Programming Abstractions

CS106B

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Today's Topics

Abstract Data Types (ADTs)

- Vector
- Grid

C++ Functions and Parameters

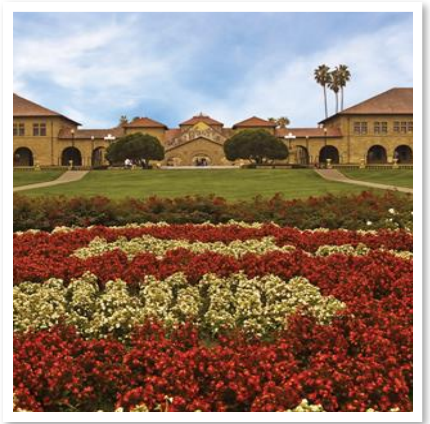
- "Pass by reference" for containers like Vector and Grid

Fauxtoshop

- Assignment 1 orientation
- Grid practice

ADTs

VECTOR, GRID



ADTs

- Programming language independent models of common containers
- They encompass not only the nature of the data, but ways of accessing it

- They form a rich **vocabulary** of **nouns** and **verbs**, often drawing on analogies to make their use intuitive, and to give code written in them a certain **literary** quality

Vector

- ADT abstraction similar to an array
- Many languages have a version of this
  - (remember, ADTs are conceptual abstractions that are language-independent)

- In C++ we declare one like this:

```
Vector<string> lines;
```

- This syntax is called **template** syntax
  - Vectors can hold many things, but they all have to be the same type
  - The type goes in the < > after the class name Vector
    - `Vector<int> assignment3Scores;`
    - `Vector<double> measurementsData;`
    - `Vector<Vector<int>> allAssignmentScores;`

Vector

- Declaring a Vector:
  - `Vector<int> assignment3Scores;`
  - `Vector<double> measurementsData;`
  - `Vector<Vector<int>> allAssignmentScores;`

- Using a Vector:
  - `assignment3Scores.append(98);`
  - `assignment3Scores.append(85);`
  - `assignment3Scores.append(92);`
  - `cout << assignment3Scores[0]; // prints 98`
  - `cout << assignment3Scores[2]; // prints 92`

Parameter Passing in C++

IMPORTANT C++ DETAIL FOR WORKING WITH CONTAINERS LIKE VECTOR

"Pass by value"
(default behavior of parameters)

```
int main(){
   int n = 5;
   foo(n);
   cout << n << endl;
   return 0;
}

void foo(int n) {
    n++;
}
```

What is printed?

A. 5
B. 6
C. Error or something else

"Pass by reference"

```
int main(){
    int n = 5;
    foo(n);
    cout << n << endl;
    return 0;
}

void foo(int &n) {
     n++;
}
```

What is printed?

A. 5
B. 6
C. Error or something else

Often used when you would want to "return" several values from a function (but there is only one return value allowed)

```
#include "random.h" //Stanford library for random numbers


void pickLotto(int& first, int& second, int& third) {
  first = randomInteger(0,10);
  second = randomInteger(0,10);
  third = randomInteger(0,10);
}


int main(){
  int lotto1 = 0;
  int lotto2 = 0;
  int lotto3 = 0;
  pickLotto(lotto1, lotto2, lotto3);
  cout << lotto1 << " " << lotto2 << " " << lotto3 << endl;
  return 0;
}
```

Pass by reference

Always pass containers like Vector (and Grid, which we'll see next) by reference in this class!

- For efficiency reasons—don't want to make a big copy every time!
- If you aren't interested in actually changing the object (i.e., by reference is purely for efficiency), then this is a little bit overkill because it does allow the object to be changed
  - Use "const" to communicate that you won't change the structure

```
void printFirst(const Vector<int>& input) {
    cout << input[0] << endl; // "read-only" access
    //input[0] = 5; // this would not be allowed by compiler
}
```

Grid container

ESSENTIALLY A MATRIX (LINEAR ALGEBRA FANS CELEBRATE NOW)

Grid

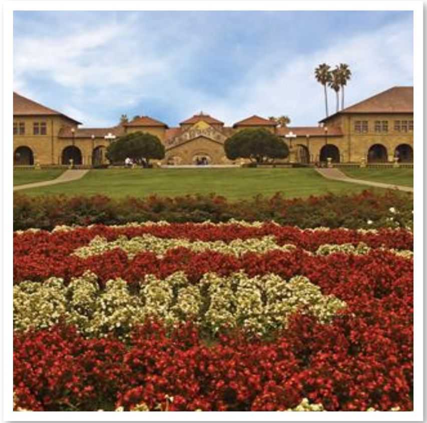
- ADT abstraction similar to an array of arrays (matrix)
- Many languages have a version of this
  - (remember, ADTs are conceptual abstractions that are language-independent)

- In C++ we declare one like this:

```
Grid<int> chessboard;
Grid<int> image;
Grid<double> realMatrix;
```

Code example: Fauxtoshop

"FAUX"—PRONOUNCED "FOH"—IS A FRENCH WORD THAT MEANS FAKE OR COUNTERFEIT



Grids and loops and loops!

```
void printMe(const Grid<int>& grid, int row, int col) {
    for (int r = row - 1; r <= row + 1; r++) {
        for (int c = col - 1; c <= col + 1; c++) {
            if (inBounds(r, c)) {
                cout << grid[r][c] << " ";
            }
        }
        cout << endl;
    }
}
```

How many 0's does this print with input `row = 2`, `col = 3`?
(and grid as shown on right)

(A) None or 1
(B) 2 or 3
(C) 4 or 5
(D) 6 or 7

2	1	2	0	0
1	0	2	1	2
0	0	0	1	1
2	2	2	2	2
1	1	0	1	1

Handy loop idiom: iterating over “neighbors” in a Grid

```
void printNeighbors(const Grid<int>& grid, int row, int col) {
    for (int r = row - 1; r <= row + 1; r++) {
        for (int c = col - 1; c <= col + 1; c++) {
            if (inBounds(r, c)) {
                cout << grid[r][c] << " ";
            }
        }
        cout << endl;
    }
}
```

row - 1 col – 1	row - 1 col + 0	row - 1 col + 1
row + 0 col - 1	row col	row + 0 col +1
row + 1 col - 1	row + 1 col + 0	row + 1 col + 1

These nested for loops generate all the pairs in the cross product {-1,0,1} x {-1,0,1}, and we can add these as offsets to a (r,c) coordinate to generate all the neighbors (note: often want to test for and exclude the (0,0) offset, which is “myself” not a neighbor)