Introduction to Computing

MCS1101B

Lecture 5

Array

- Many applications require multiple data items that have common characteristics

  In mathematics, we often express such groups of data items in indexed form:

  - $x_1, x_2, x_3, \ldots, x_n$

- **Array** is a *data structure* which represents a ***collection of data items*** of the ***same datatype*** *(e.g. float/int/char/…)*

Example:

```
int A[5], i;

for (i = 0; i < 5; ++i)
        scanf("%d", &A[i]);

for (i = 0; i < 5; ++i)
        printf("%d", &A[i]);
```

Array(contd.)

- Declaration
  - <type> **<name>**[<no_of_elements>]
  - int a[100];
  - Float b[20];
- Initialization
  - int a[5] = {2,4,5,2,6};
  - int b[4] = {1,3,5}
- Accessing an element of array
  - a[2] →5
  - b[0] →1
  - b[3] → ?
  - a[5] →?

- Assignment of value later on in the program
  - It is same as a normal variable
  - b[3] = 3.14;
  - a[2] = 1000;
- A single variable has a name
- An array variable has a **<name>**
  - It's a collection of single variables
  - Variables are accessed using <index>
  - Therefore, <name>[<index>] is a specific variable in an array

Array (contd.)

Array declaration syntax:
<type> <name>[<size>];
e.g. int arr[8];

Size of array

Access elements using index
arr[0], arr[1], … arr[7]
Size of array == number of elements
(size=n) implies that the indexes are
from 0 to n-1

Name of array

&arr[0]

arr[3]

&arr[3]

Data assignment examples:
arr[5] = 7;
scanf("%d", &arr[3]);

Integer array	10	20	35	47	3	7	-10	100
index	0	1	2	3	4	5	6	7
Memory address	1002	100A	1012	101A	1022	102A	1032	103A
	1002	1010	1018	1026	1034	1042	1050	1058

Hexadecimal

Decimal equivalent

Array – examples to try

- Print all elements of an array
- Scan elements into an array
- Copy elements of on array into another
- Sum of all elements in an array
- Multiply all elements in an array
- Find Min/Max element in an array
- Search for an element in an array
- Sum two equal-sized arrays element-wise, and store the results in another array

- Find minimum of a set of 10 numbers

- Write the code in a way so that the code works for a set of any given number (i.e. not only 10)

Array (contd.)

Write the code in a way so that the code works for a set of any given number (i.e. not only 10)

- Recall **const** qualifier
  - ```
    const int size = 10;
    int A[size], i;
    for (i = 0; i < size ; ++i)
        scanf("%d", &A[i]);
    ```
- Another way …
  - #define SIZE 10
  - This is called a preprocessor/macro -- *we will learn about preprocessors later in the course*
    ```

Searching for an Element (key) in an Array

- You have an array filled with integer elements
  - Can be hard coded
  - Can be user input
  - Can be read from file *<we will see how later how>*
- You take an integer (*key*) user input from user
- Search through the array to check if the *key* exists in the array
  - Go through the array one element at a time in using a loop
  - Check is the element matches the *key* or not
- Print appropriate message to show the result of the exercise
- This is called a *linear search*

Functions (recall)

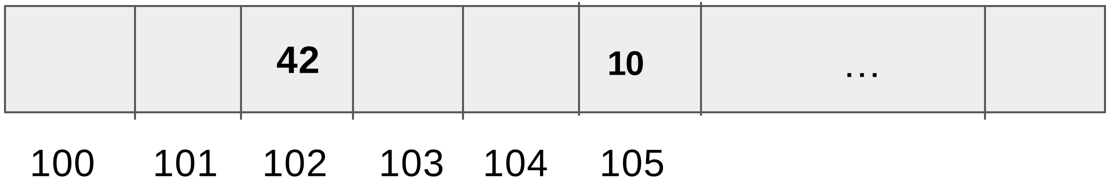
Passing of variables

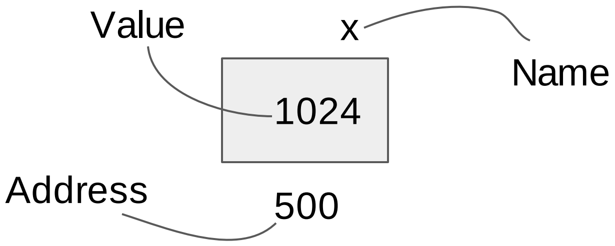
- Variables values are copied when then are passed (by calling) to a function
- The actual variables are not passed
- So a change made to a variable within a function will not reflect in the variable at the end of the caller *– recall the swap function*

- But scanf, which is also a function, *is able to change the values of a local variable – How does it do it?*
- Recall the AddressOf (&) operator
  - scanf (“%d”, **&a**);
  - it sends (copies) the memory address of a variable
  - scanf makes change in that memory location
  - thereby changing the value of the variable

Pointers

- Each memory cell (byte) has an unique address
- Each memory cell can hold a value
- Contiguous memory cells have sequential addresses





Pointers

- Pointers are a **special variables** that can **store memory addresses**
- ***Declaration*** of a pointer variable
  - <type> *****<name>;
  - Variable value (*memory address*) can be accessed using <name>
- ***Access*** the value at the stored address
  - *****<name>
  - It will treat the value at the stored location as the declared <type>

Examples:

```
//actual variables
int a; float b; char c;
//pointer variables
int *iptr;    float *fptr;    char *cptr;

a = 10; //set value of a as 10
iptr = &a;   //address of variable a

printf("%p", iptr); // will print address of a
printf("%d", *iptr); // will print value of a
```

Pointers (contd.)

