

# 8042 Final Project Report

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|                                       |          |
|---------------------------------------|----------|
| <b>Purpose</b>                        | <b>2</b> |
| <b>Requirements</b>                   | <b>2</b> |
| <b>Platforms</b>                      | <b>2</b> |
| <b>Language</b>                       | <b>2</b> |
| <b>Usage Guide</b>                    | <b>2</b> |
| Compiling                             | 2        |
| Executing                             | 3        |
| Additional Details                    | 3        |
| <b>Overview of Requirements</b>       | <b>4</b> |
| Import & Retrieve GIS Records         | 4        |
| World                                 | 4        |
| Import                                | 4        |
| BufferPool                            | 5        |
| Geographic Coordinate Matching        | 5        |
| PR Quadtree                           | 5        |
| Find Geographic Coordinate            | 6        |
| Geographical Region Matching          | 6        |
| Find Geographic Coordinates in Region | 6        |
| Feature Name & State Matching         | 6        |
| Quadratic Hashtable                   | 7        |
| Insert & Find                         | 7        |
| Display Indices                       | 7        |
| Logger                                | 7        |
| toString                              | 7        |
| <b>Data Structures</b>                | <b>8</b> |
| <b>Test Run</b>                       | <b>8</b> |

# Purpose

This project aims to create a program that is able to create and maintain a database of imported GIS records. The program will index these records into a PR Quadtree and Quadratic Hashtable to support search features for records that fit geographic coordinates, feature and state names, and fall within a geographical region.

# Requirements

| Task   | Status            |
|--|-------------------|
| Import new GIS records into the database file  | Fully implemented |
| Retrieving data for all GIS records matching given geographic coordinates                  | Fully implemented |
| Retrieving data for all GIS records matching a given feature name and state                | Fully implemented |
| Retrieving data for all GIS records that fall within a given rectangular geographic region | Fully implemented |
| Display the in-memory indices in a human-readable manner                                   | Fully implemented |

# Platforms

Assignment 1 has been tested on:

- Fedora 37

# Language

- C++

# Usage Guide

## Compiling

Compiling is simple as there is just one \*.cpp file, GIS.cpp. The rest of files consist of header files that must be present in order for the code to function as intended.

**G++ GIS.cpp -o GIS**

## Executing

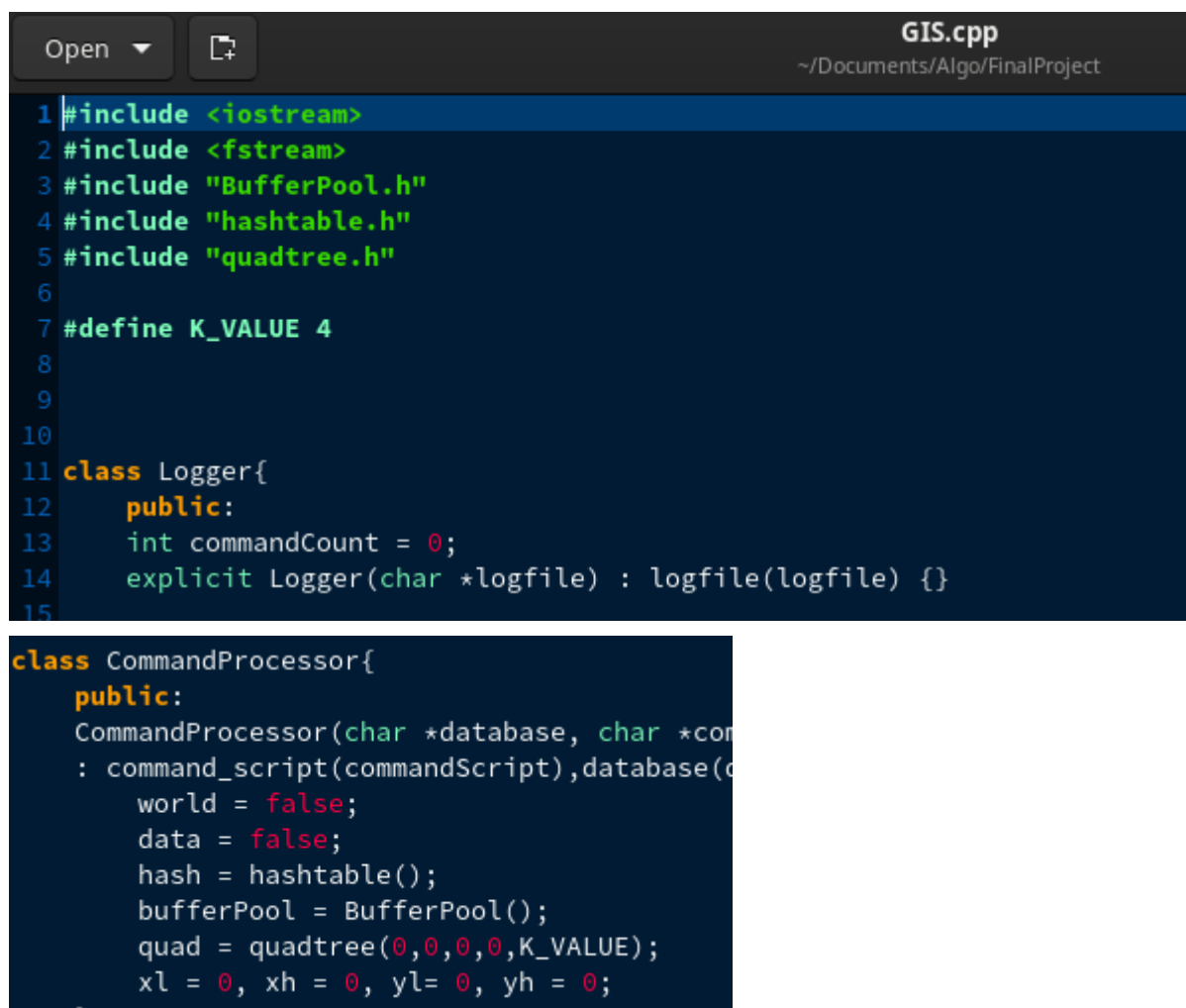
Executing the program is done exactly as suggested by the program document. The format is as follows:

**`./GIS <database file name> <command script file name> <log file name>`**

The command script file structure is expected to be the same as presented in the demonstrations. Any alterations will likely result in the program not functioning as intended.

