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# Artificial Intelligence Engineering (Level-1)

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# Level-1

- Module 1: Introduction to AI and Machine Learning
- Module 2: Linear Algebra, Statistics and Probability for AI
- Module 3: Neural Network Architecture
- Module 4: Building Machine Learning Models
- Module 5: Deep Learning Concepts
- Module 6: Python Data Structure
- Module 7: Data Handling with Pandas and NumPy
- Module 8: Python for AI
- Module 9: Classification AI Project
- Module 10: Prediction AI Project

# Artificial Intelligence Engineering (Level-1)

## Module 6: Python Data Structure

# Content

- Why Python Data Structure needs?
- List
- Sets
- Tuples
- Dictionary
- Linked Lists
- Binary Tree
- Graphs

# Why Python Data Structure needs?

- In AI projects, using the right data structures in Python is crucial for efficient data processing, model building, and performance optimization.
  - Efficient data handling and processing
  - Data preprocessing and feature engineering
  - Storing and managing model parameters
  - Graph structures for neural network
  - Optimizing search and retrieval
  - Handling sequential data

# List

- The most basic data structure in Python is the sequence.
- Each element of a sequence is assigned a number - its position or index. The first index is zero, the second index is one, and so forth.
- Python has six built-in types of sequences.
- The list is a most versatile datatype available in Python
- Items in a list need not be of the same type.
- Creating a list is as simple as putting different comma-separated values between square brackets.

# Basic List Operations

- Lists respond to the **+** and ***** operators much like strings; they mean concatenation and repetition here too, except that the result is a new list, not a string.

| Python Expression | Results | Description |
|---|---|---|
| len([1, 2, 3]) | 3 | Length |
| [1, 2, 3] + [4, 5, 6] | [1, 2, 3, 4, 5, 6] | Concatenation |
| ['Hi!'] * 4 | ['Hi!', 'Hi!', 'Hi!', 'Hi!'] | Repetition |
| 3 in [1, 2, 3] | True | Membership |
| for x in [1, 2, 3]: print x, | 1 2 3 | Iteration |

# List Functions & Methods

| Function | Description |
|---|---|
| cmp(list1, list2) or list1==list2 | Compares elements of both lists. |
| len(list) | Gives the total length of the list. |
| max(list) | Returns item from the list with max value. |
| min(list) | Returns item from the list with min value |
| list(seq) | Converts a tuple into list. |

# List Functions & Methods

| Method | Description |
| --- | --- |
| list.append(obj) | Appends object obj to list |
| list.count(obj) | Returns count of how many times obj occurs in list |
| list.extend(seq) | Appends the contents of seq to list |
| list.index(obj) | Returns the lowest index in list that obj appears |
| list.insert(index, obj) | Inserts object obj into list at offset index |

# List Example

```
languages = ["Python", "C", "C++", "Java", "Perl"]
list1 = ['physics', 'chemistry', 1997, 2000];
list2 = [1, 2, 3, 4, 5, 6, 7 ];
print ("list1[0]: ", list1[0])
 print ("list2[1:5]: ", list2[1:5])
for lan in languages:
print ("A programming language : %s" % lan)
#Updating List Elements
languages[1]="Android“
 print ("languages[0:4]: ", languages[0:4])
 #Delete List Elements
del list2[0]
 print ("list2[0:5]: ", list2[0:5])
 print("Length = ",len(languages))
print("list1+list2 = ",list1+list2)
print("list1 * 4 = ",list1*4)
 print ("3 in list2", 3 in list2)
 print("list1[-2] : ",list1[-2])
 print("list1[1:] : ",list1[1:])
```

