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Research article

An Alternate Efficient Sorting Algorithm Applicable for Classification of Versatile Data

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Abstract

This paper plans a new alternate sorting technique, "Zigzag Sort" which has exclusively been developed to sort an odd number of elements. The initial pass (step) involves scanning elements in the left-to-right direction pair-wise and swapping elements in each pair as per the necessity to keep elements in each pair in the sorted order with keeping the last element unprocessed. The next pass involves the identical approach in the reverse direction. Thus in a zigzag way, one in the left-to-right direction, followed by the next in the right-to-left direction, a maximum of n passes are executed to sort n elements offering the complexity of $O(n^2)$. Under our numerical observations, discussions and conclusions, it has been revealed that the "Zigzag Sort" technique is an efficient and stable sorting technique for a versatile data.

Keywords: Sorting, Swapping, Data Structure

1. Introduction

In data structures, a sorting algorithm is an algorithm that arrays input elements of a list in a certain order. There are many sorting techniques available like “Selection Sort”, “Bubble Sort”, “Marge Sort”, “Quick Sort”, “Heap Sort”, “Bin Sort”, “Radix Sort”. Several researchers [1, 2…., 9] confined their attention in this connection and explored number of different sorting algorithms. There is a “Folk Theorem” to the effect that sorting n elements “requires n log n time”. We observed that the statement of Folk Theorem is not always true; if the key type is such that “Bin Sort” or “Radix Sort” can be used to advantage, then O(n) time suffices. However, these sorting algorithms believe on keys being of a special type i.e. a type with a limited set of values. All the other general sorting algorithms we have studied believe only on the fact that we can test whether one key value is less than another. We should notice that in some of the sorting algorithms progress toward determining the proper order for the elements is made when we compare two keys, and then the flow for control in the algorithm goes one of only two ways. In contrast, an algorithm like “Bin Sort” causes one of n different things to happen in only one step, by storing a record with an integer key in one of n bins depending on the value of that integer. All programs use a capability of programming languages and machines that is much more powerful than a simple comparison of values, namely the ability to find in one step a location in an array, given the index of that location [1]. “Zigzag Sort” is exclusively developed for sorting an odd number of elements indirectly influenced by the existing Sorting Algorithms. The algorithm carries an overhead as the process of sorting an even number of elements using this technique can only be initiated by inserting the reasonably largest element of equivalent type into the list to make the number an odd one and finally to discard the same from the sorted list. The initial pass in the algorithm involves scanning elements in the left-to-right direction pair-wise and swapping elements in each pair as per the necessity to keep elements in each pair in the sorted order with keeping the last element in the sequence unprocessed. The following pass involves the identical approach in the reverse direction. Thus in a zigzag way, one in the left-to-right direction, followed by the next in the right-to-left direction, a maximum of N passes are executed to complete the process of sorting N elements. The time to execute the sorting a set of elements using this approach evidently increases with the number of elements. Section 2 presents the algorithmic approach. An application of the proposed algorithm is shown in section 3. Results and analysis based on these results are presented in section 4. Section 5 depicts conclusions on the entire approach.

2. Algorithmic Approach

The algorithm [3] of the “Zigzag Sort” illustrated in Figure 2.1:

```
ZIGZAG_SWAP_SORT (ARRAY [N], N)
If N is even then N = N+1 and Array [N-1] = Highest Type Value
    1.  Start
    2.  Loop from i = 0 to N-1
    3.  If i is even
        Loop from K = 0 to K <= (N/2)-1
        If Array [2*K] > Array [2*K+1]
        Interchange Array [2*K] and Array [2*K+1]
        End of if
        End of Loop
        End of outer if
    4.  If i is odd
        Loop from K = 0 to K <= (N/2)-1
        If Array [(N-1) - 2*K] < Array [(N-1) - (2*K+1)]
        Interchange Array [(N-1) - 2*K] and Array [(N-1) - (2*K+1)]
        End of if
        End of Loop
        End of outer if
    5.  End of outer Loop  (2)
    6.  End
```

Figure: 2.1: Algorithm of the Proposed Sorting Technique

3. Application of Proposed Sorting Algorithm with Numerical Example

In Section 3, we discuss application aspect of the proposed sorting technique. To serve our purpose, we consider two cases of odd and even number of input elements. Case I illustrates an implementation for an odd number of elements, whereas Case 2 illustrates the same for an even number of elements.

