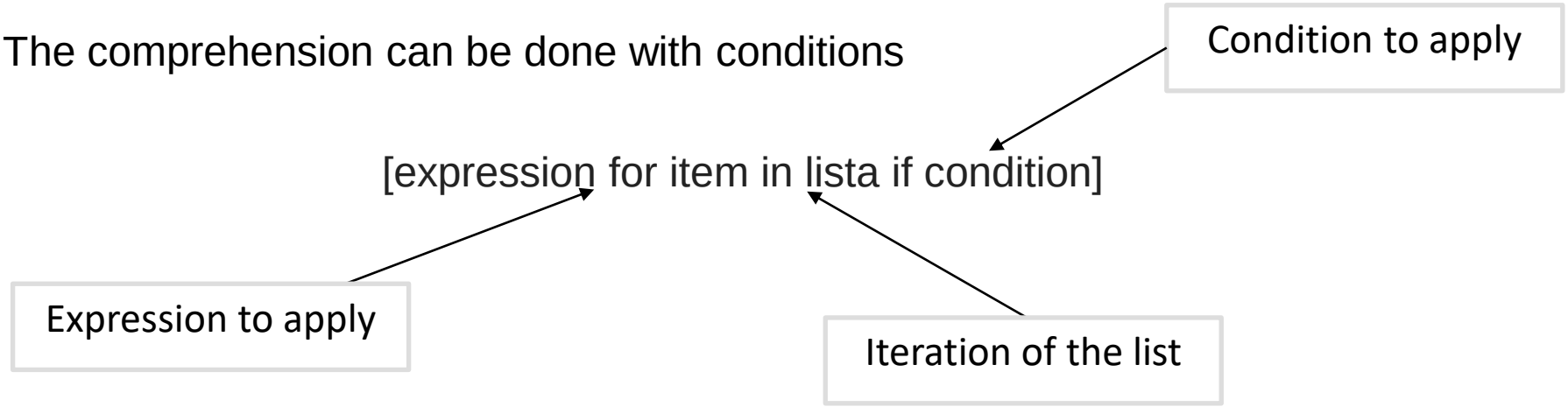


- Let's take the example of getting the square root of each element in a list.

```
import math
lista=[1,4,9,16,25]

listasqrt =[math.sqrt(x) for x in lista]
print(listasqrt)
```

Python: List Comprehension

- The comprehension can be done with conditions



- Example:
  - Apply the square root to the multiple of 2 lesser than 10

```
import math
lista=[1,4,9,16,25]
listasqrt =[math.sqrt(x) for x in lista if x<10 and x%2==0]
print(listasqrt)
```

Python: Numpy module

- The standard Python data types are not very suited for mathematical operations.
- Image that you need calculate the double of each position of a list. You need a for cycle for that.
- With `numpy` module we can:

```
import numpy as np
xs = [12, 10, 32, 3, 66, 17, 42, 99, 20]
xs = np.array(xs)

print(2*xs)
```

Python: Numpy module

- One of the most important properties an array is its **shape**

```
>>> import numpy as np
>>> a = np.array([2, 3, 8])
>>> a.shape
(3,)
```

```
>>> b = np.array([
[2, 3, 8],
[4, 5, 6],
])
>>> b.shape
(2, 3)
```