## Additional Details

The PR Quadtree's limit of K data objects in each node is by default set to 4, but can be adjusted. The program does not have a way to adjust for that is inline, but the code can be adjusted to allow this by changing a default define value in GIS.cpp.



```
1 #include <iostream>
2 #include <fstream>
3 #include "BufferPool.h"
4 #include "hashtable.h"
5 #include "quadtree.h"
6
7 #define K_VALUE 4
8
9
10
11 class Logger{
12 public:
13     int commandCount = 0;
14     explicit Logger(char *logfile) : logfile(logfile) {}
15
16
17
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# Overview of Requirements

## Import & Retrieve GIS Records

There are three key components of the importing and retrieving of GIS records that were implemented for this project: the world definition function, the import itself, and the BufferPool.

### World

The world command and function serves to determine the world boundaries when running the application. For importing this is essential as if an imported record is out of bounds of the given world boundaries, it should not be imported.

Implementing this required two simple functionalities: a function to change DMS coordinates to total seconds, and a method to compare those coordinates to the world boundaries.

The first function was a simple implementation of a formula to parse the DMS coordinates as its three separate sections (The DMS format has three sections that are as follows: [D]DDMMSS[Direction]) by multiplying the degrees by 3600, the minutes by 60, then totaling them with the seconds and making negative or positive depending on the direction.

This function is used in processing the world boundaries as well before entering in the quadtree and making GIS records.

The second function is much simpler, and only requires comparing the coordinates to ensure it is smaller in both longitude and latitude than the right and top borders, and larger than the left and bottom borders.

This function is used for the area coordinate match as well as during the inserting process of the quadtree. If it is found not within bounds, the quadtree insertion does not occur and the record is not put in the database or hashtable.

### Import

The import functionality reads in new GIS records to be inserted into the database file. On the surface this is very simple, a read and write, but there is more that is required in order to be able to work with our quadtree and hashtable.

First the record is parsed into its individual parts to make a GISRecord object. This essential is an object of all the data in a GISRecord as well as containing a few other objects that are used for the quadtree and also containing the file offset of that record in the database. The file offset is kept track of by an int that increments every time a record is imported. The GIS Records coordinates and offset are then attempted to be inserted into the quadtree. The quadtree contains a check if the coordinates are within the world boundary and returns false if it isn't within. If it is within, then the feature name, state, and offset are inserted into the hashtable and written to the database.

## BufferPool

The BufferPool is implemented to be a front end for the database, providing an additional place to grab records from instead of the database.

The BufferPool acts as LRU cache storing up to 15 records. An LRU cache is data structure with a fixed size that when full always removes the least recently used data entry. While there are a few solutions to implement this, I choose the easiest method as I had time restrictions to consider. This method simply uses a list as its base structure. A hashmap could be included to speed up searching to  $O(1)$ , but for the case of this assignment just a list will do as the size of our structure is small.

Whenever a search is performed and a GISRecord is needed from the database, the BufferPool is checked first. If found, it grabs it from it instead. After each search is completed, all records found, including any that may have been in the BufferPool, are then pushed to the front of the list, then if over the size of 15, it pushes back any records until it is size of 15 again.

As a note, this functionality is altered slightly when the filter option for the `what_is_in` command is active. While this option is active, GIS records may be grabbed from the Bufferpool and database and then not actually get used. For the database grabbing from the quadtree results there is no way to prevent this as that data isn't known, but for the BufferPool this can be prevented by doing the filter during the find for the BufferPool as well.

## Geographic Coordinate Matching

The key component of implementing this functionality is the PR quadtree and its insert and find functionalities, specifically the find for a specific coordinate not an area. The area match functionality will be discussed in a later section.

### PR Quadtree

The PR or point region quadtree implementation was the most difficult part of this project by far, as it required many working parts. A PR Quadtree is a tree data structure where each of its internal nodes has exactly four children nodes that may contain up to K coordinate data objects if a leaf node, or another 4 child nodes. Each internal node represents an area of an overall world. This region is split into 4 sections for its child nodes that act as the determining factor of what node a coordinate is stored in.

Its implementation can be broken down into three key parts: the coord object, the node object, and the quadtree itself.

The coord object is an object made to act as the data stored in the leaf nodes of the quad tree. It stores coordinates longitude and latitude as well as any offsets for that coordinate. It houses the functionalities to determine if it is in a given area which will be used for area matching.

The code objects are the nodes of the quadtree. Each node stores a vector of coordinate objects, a bool to confirm it is a leaf node, four long values to define the nodes boundaries, and pointers to four child nodes that are unutilized. A size int is also present that can change the maximum number of data entries each node can carry. This value is hard coded, but can be changed if you adjust a value in the top of the GIS.ccp file. This will have more details in the user guide.

The quadtree itself is the initializer for the root node of the tree. On initialization, the world boundaries are assigned to the root node which starts off as a leaf node. Once K+1 data entries are inserted into a leaf node, it splits its boundaries into 4 quadrants and initialises the child node inside itself, each assigned one of the 4 boundaries, and becomes an internal node which no longer carries data entries. The data values of that node are then removed and distributed depending on each child node based on if they fit in the sub quadrants. While traversing a tree, if a node is internal, it recursively travels to its child nodes until a leaf node is found to get or insert data into.

## Find Geographic Coordinate

The find implementation works just like the insert, but instead of writing data it's comparing and getting. Using a given set of coordinates, the tree is traversed recursively by comparing each node and child node's boundaries to determine a path to where the data would be stored. Once a leaf node is found, the data is either found to be there and returned, or it is not found and the search stops as there would be no other possible locations for the data to be.

## Geographical Region Matching

The key component of implementing this functionality is the PR quadtree, its find functionalities, specifically the find for all GIS records in a given area.

### Find Geographic Coordinates in Region

The find in the region works very similarly to the coordinate find with some minor changes. For a given region, any data points have to be checked if they are within said area. If they are, they are entered into a vector. A data structure is needed to store the results as a region search is likely to have multiple results. To traverse the tree, child node boundaries are compared to the given boundaries. If they are found to overlap at all, then that region must be explored as a point may exist that fits in the area. Once a leaf node is reached, and data is or isn't retrieved, the function continues to search for any remaining nodes that fit the area.

## Feature Name & State Matching

The key component of implementing this functionality is a hashtable and its insert and find functionalities. This implementation was based loosely on the assignment 2 cuckoo hashtable with various adjustments made to fit the functionality of quadratic probing.

## Quadratic Hashtable

The base data structure of this implementation is a vector object storing NameIndex objects. NameIndex objects store a feature name, state, and offset as well as include various string functionality. The hash table also keeps track of the longest probe of an insert and the current maximum entries.

The hash function used is elf hash which is implemented in the NameIndex object. This is used in conjunction with quadratic probing to resolve collisions when inserting and to find data while searching.

## Insert & Find

To insert or find, a NameIndex is created using a given feature name and state. The hash function is then run on the object to get a baseline hash. This is treated as the starting point in the process as it enters a while loop. The index is then calculated by running the baseline through the quadratic formula that starts at zero. This position is checked to see if it is available for insert or if it matches the find params for find. If it matches or is available, the loop exits. If it doesn't the quadratic formula params increase and the loop restarts. This continues until a successful insert or a match is found. In the case of find, this process is limited to the longest probe sequence amount of times.

## Display Indices

This functionality uses a logger class as well as all the previously discussed structures toString methods to parse and present their indices in a readable format.

## Logger

The logger class handles any output to the log file, but does not necessarily handle the processing of the output. Instead it has set start and end logs, a log for the commands given, and a log for command output. How the logging is presented is driven by each object's toStrings and the command functions instead.

## toString

All relevant objects and data structures have functions to return their relevant data in multiple forms depending on the need. This includes the quadtree and its nodes coordinates, the coordinates themselves, the hashtable and its NameIndex objects, the NameIndex itself, the BufferPool GISRecords and GISRecords themselves as well as various smaller prints for specific needs of command outputs.



# Data Structures

As almost anything could be considered a data structure (a string is technically a data structure, I will limit this table to the data structures I've implemented that I think are most pertinent to disclose.

| Structure         | Use  | File        |
|-------------------|--|-------------|
| NameIndex         | Storage of the feature name, state abbreviation, and database offset of a GIS record                               | NameIndex.h |
| hashtable         | Organization of NameIndex records  | hashtable.h |
| vector<NameIndex> | Storage of the NameIndex records within the hashtable  | hashtable.h |
| coord             | Storage of the longitude, latitude, and offsets of said coordinates  | coord.h     |
| node              | Storage of coord records and node pointers to child nodes  | node.h      |
| vector<coord>     | Storage of the coord records within the node   | node.h      |
| quadtree          | Organization of the node and coord records   | quadtree.h  |
| BufferPool        | LRU Cache that organizes the most recently accessed GISRecords from the database                                   | pool.h      |
| GISRecord         | Storage and organization of the individual data elements within a GIS record as well as its offset in the database | GISRecord.h |
| list<GISRecord>   | Storage of all GISRecords within the BufferPool  | pool.h      |

## Test Run

The test run was run using the script file *script01.txt*.

