Data Structure and Algorithm

Laboratory Activity No. 7

Doubly Linked Lists

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# Objectives

Introduction

A doubly linked list is a type of linked list data structure where each node contains three components:

Data - The actual value stored in the node

Previous pointer - A reference to the previous node in the sequence

Next pointer - A reference to the next node in the sequence.

This laboratory activity aims to implement the principles and techniques in:

* Writing algorithms using Linked list
* Writing a python program that will perform the common operations in a Doubly linked list
* A doubly linked list is particularly useful when you need frequent bidirectional traversal or easy deletion of nodes from both ends of the list.

# Methods

* Using Google Colab, type the source codes below:

class Node:

"""Node class for doubly linked list"""

def \_\_init\_\_(self, data):

self.data = data

self.prev = None

self.next = None

class DoublyLinkedList:

"""Doubly Linked List implementation"""

def \_\_init\_\_(self):

self.head = None

self.tail = None

self.size = 0

def is\_empty(self):

"""Check if the list is empty"""

return self.head is None

def get\_size(self):

"""Get the size of the list"""

return self.size

def display\_forward(self):

"""Display the list from head to tail"""

if self.is\_empty():

print("List is empty")

return

current = self.head

print("Forward: ", end="")

while current:

print(current.data, end="")

if current.next:

print(" ↔ ", end="")

current = current.next

print()

def display\_backward(self):

"""Display the list from tail to head"""

if self.is\_empty():

print("List is empty")

return

current = self.tail

print("Backward: ", end="")

while current:

print(current.data, end="")

if current.prev:

print(" ↔ ", end="")

current = current.prev

print()

def insert\_at\_beginning(self, data):

"""Insert a new node at the beginning"""

new\_node = Node(data)

if self.is\_empty():

self.head = self.tail = new\_node

else:

new\_node.next = self.head

self.head.prev = new\_node

self.head = new\_node

self.size += 1

print(f"Inserted {data} at beginning")

def insert\_at\_end(self, data):

"""Insert a new node at the end"""

new\_node = Node(data)

if self.is\_empty():

self.head = self.tail = new\_node

else:

new\_node.prev = self.tail

self.tail.next = new\_node

self.tail = new\_node

self.size += 1

print(f"Inserted {data} at end")

def insert\_at\_position(self, data, position):

"""Insert a new node at a specific position"""

if position < 0 or position > self.size:

print("Invalid position")

return

if position == 0:

self.insert\_at\_beginning(data)

return

elif position == self.size:

self.insert\_at\_end(data)

return

new\_node = Node(data)

current = self.head

# Traverse to the position

for \_ in range(position - 1):

current = current.next

# Insert the new node

new\_node.next = current.next

new\_node.prev = current

current.next.prev = new\_node

current.next = new\_node

self.size += 1

print(f"Inserted {data} at position {position}")

def delete\_from\_beginning(self):

"""Delete the first node"""

if self.is\_empty():

print("List is empty")

return None

deleted\_data = self.head.data

if self.head == self.tail: # Only one node

self.head = self.tail = None

else:

self.head = self.head.next

self.head.prev = None

self.size -= 1

print(f"Deleted {deleted\_data} from beginning")

return deleted\_data

def delete\_from\_end(self):

"""Delete the last node"""

if self.is\_empty():

print("List is empty")

return None

deleted\_data = self.tail.data

if self.head == self.tail: # Only one node

self.head = self.tail = None

else:

self.tail = self.tail.prev

self.tail.next = None

self.size -= 1

print(f"Deleted {deleted\_data} from end")

return deleted\_data

def delete\_from\_position(self, position):

"""Delete a node from a specific position"""

if self.is\_empty():

print("List is empty")

return None

if position < 0 or position >= self.size:

print("Invalid position")

return None

if position == 0:

return self.delete\_from\_beginning()

elif position == self.size - 1:

return self.delete\_from\_end()

current = self.head

# Traverse to the position

for \_ in range(position):

current = current.next

# Delete the node

deleted\_data = current.data

current.prev.next = current.next

current.next.prev = current.prev

self.size -= 1

print(f"Deleted {deleted\_data} from position {position}")

return deleted\_data

def search(self, data):

"""Search for a node with given data"""

if self.is\_empty():

return -1

current = self.head

position = 0

while current:

if current.data == data:

return position

current = current.next

position += 1

return -1

def reverse(self):

"""Reverse the doubly linked list"""

if self.is\_empty() or self.head == self.tail:

return

current = self.head

self.tail = self.head

while current:

# Swap next and prev pointers

temp = current.prev

current.prev = current.next

current.next = temp

# Move to the next node (which is now in prev due to swap)

current = current.prev

# Update head to the last node we processed

if temp:

self.head = temp.prev

print("List reversed successfully")

def clear(self):

"""Clear the entire list"""

self.head = self.tail = None

self.size = 0

print("List cleared")

# Demonstration and testing

def demo\_doubly\_linked\_list():

"""Demonstrate the doubly linked list operations"""

print("=" \* 50)

print("DOUBLY LINKED LIST DEMONSTRATION")

print("=" \* 50)

dll = DoublyLinkedList()

# Insert operations

dll.insert\_at\_beginning(10)

dll.insert\_at\_end(20)

dll.insert\_at\_end(30)

dll.insert\_at\_beginning(5)

dll.insert\_at\_position(15, 2)

# Display

dll.display\_forward()

dll.display\_backward()

print(f"Size: {dll.get\_size()}")

print()

# Search operation

search\_value = 20

position = dll.search(search\_value)

if position != -1:

print(f"Found {search\_value} at position {position}")

else:

print(f"{search\_value} not found in the list")

print()

# Delete operations

dll.delete\_from\_beginning()

dll.delete\_from\_end()

dll.delete\_from\_position(1)