Case I. Application for Odd Number of Input Elements

Suppose seven elements are taken, which are as follows:

20 50 100 10 2 500 400

For these above seven elements, position of the each element in the array after each pass will be as follows:

AFTER PASS 1:	20	50	10	100	2	500	400
AFTER PASS 2:	20	10	50	2	100	400	500
AFTER PASS 3:	10	20	2	50	100	400	500
AFTER PASS 4:	10	2	20	50	100	400	500
AFTER PASS 5:	2	10	20	50	100	400	500
AFTER PASS 6:	2	10	20	50	100	400	500
AFTER PASS 7:	2	10	20	50	100	400	500

In this example, sorting has been completed after pass 5 but loop has been repeated twice more (pass 6 and pass 7). This sorting technique is only applicable for odd number of elements, but in case of even number of elements this is only applicable through an approach stated separately.

Case II. Application for Even Number of Input Elements

Suppose eight elements has been considered, which are as follows:

10 1 15 800 100 400 300 5

As the number of elements inputted through keyboard is even, first we have to make the number of elements odd. So, an external element 2147483647 has been inserted at the end of the list of values.

After insertion of external element the list of unsorted values will be as follows:

10 1 15 800 100 400 300 5 2147483647

For the above list of values, the position of each element of the array after each pass will be as follows:

AFTER PASS 1:	1	10	15	800	100	400	5	300	2147483647
AFTER PASS 2:	1	10	15	100	800	5	400	300	2147483647
AFTER PASS 3:	1	10	15	100	5	800	300	400	2147483647
AFTER PASS 4:	1	10	15	5	100	300	800	400	2147483647
AFTER PASS 5:	1	10	5	15	100	300	400	800	2147483647
AFTER PASS 6:	1	5	10	15	100	300	400	800	2147483647
AFTER PASS 7:	1	5	10	15	100	300	400	800	2147483647
AFTER PASS 8:	1	5	10	15	100	300	400	800	2147483647
AFTER PASS 9:	1	5	10	15	100	300	400	800	2147483647

In the above passes, after pass 6 sorting has been completed, but loop has been repeated thrice more (pass 7, pass 8 and pass 9).

4. Result and Analysis

Section 4.1 illustrates execution for odd number of inputted elements and section 4.2 illustrates execution for even number of inputted elements. Section 4.3 is a presentation of analysis based on the observed result.

4.1 Results for Odd Number of Elements

Figure 4.1 is an extract from the screen showing the result of execution for odd number of elements.

```
Enter the number of elements to be sorted: 7

Enter a number: 20
Enter a number: 50
Enter a number: 100
Enter a number: 10
Enter a number: 2
Enter a number: 500
Enter a number: 400

Unsorted array is as follows:
20 50 100 10 2 500 400

Result after pass 1:
20 50 10 100 2 500 400

Result after pass 2:
20 10 50 2 100 400 500

Result after pass 3:
10 20 2 50 100 400 500

Result after pass 4:
10 2 20 50 100 400 500

Result after pass 5:
2 10 20 50 100 400 500

Result after pass 6:
2 10 20 50 100 400 500

Result after pass 7:
2 10 20 50 100 400 500
Finally Sorted array is as follows:
  2   10   20   50 100 400  500
```

