Introduction to Programming

-Random numbers · Mathematical libraries-

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Today's topics

• How to use pseudorandom numbers.

- #include
- Initialization
- Random integer numbers
- Random real numbers
- How to use mathematical libraries.
 - Mathematical function, mathematical constants
 - How to compile with math.h (gcc filename -lm)

Include of header file (#include)

- We have described "#include<stdio.h>" at the beginning of our programs.
- This loads the file in order to use "printf" and "scanf" functions.
- In the C Programming Language, files called "standard header files" containing functions are set up.
- According to the function used in the program, it is necessary to include the standard header files.
- The main standard header files are the following:

stdio.h: printf, scanf and so on (Input/Output)
stdlib.h: rand, srand, exit, malloc and so on
math.h: exp, sqrt, sin, cos and so on (Mathematical function)
string.h: strcpy, strlen and so on (String manipulations)
time.h time and so on (Time manipulations)

Pseudorandom numbers

Usage of pseudorandom numbers in a program.

What's random numbers?

- Random numbers are a sequence of numbers that are arranged so that each number appears in completely the same process
- In C Programming Language, random numbers are generated with "rand" function.
- However, "rand" returns a number that doesn't occur in exactly the same process as a random number, known as a pseudorandom number.
- "rand" function generates random numbers based on a certain value. Therefore, if the initial value is the same then the exact same sequence of random numbers will appear.

Pseudorandom numbers

How to generate: including time.h and stdlib.h

#include <time.h> /* Time manipulations functions*/
#include <stdlib.h> /*rand functions*/

Initialization of random numbers according to current time

srand((unsigned)time(NULL)); /* Initialization of rand */

If you want to have the same sequence of numbers, specify a fixed value like "srand (integer value)".
 For example, "srand(56);"

Pseudorandom numbers (Regularity remains)

rand() returns a random integer value from 0 to RAND_MAX

a = rand();

(RAND_MAX is a compiler-dependent constant)

The following returns a random real value from 0 to 1

 $a = rand() / (RAND_MAX +1.0);$

The following returns a random integer value from 0 to N

a = (int) (rand()/(RAND_MAX +1.0)*N);

Example of Pseudorandom

 \Rightarrow

```
Dice (dice.c) -
#include <stdio.h>
#include <time.h>
#include <stdlib.h>
int main(void){
    int a;
    srand((unsigned) time(NULL));
    a = (int) (rand()/(RAND_MAX+1.0)*6);
    printf("Result is %d. \u00e4n", a+1);
    return 0:
}
```

- you generate random integer numbers that are "greater than or equal to 0 and less than 6" first.
- Then you add 1 to the numbers when the numbers are displayed.

Example 1

Write a program to display today's fortune

This program will display a message with probability in the table.

Probability	30%	60 %	10 %
Message	Very lucky	lucky	Not lucky

- When you finish writing the source code and successfully compile it, execute the file several times and confirm that it works roughly according to probability.
- Regarding the "time" used to initialize random numbers, the time function returns the time measured in seconds from UTC
- If you want to display the results in days, write the source code as shown the following:

srand((unsigned)time(NULL)/(60*60*24));

Hint of example 1

- Don't forget to include header file and initialize random numbers.
- Use if statement in order to determine the branches:
 - if(a<0.3) printf("...")
 else if(a<0.9) printf("...")
 else printf("...")</pre>

Mathematical libraries

• You can use mathematical functions and constants (for examples, sin, log, π and so on) in the program including math.h.



Without this, an error will occur.

This example is written using "10 natural logarithms":
 a= log(10.0);

Mathematical libraries

Mathematical functions

How to use	Meaning	How to use	Meaning
fabs(x)	Absolute	exp(x)	Exponential
log(x)	Natural logarithm	log10(x)	Common logarithm
pow(x,y)	x to the power of y	sqrt(x)	Square root
cos(x)	cos	acos(x)	arccos
sin(x)	\sin	asin(x)	arcsin
tan(x)	an	atan(x)	arctan
atan2(y,x)	$\arctan(y/x)$	cosh(x)	\cosh
sinh(x)	sinh	tanh(x)	tanh
floor(x)	The largest integer not greater than x		
ceil(x)	The smallest integer not less than x		

Mathematical constants

How to use	Meaning	How to use	Meaning
M_PI	π	M_SQRT2	Square root of 2
M_E	e	M_LN10	$\log_e 10$

Example 2

Example 2: Write a program to calculate the integrated value by using random numbers:

How to calculate

- Repeat generating of random numbers (x, y) which are "greater than or equal to 0 less than 1" depending on the inputted value.
- Calculate the ratio "r" that satisfies $y < \sin(\pi x)$.
- This ratio will converge at $\int_0^1 \sin \pi x = \frac{2}{\pi}$.
- Display the value "r" and Error for $2/\pi$.
- For example:

How many trials? 1000 [Enter] Result is 0.652000 (Error: -0.015380)

Hints of example 2

- Don't forget to include header files (time.h,stdlib.h,math.h).
- Don't forget to put "-Im" when compiling the file.
- This question uses the x and y axis of coordinate on a 1x1 square.
- Points are spread in the square and we will calculate how many points are inside of the curve (the shaded area in the figure).
- The ratio : <u>Number of points satisfying the conditions</u> Number of all points
- Use an int type variable for counting numbers of points.
- Note that you use cast operator when you calculate the ratio.



Summary

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