```
log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

1 Course Project for COMP 8042
2 Student Name: Bryan Hill, Student Id: A01020530
3 Begin of GIS Program log:
4 dbFile: db.txt
5 script: script01.txt
6 log: log.txt
7 Start Time: Fri Dec 2 22:15:29 2022
8
9 world 0794530W 0792630W 381000N 383000N
10
11 -----
12 Latitude/longitude values in index entries are shown as signed integers, in total seconds.
13 -----
14                                     World boundaries are set to:
15                                     138600
16                                     -287130 -285990
17                                     137400
18 -----
19 1: import ./VA_Monterey.txt
20
21 Imported Features by name: 1024
22 Longest probe sequence: 3
23 Imported Locations: 62
24
25 -----
26 2: debug world
27
28 -----
29
30 Latitude/longitude values in index entries are shown as signed integers, in total seconds.
31 -----
32                                     World boundaries are set to:
33                                     138600
34                                     -287130 -285990
35                                     137400
36 -----
37 3: debug quad
38
39 r
40 + NE
41 [(138536, -286231)10]34 [(138580, -286263)13] [(138486, -286269)28] [(138302, -286213)29]
42 + NW
43 + NE
44 [(138530, -286299)12] [(138576, -286313)9] [(138593, -286342)1]
45 [(138593, -286403)5] [(138593, -286390)11] [(138591, -286358)20] [(138597, -286383)55]
46 [(138492, -286316)47]
47 *
48
49 [(138508, -286475)37] [(138574, -286428)46]
50 + SE
51 + NE
52 [(138424, -286301)36]
53 [(138438, -286321)41] [(138445, -286319)22] [(138414, -286329)32] [(138413, -286324)39]
54 *
```

