FProjectLBandDP

0.3.0

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Chapter 1

Description

This project is a take on the knapsack problem. It uses N number of objects and runs them through two different algorithms, CreateBruteForceTree() and RandomTree(). The goal here is to return a binary tree with the highest weight to price ratio.

1.1 Examples

If you are wanting to set N go to line 343 in the code and change it, otherwise it will default to 50 objects used.

1. Point your browser to this repository (https://github.com/dapervis/CPTR227Final↩ Project)
2. Press the "Use this template" button
3. Give your repository a new name
4. Write a short (one sentence) description of what your project will do
5. Click the Create repository from template button

1.2 Reason For this Project

We chose this project because its a very unique problem that doesn't have an exact solution. It is very interesting to see what different people and ourselves have come up with to try to solve the knapsack problem in the most efficient way.

1.3 Data Structures Used

1. Sort - We used sort to make parsing the data into the binary tree more efficient since they would already be in greatest to least ratio order
2. Binary Tree - We chose binary trees to store the data in a a easy to read and understand pattern.

1.4 Algorithms Used

1. Brute Force - Brute force was used since it will come up with the best possible scenario, however, it is also the slowest algorithm possible and won't be useful in every setting.
2. Random - Random was used for its quick ability to choose data points and throw them into the "knapsack" as fast as possible.

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

File Index

3.1 File List

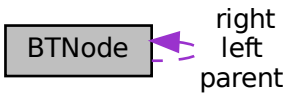
Here is a list of all files with brief descriptions:

Chapter 4

Class Documentation

4.1 BTNode Class Reference

Collaboration diagram for BTNode:



Public Member Functions

- BTNode (Products dataVal)
- char nodeName ()
- Products nodeData ()
- int nodeRatio ()

Public Attributes

- BTNode * left
- BTNode * right
- BTNode * parent

4.1.1 Detailed Description

Definition at line 48 of file main.cpp.

4.1.2 Constructor & Destructor Documentation

4.1.2.1 BTNode()

```
BTNode::BTNode (
            Products dataVal )  [inline]
```

BTNode constructor

Parameters

dataVal	This is the product that is put into the binary tree.

Definition at line 59 of file main.cpp.

```
59                              {
60       //cout « "name = " « name « endl;
61       left = NULL;
62       right = NULL;
63       parent = NULL;
64       objName = name++;
65       data = dataVal;
66   }
```

4.1.3 Member Function Documentation

4.1.3.1 nodeData()

```
Products BTNode::nodeData ( )  [inline]
```

This reports the node's data

Definition at line 78 of file main.cpp.

```
78                          {
79         return(data);
80     }
```

4.1.3.2 nodeName()

```
char BTNode::nodeName ( )  [inline]
```

This reports the node's name

Definition at line 71 of file main.cpp.

```
71                      {
72         return(objName);
73     }
```

4.1.3.3 nodeRatio()

```
int BTNode::nodeRatio ( )  [inline]
```

This reports the node's ratio, currently breaks something by converting it to an int, don't use for comparisons.

Definition at line 85 of file main.cpp.

```
85                      {
86          return(data.ratio);
87      }
```

4.1.4 Member Data Documentation

4.1.4.1 left

```
BTNode* BTNode::left
```

Definition at line 50 of file main.cpp.

4.1.4.2 parent

```
BTNode* BTNode::parent
```

Definition at line 52 of file main.cpp.

4.1.4.3 right

```
BTNode* BTNode::right
```

Definition at line 51 of file main.cpp.

The documentation for this class was generated from the following file:

- /home/daniel/Final/CPTR227FinalProject/src/main.cpp

4.2 Products Class Reference

Public Member Functions

- Products ()
- Products (double p, double w)

Public Attributes

- double price
- double weight
- double ratio

4.2.1 Detailed Description

This is class has 2 different parameters used to make this object

Definition at line 22 of file main.cpp.

