

**HACETTEPE UNIVERSITY
DEPARTMENT OF COMPUTER ENGINEERING**

**BBM203 PROGRAMMING LAB.
ASSIGNMENT 1**

Subject : Data Structures and Algorithms
Submission Date : 22.10.2018
Deadline : 04.11.2018 23:59:59
Programming Language : C
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1. INTRODUCTION / AIM:

In this experiment, you are expected to gain knowledge on C language including read-write files, arrays, matrices, recursion and dynamic memory allocation. Prior knowledge on basic C syntax is assumed.

2. BACKGROUND INFORMATION

2.1. C LANGUAGE

C is an imperative procedural language. It was designed to be compiled using a relatively straightforward compiler, to provide low-level access to memory, to provide language constructs that map efficiently to machine instructions, and to require minimal run-time support.

Despite its low-level capabilities, the language was designed to encourage cross-platform programming. A standards-compliant and portably written C program can be compiled for a very wide variety of computer platforms and operating systems with few changes to its source code.

The language has become available on a very wide range of platforms, from embedded microcontrollers to supercomputers.

2.2. ARRAYS

Array types in C are traditionally of a fixed, static size specified at compile time. However, it is also possible to allocate a block of memory at run-time, using the standard library's malloc function. C's unification of arrays and pointers means that declared arrays and these dynamically allocated simulated arrays are virtually interchangeable.

Static

```
int array[10];
```

Dynamic

```
int * array = malloc(10 * sizeof(int));
```

Since arrays are always accessed via pointers, array accesses are typically not checked against the underlying array size. Array bounds violations are therefore possible and rather common in carelessly written code, and can lead to various repercussions, including illegal memory accesses, corruption of data, buffer overruns, and run-time exceptions. If bounds checking is desired, it must be done manually.

2.3. MULTI-DIMENSIONAL ARRAYS

C does not have a special provision for declaring multi-dimensional arrays, but rather relies on recursion within the type system to declare arrays of arrays, which effectively accomplishes the same thing. The index values of the resulting "multi-dimensional array" can be thought of as increasing in row-major order.

Multi-dimensional arrays are commonly used in numerical algorithms to store matrices. The structure of the C array is well suited to this particular task. However, since arrays are passed merely as pointers, the bounds of the array must be known fixed values or else explicitly passed to any subroutine that requires them, and dynamically sized arrays of arrays cannot be accessed using double indexing. (A workaround for this is to allocate the array with an additional "row vector" of pointers to the columns.).

2.4. DYNAMIC MEMORY ALLOCATION

The task of fulfilling an allocation request consists of locating a block of unused memory of sufficient size. Memory requests are satisfied by allocating portions from a large pool of memory called the heap or free store. At any given time, some parts of the heap are in use, while some are "free" (unused) and thus available for future allocations.

The C dynamic memory allocation functions are defined in `stdlib.h` header.

Function	Description
<code>malloc</code>	allocates the specified number of bytes
<code>realloc</code>	increases or decreases the size of the specified block of memory. Reallocates it if needed
<code>calloc</code>	allocates the specified number of bytes and initializes them to zero
<code>free</code>	releases the specified block of memory back to the system

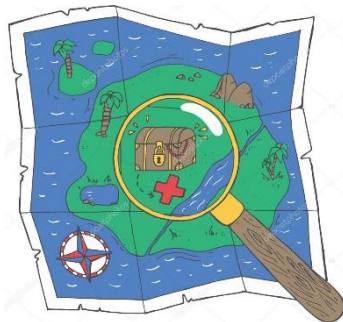
2.5. RECURSION

Recursion is the process of repeating items in a self-similar way. In programming languages, if a program allows you to call a function inside the same function, then it is called a recursive call of the function. The C programming language supports recursion, i.e., a function to call itself. But while using recursion, programmers need to be careful to define an exit condition from the function, otherwise it will go into an infinite loop.