```
log.txt
~/Documents/Algo/FinalProject/cmake-build-debug

55
56      *
57
58      *
59
60      [(138312, -286345)31]
61      [(138367, -286392)0] [(138370, -286393)40] [(138352, -286353)49]
62 [(138309, -286449)3] [(138341, -286500)25]
63 [(138108, -286269)23] [(138105, -286231)30] [(138193, -286273)45]
64 L SW
65      [(138293, -286416)48] [(138287, -286337)59]
66      + NW
67      [(138282, -286486)58] [(138266, -286484)15] [(138267, -286486)57]
68      [(138257, -286517)52] [(138284, -286490)53] [(138282, -286491)61]
69      *
70
71      *
72
73 [(138012, -286374)43]
74 [(138047, -286523)50] [(138023, -286502)19]
75 + NW
76      [(138326, -286638)17] [(138532, -286612)21] [(138315, -286582)26]
77      *
78
79      [(138080, -286562)60] [(138234, -286561)42]
80      *
81
82      + SE
83      + NE
84      *
85
86      [(137891, -286219)38] [(137904, -286253)8] [(137889, -286229)54]
87      *
88
89      [(137708, -286224)24] [(137722, -286212)33] [(137731, -286205)35]
90      + NW
91      *
92
93      [(137945, -286479)16] [(137942, -286438)2]
94      + SE
95      [(137827, -286304)7] [(137845, -286311)27]
96      *
97
98      [(137725, -286314)18]
99      [(137772, -286376)44] [(137773, -286358)6] [(137772, -286356)56]
100 [(137756, -286433)4]
101      *
102
103      *
104
105      [(137860, -286627)14] [(137896, -286628)51]
106
107 -----
108 4: debug      hash
```

```
log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

109
110 Format of display is
111 Slot number: data record
112 Current table size is 1024
113 Number of elements in table is 62
114
115 17: [Barren Rock:VA, [29]]
116 33: [Seybert Hills:VA, [49]]
117 49: [Hightown Church:VA, [17]]
118 50: [Thorny Bottom Church:VA, [36]]
119 97: [Little Doe Hill:VA, [23]]
120 113: [Elk Run:VA, [9]]
121 161: [Highland Wildlife Management Area:VA, [16]]
122 193: [Peck Run:VA, [28]]
123 225: [Laurel Run:VA, [22]]
124 226: [West Strait Creek:VA, [39]]
125 241: [Monterey:VA, [53]]
126 242: [Highland Elementary School:VA, [57]]
127 289: [Monterey District:VA, [60]]
128 353: [Central Church:VA, [5]]
129 354: [Key Run:VA, [20]]
130 401: [Wooden Run:VA, [41]]
131 417: [Asbury Church:VA, [0]]
132 418: [Highland High School:VA, [15]]
133 420: [Simmons Run:VA, [32]]
134 423: [Sounding Knob:VA, [50]]
135 449: [Hamilton Chapel:VA, [14]]
136 450: [Trimble:VA, [51]]
137 497: [Miracle Ridge:VA, [25]]
138 498: [Possum Trot:VA, [47]]
139 513: [Monterey Mountain:VA, [26]]
140 514: [Swope Hollow:VA, [35]]
141 529: [Rich Hills:VA, [48]]
142 545: [Meadow Draft:VA, [24]]
143 561: [Seybert Chapel:VA, [31]]
144 577: [Blue Grass School (historical):VA, [55]]
145 578: [Monterey Methodist Episcopal Church:VA, [58]]
146 580: [Strait Creek School (historical):VA, [59]]
147 593: [Davis Run:VA, [8]]
148 609: [Vance Hollow:VA, [38]]
149 610: [New Hampden:VA, [46]]
150 625: [Jack Mountain:VA, [19]]
151 626: [Town of Monterey:VA, [61]]
152 641: [Claylick Hollow:VA, [6]]
153 642: [Lantz Mountain:VA, [21]]
154 657: [Seldom Seen Hollow:VA, [30]]
155 658: [Southall Chapel:VA, [33]]
156 660: [Clover Creek Presbyterian Church:VA, [56]]
157 705: [Hannah Field Airport:VA, [42]]
158 769: [Union Chapel:VA, [37]]
159 770: [White Run:VA, [40]]
160 785: [Frank Run:VA, [11]]
161 801: [Crab Run:VA, [7]]
162 833: [Smith Field:VA, [54]]

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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug

