Assignment 4 - The Perambulations of Denver Long

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Purpose

Assignment 4 is the implementation of Hamiltonian paths, where two vertices are connected by an edge, each vertex is only visited once, and the path starts and ends with the same vertex. These paths can be directed or undirected (symmetric about a matrix's diagonal or not). Three files called graph.c, path.c, and stack.c will be used to create and manipulate the paths. tsp.c will use these three files and take on command line arguments h, v, u, i, and o for testing purposes.

Breakdown of Files

- graph.h specifies the interface to the graph ADT
- graph.c implements the graph ADT
- path.h specifies the interface to the path ADT
- path.c implements the path ADT
- stack.h specifies the interface to the stack ADT
- stack.c implements the stack ADT
- tsp.c contains main() and may contain any other necessary functions
    - Takes command line options h (help message), v (verbose printing), u (specifies graph is undirected), i infile (specifies input file), o outfile (specifies output file)
- vertices.h defines macros regarding vertices
- Makefile contains commands for executing, cleaning, and formatting
- README.md describes program and Makefile
- DESIGN.pdf includes design/design process, pseudocode, and explanations
- diego.graph, mythical.graph, short.graph, solarsystem.graph, and ucsc.graph are example graph files of predetermined locations and edge weights

Command Line Arguments

- h: prints help message describing the purpose of the graph and the command-line options it accepts, exiting the program afterwards

- v: enables verbose printing (prints all Hamiltonian paths found as well as the total number of recursive calls to dfs)
- u: specifies that the graph should be undirected
- i (infile): specifies the input file path that has locations and edges of a graph (default is set as stdin)
- o (outfile): specifies the output file path that the program prints to (default output is set as stdout)

Pseudocode

graph.c

define Graph structure as stated in header file

*graph_create

initialize graph memory using pointer G with 0's

let G's vertices variable be vertices

let G's undirected variable be undirected

return G

graph_delete

free memory using pointer G

set G to null/none

return nothing (graph_delete is void type)

graph_vertices

return G's variable vertices

graph_add_edge

if i or j is out of bounds (greater than G's vertices):

return false

set matrix of row i and column j be = to variable k (represents edge weight)

if G is undirected:

set matrix of row j and column i also = to k

assuming above requirements are met:

return true

graph_has_edge

if i and j are both less than the max possible vertex value, and the edge weight k

between i and j is greater than zero (meaning it has a valid edge):

return true

if none of the above conditions are met, return false

graph_edge_weight

if i and j are both less than the max possible vertex value, and the edge weight k

between i and j is greater than zero (meaning it has a valid edge):

return the edge k

if none of the above conditions are met, return 0

graph_visited

if v is in G's array visited:

return true

if v is not in visited, return false

graph_mark_vistited

if vertices.h's START_VERTEX <= v <= vertices.h's VERTICES:

mark v as visited with visited[v] = true

graph_mark_unvisited

if START_VERTEX <= v <= VERTICES:

mark v as unvisited with visited[v] = false

graph_print

check that i and j are in bounds

check that k exists for i and j (0 or not)

for every i, then for every j (both until G's vertices value):

print the corresponding k edge value in matrix of row i and column j

path.c

define Path structure as stated in header file

*path_create

initialize path memory using pointer p (initialize to size of path)

call stack_create and set it = to vertices

set path length variable = 0

path_delete

free pointer p’s vertices
free pointer p
set p to null/none

path_push_vertex

keep track of return status with a boolean
if vertices stack is empty:
    call stack_push on p’s vertices with v and return it
else:
    keep track of current stack top
    let the return status be what stack_peek on p’s vertices and current top is
    call stack_push on p’s vertices with v
    if the return status is true:
        increase p’s length by graph_edge_weight of current top and v
        return true
    if above conditions aren’t met, return false
if main conditions aren’t met, return false here too