Figure: 4.1: Results for odd number of elements

4.2 Results for Even Number of Elements

Figure 4.2 is an extract from the screen showing the result of execution for even number of elements.

```
Enter the number of elements to be sorted: 8

Enter a number: 10
Enter a number: 1
Enter a number: 15
Enter a number: 800
Enter a number: 100
Enter a number: 400
Enter a number: 300
Enter a number: 5

Unsorted array is as follows:
10 1 15 800 100 400 300 5

Result after pass 1:
1 10 15 800 100 400 5 300 2147483647

Result after pass 2:
1 10 15 100 800 5 400 300 2147483647

Result after pass 3:
1 10 15 100 5 800 300 400 2147483647

Result after pass 4:
1 10 15 5 100 300 800 400 2147483647

Result after pass 5:
1 10 5 15 100 300 400 800 2147483647

Result after pass 6:
1 5 10 15 100 300 400 800 2147483647

Result after pass 7:
1 5 10 15 100 300 400 800 2147483647

Result after pass 8:
1 5 10 15 100 300 400 800 2147483647

Result after pass 9:
1 5 10 15 100 300 400 800 2147483647
Finally Sorted array is as follows:
   1    5   10   15 100 300  400 800 _
```

Figure: 4.2: Results for even number of elements

It is calculated that 2147483647 is the highest integer as per Bloodshed Dev-C++ compiler. We have used this number as an external element to make the number of elements odd.

4.3 Analysis based on the Observed Result

Table: 4.3.1: Data on number of inputs and respective execution times

No. of input(s)	Execution time
0	0.001
1	0.001
2	0.002
3	0.003
4	0.003
5	0.003
6	0.004
7	0.003
8	0.003

No. of input(s)	Execution time
9	0.004
10	0.003
11	0.004
15	0.005
20	0.01
25	0.012
30	0.014
35	0.014
40	0.02

No. of input(s)	Execution time
45	0.022
50	0.025
60	0.028
70	0.031
80	0.035
90	0.041
100	0.043
110	0.048
130	0.055

No. of input(s)	Execution time
150	0.062
170	0.075
200	0.081
205	0.085
210	0.086
220	0.089
230	0.091
250	0.099
270	0.106

No. of input(s)	Execution time
300	0.1
330	0.097
350	0.1
370	0.105
400	0.11

4.4 Graphical Representation of Number of Input(s) vs. Execution Time

The graphical representation of execution is illustrated in Figure 4.4.1.

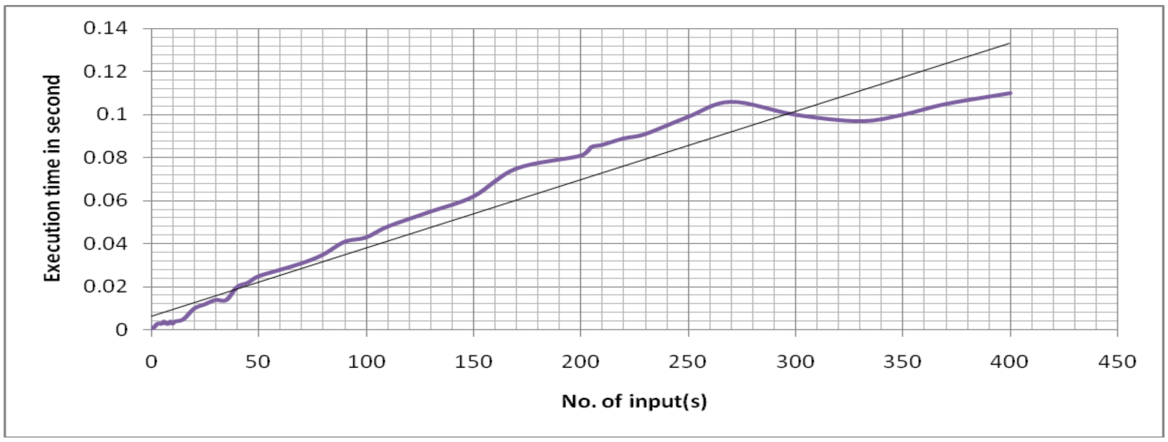


Figure: 4.4.1: Graphical representation of number of inputs and execution time

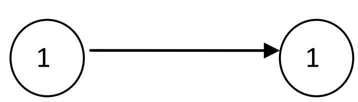
The execution is done at the platform with following configurations:

