COMP1511 - Programming Fundamentals

Term 1, 2020 - Lecture 7

What did we learn last week?

Code Style and Code Reviews

- Making our code understandable

Functions

- Separating code for reuse

Arrays

- Collections of identical variables

What are we covering today?

Functions and Libraries

- A recap of functions
- Using functions from other files

Arrays and 2D Arrays

- A recap of arrays
- Arrays inside arrays!

Recap of Functions

Code outside of our main that we can use (and reuse)

- Has a name that we use to call it
- Has an output type and input parameters
- Has a body of code that runs when it is called
- Uses return to exit and give back its output

Functions in Code

```c
// a function declaration
int add (int a, int b);

int main (void) {
    int firstNumber = 4;
    int secondNumber = 6;
    // use the function here
    int total = add(firstNumber, secondNumber);
    return 0;
}

// the function is defined here
int add (int a, int b) {
    return a + b;
}
```

Why use functions?

Why do we separate code into functions?

Saves us from repeating code

- Instead of replicating code, we can write it once
- This also makes the code much easier to modify

Easier to organise code

- Complex functionality can be hidden inside a function
- The flow of the program can be read easily with clear function names

C Libraries

We've already used `stdio.h` several times

- C has other standard libraries that we can make use of
- The simple C reference in the Weekly Tests has some information
- **`math.h`** is a useful library of common maths functions
- **`stdlib.h`** has some useful functions
- Look through the references (including **`man`** manuals in linux)
- Don't worry if you don't understand the functions yet, some of them have no context in the programming we've done so far

Using Libraries

```
// include some libraries
#include <math.h>
#include <stdlib.h>
#include <stdio.h>

int main (void) {
    int firstNumber = -4;
    int secondNumber = 6;

    // change a number to its absolute value
    firstNumber = abs(firstNumber);

    // calculate a square root
    int squareRoot = sqrt(firstnumber);
    printf("The final number is: %d", squareRoot);
    return 0;
}
```

Libraries

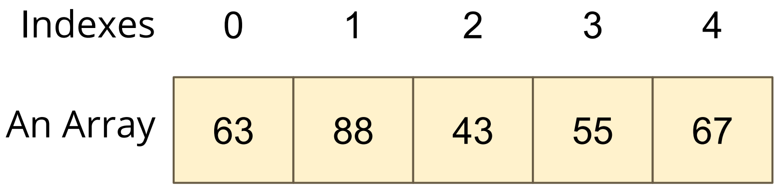
More complexity means more use of functions

- We've already seen **`printf()`** and **`scanf()`**
- We'll be using libraries with memory management
- And in other upcoming topics . . .

Recap of Arrays

A collection of variables

- Contains multiple variables all of the same type
- Declared using a variable type and a size
- Individual variables are accessed using an index



Using Arrays in C

Some example code of an array

```
int main (void) {
    // declare an array of doubles, size 4, initially all 0
    double myArray[4] = {0};

    // assign a value
    myArray[1] = 0.95;
    // test a value
    if (myArray[2] < 1) {
        // print out a value
        printf("Third element is: %lf", myArray[2]);
    }
```

Accessing multiple values at once

Loops and Arrays go together perfectly

- Accessing all members is a reasonably simple while loop

```
int main (void) {
    // declare an array of doubles, size 4, initially all 0
    double myArray[4] = {0};

    // loop through the array and output the elements
    int i = 0;
    while (i < 4) {
        printf("%lf\n", myArray[i]);
        i++;
    }
```

Creating Arrays with certain sizes

Arrays start at an exact size and don’t change

- When we create an array, we give it a size and a type
- Both of those are fixed and won’t change

```
int main (void) {
    // declare an array of doubles,
    // size 4
    double myArray[4] = {0};

}
```

```
int main (void) {
    // This declaration is not
    // possible!
    int arraySize = 4;
    double myArray[arraySize] = {0};

}
```

We can’t declare an array with a variable size like this!

