Informatica e Sistemi in tempo Reale

Introduzione alla Programmazione C- II

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October 5, 2011

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?

dloop.c

```
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:

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 :
        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

dice.c

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

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?

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");

    return 0;
}
```


Questions

- Index out of bounds is a programming error
  - Why the compiler does not complain?
  - 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- and three-dimensional arrays (matrices):

```
double mat[3][3];
int cube[4][4][4];

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

- Static and dynamic initialisation

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;
    for (i=0; i<9; i++) {
        mat[i/3][i%3] = 2.0;
    }
    printf("Done\n");
    return 0;
}
```

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

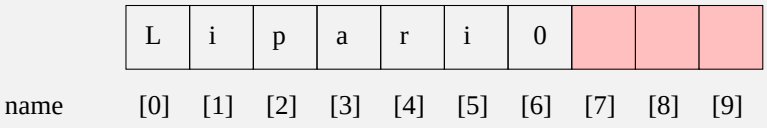
```
char name[20];
```

- 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 declare an array of 11 characters! (one extra to store the final 0)
- Here is an example of how to compute the length of a string

```
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");
```


String content

- What is in a string?

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

Examples

stringex.c

```
int main()
{
    char name[] = "Giuseppe";
    char surname[] = "Lipari";
    char name2[] = "Roberto";
    char result[25];

    printf("Comparing %s with %s\n", name, name2);
    int r = strncmp(name, name2, 9);
    if (r == 0) printf("Same string\n");
    else if (r > 0) printf("%s after %s\n", name, name2);
    else if(r < 0) printf("%s before %s\n", name, name2);
    printf("Code : %d\n", r);

    strncpy(result, name, 25);
    strncat(result, " ", 25);
    strncat(result, surname, 25);
    printf("Result: %s\n", result);
    return 0;
}
```


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

- An example: this function elevates a double number to an integer power

```
/* 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

- This is how the function is called.
- The formal parameters x and y are substituted by the actual parameters (the values of xx and yy)

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
- We say that in C parameters are passed *by value*
- There is only one exception to this rule: arrays
  - An array parameter is never copied, so modification to the local parameter are immediately reflected to the original array

Array parameters

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 initialised when 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

Definitions

- **Global variables** are variables defined outside of any function
- **Local variables** are defined inside a function
- **The visibility** (or scope) of a variable is the set of statements that can “see” the variable
  - remember that a variable (or any other object) must be declared before it can be used
- **The lifetime** of a variable is the time during which the variable exists in memory

Examples

```
#include <stdio.h>

int pn[100];

int is_prime(int x)
{
    int i,j;
    ...
}

int temp;

int main()
{
    int res;
    char s[10];
    ...
}
```

pn is a global variable
scope: all program
lifetime: duration of the program

x is a parameter
scope: body of function is_prime
lifetime: during function execution

i,j are local variables
scope: body of function is_prime
lifetime: during function execution

temp is a global variable
scope: all objects defined after temp
lifetime: duration of the program

res and s[] are local variables
scope: body of function main
lifetime: duration of the program

Global scope

- A **global variable** is declared outside all functions
  - This variable is created before the program starts executing, and it exists until the program terminates
  - Hence, it's **lifetime** is the program duration
- The **scope** depends on the point in which it is declared
  - All variables and functions defined after the declaration can use it
  - Hence, it's scope depends on the position

Local variables

- Local variables are defined inside functions

```
int g;

int myfun()
{
  int k; double a;
  ...
}

int yourfun()
{
  ...
}
```

g is global

k and a are local to myfun()

in function yourfun(), it is possible to use variable g but you cannot use variable k and a (out of scope)

- k and a cannot be used in `yourfun()` because their scope is limited to function `myfun()`.

Local variable lifetime

- Local variable are *created* only when the function is invoked;
- They are *destroyed* when the function terminates
  - Their lifetime corresponds to the function execution
  - Since they are created at every function call, they hold only temporary values useful for calculations