```
int a=10;  // a is an integer variable, initialized with value 10
int *ptr;    // ptr is an integer pointer variable, uninitialized
printf ("%d", a);       ⇒ 10
printf ("%p", ptr);     ⇒ <some garbage value as an memory address>
printf ("%p", &a);      ⇒ memory address of the variable a
printf ("%p", &ptr);    ⇒ memory address of the variable ptr
ptr = &a;               //stores the address of a on ptr
printf ("%p", ptr);     ⇒ value of ptr / address of the variable a
printf ("%d", *ptr);    ⇒ access data as integer at the location stored in ptr
printf ("%p", &ptr);    ⇒ the address of the variable ptr; remains the same
```

Pointer types: Size

- *It depends on the maximum possible number value for address in a machine*
- A 64-bit processor allows the machine to have 64 bit address - so it needs 8 bytes to store that address
    - sizeof (int) ⇒ 4, sizeof (int*) ⇒ 8
    - sizeof (char) ⇒ 1, sizeof (char*) ⇒ 8
    - sizeof (double) ⇒ 8, sizeof (double*) ⇒ 8
    - sizeof (long double) ⇒ 16, sizeof (long double*) ⇒ ?

You can check using

printf("%ld %ld", sizeof (long double), sizeof (long double))*

Pointer Arithmetic

```
int a;                //consider sizeof int as 8
int *ptr = &a;
```

pointer + integer

ptr + 1 will be translated as value stored in ptr + sizeof int
ptr + 2 will be translated as value stored in ptr + 2 * sizeof int
i.e., ptr+i will be translated as value stored in ptr + (i * sizeof int)

Similarly for char *cptr; cptr+i will yield value stored in cptr + (i * sizeof char),
for double *dptr; dptr+i will yield value stored in dptr + (i * sizeof double), etc.

<type>* ptr + <int_val> is equivalent to **ptr + <int_val> * sizeof(<type>)**

Array and Pointers

- Array elements are accessed using indexes
    - int arr[10];
        - Allocates a memory block equal to the size of 10 integers in total
        - Elements accessed as arr[0], arr[1], etc.
    - The **arr** is the address of the entire memory block; it is of type int* (read as *integer pointer*)
    - Therefore It can also be accessed similar to pointers variables
    - So *arr is arr[0]
        - How do you access the rest? → you can use pointer arithmetic

Array and Pointers (contd.)

- *Adding 1 to a pointer variable means increasing the value of the pointer by the size of the type of that pointer*
- *Adding 1 to an int* variable means adding sizeof(int) to the value of the variable*

So,

arr[1] == *(arr + 1), arr[2] == *(arr + 2), ...

i.e., arr[i] = *(arr + i)

Also,

arr + i = &arr[i]

Functions and Pointers

- Since variables passed to the functions are basically a copy
- Pointers to the variables are used instead of a variable to pass the **reference** to a variable - only when required
    - Addresses of the variable is copied
    - Changes made by function are done to the memory address
    - So when function exits, it only forgets the memory location and not the changes made ot that location

So, Let's recall Swap

```
void swap (int a, int b)
{
        int tmp;
        tmp = a;
        a = b;
        b = tmp;
}
```

```
void swap (int *a, int *b)
{
        int tmp;
        tmp = *a;
        *a = *b;
        *b = tmp;
}
```

Functions and Arrays

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```
void swap (int *a, int *b)
{
        int tmp;
        tmp = *a;
        *a = *b;
        *b = tmp;
}
```

Functions Calling Functions

- int f1() {...}
- int f2()

  {...

  f1();

  ...}
- int f3() {... f2(); ...}

- int f4() {... f3(); ...}
- int f5() {... f2(); ...}

- int f6() {... f7(); ...}
- int f7() {... f6(); ...}

- int f8() {... f8(); ...}

- These are basically never ending calls to one another

  →can this happen?

Recursion

- A function calling itself
  - Directly call made to self
  - Indirectly call made to self via another function
  - Indirectly call made to self via a sequence of function calls
- This is known as recursion
  - Both in mathematics and in programming

- Example (math)
  - $f(n) = n*f(n-1),\ f(0)=1$
  - $f(n) = f(n-1) + f(n-2),\ f(0)=0,\ f(1)=1$

    $\rightarrow$ what function is this?
  - $f(x) = x * g(x),\ g(x) = 2 + f(x-1)$

    $\Rightarrow f(x) = 2 * x + 2 * f(x-1)$

Recursion (contd.)

- Requires careful coding
- Needs to make sure that your program terminates
- You need to first define the base cases (exit condition) for your function
- Then you write the logic of the rest of the function
- For breaking the call sequence of a recursive function
  - a **return** statement is generally used with some if condition
  - You can also use if-else
- Exercise:
  - Implement the factorial function using recursion
  - Implement the gcd function using recursion

In The Next Class…

- You will learn about structures
- You will learn about files