CMSC 106
Lecture Set #10

Set Started:

Tuesday, October 30, 2007

Data Structures

- Holds a collection of data
- several individual variables
  - each stores its own value
  - each is independent of the other
  - but the group can be allocated as a whole
- Many Data Structures
  - arrays, stacks, queues
  - structures
  - linked list, tree, hash table, graph, …
- Classifications
  - Homogeneous data structure vs Heterogeneous data structure
  - Statically sized or Dynamically sized
  - Single Unit or Linked Data Structures

Array Indexing

- C provides a special syntax for accessing cells in an array
  - Allocation of space for array named a:

    ```
    int a[5];
    ```

    - This creates five `int` variables "named"::`a[0],a[1],a[2],a[3],a[4]`
  - To modify contents of cell #2 to 6 and cell #1 to 74:

    ```
    a[2] = 6;
    a[1] = 74;
    ```

  - To use the contents of cell #2 and cell #1 :

    ```
    printf("value = %d\n",(a[1]-a[2]));
    ```

- This access mechanism to the individual elements is called array indexing
  - In Java / C / C++, array cells are indexed beginning at 0 and going up to n-1 (n is number of cells)
  - Beware: start at 0! and end at one less than the size!!

Square Brackets: [ ] and specifying the length

- Two independent uses in C:
  - Array object creation

    ```
    int a[10];
    ```

  - Array indexing

    ```
    a[0]
    ```

- Nothing in the array or about the array to indicate size of the array after it is created
- Often we use a symbolic constant to specify the size of the array

```
#define SIZE 10
int main(){
    int a[SIZE];
```

Summary of Arrays

- Arrays are:
  - Sequences of cells holding values of the same type ("base type")
  - All arrays are declared and access based on that base type – all arrays are of a type
- To define an array variable:

```
int a[SIZE];  //an array with base type int
  assuming SIZE was previously #defined as 10
```

- To access individual array cells: use indexing
  - `a[0], a[1], …, a[9]`
  - Cells are just like variables:
    - They may be read: `x = a[3];`
    - They may be written: `a[2] = 7;`

A Common Programming Idiom

- To process all elements in array a…
- Do following:

```
int j = 0;
for (j = 0; j < SIZE; j++){
  …process the one element at a[j]…
}
```

- Remember:
  - The lowest index is always 0
  - So use `i < SIZE`, not `i <= SIZE`

Examples

- filling an integer array using scanf
- counting elements in a character array
- adding and averaging values in a floating point array

Array Initializers

- Use curly braces and commas to list elements the array contains at startup:

```
#define SIZE 10
int main(){
    int arr1[5] = {3,2,1,8,4};
    char arr2[3] = {'J','a','n'};
    float arr3[4] = {2.4,3.6,1,5};
```

- If there are too many values given, compilation error is given.
- If there are too few values given, the array elements for which no value is given are assigned 0.
- If no array size is specified, it will assume you meant the exact number of the number of initializing values.

Passing Arrays as arguments

- The name of an array is a reference to (address of) the space where the array is stored
  - the [] dereference that address and add the offset determined by the value inside the brackets
  - an array argument is always a copy of that address
  - so when you modify the array argument, you do modify the original array
- An array contains elements of a base type
- The element of the array is treated like that base type if passed

Parallel Arrays

- Multiple arrays used to store related data

```
int id[MAXSIZE];
float score[MAXSIZE];
char grade[MAXSIZE];
```

- index determines which person's information : student with id 91 has an 82.22 average which is calculated to be a B

63	67.32	D
94	92.14	A
12	87.54	B
91	82.22	B
14	74.13	C
99	58.40	F
42	80.11	B

2-Dimensional Arrays

- Declared with two dimensions of size
  - rows and columns
  - two pair of square brackets
- Indexed with two individual indexes

```
#define ROWMAX 5
#define COLMAX 6
int main(){
    int matrix[ROWMAX][COLMAX];
    …
    for (row = 0; row < ROWMAX; row++)
        for (col = 0; col < COLMAX; col++)
            matrix[row][col] = row * col;
    …
}
```

Array Initializers

- Two methods
  - indicating rows and columns
  - as one list of values
- like single dimensional arrays – unitialized values set to 0 when an initializer is used

n-Dimensional Arrays

- Three or more dimensions

```
#define SIZE1 5
#define SIZE2 3
#define SIZE3 4
…
int arr[SIZE1][SIZE2][SIZE3];
for (row = 0; row < SIZE1; row++){
    for (col = 0; col < SIZE2; col++){
        for (depth = 0; depth < SIZE3; depth++){
            printf("%.2f  ",arr[row][col][depth]);
        }
        printf("\n");
    }
   printf("-----------------------------------\n");
}
```

Passing to Functions

- In the Parameter List
  - For a single dimensional array – the size does not need to be indicated in the parameter list.
  - For a multi dimensional array – only the first dimension of size can be omitted in the parameter list.
- In the Argument List
  - For the argument when passing a whole array – no indices are given at all.
  - For the argument when passing a single element – all indices need to be indicated (in the correct range).
- Can not be used as the return type of a function.

In class Example

- Fill a SIZExSIZE matrix
- Print a SIZExSIZE matrix
- multiply two SIZExSIZE matricies
- in both orders to show that it isn't commutative