163 849: [Bear Mountain:VA, [43]]
164 881: [Bluegrass Valley:VA, [1]]
165 897: [Buck Hill:VA, [2]]
166 898: [Burners Run:VA, [3]]
167 913: [Trimble Knob:VA, [52]]
168 929: [Forks of Waters:VA, [10]]
169 930: [New Salem Church:VA, [27]]
170 945: [Mount Carlyle:VA, [4]]
171 946: [Hupman Valley:VA, [18]]
172 948: [Strait Creek:VA, [34]]
173 951: [Clover Creek:VA, [44]]
174 961: [Ginseng Mountain:VA, [12]]
175 962: [Gulf Mountain:VA, [13]]
176 977: [Doe Hill:VA, [45]]
177
178 -----
179 5: what_is_at 382812N 0793156W
180
181 The following feature(s) were found at [(38d 28m 12s North, 79d 31m 56s West)]
182 47: Possum Trot Highland VA
183
184 -----
185 6: debug pool
186
187 MRU
188 47: 1496110|Possum Trot|Populated Place|VA|51|Highland91|(38d 28m 12s North, 79d 31m 56s West)|
189 38.470119|-79.532272|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|768|2520|Monterey|09/28/1979|
190 LRU
191 -----
192 7: what_is Church VA
193
194 No records match Church and VA
195 -----
196 8: what_is Central Church VA
197
198 The following feature(s) were found at Central Church VA
199 5: Highland (38d 29m 53s North, 79d 33m 23s West)
200 -----
201 9: what_is Town of Monterey VA
202
203 The following feature(s) were found at Town of Monterey VA
204 61: Highland (38d 24m 42s North, 79d 34m 51s West)
205 -----
206 10: what_is Smith Field VA
207
208 The following feature(s) were found at Smith Field VA
209 54: Highland (38d 18m 9s North, 79d 30m 29s West)
210 -----
211 11: what_is Smith Field CO
212
213 No records match Smith Field and CO
214 -----
215 12: debug pool

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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

216
217 MRU
218 54: 1498741|Smith Field|Airport|VA|51|Highland91|(38d 18m 9s North, 79d 30m 29s West)|38.302624|-79.508102|(0d 0m
0s South, 0d 0m 0s West)|0.000000|0.000000|617|2024|Monterey SE|09/01/1992|
219 61: 2391311|Town of Monterey|Civil|VA|51|Highland91|(38d 24m 42s North, 79d 34m 51s West)|38.411583|-79.580856|(0d
0m 0s South, 0d 0m 0s West)|0.000000|0.000000|884|2900|Monterey|02/19/2008|
220 5: 1482434|Central Church|Church|VA|51|Highland91|(38d 29m 53s North, 79d 33m 23s West)|38.498173|-79.556435|(0d 0m
0s South, 0d 0m 0s West)|0.000000|0.000000|773|2536|Monterey|09/28/1979|
221 47: 1496110|Possum Trot|Populated Place|VA|51|Highland91|(38d 28m 12s North, 79d 31m 56s West)|
38.470119|-79.532272|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|768|2520|Monterey|09/28/1979|
222 LRU
223
224 -----
225 13: what_is_at 382812N 0793156W
226
227 The following feature(s) were found at [(38d 28m 12s North, 79d 31m 56s West)]
228 47: Possum Trot Highland VA
229
230 -----
231 14: debug pool
232
233 MRU
234 47: 1496110|Possum Trot|Populated Place|VA|51|Highland91|(38d 28m 12s North, 79d 31m 56s West)|
38.470119|-79.532272|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|768|2520|Monterey|09/28/1979|
235 54: 1498741|Smith Field|Airport|VA|51|Highland91|(38d 18m 9s North, 79d 30m 29s West)|38.302624|-79.508102|(0d 0m
0s South, 0d 0m 0s West)|0.000000|0.000000|617|2024|Monterey SE|09/01/1992|
236 61: 2391311|Town of Monterey|Civil|VA|51|Highland91|(38d 24m 42s North, 79d 34m 51s West)|38.411583|-79.580856|(0d
0m 0s South, 0d 0m 0s West)|0.000000|0.000000|884|2900|Monterey|02/19/2008|
237 5: 1482434|Central Church|Church|VA|51|Highland91|(38d 29m 53s North, 79d 33m 23s West)|38.498173|-79.556435|(0d 0m
0s South, 0d 0m 0s West)|0.000000|0.000000|773|2536|Monterey|09/28/1979|
238 LRU
239
240 -----
241 15: what_is_at 381816N 0793700W
242
243 No records match 381816N and 0793700W
244
245 -----
246 16: what_is_at 381816N 0793708W
247
248 The following feature(s) were found at [(38d 18m 16s North, 79d 37m 8s West)]
249 51: Trimble Highland VA
250
251 -----
252 17: what_is_at 381612N 0793256W
253
254 The following feature(s) were found at [(38d 16m 12s North, 79d 32m 56s West)]
255 44: Clover Creek Highland VA
256
257 -----
258 18: what_is_at 382951N 0793238W
259
260 The following feature(s) were found at [(38d 29m 51s North, 79d 32m 38s West)]
261 20: Key Run Highland VA
```

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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

262
263 -----
264 19: what_is_at 382856N 0793031W
265
266 The following feature(s) were found at [(38d 28m 56s North, 79d 30m 31s West)]
267 10: Forks of Waters Highland VA
268 34: Strait Creek Highland VA
269
270 -----
271 20: what_is_in 382812N 0793156W 60 90
272
273 The following feature(s) were found at (38d 28m 12s North +/- 60, 79d 31m 56s West +/- 90)
274 10: Forks of Waters VA (38d 28m 56s North, 79d 30m 31s West)
275 34: Strait Creek VA (38d 28m 56s North, 79d 30m 31s West)
276 28: Peck Run VA (38d 28m 6s North, 79d 31m 9s West)
277 12: Ginseng Mountain VA (38d 28m 50s North, 79d 31m 39s West)
278 47: Possum Trot VA (38d 28m 12s North, 79d 31m 56s West)
279 41: Wooden Run VA (38d 27m 18s North, 79d 32m 1s West)
280 22: Laurel Run VA (38d 27m 25s North, 79d 31m 59s West)
281
282 -----
283 21: what_is_in 382012N 0792330W 60 90
284
285 The following feature(s) were found at (38d 20m 12s North +/- 60, 79d 23m 30s West +/- 90)
286
287 -----
288 22: what_is_in 382148N 0793109W 15 15
289
290 The following feature(s) were found at (38d 21m 48s North +/- 15, 79d 31m 9s West +/- 15)
291 23: Little Doe Hill VA (38d 21m 48s North, 79d 31m 9s West)
292
293 -----
294 23: what_is_in -long 382148N 0793109W 15 15
295
296 The following feature(s) were found at (38d 21m 48s North +/- 15, 79d 31m 9s West +/- 15)
297 Feature ID : 1484896
298 Feature Name : Little Doe Hill
299 Feature Cat : Summit
300 State : VA
301 County : Highland
302 Longitude : 79d 31m 9s West
303 Latitude : 38d 21m 48s North
304 Elev in ft : 3241
305 USGS Quad : Monterey SE
306 Date created : 09/28/1979
307
308 -----
309
310 24: what_is_in 382148N 0793109W 60 60
311
312 The following feature(s) were found at (38d 21m 48s North +/- 60, 79d 31m 9s West +/- 60)
313 23: Little Doe Hill VA (38d 21m 48s North, 79d 31m 9s West)
314 30: Seldom Seen Hollow VA (38d 21m 45s North, 79d 30m 31s West)
315
```

