Comp 363 - Design and Analysis of Computer Algorithms

Spring Semester 2020 - Week 12 - part 2

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- start to implement algorithm by considering outline of underlying structure
- consider an implementation relative to earlier example
- i.e. family members who have visited sites in Egypt...
- e.g.
- keep an initial queue for names of family members to check
- then pop a name off queue
- check this name to see if they have visited a defined location in Egypt, e.g. Giza
- o if yes search is finished
- o if no add all neighbours for this current family member to queue
- then, loop and repeat search
- if queue is empty
- o no family member has visited Giza...

graphs - implement algorithm - part 2

- initial graph may be defined as follows
- using patterns of usage we've already seen for Python

```
# define graph for family members
graph = {}
graph["me"] = ["emma", "daisy", "yvaine"]
graph["daisy"] = ["rose", "violet"]
graph["emma"] = ["violet"]
graph["yvaine"] = ["tristram", "cat"]
graph["rose"] = []
graph["violet"] = []
graph["tristram"] = []
graph["cat"] = []
```

current output is as follows for graph nodes

```
{
  'me': ['emma', 'daisy', 'yvaine'],
  'daisy': ['rose', 'violet'],
  'emma': ['violet'],
  'yvaine': ['tristram', 'cat'],
  'rose': [],
  'violet': [],
  'tristram': [],
  'cat': []
}
```

- then begin by defining queue
 - using double-ended queue function (deque) in Python

```
# imports
from collections import deque

# define and create new queue
name_queue = deque();
```

- then add all neighbours for node me
- add to queue we'd like to query and search

- begin by adding immediate neighbour nodes to queue
 - including emma, daisy and yvaine
- current queue output is as follows

```
deque(['emma', 'daisy', 'yvaine'])
```

- initial queue to query for family members
- now continue to check and populate queue using graph
- *e.g.*

```
name_queue += graph["me"]
```

- do not want to do this manually
 - add a while loop to check queue
- use this loop as follows,
 - while the queue is not empty
 - o get first name in queue
 - o check if name has visited Giza
 - if yes return, a family member found who travels to Egypt
 - otherwise add their neighbour nodes to queue to broaden search
 - exit loop if no matched name found...

graphs - implement algorithm - part 6

modify and update graph to include details for places visited

```
# define graph for family members
graph = {}
graph["me"] = [["emma", "cairo"], "daisy", "yvaine"]
graph["daisy"] = ["rose", "violet"]
graph["emma"] = [["violet", "giza"]]
graph["yvaine"] = ["tristram", "cat"]
graph["rose"] = []
graph["violet"] = []
graph["tristram"] = []
graph["cat"] = []
```

- many different options for storing such data
- this example works fine for querying graph of family members...
- update now includes two family members who have visited locations in Egypt
 - e.g. Cairo and Giza

graphs - implement algorithm - part 7

while loop may be defined as follows

```
# query the queue while not empty
while name_queue:
    # get first name from queue
   name = name_queue.popleft()
    # check if the current node has visited giza
    if visited_giza(name):
        # print family member who has visited Giza...
        print(name)
        return True
    else:
        # check if name is array or not...
        if (isinstance(name, list)):
            # add just the name to queue...
            name_queue += graph[name[0]]
        else:
            # they haven't visited giza - add neighbour nodes...
            name queue += graph[name]
print("no family member has visited Giza...")
# no family member has visited giza
return False
```

- in this example
- a check for a visit to Giza function visited_giza(name)
- then simple check of name variable
- ensure we pass required string for name in graph

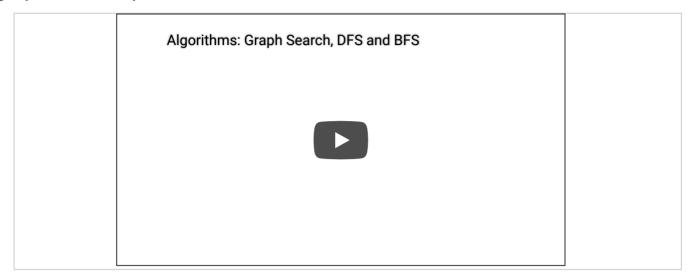
graphs - implement algorithm - part 8

add function visited_giza() as follows

```
# check name in graph
def visited_giza(name):
   if "giza" in name:
      # return just the name from the array...
      return name[0]
```