Output

```
OneDrive/Desktop/python_oct/test.py
list1[0]:  physics
list2[1:5]:  [2, 3, 4, 5]
A programming language : Python
A programming language : C
A programming language : C++
A programming language : Java
A programming language : Perl
languages[0:4]:  ['Python', 'Android', 'C++', 'Java']
list2[0:5]:  [2, 3, 4, 5, 6]
Length =  5
list1+list2 =  ['physics', 'chemistry', 1997, 2000, 2, 3, 4, 5, 6, 7]
list1 * 4 =  ['physics', 'chemistry', 1997, 2000, 'physics', 'chemistry', 1997, 2
000, 'physics', 'chemistry', 1997, 2000, 'physics', 'chemistry', 1997, 2000]
3 in list2 True
list1[-2] :  1997
list1[1:] :  ['chemistry', 1997, 2000]
```

# Sets

- A Python set data structure is a non-duplicate data collection that is modifiable.
- Sets are mainly used for membership screening and removing redundant entries.
- These processes use the Hashing data structure, a popular method for traversal, insertion, and deletion of elements that typically takes O(1) time.

# Set Example

```
# Creating a Python set
Set = {"Python", "Data", "Structures", "Tutorial"}
 print("The Python Set is: ")
print(Set)
# Accessing the set elements
 for ind, i in enumerate(Set):
 print(ind, i)
# Finding the intersection of two sets
Set_ = {1, 2, "Python", "Data"}
print("Intersection: ", Set.intersection(Set_))
 # Union of two sets
print("Union: ", Set.union(Set_))
```

Output

```
The Python Set is:
{'Structures', 'Data', 'Tutorial', 'Python'}
0 Structures
1 Data
2 Tutorial
3 Python
Intersection:  {'Data', 'Python'}
Union:  {1, 2, 'Structures', 'Data', 'Tutorial', 'Python'}
```

# Tuples

- A tuple is a sequence of immutable Python objects.
- Tuples are sequences, just like lists.
- The differences between tuples and lists are, the tuples cannot be changed unlike lists and tuples use parentheses, whereas lists use square brackets.
- Cannot add elements to a tuple. Tuples have no append or extend method.
- Cannot remove elements from a tuple. Tuples have no remove or pop method.
- Cannot find elements in a tuple. Tuples have no index method.

# Tuple Example1

```python
# Zero-element tuple.
a = ()
# One-element tuple.
b = ("one",)
# Two-element tuple.
c = ("one", "two")
print(a)
print(len(a))
print(b)
print(len(b))
print(c)
print(len(c))
```

Output

```
()
0
('one',)
1
('one', 'two')
2
```

# Tuple Example2

Output

```
# tuple, immutable
tuple = ('cat', 'dog', 'mouse')
# This causes an error.
  #tuple[0] = 'feline’
```

```
Traceback (most recent call last):
  File "c:\Users\User\OneDrive\Desktop\python_oct\test.py", line 16, in <mo
    tuple[0] = 'feline'
    ~~~~~^^^
TypeError: 'tuple' object does not support item assignment
```

```
# Create packed tuple.
pair = ("dog", "cat")
# Unpack tuple.
(key, value) = pair
print(key)
print(value)
```

```
dog
cat
```

# Tuple Example3

```
#no parenthesis
# A trailing comma indicates a tuple.
one_item = "cat",
# A tuple can be specified with no parentheses.
two_items = "cat", "dog"
print(one_item)
print(two_items)
```

Output

```
('cat',)
('cat', 'dog')
```

```
# Max and min for strings.
friends = ("sandy", "michael", "aaron", "stacy")
print(max(friends))
 print(min(friends))
# Max and min for numbers.
earnings = (1000, 2000, 500, 4000)
print(max(earnings))
print(min(earnings))
```

```
stacy
aaron
4000
500
```

# Tuple Example4

```
# Search for a value.
if "cat" in pair:
    print("Cat found")
# Search for a value not present.
if "bird" not in pair:
    print("Bird not found")
```

Output

```
Cat found
Bird not found
```

```
# Three-item tuple.
items = ("cat", "dog", "bird")
# Get index of element with value "dog".
index = items.index("dog")
print(index, items[index])
```

```
1 dog
```

# Dictionary

- Each key is separated from its value by a colon (:), the items are separated by commas, and the whole thing is enclosed in curly braces.
- An empty dictionary without any items is written with just two curly braces, like this: {}.
- Keys are unique within a dictionary while values may not be.
- The values of a dictionary can be of any type, but the keys must be of an immutable data type such as strings, numbers, or tuples.
- To access dictionary elements, square brackets can be used along with the key to obtain its value.