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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

317 25: what_is_in 382148N 0793109W 120 120
318
319 The following feature(s) were found at (38d 21m 48s North +/- 120, 79d 31m 9s West +/- 120)
320 23: Little Doe Hill VA (38d 21m 48s North, 79d 31m 9s West)
321 30: Seldom Seen Hollow VA (38d 21m 45s North, 79d 30m 31s West)
322 45: Doe Hill VA (38d 23m 13s North, 79d 31m 13s West)
323 43: Bear Mountain VA (38d 20m 12s North, 79d 32m 54s West)
324
325 -----
326 26: what_is_in 382148N 0793109W 180 180
327
328 The following feature(s) were found at (38d 21m 48s North +/- 180, 79d 31m 9s West +/- 180)
329 23: Little Doe Hill VA (38d 21m 48s North, 79d 31m 9s West)
330 30: Seldom Seen Hollow VA (38d 21m 45s North, 79d 30m 31s West)
331 45: Doe Hill VA (38d 23m 13s North, 79d 31m 13s West)
332 59: Strait Creek School (historical) VA (38d 24m 47s North, 79d 32m 17s West)
333 43: Bear Mountain VA (38d 20m 12s North, 79d 32m 54s West)
334 2: Buck Hill VA (38d 19m 2s North, 79d 33m 58s West)
335
336 -----
337 27: what_is_in -long 382148N 0793109W 180 180
338
339 The following feature(s) were found at (38d 21m 48s North +/- 180, 79d 31m 9s West +/- 180)
340 Feature ID : 1484896
341 Feature Name : Little Doe Hill
342 Feature Cat : Summit
343 State : VA
344 County : Highland
345 Longitude : 79d 31m 9s West
346 Latitude : 38d 21m 48s North
347 Elev in ft : 3241
348 USGS Quad : Monterey SE
349 Date created : 09/28/1979
350
351 Feature ID : 1486995
352 Feature Name : Seldom Seen Hollow
353 Feature Cat : Valley
354 State : VA
355 County : Highland
356 Longitude : 79d 30m 31s West
357 Latitude : 38d 21m 45s North
358 Elev in ft : 2461
359 USGS Quad : Monterey SE
360 Date created : 09/28/1979
361
362 Feature ID : 1495470
363 Feature Name : Doe Hill
364 Feature Cat : Summit
365 State : VA
366 County : Highland
367 Longitude : 79d 31m 13s West
368 Latitude : 38d 23m 13s North
369 Elev in ft : 3970
370 USGS Quad : Monterey
```



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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug

369 Elev in ft : 3970
370 USGS Quad : Monterey
371 Date created : 09/28/1979
372
373 Feature ID : 1673781
374 Feature Name : Strait Creek School (historical)
375 Feature Cat : School
376 State : VA
377 County : Highland
378 Longitude : 79d 32m 17s West
379 Latitude : 38d 24m 47s North
380 Elev in ft : 3068
381 USGS Quad : Monterey
382 Date created : 11/13/1995
383
384 Feature ID : 1495244
385 Feature Name : Bear Mountain
386 Feature Cat : Summit
387 State : VA
388 County : Highland
389 Longitude : 79d 32m 54s West
390 Latitude : 38d 20m 12s North
391 Elev in ft : 3530
392 USGS Quad : Monterey SE
393 Date created : 09/28/1979
394
395 Feature ID : 1482110
396 Feature Name : Buck Hill
397 Feature Cat : Summit
398 State : VA
399 County : Highland
400 Longitude : 79d 33m 58s West
401 Latitude : 38d 19m 2s North
402 Elev in ft : 3291
403 USGS Quad : Monterey SE
404 Date created : 09/28/1979
405
406
407 -----
408 28: what_is_in -filter structure 382600N 0793310W 120 120
409
410 The following feature(s) were found at (38d 26m 0s North +/- 120, 79d 33m 10s West +/- 120)
411 59: Strait Creek School (historical) VA (38d 24m 47s North, 79d 32m 17s West)
412 36: Thorny Bottom Church VA (38d 27m 4s North, 79d 31m 41s West)
413 31: Seybert Chapel VA (38d 25m 12s North, 79d 32m 25s West)
414 0: Asbury Church VA (38d 26m 7s North, 79d 33m 12s West)
415 58: Monterey Methodist Episcopal Church VA (38d 24m 42s North, 79d 34m 46s West)
416 15: Highland High School VA (38d 24m 26s North, 79d 34m 44s West)
417 57: Highland Elementary School VA (38d 24m 27s North, 79d 34m 46s West)
418
419 -----
420 29: what_is_in -filter water 382850N 0793030W 120 240
421
422 The following feature(s) were found at (38d 28m 50s North +/- 120, 79d 30m 30s West +/- 240)
```