path_pop_vertex

keep track of return status with a boolean
call stack_pop on p’s vertices with x and if this value is false:
    return false
keep track of current stack top
let the return status be what stack_peek on p’s vertices and current top is
call stack_pop on p’s vertices with x
if the return status is false:
    return false
decrease p’s length by graph_edge_weight of current top and x
if above conditions aren’t met, return

path_vertices

return stack_size of p’s vertices

path_length

return p’s length

path_copy

set the length of the destination to the length of the source

call stack_copy on the destination's vertices and the source's vertices

path_print

print path length using p's length to outfile

call stack_print on p's vertices with cities and print to outfile as well

stack.c

define Stack structure as stated in header file

*stack_create

initialize stack memory (calling it s, a pointer)

if s:

initialize s's top variable = 0

let s's capacity variable = capacity

initialize the array items to the size of s's capacity and make everything 0

(this allocates enough memory for items given s's capacity)

if not s's items:

free pointer s

set pointer s to null/none

return s

stack_delete

to delete the stack, look at pointer s and s's items:

free pointer s's items

free pointer s itself

set pointer s to null/none

return nothing (stack_delete is void type)

stack_empty

if the top of s is 0 (meaning there is nothing in the stack):

return true

if the above condition isn't met, then return false

stack_full

if the top of the stack is (greater than or) equal to its capacity:

return true

if the above condition isn't met, return false

stack_size

the top of the stack is the greatest it can be, so return s's top

stack_push

if stack is full:

return false

otherwise, set x to be the stack top's content

increment top by one so that the new top is the next empty slot

once all actions are complete, return true

stack_pop

if stack is empty:

return false

otherwise, decrement the top of the stack (since we lost one slot)

set what x points to as the stack's second-to-top content

return true

stack_peek

if stack is empty:

return false

otherwise, set what x points to as the stack's second-to-top content (like what we did in stack_pop but without changing the top-most element)

return true

stack_copy

set the capacity of the destination to the capacity of the source

set the top of the destination to the top of the source

for every iter until the top of the source:

set the items[iter] of the destination to the items[iter] of the source

stack_print

for every iter until the top of the source:

print outfile and cities[stack items[iter]]

if iter+1 isn't the top of the stack:

print outfile with “->”

print outfile and new line

tsp.c

define the command line options h, v, u, i, and o

create variable to keep track of recursion calls

dfs function

establish variables for keeping track of return status and recursion call count

create a boolean called based condition set to true that will check if visited

create a boolean flag for checking the -v command line option

let length be a call to graph_vertices

call path_push_vertex to push v onto the current path

check the weight of the two vertices v and w

if the weight of a combination of vertices is not 0 and it wasn't visited:

set base condition to false (meaning not all vertices were visited)

if the base condition is true (meaning all vertices were visited):

if the vertices of the path is the same as the vertices of the graph:

create a temporary path (calling it temp_path)

copy everything in the current path to the temporary path

while going through the vertices of the temporary path:

pop vertices of the temporary path and check with return status variable

free the temporary path's memory by calling path_delete

push the final vertex of the Hamiltonian path onto the current path

check if the verbose flag is set to true

if so, print the current file to the outfile using cities

compare the shortest path and the current path

if the shortest path is 0 or if the current path length is smaller than the shortest path length:

copy the current path onto the shortest path

pop the extra vertex from the current path mark v as visited

for w starting from 0 until the size of graph_vertices:

use variable weigh to track graph_edge_weight of v and w

if weight is 0, continue searching

if w was visited on the graph, continue searching

increment recursion call count variable by 1

call dfs again with same parameters except w instead of v

mark v as visited

pop the extra vertex from the current path

own strdup function(char destination pointer, char source pointer)

initialize a character type variable

while variable = source pointer:

if variable is a newline or carriage return:

set destination pointer to 0

break out of for loop

set the destination pointer to the source pointre

increment both destination and source by 1

set destination pointer to 0

return 0

main function

set file types to stdin and stdout by default

create a graph pointer (calling it gptr)

create a path pointer (calling it current_path)