# Dictionary

- Can update a dictionary by adding a new entry or a key-value pair, modifying an existing entry, or deleting an existing entry.
  - Can either remove individual dictionary elements or clear the entire contents of a dictionary.
    - Can also delete entire dictionary in a single operation.

# Dictionary Example

```
dict = {'Name': 'Zara', 'Age': 7, 'Class': 'First'}
print ("dict['Name']: ", dict['Name'])
print ("dict['Age']: ", dict['Age'])
dict['Age'] = 8; # update existing entry
dict['School'] = "DPS School"; # Add new entry
print ("dict['Age']: ", dict['Age'])
print ("dict['School']: ", dict['School'])
```

Output

```
dict['Name']:  Zara
dict['Age']:  7
dict['Age']:  8
dict['School']:  DPS School
```

# Properties of Dictionary

- Dictionary values have no restrictions.
- Dictionary values can be any arbitrary Python object, either standard objects or user defined objects. However, same is not true for the keys.
- There are two important points in using dictionary keys
- More than one entry per key not allowed. o No duplicate key is allowed. When duplicate keys encountered during assignment, the last assignment wins.
- Keys must be immutable. o Can use strings, numbers or tuples as dictionary keys but something like ['key'] is not allowed.

# Dictionary Functions & Methods

| Function | Description |
|---|---|
| cmp(dict1, dict2) | Compares elements of both dict. |
| len(dict) | Gives the total length of the dictionary. This would be equal to the number of items in the dictionary. |
| str(dict) | Produces a printable string representation of a dictionary |
| type(variable) | Returns the type of the passed variable. If passed variable is dictionary, then it would return a dictionary type. |