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log.txt
~/Documents/Algo/FinalProject/cmake-build-debug
Save

422 The following feature(s) were found at (38d 28m 50s North +/- 120, 79d 30m 30s West +/- 240)
423 41: Wooden Run VA (38d 27m 18s North, 79d 32m 1s West)
424 22: Laurel Run VA (38d 27m 25s North, 79d 31m 59s West)
425 34: Strait Creek VA (38d 28m 56s North, 79d 30m 31s West)
426 28: Peck Run VA (38d 28m 6s North, 79d 31m 9s West)
427 9: Elk Run VA (38d 29m 36s North, 79d 31m 53s West)
428 11: Frank Run VA (38d 29m 53s North, 79d 33m 10s West)
429 20: Key Run VA (38d 29m 51s North, 79d 32m 38s West)
430 32: Simmons Run VA (38d 26m 54s North, 79d 32m 9s West)
431 39: West Strait Creek VA (38d 26m 53s North, 79d 32m 4s West)
432
433 -----
434 30: what_is_in -filter pop 382000N 0793530W 3600 3600
435
436 The following feature(s) were found at (38d 20m 0s North +/- 3600, 79d 35m 30s West +/- 3600)
437 47: Possum Trot VA (38d 28m 12s North, 79d 31m 56s West)
438 46: New Hampden VA (38d 29m 34s North, 79d 33m 48s West)
439 53: Monterey VA (38d 24m 44s North, 79d 34m 50s West)
440 44: Clover Creek VA (38d 16m 12s North, 79d 32m 56s West)
441 51: Trimble VA (38d 18m 16s North, 79d 37m 8s West)
442
443 -----
444 31: debug pool
445
446 MRU
447 51: 1496325|Trimble|Populated Place|VA|51|Highland91|(38d 18m 16s North, 79d 37m 8s West)|38.304569|-79.618935|(0d
0m 0s South, 0d 0m 0s West)|0.000000|0.000000|777|2549|Monterey SE|09/28/1979|
448 44: 1495400|Clover Creek|Populated Place|VA|51|Highland91|(38d 16m 12s North, 79d 32m 56s West)|
38.270123|-79.548935|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|570|1870|Monterey SE|09/28/1979|
449 53: 1498517|Monterey|Populated Place|VA|51|Highland91|(38d 24m 44s North, 79d 34m 50s West)|38.412342|-79.580605|
(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|882|2894|Monterey|09/28/1979|
450 46: 1496000|New Hampden|Populated Place|VA|51|Highland91|(38d 29m 34s North, 79d 33m 48s West)|
38.492897|-79.563385|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|792|2598|Monterey|09/28/1979|
451 47: 1496110|Possum Trot|Populated Place|VA|51|Highland91|(38d 28m 12s North, 79d 31m 56s West)|
38.470119|-79.532272|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|768|2520|Monterey|09/28/1979|
452 39: 1488259|West Strait Creek|Stream|VA|51|Highland91|(38d 26m 53s North, 79d 32m 4s West)|38.448177|-79.534492|
(38d 25m 25s North, 79d 35m 53s West)|38.423611|-79.598053|779|2556|Monterey|09/28/1979|
453 32: 1487250|Simmons Run|Stream|VA|51|Highland91|(38d 26m 54s North, 79d 32m 9s West)|38.448452|-79.535881|(38d 26m
43s North, 79d 34m 31s West)|38.445278|-79.575279|780|2559|Monterey|09/28/1979|
454 20: 1484574|Key Run|Stream|VA|51|Highland91|(38d 29m 51s North, 79d 32m 38s West)|38.497620|-79.543938|(38d 32m 50s
North, 79d 32m 23s West)|38.547340|-79.539772|754|2474|Monterey|09/28/1979|
455 11: 1483527|Frank Run|Stream|VA|51|Highland91|(38d 29m 53s North, 79d 33m 10s West)|38.498173|-79.552826|(38d 33m
4s North, 79d 33m 41s West)|38.551228|-79.561440|780|2559|Monterey|09/28/1979|
456 9: 1483281|Elk Run|Stream|VA|51|Highland91|(38d 29m 36s North, 79d 31m 53s West)|38.493454|-79.531433|(38d 31m 21s
North, 79d 30m 56s West)|38.522617|-79.515602|757|2484|Monterey|09/28/1979|
457 28: 1486118|Peck Run|Stream|VA|51|Highland91|(38d 28m 6s North, 79d 31m 9s West)|38.468452|-79.519211|(38d 26m 34s
North, 79d 29m 32s West)|38.442898|-79.492271|728|2388|Monterey|09/28/1979|
458 34: 1487661|Strait Creek|Stream|VA|51|Highland91|(38d 28m 56s North, 79d 30m 31s West)|38.482342|-79.508659|(38d
24m 42s North, 79d 32m 22s West)|38.411667|-79.539444|705|2313|Monterey|09/28/1979|
459 22: 1484722|Laurel Run|Stream|VA|51|Highland91|(38d 27m 25s North, 79d 31m 59s West)|38.457066|-79.533104|(38d 28m
1s North, 79d 33m 31s West)|38.466946|-79.558609|766|2513|Monterey|09/28/1979|
460 41: 1488473|Wooden Run|Stream|VA|51|Highland91|(38d 27m 18s North, 79d 32m 1s West)|38.455120|-79.533661|(38d 26m