Using Constants for Array Sizes

If we do want to be able to change the size in code . . .

- We can use a constant to set the size
- Unlike a variable, this cannot change after it is compiled
- It does make our lives much easier if we need a change mid-project

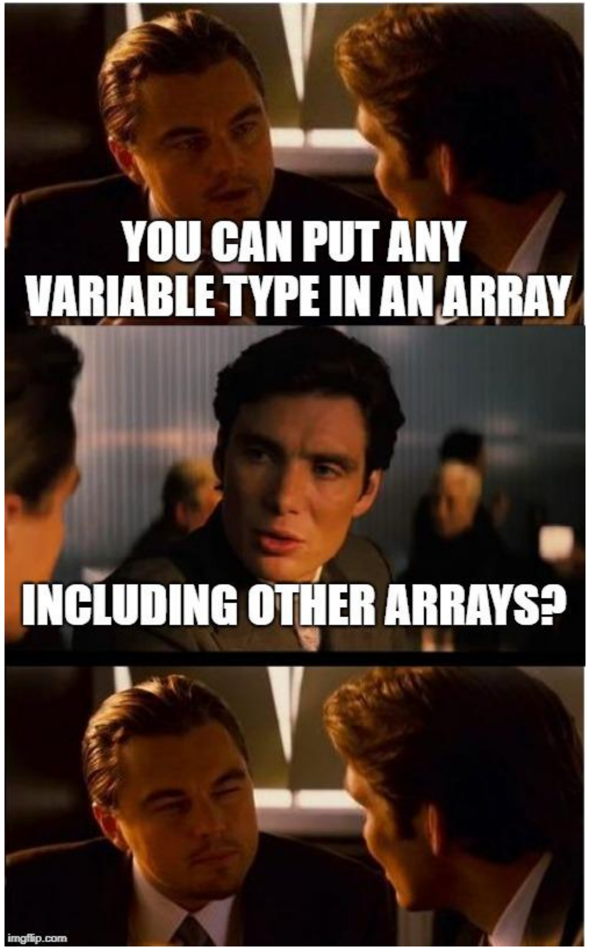
```c
#define ARRAY_SIZE 4

int main (void) {
    // This declaration allows us to change the
    // array size while coding
    double myArray[ARRAY_SIZE] = {0};
}
```

Arrays inside Arrays

An Array is a type of variable

An Array can contain any type of variable

- Arrays can be put inside other arrays!
- We call these multi-dimensional arrays
- Think of them as a grid, two or more dimensions



Two Dimensional Arrays

Arrays inside arrays

- Can be thought of like a grid
- The outer array contains arrays
- Each array is a row of the grid
- Addressed using a pair of integers like coordinates
- All inner arrays are of the same type

Indexes	0	1	2	3	4
0	63	88	43	55	67
1	54	52	91	21	32
2	77	58	1	61	79

A 2D Array

Two Dimensional Arrays in Code

```
int main (void) {
    // declare a 2D Array
    int grid[4][4] = {0};

    // assign a value
    grid[1][3] = 3;
    // test a value
    if (grid[2][0] < 1) {
        // print out a value
        printf("The bottom left square is: %d", grid[3][0]);
    }
```

Break Time

Let’s take five minutes break

- We're building up to much harder (and maybe frustrating) problems
- Remember that most hard problems are made up of smaller, easier problems
- Look for ways to break things down into parts that you can manage with the coding skills you've learnt!