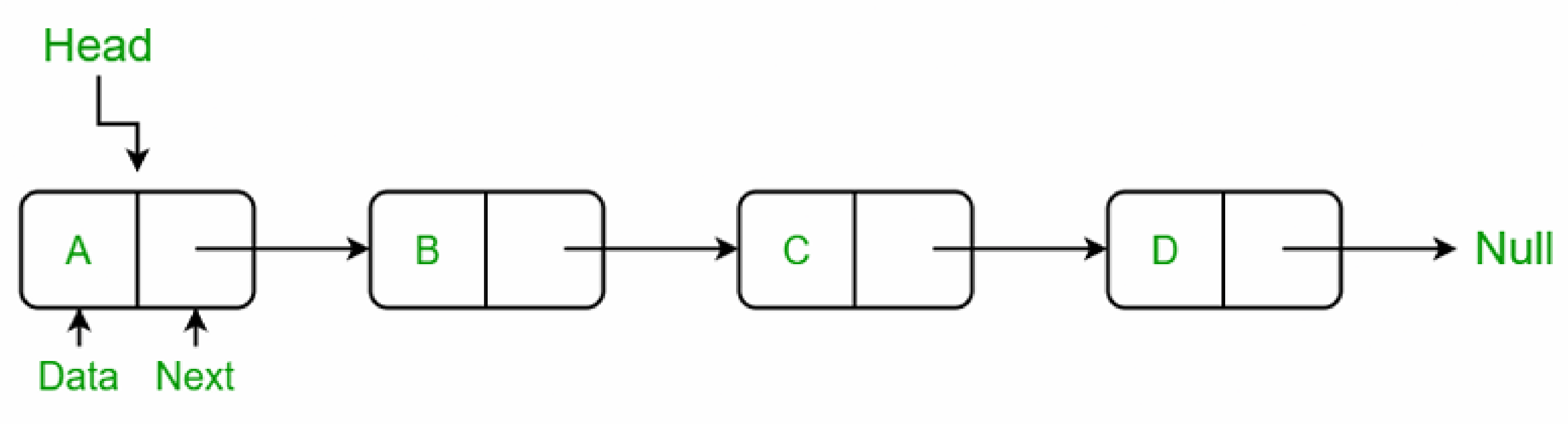
# Dictionary Functions & Methods

| Method | Description |
|---|---|
| dict.clear() | Removes all elements of dictionary dict. |
| dict.copy() | Returns a shallow copy of dictionary dict |
| dict.fromkeys() | Create a new dictionary with keys from seq and values set to value. |
| dict.get(key, default=None) | For key key, returns value or default if key not in dictionary |
| dict.has_key(key) | Returns true if key in dictionary dict, false otherwise |
| dict.items() | Returns a list of dict's (key, value) tuple pairs |
| dict.keys() | Returns list of dictionary dict's keys |
| dict.setdefault (key,default=None) | Similar to get(), but will set dict[key]=default if key is not already in dict |
| dict.update(dict2) | Adds dictionary dict2's key-values pairs to dict . |

# Linked Lists

- A linked list is a linear data structure, in which the elements are not stored at contiguous memory locations.
- The elements in a linked list are linked using pointers.
- A linked list is represented by a pointer to the first node of the linked list.
- The first node is called the head.
- If the linked list is empty, then the value of the head is NULL.
- Each node in a list consists of at least two parts:
  - Data
  - Pointer (Or Reference) to the next node

# Linked Lists



# Node Example

```
# Creating a node class
class Node:
    def __init__(self, value):
        self.value = value
        self.next = None
# Creating a linked list class
class LinkedList:
    def __init__(self):
        self.head = None
# Ini alizing a linked list
list_ = LinkedList()
# Creating the nodes
list_.head = Node("Python")
second_node = Node("Tutorial")
third_node = Node("Data
Structures")
```

```
# Connecting the nodes
list_.head.next =
second_node
second_node.next =
third_node
# Printing the linked list
while list_.head != None:
    print(list_.head.value,
end = "\n")
    list_.head =
list_.head.next
```

Output

```
Python
Tutorial
Data Structures
```

# Binary Tree

- A tree is a hierarchical data structure.
- A binary tree is a tree whose elements can have almost two children.
- A Binary Tree node contains the following parts.
  - Data
  - Pointer to left child
  - Pointer to the right child

**# A Python class that represents an individual node in a Binary Tree class Node:**

```
def __init__(self,key):
self.le = None
self.right = None
self.val = key
```

# Binary Example

**# Adding data to the tree**

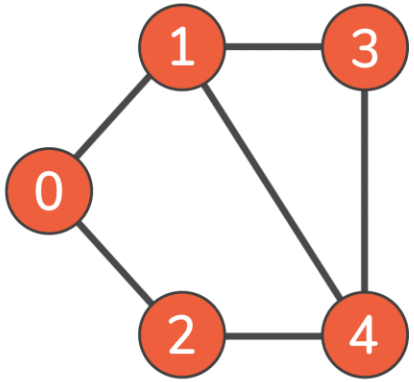
```
# Python program to introduce Binary Tree
# A class that represents an individual
node in a Binary Tree
class Node:
def __init__(self,key):
 self.left = None
self.right = None
self.val = key
 # create root
 root = Node(1)
 ''' following is the tree after above
statement
1 / \ None None'’
root.left = Node(2);
root.right = Node(3);
''' 2 and 3 become left and right
children of 1
1 / \
   2  3
 / \ / \
None None None None'’
root.left.left = Node(4);
 '''4 becomes left child of 2
 1
/ \
2   3
/ \ / \
4 None None None
 / \ None None'''
```

