ENGG1003 - Friday Week 5

Arrays and Functions: Together at Last!

Does anyone even read the title page?

Also: Maybe Strings & ASCII Codes

Brenton Schulz

University of Newcastle

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The Story So Far

- Course summary:
  - Flow control
    - `if()`
    - `while()`
    - `for()`
    - `switch()`
  - Variables and data types
  - Functions
  - Arrays
- Today: Arrays and functions together
  - Subtext: Pointers
- Today (maybe): Strings
- Tuesday: File input-output (I/O)

Programming Assignment And Quiz

- The programming assignment will use everything from the previous slide
- The quiz can include everything up to, and including, the Week 5 Tuesday lecture
  - Held in Friday 9-10am lecture
    - 40 mins: 9:10am - 9:50m
  - It will be hand written
    - Yes, *real paper*
  - Mix of:
    - Multiple choice
    - Code reading & analysis
    - Short code writing (1-3 lines)
  - You will **not** be asked to write out a whole program by hand

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  - Pass an array element, eg:

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2 // ...
3 int array[12];
4 // ...
5 function(array[6]);
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  - Pass an array element, eg:

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2 // ...
3 int array[12];
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```

  - Give a function a *pointer* to an array
    - Ok, lets break this one down a bit...

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  - Passing a whole array *copies* everything
  - This is a bad idea so C doesn't support it
  - (Advanced) Arguments are put to the *stack*
    - Google stack Vs heap memory allocation for more information. This is beyond ENGG1003.

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- Instead, C passes a *pointer*
  - This is the *memory address* of the array's start
  - In C, `name` is equivalent to `&name[0]`

Arrays in Memory

- Review: When we declare an array, eg,

```
1 int x[20];
```

  the compiler allocates 20*sizeof(int) = 80 bytes to store it
- The *memory address* of `x[0]` is some seemingly random number, `p`
- `p` is a *byte* address
- Other elements are stored in sequential memory addresses:
  - The address of `x[1]` is `p + 4`
  - The address of `x[i]` is `p + i*4`

Arrays in Memory

- Therefore, to access a given element, `i`, of an array all we need is:
  - A pointer, `p` to the first element
  - Knowledge of the arrays *data type*
    - Specifically, the type's *size*
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- Key syntax element: the `*` character

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- Key syntax element: the `*` character
- Inside the function use `var[i]` syntax

Key Points

- Because arrays are passed via a pointer the function gets *the actual array*
- Modifying the array in the function modifies the original variable
- You don't *need* a return value
  - In a technically incorrect way: all the array's elements are "returned"

Example

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- Write a function which zeros the first N elements of an array of `ints`
  - Function prototype:
    - `void zero(int *x, int N);`
  - The value of `N` is needed because C won't tell you how long an array is *within the context of the function*
    - (Advanced) `sizeof(x)` will just be the size of the pointer - 4, or 8 bytes

Example

- Function definition:

```
1 // Zeros first N elements of x
2 void zero(int *x, int N) {
3   int i; // Array index loop counter
4   for(i = 0; i < N; i++)
5     x[i] = 0; // Use array syntax
6   return; // Optional
7 }
```

Other Examples

- Lets write and test these live...
- Write a function which:
  - Returns the sum of an array of length N
  - Returns the maximum value in an array of length N
  - Fills an array with integers between two given numbers `min` and `max`
    - Prototype:

```
void countArray(int *x,
                int min, int max);
```

    - eg: countArray(x, 10, 15) sets:

```
x[] = {10, 11, 12, 13, 14, 15}
```

Strings

- A *string* is the "data type" which stores human-readable text
- C does not have a `string` data type
  - Most newer languages do
- In C, strings are stored in arrays of type `char`
  - Their "length" is defined by a terminating zero
  - Terminating means it goes after the last character

String Syntax

- Since C strings are arrays of type `char` they are declared with normal array syntax:

```
1 char name[200];
```

- The "size" of a string is known as the *length*
- Strings get terminated with a 0
  - Ok, technically NULL but its just a zero in memory
  - Often NULL is written `\0`
- The length is the number of bytes from (and including) the "start" pointer and the `\0`

Strings in Memory

- Each character is a single byte
- The terminating NULL is also a single byte
  - Be aware of this when declaring array sizes
- Everything beyond the NULL is "garbage"
  - Doesn't matter what the array size is
- The string "hello" would be stored as:

(Addresses are made up numbers)

Address:	10	11	12	13	14	15	16	17
Data:	??	h	e	l	l	o	\0	??

Using Strings

- String initialisation uses the syntax:

```
1 char str[6] = {'h', 'e', 'l', 'l', 'o', '\0'};
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- Terrible, isn't it?
- If the string is *constant* you can do this:

```
1 char str[] = "This is a constant string.";
```

  - Attempting to modify `str[]` will cause a crash
  - The compiler automatically inserts the `\0`
  - (Advanced) Strings between " and " are stored in the "program memory" and can't be modified for security reasons

Constants

- Aside: any variable which must not be modified can be declared `const`:

```
1 const char str[] = "This is a help message.";
```

- The `const` keyword causes a compiler error, instead of a segmentation fault, if you try to modify the variable
- You can do this to any data type, eg:

```
1 const float pi = 3.14159;
```

String Format Specifiers

- To `printf()` or `scanf()` a string use the `%s` format specifier
- Eg:

```c
#include <stdio.h>
main() {
  char str[] = "Hello world!";

  // NB: Passing array pointer to function
  // just uses the array name as argument
  printf("%s\n", str);
}
```

ASCII Codes

- In C, letters stored in `char`'s are typed: `'a'`
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- But what is *actually* stored? Doesn't `char` just store a number from -128 to +127?
- Yes! The ASCII standard converts "letters" to numbers

ASCII Codes

- The ASCII standard allocates a number to all letters, numbers, punctuation characters, and several "control" character
- ASCII is used almost everywhere
  - The unicode standard UTF-8 is a superset of ASCII
- Lets check one out here
- Knowledge of ASCII and `char` processing in C is necessary for programming assignment 1

Char Variables

- There are two ways to interpret a `char` variable:
  - As a text character
  - As a number
- The `%c` format specifier tells `printf()` and `scanf()` to convert between ASCII characters and numbers
- Eg, this will read a character from `stdin` and store its ASCII value in `c`:

```
1 char c;
2 scanf("%c", &c)
```

Char Variables

- What happens if you enter the number `5`?

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- It will store the number 53, as that is the ASCII code for '5'

ASCII Letters

- The project requires you to process text and identify letters
- The following table shows the numerical values which letters can occupy under the ASCII standard:

A	65	a	97
B	66	b	98
C	67	c	100
...		...	
Y	89	y	121
Z	90	z	122

Char Variables

- The numerical value of a character can be printed with `%d` and a cast:

```
1 char c;
2 printf("%d", (int)c);
```

- Characters can be used in *arithmetic* without a problem, eg:

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1 char c;
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- You use this in the project