2.6. ONLINE RESOURCES

- Wikipedia C Entry: [https://en.wikipedia.org/wiki/C_\(programming_language\)](https://en.wikipedia.org/wiki/C_(programming_language))
- C Tutorial : <https://www.tutorialspoint.com/cprogramming>

3. EXPERIMENT



In this experiment, it is aimed to find the hidden treasure within a treasure map designed as a matrix.

For this purpose, the map and key data must be read from the file. Afterwards, the key must be moved on the map depending on the rules. The result of the multiplication of the map matrix and the key matrix will give an idea of the place of the treasure.

You should use matrix structure to implement all these operations in the C programming language. To store the matrices, you must use dynamic memory allocation.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	1	5	8	6	9	4	7	5	1	2	9	2	8	3	6
0	1	5	8	3	2	8	4	6	9	3	7	4	6	8	9	3
0	1	6	2	9	3	5	8	9	2	6	1	8	9	7	3	1
0	5	7	5	8	1	3	4	8	5	1	5	8	9	3	5	2
0	9	4	7	5	1	2	9	4	7	5	1	2	9	2	8	3
0	8	4	6	9	3	7	8	4	6	9	3	7	4	6	8	9
0	5	8	9	2	6	1	5	8	9	2	6	1	8	9	7	3
0	3	8	1	3	4	8	5	1	5	3	8	1	3	4	8	5
0	7	5	1	2	9	4	7	5	1	7	5	1	2	9	4	7
0	6	9	3	7	8	4	6	9	3	6	9	3	7	8	4	6
0	9	2	6	1	5	8	9	2	3	4	8	5	1	5	8	9
0	8	4	6	9	3	7	3	7	2	9	4	7	5	1	2	9
0	5	8	9	2	6	1	6	1	7	8	4	6	9	3	7	4
0	3	8	1	3	4	8	2	9	1	5	8	9	2	6	1	8
0	7	5	1	2	9	4	8	1	3	4	8	8	4	6	8	4
0	8	4	6	9	3	7	5	1	2	9	4	5	8	9	5	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1 An Example For Treasure Map Matrix

The treasure map is designed as a matrix as shown in Table 1. The size of the map matrix is not fixed but must be determined according to the input file that will be given at runtime. Each element of the map matrix is a number. The elements of the matrix placed in the edges are zeros. That show you the boundary of the map.

0	-1	0
-1	20	-1
0	-1	0

Table 2 An Example Of Key Matrix

As shown in Table 2, the key is designed as a square matrix with degree n that is an odd value (e.g. 3,5,7). n is a variable that will be determined at runtime. By using the key matrix, the hidden treasure can be found in the map.

In order to find treasure, we slide the key matrix on the map. The part of the map matrix that is covered by the key specify a sub-matrix on the map. By multiplying the key matrix by the obtained sub-matrix, we find the direction of the next sliding. The direction is computed by taking mod five of multiplication result (result % 5). The result of the mod operation is interpreted as follows:

- 0: Found treasure
- 1: Go up
- 2: Go down
- 3: Go right
- 4: Go left

The search operation must be start from the top left corner of the map matrix. The details of the first step are shown in Table 3. In order to get a full score from this assignment, you have to design search function recursively.



0	0	0	X	0	-1	0	=	58	$58 \% 5 = 3$			1,1:58
0	3	1		-1	20	-1						
0	1	5		0	-1	0						
A				B				C	D	E	F	G

Table 3 Start Search

- A: Sub-matrix
- B: Key Matrix
- C: Multiplication of matrices A and B
- D: Remaining part of the mod (5,C)
- E: Estimated direction
- F: Final direction
- G: Output: write center cell address of sub-matrix and C



0	0	0	X	0	-1	0	=	146	146 % 5 = 1			4,1:146
5	8	6		-1	20	-1						
8	3	2		0	-1	0						
A'				B				C	D	E	F	G

Table 4 Handling the exception for the estimated direction.