**the tree structure looks like below**

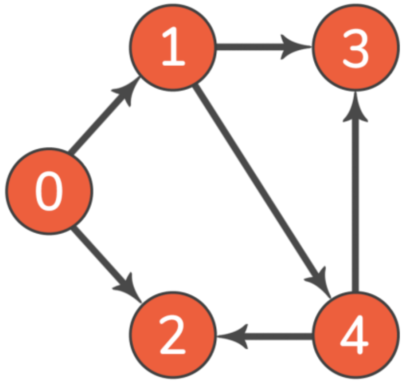
```
Tree
 ----
1 <-- root
/ \
2 3
/
 4
```

# Graphs

- A graph is a nonlinear data structure consisting of nodes and edges.
- The nodes are sometimes also referred to as vertices and the edges are lines or arcs that connect any two nodes in the graph.
- More formally a Graph can be defined as a Graph consisting of a finite set of vertices (or nodes) and a set of edges that connect a pair of nodes.

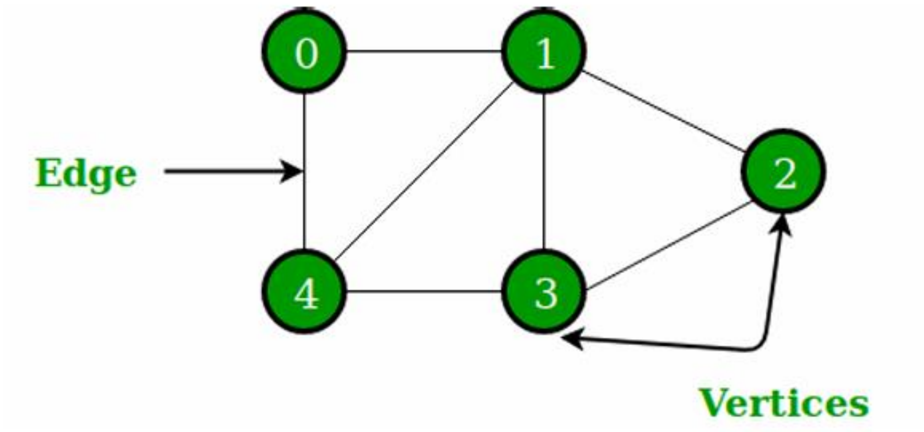



Undirected




Directed

# Graphs




- In the above Graph, the set of vertices V = {0, 1, 2, 3, 4} and the set of edges E = {01, 12, 23, 34, 04, 14, 13}.
- The following two are the most commonly used representations of a graph.
  - Adjacency Matrix
  - Adjacency List

# Adjacency Matrix

- Adjacency Matrix is a 2D array of size V x V where V is the number of vertices in a graph.
- Let the 2D array be adj[][], a slot adj[i][j] = 1 indicates that there is an edge from vertex i to vertex j.
- The adjacency matrix for an undirected graph is always symmetric. Adjacency Matrix is also used to represent weighted graphs.
- If adj[i][j] = w, then there is an edge from vertex i to vertex j with weight w.