4.2.2 Constructor & Destructor Documentation

4.2.2.1 Products() [1/2]

```
Products::Products ( )  [inline]
```

Definition at line 31 of file main.cpp.

```
31                {
32
33     }
```

4.2.2.2 Products() [2/2]

```
Products::Products (
            double p,
            double w )  [inline]
```

This is the constructor for this class

Parameters

p	The price for the product.
w	The weight for the product.

Definition at line 41 of file main.cpp.

```
41                                  {
42         price = p;
43         weight = w;
44         ratio = w/p;
45     }
```

4.2.3 Member Data Documentation

4.2.3.1 price

```
double Products::price
```

Definition at line 27 of file main.cpp.

4.2.3.2 ratio

```
double Products::ratio
```

Definition at line 29 of file main.cpp.

4.2.3.3 weight

```
double Products::weight
```

Definition at line 28 of file main.cpp.

The documentation for this class was generated from the following file:

- /home/daniel/Final/CPTR227FinalProject/src/main.cpp

Chapter 5

File Documentation

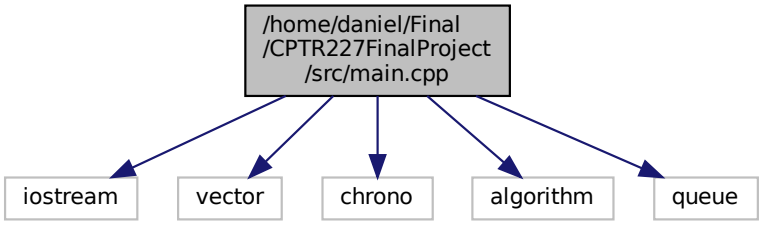
5.1 /home/daniel/Final/CPTR227FinalProject/README.md File Reference

5.2 /home/daniel/Final/CPTR227FinalProject/src/main.cpp File Reference

This is the final project made with code from HW11.

```
#include <iostream>
#include <vector>
#include <chrono>
#include <algorithm>
#include <queue>
```

Include dependency graph for main.cpp:



Classes

- class Products
- class BTNode

Functions

- BTNode * addNode (BTNode *rootNode, BTNode *n)
- BTNode * addNode (BTNode *rootNode, Products dataval)
- int randomGen (int min, int max)
- std::vector< Products > genProducts (int n)
- void printTree (BTNode *rootNode)
- void printBT (const string &prefix, BTNode *node, bool isLeft)
- void printBT (BTNode *node)
- bool comparator (const Products &a, const Products &b)
- void createTreeBruteForce (vector< Products > &tree, int index)
- void RandomTree (vector< Products > &tree, int index)
- void createTree (vector< Products > &tree, int index)
- int main (int, char **)

5.2.1 Detailed Description

This is the final project made with code from HW11.

This program is based on the knapsack problem and uses a binary tree to store the data.

Author

Daniel Pervis and Lee Beckermeyer

Date

4/21/2021

5.2.2 Function Documentation

5.2.2.1 addNode() [1/2]

```
BTNode* addNode (
            BTNode * rootNode,
            BTNode * n )
```

This function adds a node to a binary search tree.

Parameters

rootNode	is the pointer to the tree's root node
n	is the node to add

Returns

pointer to rootNode if successful, NULL otherwise

Definition at line 105 of file main.cpp.

```
105                                                 {
106     BTNode* prev = NULL;
107     BTNode* w = rootNode;
108     if(rootNode == NULL) { // starting an empty tree
109         rootNode = n;
110     } else {
111         // Find the node n belongs under, prev, n's new parent
112         while(w != NULL) {
113             prev = w;
114             if(n->nodeData().ratio < w->nodeData().ratio){
115                 //cout << w->nodeData().ratio << " added" << endl;
116                 w = w->left;
117             } else if(n->nodeData().ratio > w->nodeData().ratio) {
118                 //cout << w->nodeData().ratio << " added" << endl;
119                 w = w->right;
120             } else { // data already in the tree
121                 return(NULL);
122             }
123         }
124         // now prev should contain the node that should be n's parent
125         // Add n to prev
126         if(n->nodeData().ratio < prev->nodeData().ratio) {
127             prev->left = n;
128         } else {
129             prev->right = n;
130         }
131     }
132     return(rootNode);
133 }
```