Processor:	1st generation Intel Dual Core @ 2.0 GHz
Main memory:	1 GB
Operating System:	Windows XP Service Pack 2
Input taking method:	The input(s) are taken randomly

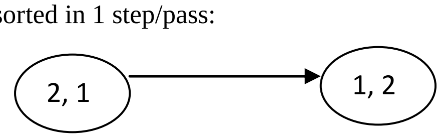
The graphical representation is derived from data given in Table: 4.3.1

4.5 Mathematical Induction of "<=n" Steps or Passes

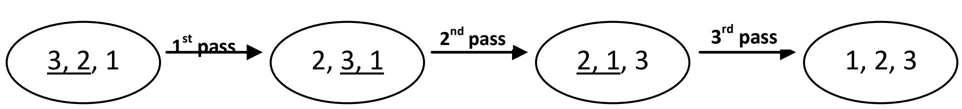
Let, P(n) implies that, n number of elements will be sorted in <= n steps/passes.
In case of P(1), number of elements =1;
And 1 element will be sorted in one step that can be written directly:



Therefore n=1, then P(1) is true, as it takes n i.e. 1 step. That is number of step/pass taken <= 1.
Again, when n = 2; number of elements = 2;
These two elements can be sorted in 1 step/pass:



Therefore when n=2, then P(2) is true, as it takes <= 2 steps/passes.
Again, when n = 3, number of elements = 3;
These three elements can be sorted in 3 steps/passes.



Therefore when n = 3.then P(3) is true as it takes <= 3 steps/passes.
Let we assume that P(m) is true;
That is at m(< n) it is true.
Therefore P(m): m number of elements sorted in <= m steps = k

In the case of (m+1);
Therefore for (m+1) elements:
m elements will be sorted by P(m) in <= m steps, and for the next element[(m+1)th element], it will take one more pass/step to arrange.
So, for sorting (m+1) elements we require <= (m+1) steps/passes.
Therefore P(m+1) is true as it takes <= (m+1) passes/steps.
Hence by mathematical induction it shows that to arrange n number of elements it takes maximum of n steps/passes.

4.6 Stability of Proposed Sorting Algorithm

Stable sorting algorithms maintain the relative order of records with equal keys. A key is that portion of the record which is the basis for the sort; it may or may not include all of the record. If all keys are different then this distinction is not necessary. But if there are equal keys, then a sorting algorithm is stable if whenever there are two records (let's say R and S) with the same key, and R appears before S in the original list, then R will always appear before S in the sorted list. When equal elements are indistinguishable, such as with integers or more generally, any data where the entire element is the key, stability is not an issue.
The sorting of proposed algorithm is stable enough. Stability of this sorting technique can be examined from the following example:
5 elements have been taken to be sorted which are as follows:

7 9(a) 5 1 9(b)

AFTER PASS 1:	7	9(a)	1	5	9(b)
AFTER PASS 2:	7	1	9(a)	5	9(b)
AFTER PASS 3:	1	7	5	9(a)	9(b)
AFTER PASS 4:	1	5	7	9(a)	9(b)
AFTER PASS 5:	1	5	7	9(a)	9(b)

4.7 Time Complexity

The complexity of the proposed sorting technique, "Zigzag Sort" algorithm if is used to sort n elements is observed as $O(n^2)$.

5. Conclusion and Policy Recommendation

In this paper, a sorting technique, "Zigzag Sort" has been proposed for a versatile data. Graphical representation of number of input(s) vs. execution time has been displayed in fig. 4.4.1 and Mathematical Induction of the suggested sorting technique is described in sub-section 4.4. The developed sorting technique, "Zigzag Sort" is sufficiently stable which is utmost useful to reduce the execution time. From this point of view the suggested sorting technique is quite efficient with an overhead of adding a reasonably largest element in the case of even number of elements. Further process is on to eliminate the overhead.

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