create a path pointerer (calling it shortest_path)

use getopt to parse through the options

use switch and cases for each of the five options

if h, print help message

if v, print all Hamiltonian paths found and total number of calls to dfs

if u, make graph undirected (set a false boolean to true) if i, specify input file path containing cities and edges of graph

use optarg set to read

check that the file is not null (print error if so)

if o, specify output file path to print to

use optarg set to write

check that the file is not null (print error if so)

use sscanf to read the number of cities (first number in infile)

create enough memory to look at the names of cities based on number of cities

check that the number is valid as given in vertices.h (print error and close file if not valid)

create enough memory to look at the actual cities

check again that there are no errors aka that the lines are not malformed (if malformed are present, again, print error and close file)

use the previous allocated memory to create an array of cities

create graph with graph_create

if -u is an inputted option, make graph undirected (use a boolean)

while true:

use sscanf to parse through matrix row, column, and weight

check that row and column values are within bounds

if not, print error and close file

add row value, column value, and edge to graph using graph_add_edge

use current_path and shortest_path to call DFS function

push start vertex (0 at first) to current_path using path_push_vertex

print the path using current_path, the provided outfile, and given cities

print the total number of recursive calls + 1 from the DFS function

free both path memory as well as graph memory (use _delete functions)

Overall Description

graph.c creates the needed functions for initializing the graph. path.c does the same for creating the path, and stack.c does the same for creating the stack. Each file makes use of a structure that defines variables and pointers needed to connect the functions. All files are of type uint32_t, bool, or void, which will return a 32-bit integers, true/false, or nothing respectively. All functions in each of these files are used to implement the main function in tsp.c. This is the main test harness, the file that will take on command line arguments and simulate Hamiltonian paths based on combinations of arguments. tsp.c contains the depth-first search (which finds the shortest path), has a function that removes extraneous newlines/carriage return characters, and the main function (which parses through command line arguments and displays the output).

malloc() and calloc() are used as necessary in all of the files. These commands create dynamic memory that can be manipulated by various sizes, especially if they are unknown at the time of creation (which they are in this assignment). This is really useful because we make use of different sizes of pointers and variables based on different inputs. All allocated memory was freed in tsp.c towards the end of the file.

Notes

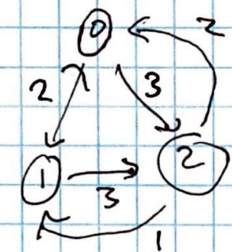
- The pseudocodes provided in the assignment document was used for the most part (more on this in README.md)
- Header files were included as necessary (vertices.h in graph.c, all headers in tsp.c, etc.)
    - Header files are taken from the resources repository
- Example graph files were taken from the resources repository as well
- My output doesn't match the expected output all the time according to the pipeline, which I don't understand
    - Specifically, it matches ucsc.graph and mythical.graph and partially matches solarsystem.graph
- My program does not pass valgrind according to the pipeline, but I know for a fact that my dynamic memory was freed that variables were initialized
    - This could be due to me misinterpreting valgrind's output on my local device

Other (visualized graph pattern)

$\boxed{\text{ucsc\_graph}}$

graph_print

	0	1	2
0	0	2	3
1	2	0	3
2	2	1	0



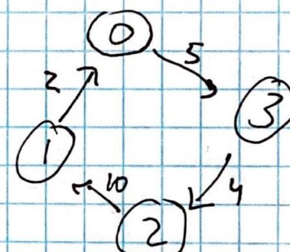
3 locations

3 recur calls cow → stere → mem → cow

$\boxed{\text{mythical}}$

	0	1	2	3
0	0	0	0	5
1	2	0	0	0
2	0	10	0	0
3	0	0	4	0

assume rest are 0s?



must be 12+9=21 ✓
0 to 3 to 2 to 1
(only path)

exe: 21 len
asg → sharg → oly → oly → asg 4 calls

need
gptr → graph
current } paths
shortest