# Adjacency Matrix

```
class Graph:
 def __init__(self,numvertex):
self.adjMatrix = [[-1]*numvertex for x in
range(numvertex)]
self.numvertex = numvertex
self.vertices = {}
self.verticeslist =[0]*numvertex
 def set_vertex(self,vtx,id):
 if 0<=vtx<=self.numvertex:
self.vertices[id] = vtx
self.verticeslist[vtx] = id

 def set_edge(self,frm,to,cost=0):
 frm = self.vertices[frm]
 to = self.vertices[to]
self.adjMatrix[frm][to] = cost
```

```
# for directed graph do not add this
self.adjMatrix[to][frm] = cost
 def get_vertex(self):
return self.verticeslist

def get_edges(self):
 edges=[]
 for i in range (self.numvertex):
for j in range (self.numvertex):
if (self.adjMatrix[i][j]!=-1):
edges.append((self.verticeslist[i],self.vert
iceslist[j],self.adjMatrix[i][j])) return
edges
 def get_matrix(self):
 return self.adjMatrix
```

```
G =Graph(6)
G.set_vertex(0,'a')
G.set_vertex(1,'b')
G.set_vertex(2,'c')
G.set_vertex(3,'d')
G.set_vertex(4,'e')
G.set_vertex(5,'f')
G.set_edge('a','e',10)
G.set_edge('a','c',20)
G.set_edge('c','b',30)
G.set_edge('b','e',40)
G.set_edge('e','d',50)
G.set_edge('f','e',60)
print("Vertices of Graph")
print(G.get_vertex())
print("Edges of Graph")
print(G.get_edges())
print("Adjacency Matrix of
Graph")
print(G.get_matrix())
```

# Adjacency Matrix

Output

Vertices of Graph

[‘a’, ‘b’, ‘c’, ‘d’, ‘e’, ‘f’]

Edges of Graph

[(‘a’, ‘c’, 20), (‘a’, ‘e’, 10), (‘b’, ‘c’, 30), (‘b’, ‘e’, 40), (‘c’, ‘a’, 20), (‘c’, ‘b’, 30), (‘d’, ‘e’, 50), (‘e’, ‘a’, 10), (‘e’, ‘b’, 40), (‘e’, ‘d’, 50), (‘e’, ‘f’, 60), (‘f’, ‘e’, 60)]

Adjacency Matrix of Graph

[[-1, -1, 20, -1, 10, -1], [-1, -1, 30, -1, 40, -1], [20, 30, -1, -1, -1, -1], [-1, -1, -1, -1, 50, -1], [10, 40, -1, 50, -1, 60], [-1, -1, -1, -1, 60, -1]]

# Adjacency List

- An array of lists is used. The size of the array is equal to the number of vertices. Let the array be an array[].
- An entry array[i] represents the list of vertices adjacent to the $i^{th}$ vertex.
- This representation can also be used to represent a weighted graph. The weights of edges can be represented as lists of pairs.

# Adjacency Matrix

```
class AdjNode:
def __init__(self, data):
 self.vertex = data
 self.next = None
# A class to represent a graph. A graph
 # is the list of the adjacency lists.
 # Size of the array will be the no. of the
 # vertices "V"
class Graph:
 def __init__(self, ver ces):
self.V = ver ces
 self.graph = [None] * self.V
# Function to add an edge in an
undirected graph
def add_edge(self, src, dest):
```

```
# Adding the node to the source node
node = AdjNode(dest)
 node.next = self.graph[src]
self.graph[src] = node
 # Adding the source node to the
 destination as
# it is the undirected graph
node = AdjNode(src)
node.next = self.graph[dest]
self.graph[dest] = node
 # Function to print the graph
def print_graph(self):
 for i in range(self.V):
 print("Adjacency list of vertex {}\n
head".format(i), end="")
 temp = self.graph[i] while temp:
 print(" -> {}".format(temp.vertex),
end="")
temp = temp.next print(" \n")
```

```
# Driver program to the
above graph class
 if __name__ ==
"__main__":
 V = 5
graph = Graph(V)
graph.add_edge(0, 1)
graph.add_edge(0, 4)
graph.add_edge(1, 2)
graph.add_edge(1, 3)
graph.add_edge(1, 4)
graph.add_edge(2, 3)
graph.add_edge(3, 4)
graph.print_graph()
```

# Adjacency List

Output

Adjacency list of vertex 0

head -> 4 -> 1

Adjacency list of vertex 1

head -> 4 -> 3 -> 2 -> 0

Adjacency list of vertex 2

head -> 3 -> 1

Adjacency list of vertex 3

head -> 4 -> 2 -> 1

Adjacency list of vertex 4

head -> 3 -> 1 -> 0

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