Video - Algorithms and Data Structures

graphs - Java - part 5



Graphs - Java - Breadth-first Search - UP TO 9:04

Source - Graphs - Java - YouTube

graphs - implement algorithm - breadth-first search - part 1

- clearly see how breadth-first search may be implemented for graph of family members
- check passed name variable with function visited_giza()
- if it contains required string giza
- return name of this family member
- exit graph query family mamber found...
- if we don't find required family member
- continue while loop
- need to ensure we can grab name from an inner list
- e.g. if we check emma a neighbour node to node me
- it is a list an array
- with a location of cairo
- cairo doesn't match required location of giza
 - grab the name, emma
- repeat loop to continue checking updated queue

graphs - implement algorithm - breadth-first search - part 2

now update our app as follows

```
def search(name):
    # define and create new queue
    name queue = deque();
    # add all neighbours of 'me' to queue
    name_queue += graph[name]
    # query the queue while not empty
    while name_queue:
        # get first name from queue
        name = name queue.popleft()
        # check if the current node has visited giza
        if visited_giza(name):
            # print family member who has visited Giza...
            print(name)
            return True
        else:
            # check if name is array or not...
            if (isinstance(name, list)):
                # add just the name to queue...
                name queue += graph[name[0]]
            else:
                # they haven't visited giza - add neighbour nodes...
                name queue += graph[name]
    print("no family member has visited Giza...")
    # no family member has visited giza
    return False
```

- i.e. algorithm will continue until either condition is met
 - a family member is found who has visited Giza
 - name queue is empty no family members left to check...

graphs - implement algorithm - duplication of queries

- still have an issue with current algorithm for this search
- if we check initial graph
 - family member violet is a neighbour of both daisy and emma
 - i.e. violet will currently be added to the queue twice
- currently also searching this node twice as well
- only need to search each node once
- regardless of defined neighbour
- resolve issue by identifying node as searched
- stops duplication of effort in algorithm
- may add a list of nodes already checked during search

graphs - implement algorithm - updated breadth-first search - part 1

• if we tried to search the following updated graph

```
# define graph for family members
graph = {}
graph["me"] = [["emma", "cairo"], "daisy", "yvaine"]
graph["daisy"] = ["rose", "violet"]
graph["emma"] = ["violet"]
graph["yvaine"] = [["tristram", "giza"], "cat"]
graph["rose"] = []
graph["violet"] = []
graph["tristram"] = []
graph["cat"] = []
```

- need to keep a check of names already searched
- check to avoid unnecessary duplication

graphs - implement algorithm - updated breadth-first search - part 2

update code for breadth-first search as follows,

```
def search(name):
    # define and create new queue
    name queue = deque();
    # add all neighbours of 'me' to queue
    name_queue += graph[name]
    # keep track of names already searched...
    names searched = []
    # query the queue while not empty
    while name_queue:
        # get first name from queue
        name = name_queue.popleft()
        # check if name already searched...if not, then search
        if not name in names searched:
            # check if the current node has visited giza
            if visited_giza(name):
                # print family member who has visited Giza...
                print(name[0] + " has visited " + name[1])
                return True
            else:
                # check if name is array or not...
                if (isinstance(name, list)):
                    # add just the name to queue...
                    name queue += graph[name[0]]
                    # add name to already searched
                    names searched.append(name[0])
                else:
                    # they haven't visited giza - add neighbour nodes...
                    name queue += graph[name]
                    # add name to already searched
                    names_searched.append(name)
    print("no family member has visited Giza...")
    # no family member has visited giza
    return False
```

graphs - implement algorithm - updated breadth-first search - part 3

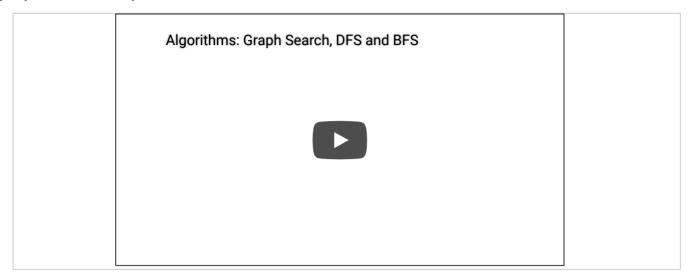
- if we then search using me as initial name
 - names_searched array keeps check of family member names already searched in graph

```
[]
['emma']
['emma', 'daisy']
['emma', 'daisy', 'yvaine']
['emma', 'daisy', 'yvaine', 'violet']
['emma', 'daisy', 'yvaine', 'violet', 'rose']
tristram has visited giza
```

• end with found node for tristram in graph...

Video - Algorithms and Data Structures

graphs - Java - part 6



Graphs - Java - Breadth-first Search - UP TO 11:42

Source - Graphs - Java - YouTube

graphs - implement algorithm - performance and time

- with above example
- as w search graph for a family member, may potentially need to follow each edge
- initially define Big O with running time of at least O(number of edges)
- also maintaing a queue of each name we need to search
- adding a single name to queue takes constant time, 0(1)
- if we perform this task for each name in graph
 - we end up with a potential time of O(number of names)
- breadth-first search will take

O(number of names + number of edges)

may be written for graphs as follows

0(V+E)

- V = number of vertices
- E = number of edges
- i.e. the nodes and edges of the graph...

Resources

various

- Python patterns implementing graphsvideos
- Graphs Java YouTube
- Joy of Data YouTube