```
int fun(int x)
{
  int i = 0;

  i += x;
  return i;
}

int main()
{
  int a, b;

  a = fun(5);
  b = fun(6);

  ...
```

i is initialized to 0 at every fun() call

at this point, a is 5 and b is 6;

Modifying lifetime

- To modify the lifetime of a local variable, use the `static` keyword

```
int myfun()
{
    static int i = 0;

    i++;

    return i;
}

int main()
{
    printf("%d ", myfun());
    printf("%d ", myfun());
}
```

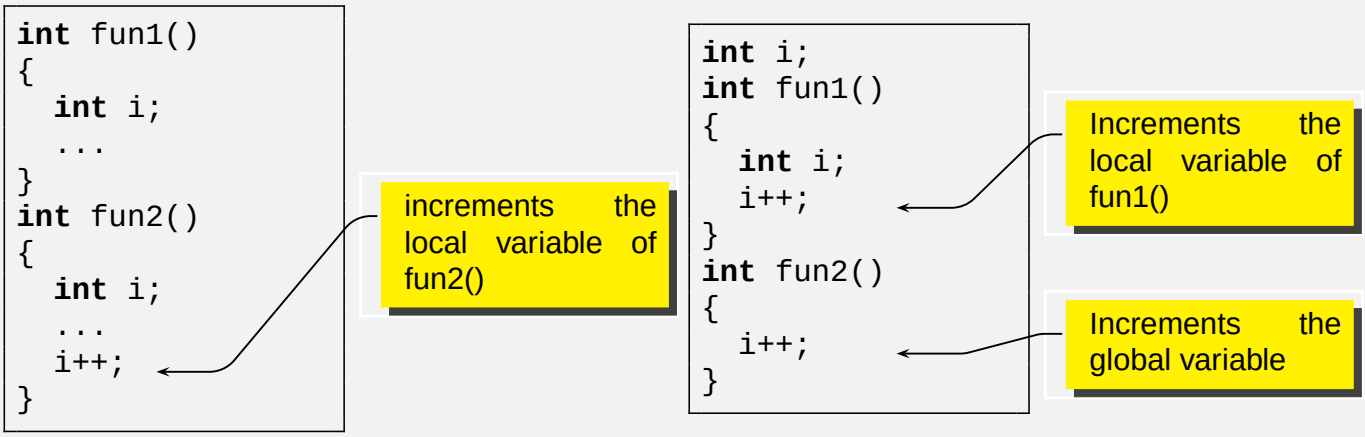
This is a static variable: it is initialised only once (during the first call), then the value is maintained across successive calls

This prints 1

This prints 2

Hiding

- It is possible to define two variables with the same name in two different scopes
- The compiler knows which variable to use depending on the scope
- It is also possible to hide a variable



Structure definition

- In many cases we need to aggregate variables of different types that are related to the same concept
- each variable in the structure is called *a field*
- the structure is sometimes called *record*
- Example

```
struct student {
    char name[20];
    char surname[30];
    int age;
    int marks[20];
    char address[100];
    char country[100];
};

struct student s1;
```

```
struct position {
  double x;
  double y;
  double z;
};

struct position p1, p2, p3;
```

Accessing data

- To access a field of a structure, use the *dot notation*

```
struct student s1;
...
printf("Name: %s\n", s1.name);
printf("Age : %d\n", s1.age);
```

```
#include <math.h>

struct position p1;
...
p1.x = 10 * cos(0.74);
p1.y = 10 * sin(0.74);
```


Array of structures

- It is possible to declare array of structures as follows:

```
struct student  my_students[20];
int i;

my_student[0].name = "...";
my_student[0].age = "...";
...

for (i=0; i<20; i++) {
    printf("Student %d\n", i);
    printf("Name: %s\n", my_student[i].name);
    printf("Age: %d\n", my_student[i].age);
...
}
```

Other operations with structures

- When calling functions, structures are passed by value
  - that is, if you modify the parameter, you modify only the copy, and the original value is not modified
- Initialization: you can use curly braces to initialize a structure