# Display after deletions

dll.display\_forward()

print(f"Size: {dll.get\_size()}")

print()

# Insert more elements

dll.insert\_at\_end(40)

dll.insert\_at\_end(50)

dll.insert\_at\_end(60)

# Display before reverse

print("Before reverse:")

dll.display\_forward()

# Reverse the list

dll.reverse()

# Display after reverse

print("After reverse:")

dll.display\_forward()

dll.display\_backward()

print()

# Clear the list

dll.clear()

dll.display\_forward()

# Interactive menu for user to test

def interactive\_menu():

"""Interactive menu for testing the doubly linked list"""

dll = DoublyLinkedList()

while True:

print("\n" + "=" \* 40)

print("DOUBLY LINKED LIST MENU")

print("=" \* 40)

print("1. Insert at beginning")

print("2. Insert at end")

print("3. Insert at position")

print("4. Delete from beginning")

print("5. Delete from end")

print("6. Delete from position")

print("7. Search element")

print("8. Display forward")

print("9. Display backward")

print("10. Reverse list")

print("11. Get size")

print("12. Clear list")

print("13. Exit")

print("=" \* 40)

choice = input("Enter your choice (1-13): ")

if choice == '1':

data = int(input("Enter data to insert: "))

dll.insert\_at\_beginning(data)

elif choice == '2':

data = int(input("Enter data to insert: "))

dll.insert\_at\_end(data)

elif choice == '3':

data = int(input("Enter data to insert: "))

position = int(input("Enter position: "))

dll.insert\_at\_position(data, position)

elif choice == '4':

dll.delete\_from\_beginning()

elif choice == '5':

dll.delete\_from\_end()

elif choice == '6':

position = int(input("Enter position to delete: "))

dll.delete\_from\_position(position)

elif choice == '7':

data = int(input("Enter data to search: "))

pos = dll.search(data)

if pos != -1:

print(f"Element found at position {pos}")

else:

print("Element not found")

elif choice == '8':

dll.display\_forward()

elif choice == '9':

dll.display\_backward()

elif choice == '10':

dll.reverse()

elif choice == '11':

print(f"Size: {dll.get\_size()}")

elif choice == '12':

dll.clear()

elif choice == '13':

print("Exiting...")

break

else:

print("Invalid choice! Please try again.")

if \_\_name\_\_ == "\_\_main\_\_":

# Run the demonstration

demo\_doubly\_linked\_list()

# Uncomment the line below to run interactive menu

# interactive\_menu()

* Save your source codes to GitHub

Answer the following questions:

* + 1. What are the three main components of a Node in the doubly linked list implementation, and what does the \_\_init\_\_ method of the DoublyLinkedList class initialize?
    2. The insert\_at\_beginning method successfully adds a new node to the start of the list. However, if we were to reverse the order of the two lines of code inside the else block, what specific issue would this introduce? Explain the sequence of operations that would lead to this problem:

def insert\_at\_beginning(self, data):

new\_node = Node(data)

if self.is\_empty():

self.head = self.tail = new\_node

else:

new\_node.next = self.head

self.head.prev = new\_node

self.head = new\_node

self.size += 1

* + 1. How does the reverse method work? Trace through the reversal process step by step for a list containing [A, B, C], showing the pointer changes at each iteration

def reverse(self):

if self.is\_empty() or self.head == self.tail:

return

current = self.head

self.tail = self.head

while current:

temp = current.prev

current.prev = current.next

current.next = temp

current = current.prev

if temp:

self.head = temp.prev

# Results

Present the visualized procedures done. Also present the results with corresponding data visualizations such as graphs, charts, tables, or image . Please provide insights, commentaries, or explanations regarding the data. If an explanation requires the support of literature such as academic journals, books, magazines, reports, or web articles please cite and reference them using the IEEE format.

Please take note of the styles on the style ribbon as these would serve as the style format of this laboratory report. The body style is Times New Roman size 12, line spacing: 1.5. Body text should be in Justified alignment, while captions should be center-aligned. Images should be readable and include captions. Please refer to the sample below:

A computer screen shot of a code

AI-generated content may be incorrect.

Figure 1 Screenshot of program

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Each node in the doubly linked list connects to both the previous and next nodes. The list starts empty and grows as new nodes are added. This structure allows easy insertion, deletion, and movement in both directions.  
  
  
  
  
  
  
  
  
  
  
A computer screen with white text

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Figure 2 Screenshot of program

The insert at beginning method efficiently handles both empty and non-empty states of a doubly linked list. It correctly updates the head, tail, and node pointers to maintain the structural integrity of the list. The use of conditional logic ensures smooth insertion, and the size counter helps keep track of the number of nodes accurately. This shows a good understanding of linked list operations and pointer manipulation.

A screen shot of a computer program

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Figure 3 Screenshot of program

The reverse(self) method efficiently reverses a doubly linked list by swapping each node’s Prev and next pointers. It handles edge cases like empty or single node lists and updates the head and tail, accordingly, showing a clear grasp of pointer manipulation and list traversal.

**Conclusion**  
The provided doubly linked list implementation clearly illustrates fundamental data structure principles, including node linkage, insertion, and bidirectional traversal. The insert at beginning method efficiently manages both empty and populated lists, ensuring the correct updating of head, tail, and node pointers while accurately tracking the list’s size. The reverse method demonstrates skillful manipulation of pointers by swapping each node’s previous and next references and properly addressing edge cases such as empty or single-node lists. In summary, the program reflects a strong grasp of linked list operations, pointer management, and handling of special scenarios.  
  
**REFERENCE**Program - Doubly Linked List in Python  
https://www.programiz.com/dsa/doubly-linked-list