5.2.2.2 addNode() [2/2]

```
BTNode* addNode (
              BTNode * rootNode,
              Products dataval )
```

Adds a new node with the passed data value

Parameters

rootNode	pointer to root node
dataval	an integer for the new node's data

Returns

pointer to root node or NULL if not successful

Definition at line 142 of file main.cpp.

```
142                                                 {
143     BTNode* newNode = new BTNode(dataval);
144     if(addNode(rootNode, newNode) == NULL) {
145         //cout << dataval.ratio << " already in tree" << endl;
146     } else {
147         //cout << dataval.ratio << " succesfully added" << endl;
148     }
149     return(rootNode);
150 }
```

5.2.2.3 comparator()

```
bool comparator (
            const Products & a,
            const Products & b )
```

compares 2 products

Parameters

a	product a
b	product b

Definition at line 256 of file main.cpp.

```
256                                                 {
257     return a.ratio > b.ratio;
258 }
```

5.2.2.4 createTree()

```
void createTree (
            vector< Products > & tree,
            int index )
```

creates a binary tree

Parameters

tree	a vector of products you want to turn into a tree.
index	the size of the vector, needed with the current implementation.

Definition at line 338 of file main.cpp.

```
338                                                 {
339     BTNode* root = new BTNode(tree[index]);
340     for (Products x : tree){
341         addNode(root, x);
342     }
343     printBT(root);
344 }
```

5.2.2.5 createTreeBruteForce()

```
void createTreeBruteForce (
            vector< Products > & tree,
            int index )
```

creates a binary tree, also checks if the knapsack is full, if the knapsack isn't full it continues until the end of the vector.

Parameters

tree	a vector of products you want to turn into a tree.
index	the size of the vector, needed with the current implementation.

Definition at line 266 of file main.cpp.

```
266                                                                 {
267     BTNode* root = new BTNode(tree[index]);
268     int weight = 0;
269     int price = 0;
270     sort(tree.begin(), tree.end(), &comparator);
271     /*for (int i = 0; i < tree.size(); i++) {
272         cout « i « " : " « tree[i].ratio « endl;
273     }*/
274     for (Products x : tree){
275             int newweight = x.weight + weight;
276             int newprice = x.price + price;
277             if(newweight>=500){
278                 continue;
279             }
280             else{
281                 weight = newweight;
282                 price = newprice;
283                 addNode(root, x);
284                 x.weight + weight;
285                 x.price + price;
286             }
287 
288 
289         }
290     cout « "Tree generated using a brute force algorithm after sorting the object's ratios" « endl;
291     cout « "Weight of the Knapsack: " « weight « " lbs" « endl;
292     cout « "Price of the Knapsack: " « price « "$" « endl;
293     cout « "Ratio of the Tree(weight/price): " « (double)500/price « endl;
294     printBT(root);
295 };
```

5.2.2.6 genProducts()

```
std::vector<Products> genProducts (
            int n )
```

generates the products.

Parameters

n	The amount of products you want generated.

Definition at line 172 of file main.cpp.

```
172                                     {
173     vector<Products> output;
174     for (int i = 0; i < n; i++) {
175         output.push_back(Products(randomGen(1,1000), randomGen(5, 200)));
176     }
177     return output;
178 }
```

5.2.2.7 main()

```
int main (
            int ,
            char **  )
```

Definition at line 348 of file main.cpp.

```
348                         {
349     srand(time(NULL));
350     vector<Products> products = genProducts(50);
351     auto max = std::max_element(products.begin(), products.end(), [](const Products& a, const Products&
        b){
352         return a.ratio < b.ratio;
353     });
354     int index = distance(products.begin(), max);
355     cout « max->ratio « endl;
356     cout « products[index].ratio « endl;
357     //sort(products.begin(), products.end(), &comparator); NO TOUCHY
358     for (int i = 0; i < products.size(); i++) {
359         cout « i « " : " « products[i].ratio « endl;
360     }
361
362     //for (Products x : products){
363     //    cout « x.ratio « endl;
364     //}
365     RandomTree(products, index);
366     createTreeBruteForce(products, index);
367
368 }
```