Python: Numpy module

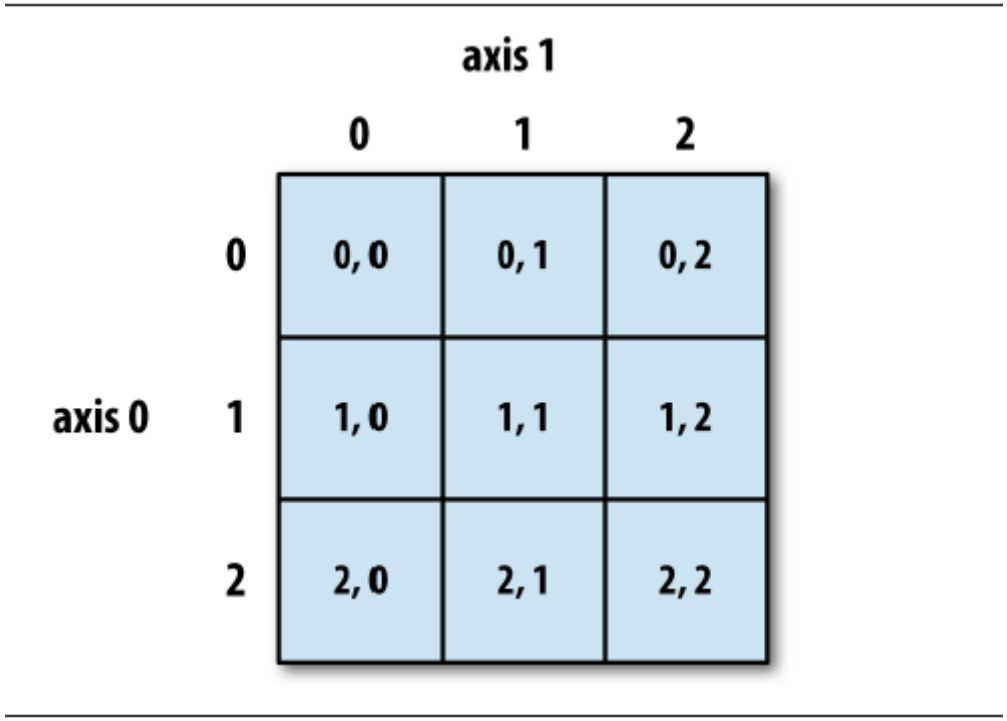
- To select certain values from an array, for 1D arrays it works just like for normal python lists:

```
>>> a = np.array([2, 3, 8])
>>> a[2]
8
>>> a[1:]
np.array([3, 8])
```

- With higher dimensional arrays:

```
>>> b = np.array([
[2, 3, 8],
[4, 5, 6],
])
>>> b[1][2] # select individual items
6
```

Python: Numpy module

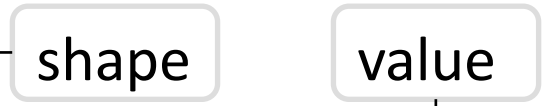


Python: Numpy module

```
>>>np.arange(3)
array([0, 1, 2])

>>>np.arange(3.0)
array([ 0.,  1.,  2.])

>>>np.arange(3,7)
array([3, 4, 5, 6])

>>>np.arange(3,7,2)
array([3, 5])
```

Values are generated within
the half-open interval [start, stop, step]

Python: Numpy module




```
>>>np.full((2, 2), 10)
array([[10, 10],
       [10, 10]])

>>>np.full((2, 2), [1, 2])
array([[1, 2],
       [1, 2]])
```

Return a new array of given shape and type, filled with *fill_value*.

```
>>> np.zeros((3, 6))
array([[ 0., 0., 0., 0., 0., 0.],
[ 0., 0., 0., 0., 0., 0.],
[ 0., 0., 0., 0., 0., 0.]])

>>>np.ones((3, 6))
```

Return a new array of given shape and type, filled with *0*.

Python: Numpy module

```
>>>shape=(1,9)
>>>b=np.ones(shape)
[[1. 1. 1. 1. 1. 1. 1. 1. 1.]]

>>>b=np.reshape(b,(3,3))
[[1. 1. 1.]
 [1. 1. 1.]
 [1. 1. 1.]]
```

Gives a new shape to an array without changing its data.