Table 5 Treasure Found!

3.1. EXECUTION

```
findtreasure [size of map matrix] [size of key matrix] [input file name] [output file name]
e.g.: ./findtreasure 18x18 3 mapmatrix.txt keymatrix.txt output.txt
```

3.2. INPUT/OUTPUT FORMAT

In the map matrix file, the numbers are separated by spaces and newlines. You do not need to check the input for errors. An example map matrix file can be given as follows:

```
00000000000000000000000000
031586947512928360
015832846937468930
016293589261897310
057581348515893520
094751294751292830
084693784693746890
058926158926189730
038134851538134850
075129475175129470
069378469369378460
092615892348515890
084693737294751290
058926161784693740
038134829158926180
075129481348846840
084693751294589580
00000000000000000000000000
```

Your program should write outputs to the output file, so that each line in the output file will contain the midpoint of the sub-matrix and also the result of multiplication. If the above input file is given, the output file should be as below:

```
1,1:58
1,4:146
4,4:140
```

3.3. DESIGN EXPECTATIONS

You must use dynamic memory allocation for your solution. Writing spaghetti, or static arrays could render your entire assignment “unacceptable” and make it subject to huge (if not complete) grade loss.

3.4. VALID PLATFORMS

Your code will be compiled against gcc version 5.4.0. You should not assume the availability of any other non- standard libraries/features. If you use a different compiler, it is your responsibility to ensure that your code has no compilation issues with the specified version of gcc.

4. EVALUATION

4.1. REQUIRED FILES

You should create and submit a ZIP archive in the following structure for evaluation. An invalid structured archive will cause you partial or full score loss.

You are required to submit a Makefile¹, which will be used to compile your program to generate the findtreasure executable.

Directory	Files	Description
Source	*.c, *.h, Makefile	Program source/header files and Makefile
Report	*.pdf	Your report (Only pdf format is accepted)

4.2. REPORTS

You must write a report which is related to your program. The topics that should be included in the report are:

- Problem definition
- Methods and solution
- Functions implemented and not implemented

4.3. GRADING

Make sure that the source code you submitted is compiled with gcc compiler under Linux OS. Applications that produce compilation or runtime errors cannot be graded.

- The program you have submitted will be tested with five different inputs. You can achieve 10 points for each correct output file, total 50 points.
- Your source code must have "Dynamic memory allocation, recursion, multidimensional array, and comment lines". You can achieve 5 points for each item, total 20 points.
- You can achieve 10 points for each topic, total 30 points for report.
- Points you can get from report is directly correlated with the total points you get from execution and code review sections. For example if you get 35/70 from first two sections points you can from report section would be at most 15 points.

LAST REMARKS:

- The output of your program will be graded automatically. Therefore, any difference of the output (even a smallest difference) from the sample output will cause an error and you will get 0 from execution. Keep in mind that a program that does not work 100% right is a program that works wrong.
- Regardless of the length, use **UNDERSTANDABLE** names to your variables, classes and functions.
- Write **READABLE SOURCE CODE** block

¹ Make file example <http://mrbook.org/tutorials/make/>

- You will use online submission system to submit your experiments. <https://submit.cs.hacettepe.edu.tr/> Deadline is: 04.11.2018 23:59:59. No other submission method (email or etc.) will be accepted.
- Do not submit any file via e-mail related with this assignment.
- **SAVE** all your work until the assignment is graded.
- The assignment must be original, **INDIVIDUAL** work. Duplicate or very similar assignments are both going to be punished. General discussion of the problem is allowed, but **DO NOT SHARE** answers, algorithms or source codes.
- You can ask your questions through course's piazza page and you are supposed to be aware of everything discussed in the page.

REFERENCES

1. [The C Programming Language \(Second Edition\), B.W. Kernighan, D. M. Ritchie](#)
2. [Let Us C \(Computer Science\) 8th Edition, Y. P. Kanetkar](#)