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DEPARTMENT OF ELECTRICAL & COMPUTER SYSTEMS ENGINEERING
ECE2071 Computer Organisation & Programming

**Lab III and Assignment 1: Are There Any Hidden Messages Among the
Digits of π ?**

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1 Objectives

In this lab activity and assignment, we will sharpen our programming skills with array operations and sorting.

2 Introduction

Perhaps some of you have read Carl Sagan's superb Sci-Fi novel "Contact". In the novel

"The main character (Ellie Arroway) is told by an alien that certain megastructures in the universe were created by an unknown advanced intelligence that left messages embedded inside transcendental numbers. To check this, Arroway writes a program that computes the digits of π in several bases, and eventually finds that the base 11 representation of π contains a sequence of ones and zeros that, when properly aligned on a page, produce a circular pattern."¹

Indeed, there may be fascinating hidden patterns in π , and waiting to be discovered!²

In this assignment, we will do our own pattern hunting, and look for palindromes among the digits of π . Palindromes are words or numbers (which are our focus in this assignment)

¹<https://math.stackexchange.com/questions/1104660/patterns-in-pi-in-contact>

²<https://theconversation.com/pi-might-look-random-but-its-full-of-hidden-patterns-55994>

that are same when we read backwards or forwards. For example, “22” or “14941” are palindrome numbers.

Palindromes have interesting scientific and engineering applications, such as in genetic sequencing technologies [1] or robotics [2].

3 Programming Assignment

The programming assignment is as follows:

1. Download the file `pi_50m.zip` containing the first 50 million decimal digits of π (the file is a zipped ordinary text file, so you need to unzip it after downloading, the actual filename you should read the digits is `pi_50m.txt`).

2. Write a C program that will

- Read the digits of π from the file `pi_50m.txt`, (See Appendix A for an example of reading a file character-by-character).³
- Search and count the number of palindromes of increasing length starting from the 2-digit long ones, record the digit distances between each successive palindromes until reaching a length that no palindrome of that length is detected.
For example, first two successive 2-digit long palindromes of π and the distance between them are as follows:

```
3.14159265358979323846264338327950288419.....
                        ^--9-dig--^
                        distance
```

So, our “digit distance” definition is the number of digits sandwiched between the beginning of the first palindrome to the beginning of the second one. In our example above, first palindrome is 33 and the second is 88. I count 9 digits as the digit distance.

- Sort the digit distances recorded separately for each palindrome length, then find the median distance.⁴
- Report the findings on the terminal window *exactly* in the following format:

Palindrome Length	Number of Palindromes	Median Digit Distance
-----	-----	-----
2	XX..XX	P..P
3	Y..YY	Q.QQQ..Q
4	ZZZ..ZZ	R..R.R
.	.	.
.	.	.
N	0	-

Where, N is the palindrome length that no palindromes are found.

³We will cover the details of standard I/O soon, but for the purpose of this lab and assignment, you can use the code provided in the appendix.

⁴Reminder: “Median is the middle number in a sorted list of numbers. To determine the median value in a sequence of numbers, the numbers must first be sorted, or arranged, in value order from lowest to highest or highest to lowest. If the list has odd number of elements, the middle one is selected. Otherwise, you must choose the smaller one of the numbers that are ‘in the middle.’” For example, this sorted list has even number of elements: (1, 2, 3, 4, 5, 6, 8, 9). You must report the smaller of (4, 5) as the median, which is 4.

3. Rename your program as `ece2071_asg1.c`, and submit as a single `.c` file containing only ASCII text characters (no other formats will be accepted). Do not submit any other files. Please read carefully the submission rules and marking procedure provided in Appendix B.

A Sample C Program for Reading a File Character-by-Character

The following example shows how to read a file one character at a time (for further details, you can refer to Chapter 11 of the textbook [3]).

```
1  #include <stdio.h>

    /*
        Compile with:
        gcc -std=c17 -pedantic -Werror ece2071_asg1.c -o ece2071_asg1 -lm
    */

    int main(void)
    {
10         int c;
            unsigned int count = 0;

            /* Do NOT change the filename! Otherwise your assignment will fail. */
            FILE *file = fopen("pi_50m.txt", "r");
            if (file == 0) {
                printf("I can't open the file for reading.\n");
                return -1;
            }

20         while ((c = fgetc(file)) != EOF) {
            /* Your palindrome number hunting routines could start here */
            count++;
        }
        printf("The file is %d characters long.\n", count);
        fclose(file);

        return 0;
    }
```

B Submission Rules and Marking Procedure

Please read carefully the following submission rules and marking procedure. They will be *strictly* applied:

1. This is a single person activity. Group submissions will not be accepted. Do not share your code with anybody, and do not use someone else's code. Please read carefully

Monash University's information pages about academic integrity, plagiarism and collusion.⁵

2. We will compile your program on a Windows 10 command window by using the following command:

```
gcc -std=c17 -pedantic -Werror ece2071_asg1.c -o ece2071_asg1 -lm
```

If no executable file is generated, we will send you the error output, and invite you to re-submit. But, if you decide to re-submit, we will consider the submission as late, and consequently you will **lose at least 50% of the allocated mark**.

Therefore, before submitting, make sure that your program compiles with the above command in a Windows 10 machine command window.

3. Be careful not to change the filename that your program should read. The statement that opens the π file has to be exactly

```
FILE *file = fopen("pi_50m.txt", "r");
```

4. Do not use any non-standard libraries. Our system will not have them, and your program will inevitably fail if you use any non-standard libraries.

5. Similarly, do not include any non-standard include (".h") files.

6. We will run the generated executable file in a command terminal window, and record the produced results (note that our Windows 10 machine has 16 GB of memory, so be careful about the memory usage limits of your program). If it produces the expected output in a reasonable time (the hard-limit is 20 minutes, if your program gets stuck in an infinite loop, the system will terminate it after 20 minutes) you will get at least 60% of the allocated mark.

We will then rank all the successful programs from shortest run time to the longest. Fastest 25% of the programs will get the full remaining 40%, second fastest group of 25% will get an extra 30%, third fastest group of 25% will receive 20% and final 25% will get an extra 10%.

7. If your program crashes when we run, we will examine the program and its output, and assign a mark between 20% and 60%. If no useful output is generated, we will examine the source code and assign a mark between 0% and 20%.

References

- [1] Novel Method Developed to Further the Understanding of DNA Palindromes. URL <https://ncifrederick.cancer.gov/about/theposter/content/novel-method-developed-further-understanding-dna-palindromes>.
- [2] M. Burke, S. Penkov, and S. Ramamoorthy. From Explanation to Synthesis: Compositional Program Induction for Learning From Demonstration. In *Proceedings of Robotics: Science and Systems*, 2019. URL <https://arxiv.org/pdf/1902.10657.pdf>.
- [3] P. Deitel and H. Deitel. *C How to Program*. Pearson, (Available on-line via Monash Library), Eighth edition, 2016.

⁵<https://www.monash.edu/students/study-support/academic-integrity>