Introduction to the C programming language

Lecture 2

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Outline

do while loop

- An alternative way to write a loop is to use the **`do - while`** loop

```
    do {
        statement1;
        statement2;
        ...
    } while(condition);
```

- The main difference between the **`while`** and the **`do - while`** is that
  - in the **`while`** loop the condition is evaluated before every iteration,
  - in the **`do - while`** case the condition is evaluated after every iteration
- Hence, with **`do - while`** the loop is always performed at least once

Nested loops

- It is possible to define a loop inside another loop. This is very useful in many cases in which we have to iterate on two variables
- What does the following program do?

loops/dloop.c

```
#include <stdio.h>
#include <math.h>

int main()
{
    int i, j;

    printf("%d\n", 2);

    for (i = 3; i <= 100; i = i + 1) {
        for (j = 2; j < i; j = j + 1) {
            if (i % j == 0) break;

            if (j > sqrt(i)) {
                printf("%d\n", i);
                break;
            }
        }
    }
    return 0;
}
```

Exercises

1. Write the equivalence between **`while`** and **`do - while`**
2. Write the equivalence between **`for`** and **`do - while`**
3. Write a program that, given two numbers, finds all common factors between them
   - Example 1: 12 and 15, will output 3
   - Example 2: 24 and 12, will output 2, 3, 4, 6

Reading C programs

- It is very important to be able to learn how to read C programs written by someone else
  - Please, take your time to read programs!
  - You must look at a program as you were the processor: try to “execute a program” on paper, writing down the values of the variables at every step
  - Also, please try to write “clean” programs!
    - so that other programs will find easy to read your own programs

switch - case

- Sometimes, we have to check several alternatives on the same value; instead of a sequence of if-then-else, we can use a *switch case* statement:

loops/switch.c

```
int main()
{
    int number;

    printf("Enter a number: ");
    scanf("%d", &number);
    switch(number) {
    case 0 :
        printf("None\n");
        break;
    case 1 :
        printf("One\n");
        break;
    case 2 :
        printf("Two\n");
        break;
    case 3 :
    case 4 :
    case 5 :
        printf("Several\n");
        break;
    default :
        printf("Many\n");
        break;
    }
}
```

Arrays

- Instead of single variables, we can declare arrays of variables of the same type
- They have all the same type and the same name
- They can be addressed by using an index

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

        a[0] = 10;
        a[1] = 20;
        i = 5;
        a[i] = a[i-1] + a[i+1];
```

- **Very important:** If the array has N elements, index starts at 0, and last element is at N-1
- In the above example, last valid element is `a[9]`

Example

arrays/dice.c

```c
#include <stdio.h>
#include <stdlib.h>

/* Counts the frequency of occurrence of a number when rolling two dices */
int main()
{
    int i;
    int d1, d2;
    int a[13];  /* uses [2..12] */

    for (i = 2; i <= 12; i = i + 1) a[i] = 0;

    for (i = 0; i < 100; i = i + 1) {
        d1 = rand() % 6 + 1;
        d2 = rand() % 6 + 1;
        a[d1 + d2] = a[d1 + d2] + 1;
    }

    for(i = 2; i <= 12; i = i + 1)
        printf("%d: %d\n", i, a[i]);

    return 0;
}
```

Quick exercise

- You have no more than 5 minutes to complete this exercise!
- Modify the previous program, so that the user can specify the number of times the two dices will be rolled
- Check that the user do not inserts a negative number in which case you print out an error and exit

Index range

- What happens if you specify an index outside the array boundaries?
- The compiler does not complain, but you can get a random run-time error!
- Consider the following program: what will happen?

arrays/outbound.c

```
#include <stdio.h>

int main()
{
    int i;
    int a[10];

    for (i=0; i<15; i++) {
        a[i] = 0;
        printf("a[%d] = %d\n", i, a[i]);
    }

    printf("Initialization completed!\n");
}
```

Questions

- Index out of bounds is a programming error
  1. Why the compiler does not complain?
  2. Why the program does not complain at run-time?
- What is the memory allocation of the program? Where is the array allocated?

Initialization

- Arrays can be initialized with the following syntax

```
        int a[4] = {0, 1, 2, 3};
```

- This syntax is only for static initialization, and cannot be used for assignment

```
        int a[4];

        a = {0, 1, 2, 3};  // syntax error!
```

Matrix

- Two-dimensional arrays (matrixes) can be defined as follows

```
        double mat[3][3];

        mat[0][2] = 3.5;
```

- It is also possible to define more than 2 dimensions:

```
        int cube[4][4][4];
```

- Initialization as follows: arrays/matrix.c

```
#include <stdio.h>

int main()
{
    int i;
    double mat[3][3] = {
        {0, 0, 0},
        {0, 0, 0},
        {0, 0, 0}
    };

    mat[0][2] = 3.5;

    //initialize the whole matrix using single vector indeces
    for (i=0; i<9; i++) {
        mat[i/3][i%3] = 2.0;
    }
    printf("Done\n");
}
```

Exercises

1. Given 2 arrays of doubles of length 3 that represents vector in a 3-dimensional space, compute the scalar product and the vectorial product
2. Given an array of 30 integers, compute max, min and average

Strings

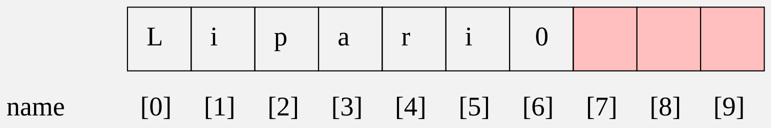
- There is not a specific type for strings in C
- A string is a sequence of char terminated by value 0
- To store strings, it is possible to use arrays of chars

```
      char name[20];
```

- Initialization:

```
      char name[20] = "Lipari";
```

  - But again, this syntax is not valid for assignments!
- In memory:



String length

- *IMPORTANT*: if you need a string with 10 characters, you must desclare an array of 11 characters! (one extra to store the final 0)
- Computing string length

```
char s[20];
...
// how many valid characters in s?
int i;
for (i=0; i<20; i++) if (s[i] == 0) break;

if (i<20) printf("String is %d characters long\n", i);
else printf("String is not valid!\n");
```

- What is in a string? strings/contents.c

```
#include <stdio.h>

int main()
{
    int i;
    char str[20] = "donald duck";

    for (i=0; i<20; i++)
        printf("%d ", str[i]);
    printf("\n");
}
```

String manipulation functions

int strcpy(char s1[, char s2[]);] copies string s2 into string s1

int strcmp(char s1[, char s2[]);] compare strings alphabetically

int strcat(char s1[, char s2[]);] append s2 to s1

int strlen(char s[ );] computes string length

printf(“%s”, str); prints string on screen

Safe versions

- Previous functions are not safe: if the string is not well terminated, anything can happen
- There are safe versions of each:

  int strncpy(char s1[, char s2[], int n);] copies at most n characters

  int strncat(char s1[, char s2[], int n);] appends at most n characters

  int strncmp(char s1[, char s2[], int n);] compares at most n characters

Function definition and declaration

- A function is defined by:
  - a unique name
  - a return value
  - a list of arguments (also called parameters)
  - a body enclosed in curly braces

```
/* returns the power of x to y */
double power(double x, int y)
{
    int i;
    double result = 1;

    for (i=0; i < y; i++)
        result = result * x;

    return result;
}
```

Function call

functions/power.c

```
int main()
{
    double myx;
    int myy;
    double res;

    printf("Enter x and y\n");
    printf("x? ");
    scanf("%lg", &myx);
    printf("y? ");
    scanf("%d", &myy);

    res = power(myx, myy);

    printf("x^y = %lgt\n", res);
}
```

Parameters

- Modifications on local parameters have no effect on the caller

```
int multbytwo(int x)
{
    x = x * 2;
    return x;
}

int main()
{
    ...
    i = 5;
    res = multbytwo(i);
    /* how much is i here? */
    ...
}
```

- x is just a *copy* of i
- modifying x modifies the copy not the original value

Array parameters

- We say that parameters are passed *by value*
  - every time we call the function, a copy is made
- There is only one exception to this rule: when we pass arrays!
  - The array is not copied, so modification to the local parameter are immediately reflected to the original variable

Array parameters

functions/swap.c

```
#include <stdio.h>

void swap (int a[])
{
    int tmp;
    tmp = a[0];
    a[0] = a[1];
    a[1] = tmp;
    return;
}

int main()
{
     int my[2] = {1,5}
     printf ("before swap: %d %d",
        my[0], my[1]);

     swap(my);

     printf ("after swap: %d %d",
        my[0], my[1]);
}
```

- The array is not copied
- modification on array a are reflected in modification on array my
  - (this can be understood better when we study pointers)
- Notice also:
  - the swap function does not need to return anything: so the return type is void
  - the array my is initialized when it is declared

Exercises

1. Write a function that, given a string, returns it’s length
2. Write a function that, given two strings s1 and s2, returns 1 if s2 is contained in s1
3. Write a function that given a string, substitutes all lower case characters to upper case