12s North, 79d 29m 30s West)|38.436787|-79.491714|760|2493|Monterey|09/28/1979|
461 57: 1673775|Highland Elementary School|School|VA|51|Highland91|(38d 24m 27s North, 79d 34m 46s West)|
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461 57: 1673775|Highland Elementary School|School|VA|51|Highland91|(38d 24m 27s North, 79d 34m 46s West)|
    38.407429|-79.579567|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|878|2881|Monterey|11/13/1995|
462 LRU
463
464 -----
465 32: import      ./_VA_Bath.txt
466
467 Imported Features by name: 41
468 Longest probe sequence:    5
469 Imported Locations:        41
470
471 -----
472 33: debug      pool
473
474 MRU
475 51: 1496325|Trimble|Populated Place|VA|51|Highland91|(38d 18m 16s North, 79d 37m 8s West)|38.304569|-79.618935|(0d
    0m 0s South, 0d 0m 0s West)|0.000000|0.000000|777|2549|Monterey SE|09/28/1979|
476 44: 1495400|Clover Creek|Populated Place|VA|51|Highland91|(38d 16m 12s North, 79d 32m 56s West)|
    38.270123|-79.548935|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|570|1870|Monterey SE|09/28/1979|
477 53: 1498517|Monterey|Populated Place|VA|51|Highland91|(38d 24m 44s North, 79d 34m 50s West)|38.412342|-79.580605|
    (0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|882|2894|Monterey|09/28/1979|
478 46: 1496000|New Hampden|Populated Place|VA|51|Highland91|(38d 29m 34s North, 79d 33m 48s West)|
    38.492897|-79.563385|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|792|2598|Monterey|09/28/1979|
479 47: 1496110|Possum Trot|Populated Place|VA|51|Highland91|(38d 28m 12s North, 79d 31m 56s West)|
    38.470119|-79.532272|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|768|2520|Monterey|09/28/1979|
480 39: 1488259|West Strait Creek|Stream|VA|51|Highland91|(38d 26m 53s North, 79d 32m 4s West)|38.448177|-79.534492|
    (38d 25m 25s North, 79d 35m 53s West)|38.423611|-79.598053|779|2556|Monterey|09/28/1979|
481 32: 1487250|Simmons Run|Stream|VA|51|Highland91|(38d 26m 54s North, 79d 32m 9s West)|38.448452|-79.535881|(38d 26m
    43s North, 79d 34m 31s West)|38.445278|-79.575279|780|2559|Monterey|09/28/1979|
482 20: 1484574|Key Run|Stream|VA|51|Highland91|(38d 29m 51s North, 79d 32m 38s West)|38.497620|-79.543938|(38d 32m 50s
    North, 79d 32m 23s West)|38.547340|-79.539772|754|2474|Monterey|09/28/1979|
483 11: 1483527|Frank Run|Stream|VA|51|Highland91|(38d 29m 53s North, 79d 33m 10s West)|38.498173|-79.552826|(38d 33m
    4s North, 79d 33m 41s West)|38.551228|-79.561440|780|2559|Monterey|09/28/1979|
484 9: 1483281|Elk Run|Stream|VA|51|Highland91|(38d 29m 36s North, 79d 31m 53s West)|38.493454|-79.531433|(38d 31m 21s
    North, 79d 30m 56s West)|38.522617|-79.515602|757|2484|Monterey|09/28/1979|
485 28: 1486118|Peck Run|Stream|VA|51|Highland91|(38d 28m 6s North, 79d 31m 9s West)|38.468452|-79.519211|(38d 26m 34s
    North, 79d 29m 32s West)|38.442898|-79.492271|728|2388|Monterey|09/28/1979|
486 34: 1487661|Strait Creek|Stream|VA|51|Highland91|(38d 28m 56s North, 79d 30m 31s West)|38.482342|-79.508659|(38d
    24m 42s North, 79d 32m 22s West)|38.411667|-79.539444|705|2313|Monterey|09/28/1979|
487 22: 1484722|Laurel Run|Stream|VA|51|Highland91|(38d 27m 25s North, 79d 31m 59s West)|38.457066|-79.533104|(38d 28m
    1s North, 79d 33m 31s West)|38.466946|-79.558609|766|2513|Monterey|09/28/1979|
488 41: 1488473|Wooden Run|Stream|VA|51|Highland91|(38d 27m 18s North, 79d 32m 1s West)|38.455120|-79.533661|(38d 26m
    12s North, 79d 29m 30s West)|38.436787|-79.491714|760|2493|Monterey|09/28/1979|
489 57: 1673775|Highland Elementary School|School|VA|51|Highland91|(38d 24m 27s North, 79d 34m 46s West)|
    38.407429|-79.579567|(0d 0m 0s South, 0d 0m 0s West)|0.000000|0.000000|878|2881|Monterey|11/13/1995|
490 LRU
491
492 -----
493 34: quit
494
495 Terminating execution of commands
496 -----
497 End Time: Fri Dec  2 22:43:09 2022
498
```