

Practical 1

Submission deadline: Saturday, 30th September, at 23:59

Maximum subsequence sum: Given n integer numbers a_1, a_2, \dots, a_n , find the maximum value of $\sum_{k=i}^j a_k$ with $1 \leq i \leq j \leq n$ (for convenience, the sum of the maximum subsequence is 0 if all the integers are negative).

We propose two algorithms to solve this problem:

Algorithm 1: $O(n^2)$

```

function maxSubSum1 (v[1..n])
  MaxSum := 0;
  for i := 1 to n do
    ThisSum := 0 ;
    for j := i to n do
      ThisSum := ThisSum + v[j]
      if ThisSum > MaxSum then
        MaxSum := ThisSum
      end if
    end for
  end for ;
  return MaxSum
end function

```

Algorithm 2: $O(n)$

```

function maxSubSum2 (v[1..n])
  ThisSum := 0; MaxSum := 0;
  for j := 1 to n do
    ThisSum := ThisSum + v[j] ;
    if ThisSum > MaxSum then
      MaxSum := ThisSum
    else if ThisSum < 0 then
      ThisSum := 0
    end if
  end for ;
  return MaxSum
end function

```

You must:

1. Implement the proposed algorithms in C (see Figure 5).
2. Validate that the algorithms work correctly. Test them on the following sequences:

sequence	result
-9, 2, -5, -4, 6	6
4, 0, 9, 2, 5	20
-2, -1, -9, -7, -1	0
9, -2, 1, -7, -8	9
15, -2, -5, -4, 16	20
7, -5, 6, 7, -7	15

Additionally, perform a second test with randomly-generated arrays (Figure 1) checking that both algorithms return the same result (Figure 2).

```

void init_seed() {
    srand(time(NULL));
    /* set the seed of a new sequence of pseudo-random integers */
}
void random_init(int v [], int n) {
    int i, m=2*n+1;
    for (i=0; i < n; i++)
        v[i] = (rand() % m) - n;
    /* generate pseudo-random numbers between -n and +n */
}

```

Figure 1: Initialization of an array with pseudo-random integers in the range $[-n, \dots, +n]$

	sumaSubMax1	sumaSubMax2
[7 0 -3 3 -1 1 -5 5 -8]	7	7
[-8 8 1 -1 7 6 -5 -4 -7]	21	21
[-1 -7 -8 -6 7 -2 1 -2 -7]	7	7
[8 -3 8 9 -9 -5 -4 3 1]	22	22
[3 8 -4 5 6 -9 -4 -8 7]	18	18
[9 -6 -6 8 2 -7 -9 5 9]	14	14
[-5 -7 -6 -3 -8 -3 -5 -9 -3]	0	0
[-3 -7 -9 7 6 5 -7 -2 -2]	18	18
[-7 0 0 7 -1 3 -9 -5 -8]	9	9
[9 -5 3 8 -1 6 9 3 4]	36	36

Figure 2: Applied on different random arrays, both functions return the same results.

- For each of the two algorithms, determine the execution times with random arrays of size n , with n equalling 500, 1000, 2000, 4000, 8000, 16000, and 32000. Use the code in Figure 3 to obtain the system time. To generate the test data, use the code in Figure 1, which generates arrays of pseudo-random numbers in the range $[-n, \dots, n]$.
- Analyse the obtained results by means of an empirical verification of the theoretical complexity (Figure 4). You will also need to perform an empirical check using an underestimated and an

```

#include <sys/time.h>
double microseconds() { /* obtains the system time in microseconds */
    struct timeval t;
    if (gettimeofday(&t, NULL) < 0 )
        return 0.0;
    return (t.tv_usec + t.tv_sec * 1000000.0);
}

```

Figure 3: Obtaining the system time

```

$ ./p1
MaxSubSum 1

```

	n	t (n)	t (n) / n ^{1.8}	t (n) / n ²	t (n) / n ^{2.2}
(*)	500	341.666	0.004736	0.001367	0.000394
	1000	1200.000	0.004777	0.001200	0.000301
	2000	4819.000	0.005509	0.001205	0.000263
	4000	19178.000	0.006296	0.001199	0.000228
	8000	85178.000	0.008031	0.001331	0.000221
	16000	332606.000	0.009006	0.001299	0.000187
	32000	1270463.000	0.009879	0.001241	0.000156

Figure 4: Part of a possible output to screen by the program that measures the execution times of the first algorithm.

overestimated bound for each algorithm.

5. Place the C source files and the .txt file with the report using the task *Practical 1 Submission* in the Algorithms page at <https://campusvirtual.udc.gal>. Remember that the deadline to complete the task is on Saturday, 30th September, at 23:59, and the files cannot be changed once submitted. **All the partners that form a team have to submit the work.**

```

#include <stdio.h>
int maxSubSum1(int v[], int n) {
    int i, j;
    long thisSum, maxSum = 0;
    for (i = 0; i < n; i++) {
        thisSum = 0;
        for (j = i; j < n; j++) {
            thisSum += v[j];
            if (thisSum > maxSum) {
                maxSum = thisSum;
            }
        }
    }
    return maxSum;
}
int maxSubSum2(int v[], int n) {
    /* ... */
}
void print_array(int v[], int n){
    /* ... */
}
void test1() {
    /* ... */
}
void test2() {
    int i, a, b;
    int v[9];
    printf("test\n");
    printf("%33s%15s%15s\n", "", "maxSubSum1", "maxSubSum2");
    for (i=0; i<10; i++) {
        random_init(v, 9);
        print_array(v, 9);
        a = maxSubSum1(v, 9);
        b = maxSubSum2(v, 9);
        printf("%15d%15d\n", a, b);
    }
}
int main() {
    init_seed();
    test1();
    test2();
    return 0;
}

```

Figure 5: Code with the maxSubSum1 function and the second test