Python: Numpy module

- **Masking** is one of the most powerful features of numpy
- Suppose, we have an array, and we want to throw away all values above a certain cut-off:

```
>>> a = np.array([230, 10, 284, 39, 76])
>>> cutoff = 200
>>> a > cutoff
np.array([True, False, True, False, False])

>>> a[a > cutoff] = 0
>>> a
np.array([0, 10, 0, 39, 76])
```

Python: Numpy module

Function	Description
`add`	Add corresponding elements in arrays
`subtract`	Subtract elements in second array from first array
`multiply`	Multiply array elements
`divide, floor_divide`	Divide or floor divide (truncating the remainder)
`power`	Raise elements in first array to powers indicated in second array
`maximum, fmax`	Element-wise maximum; `fmax` ignores `NaN`
`minimum, fmin`	Element-wise minimum; `fmin` ignores `NaN`
`mod`	Element-wise modulus (remainder of division)
`copysign`	Copy sign of values in second argument to values in first argument

Python: Numpy module

Basic array statistical methods

Method	Description
`sum`	Sum of all the elements in the array or along an axis; zero-length arrays have sum 0
`mean`	Arithmetic mean; zero-length arrays have NaN mean
`std, var`	Standard deviation and variance, respectively, with optional degrees of freedom adjustment (default denominator n)
`min, max`	Minimum and maximum
`argmin, argmax`	Indices of minimum and maximum elements, respectively
`cumsum`	Cumulative sum of elements starting from 0
`cumprod`	Cumulative product of elements starting from 1

Python: Matplotlib module

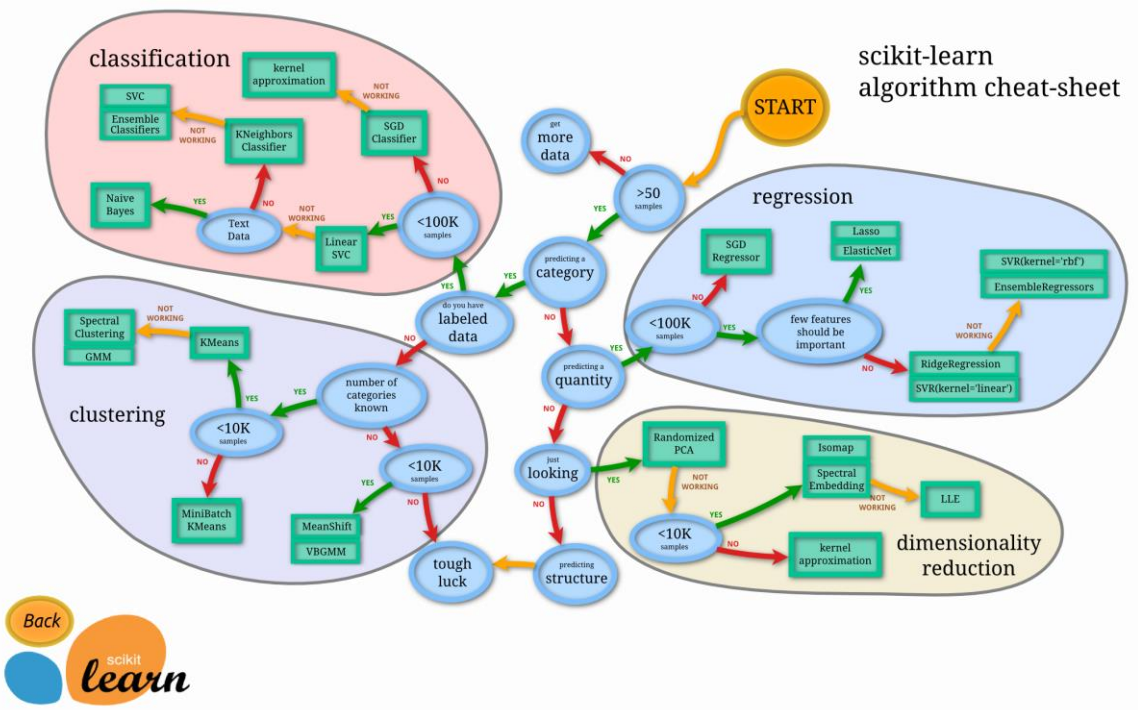
- Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python

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

# Example
x=np.arange(0.0,6.2,0.2)
# plot with specified line and marker style
plt.plot(x, np.sin(x),'o-’,x, np.cos(x),'^-')
plt.show()
```

Python: Pandas and scikit-learn Modules

- Pandas and scikit-learn modules are Python libraries designed to solve computer vision problems

- During the semester we will learn to use it.



Let’s code!

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