5.2.2.8 printBT() [1/2]

```
void printBT (
            BTNode * node )
```

An overload to simplify calling printBT

Parameters

node	is the root node of the tree to be printed

Definition at line 245 of file main.cpp.

```
246 {
247     printBT("", node, false);
248 }
```

5.2.2.9 printBT() [2/2]

```
void printBT (
            const string & prefix,
            BTNode * node,
            bool isLeft )
```

Print a binary tree

This example is modified from: https://stackoverflow.com/a/51730733

Parameters

prefix	is a string of characters to start the line with
node	is the current node being printed
isLeft	bool true if the node is a left node

Definition at line 221 of file main.cpp.

```
222 {
223     if( node != NULL )
224     {
225         cout « prefix;
226 
227         cout « (isLeft ? "L--" : "R--" );
228 
229         // print the value of the node
230         //cout « node->nodeName() « ':' « node->nodeData() « std::endl;
231         cout « node->nodeData().ratio « std::endl;
232 
233         // enter the next tree level - left and right branch
234         printBT( prefix + (isLeft ? "|   " : "    "), node->left, true);
235         printBT( prefix + (isLeft ? "|   " : "    "), node->right, false);
236     }
237 }
```

5.2.2.10 printTree()

```
void printTree (
            BTNode * rootNode )
```

prints a binary tree

Parameters

rootNode	The binary tree you want printed.

Definition at line 185 of file main.cpp.

```
185                                 {
186     queue<BTNode*> todo; // the queue of nodes left to visit
187     BTNode* cur; // current node
188     BTNode* prev; // The previous node
189 
190     todo.push(rootNode);
191 
192     while(!todo.empty()) {
193         cur = todo.front();
194         // Print current node
195         cout « cur->nodeName() « ':' « cur->nodeData().ratio « '\t';
196         // add cur->left to queue
197         if(cur->left != NULL) {
198             todo.push(cur->left);
199         }
200         // add cur->right to queue
201         if(cur->right != NULL) {
202             todo.push(cur->right);
203         }
204         // remove cur from queue
205         todo.pop();
206     }
207     cout « endl;
208 }
```

5.2.2.11 randomGen()

```
int randomGen (
            int min,
            int max )
```

Randomly generates a "double"(float in C++) number

Parameters

min	The minimum number that can be generated.
max	The maximum number that can be generated.

Definition at line 159 of file main.cpp.

```
159                                 {
160
161     double random = rand() % max + min;
162      //int random = rand() % max + min;
163      //cout << rand() % max << endl;
164      return random;
165 }
```

5.2.2.12 RandomTree()

```
void RandomTree (
            vector< Products > & tree,
            int index )
```

creates a binary tree, also checks if the knapsack is full, if the knapsack isn't full it continues until the end of the vector.

Parameters

tree	a vector of products you want to turn into a tree.
index	the size of the vector, needed with the current implementation.

Definition at line 303 of file main.cpp.

```
303                                                     {
304     BTNode* root = new BTNode(tree[index]);
305     cout << tree[index].ratio << endl;
306     int weight = 0;
307     int price = 0;
308     int n = 0;
309     while(n < 10){
310         n++;
311         Products x = tree[randomGen(0,index)];
312         int newweight = x.weight + weight;
313         int newprice = x.price + price;
314         if(newweight>=500){
315                     continue;
316                 }
317                 else{
318                     weight = newweight;
319                     price = newprice;
320                     addNode(root, x);
321                     x.weight + weight;
322                     x.price + price;
323                 }
324     }
325     cout << "Tree generated using a random algorithm" << endl;
326     cout << "Weight of the Knapsack: " << weight << " lbs" << endl;
327     cout << "Price of the Knapsack: $" << price << endl;
328     cout << "Ratio of the Tree(weight/price): " << (double)500/price << endl;
329     printBT(root);
330 };
```

Index