Problems by Parallel Studio

Let’s work with 2D Arrays

I would like to make a simple game called “The Tourist”

- The world is a square grid
- The tourist can move up, down, left or right
- Be able to print out the world, including the location of the tourist
- The tourist likes seeing new things . . .
- Track where they've been
- And lose the game if we revisit somewhere we've been

Starter Code

Working with code that's already got some functionality

- We're going to start with some code called tourist.c
- This file already has the ability to print a 2D array
- It's a bit similar to using starting code in the Assignment

Print Map

Here's a handy function that we'll be reusing

```
void printMap(int map[N_ROWS][N_COLS], int posR, int posC) {
    int row = 0;
    while (row < N_ROWS) {
        int col = 0;
        while (col < N_COLS) {
            if (posR == row && posC == col) {
                printf("T ");
            } else {
                printf("%d ", map[row][col]);
            }
            col++;
        }
        row++;
        printf("\n");
    }
}
```

Break the problem down into parts

What do we need to do?

- We need to set up our grid and the tourist's position
- The tourist needs to move one step at a time
- Each time the tourist visits a location, we set it to 1
- We also check each location to make sure it's new

The Square Grid World

Variables for the grid and the tourist's position

```c
#include <stdio.h>

// The dimensions of the map
#define N_ROWS 10
#define N_COLS 10

int main (void) {
    int map[N_ROWS][N_COLS] = {0};
    int posR = 0, posC = 0;

```

Controlling the Tourist

Next Steps

- Let’s add movement
- Then track where the Tourist has been, using the map
- After that, we'll check for places we've already been

Looping

- We can loop repeatedly for “turns” to allow the user to input directions

Movement - this code will loop

```c
printf("Please enter a numpad direction or 0 to exit: ");
int input;
scanf("%d", &input);
if (input == 4) {
    posC--;
} else if (input == 8) {
    posR--;
} else if (input == 6) {
    posC++;
} else if (input == 2) {
    posR++;
} else if (input == 0) {
    exit = 1;
} else {
    printf("Input is not a numpad direction, please use 2,4,6 or 8\n");
}
```

Tracking the Tourist using the Map

Set each location we visit to 1

```
// loop and let the user control the Tourist's movement
int exit = 0;
while (!exit) {
    // mark the location as having been visited by incrementing
    map[posR][posC] = 1;

    // show the current status
    printMap(grid, posR, posC);

    printf("Please enter a numpad direction or 0 to exit: ");

    // Movement code from previous slide goes here . . .
```

Have we been here before?

We want the game to end if the tourist revisits a location

- If the location we visit is already 1
- Then we're going to exit the game
- We can add this check after our movement

```
// Check if we've been here before
if (map[posR][posC] == 1) {
    printf("We've already been here! How boring!\n");
    exit = 1;
}
```

1 isn't as helpful as "EXPLORED"

Let's swap out the number for a more readable #define

```
#include <stdio.h>

// The dimensions of the map
#define N_ROWS 10
#define N_COLS 10

// Has the square been explored before?
#define UNEXPLORED 0
#define EXPLORED 1
```

The Tourist Game

This is now roughly complete

- We can move the tourist
- We can track where we’ve been
- We can display where we've been as well as current location
- We can exit if we revisit a location

But how safe is it?

- Try different inputs
- Try moving around a bit

What happens if…

Moving around and seeing what works

- Use the controls to move around the map
- Try entering some integers that aren’t the movement

What issues do we find?

Walking off the edge of the map

Our Tourist can walk outside of the bounds of our arrays!

Let's add some code to check if we're outside the map and stop that movement

```
    // Check if we've walked off the map
    if (posR < 0) {
        posR = 0;
    } else if (posR >= N_ROWS) {
        posR = N_ROWS - 1;
    }
    if (posC < 0) {
        posC = 0;
    } else if (posC >= N_COLS) {
        posC = N_COLS - 1;
    }
```

Where else can we take this code?

What about scoring?

- Could we give the player a score based on the number of places they visited?
- How would we calculate that?
- Also . . .
- Some of this code might be useful in understanding the first assignment

What did we learn today?

Functions and Libraries

- We can use functions that we didn't write ourselves
- We can include libraries that have many functions that can help us

Multi-Dimensional Arrays

- We can work with arrays in arrays to make things like grids