```
struct point {
    double x;
    double y;
};

struct point x = {0.5, -7.1};
```


Copying structures

- You can use normal assignment between structures of the same type
  - the result is a field-by-field copy

```
struct point {
    double x;
    double y;
};

struct point x = {4.1, 5.0};

struct point y;

y = x;
```

Converting variables between types

- Sometimes we need to convert a variable between different types
- Example:

```
int a = 5;
double x;

x = a;

x = a / 2;

a = x * 2;
```

Here we have an implicit conversion from int to double; the compiler does not complain

Here we have an implicit conversion from int to double. However, the conversion is performed on the result of the division; therefore the result is 2 and not 2.5 as one might expect!

Here we have a conversion from double to int. With this conversion, we might lose in precision, hence the compiler issues a warning

Explicit casting

- It is possible to make casting explicit as follows

```
int a;
double x;

x = ((double) a) / 2;

a = (int)(x * 2);
```

Here the conversion is not explicit. First, a is converted to double; then, the division is performed (a fractional one); then the result (a double) is assigned to x.

Here the compiler does not issue any warning, because the programmer has made it explicit that he/she wants to do this operation.

A brief overview

- In the next slides we will present a quick overview of some functions to manipulate file
- These are useful to solve some exercises
- We will come back to these functions at some point

Files

- A file is a sequence of bytes, usually stored on mass-storage devices
  - We can read and/or write bytes from/to files sequentially (as in magnetic tapes)
- File can contais sequences of bytes (binary) or sequence of characters (text files)
  - There is really no difference: a character is nothing more than a byte
  - It's the *interpretation* that counts

File operations

- Before operating on a file, we must *open* it
- then we can operate on it
- finally we have to *close the file* when we have done
- In a C program, a file is identified by a variable of type `FILE *`
  - The `*` denotes a pointer: we will see next lecture what a pointer is

Opening a file

- To open a file, call `fopen`

```
FILE *fopen(char *filename, char *mode);
```

- `filename` and `mode` are strings
  - `filename` is the name of the file (may include the path, relative or absolute)
  - `mode` is the opening mode
    - "`r`" for reading or "`w`" for writing or "`a`" for writing in append mode
- Example: open a file in reading mode

```
FILE *myfile;

myfile = fopen("textfile.txt", "r");
...

fclose(myfile);
```

Reading and writing

- At this stage, we will consider only text files
- You can use `fprintf()` and `fscan()`, similar to the functions we have already seen

Input

input.c

```
#include <stdio.h>

FILE *myfile;

int main()
{
    int a, b, c;
    char str[100];

    myfile = fopen("textfile.txt", "r");

    fscanf(myfile, "%d %d", &a, &b);
    fscanf(myfile, "%s", str);
    fscanf(myfile, "%d", &c);

    printf("what I have read:\n");
    printf("a = %d     b = %d      c = %d\n", a, b, c);
    printf("str = %s\n", str);
}
```

fprintf and fgets

output.c

```c
#include <stdio.h>

FILE *myfile1;
FILE *myfile2;

int main()
{
    int i, nlines = 0;
    char str[255];

    myfile1 = fopen("textfile.txt", "r");
    myfile2 = fopen("copyfile.txt", "w");
    fgets(str, 255, myfile1);

    while (!feof(myfile1) {
        fprintf(myfile2, "%s", str);
        nlines++;
        fgets   (str, 255, myfile1);
    }
    printf("file has been copied!\n");
    printf("%d lines read\n", nlines);
}
```


Exercises with files

- Write a program that reads a file line by line and prints every line reversed
  - **Hint:** Write a function that reverts a string
- Write a function that reads a file and counts the number of words
  - **Hint:** two words are separated by spaces, commas ",", full stop "." , semicolon ";", colon ":", question mark "?", exclamation mark "!", dash "-", brackets. see `http://en.wikipedia.org/wiki/Punctuation`
  - this is called tokenize