2021 Fall INFO6205-Final Project Report

Team member

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1. Methodology

The project aims to sort person names in Chinese with five sort algorithms, such as MSD radix sort, LSD radix sort, Dual-pivot Quicksort, Huskysort and Timsort.

Firstly, we wrote a Java class to read Chinese person names from a txt file, and stored the names as a String[].

Secondly, to sort Chinese names, we transferred Chinese words, a String[], to pinyins, a String[], by pinyin4j which is a Java package. In the meanwhile, we built a HashMap to save the relationship between the Chinese person names and the pinyins. The keys of HashMap are pinyins, and the values of HashMap are Chinese person names corresponding to the key, pinyin. Because of polyphone in Chinese, one pinyin may correspond to multiple Chinese names. Thus, we used String[] to store Chinese names as the value of HashMap, such as, HashMap = {"a1bin1": ["阿斌", "阿彬"]}.

Thirdly, we wrote MSD radix sort and Dual-pivot Quicksort methods, modified LSD radix sort method and directly referred Huskysort and Timsort. And then, we ran these sort algorithms with pinyins, a String[], as input. After the sorting step, we got sorted pinyins.

Finally, we can translate the sorted pinyins back to Chinese person names via the HashMap which we have gotten in second step. The Chinese person names are sorted.

We also wrote the unit test for each sorting algorithms and a benchmark to test the run time of these algorithms. We benchmarked the results of all methods for 250k, 500k and 1M, 2M, 4M names. We recorded the first 1000 sorted Chinese name into five txt files.

2. Implement

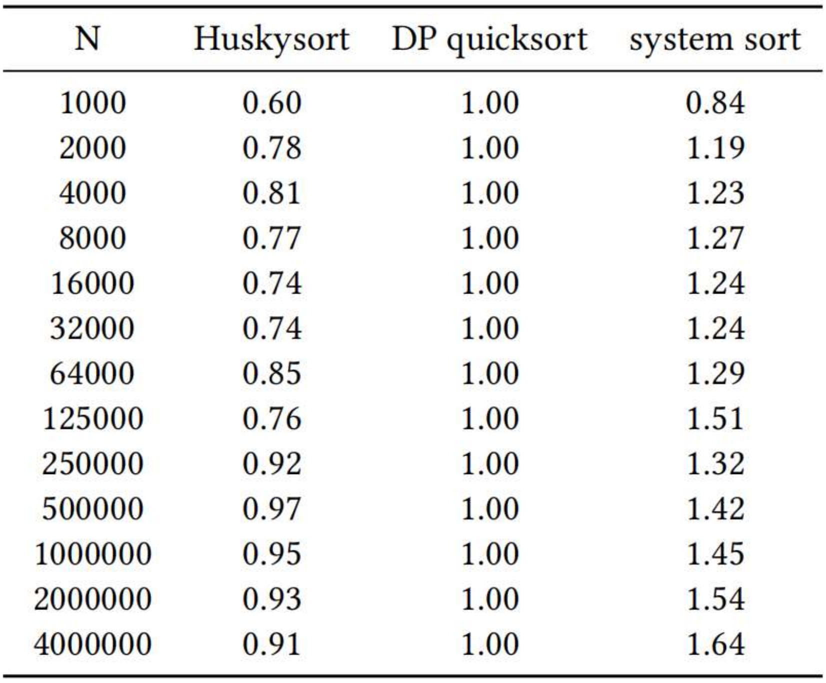
When we were executing our methodology, we used pinyin without tone at first. However, there are many Chinese words share same pinyin, but different tones. So the pinyin without tone may cause inaccurate sort results. For example, without tone, both the pinyin of “阿琛” and the pinyin of “阿臣” are “achen”. With tone, the pinyin of “阿琛” is “a1chen1” and the pinyin of “阿臣” is “a1chen2”. Thus, we decided to transfer Chinese words to the pinyin with tone by pinyin4j, which made the accuracy of our sorting method get better.

We also found there are only 999998 Chinese names in the shuffledChinese.txt, not exact 1M names. We benchmarked the results of all methods for 250k, 500k and 1M, 2M, 4M names. For 1M, 2M and 4M part, we only used 999998, 999998 * 2 and 999998 * 4 names.

3. Result Analysis

According to analyzing the result of sorting, we found that the efficiency of single sorting algorithm is limited. By combining different sorting thoughts, and by having different sorting algorithms on applying to different data types could amplify the stability of sorting algorithms and contribute to the algorithm efficiency as well.

Figure 1: Relative sort times for Huskysort, dual-pivot quicksort, system sort



N	Huskysort	DP quicksort	system sort
1000	0.60	1.00	0.84
2000	0.78	1.00	1.19
4000	0.81	1.00	1.23
8000	0.77	1.00	1.27
16000	0.74	1.00	1.24
32000	0.74	1.00	1.24
64000	0.85	1.00	1.29
125000	0.76	1.00	1.51
250000	0.92	1.00	1.32
500000	0.97	1.00	1.42
1000000	0.95	1.00	1.45
2000000	0.93	1.00	1.54
4000000	0.91	1.00	1.64

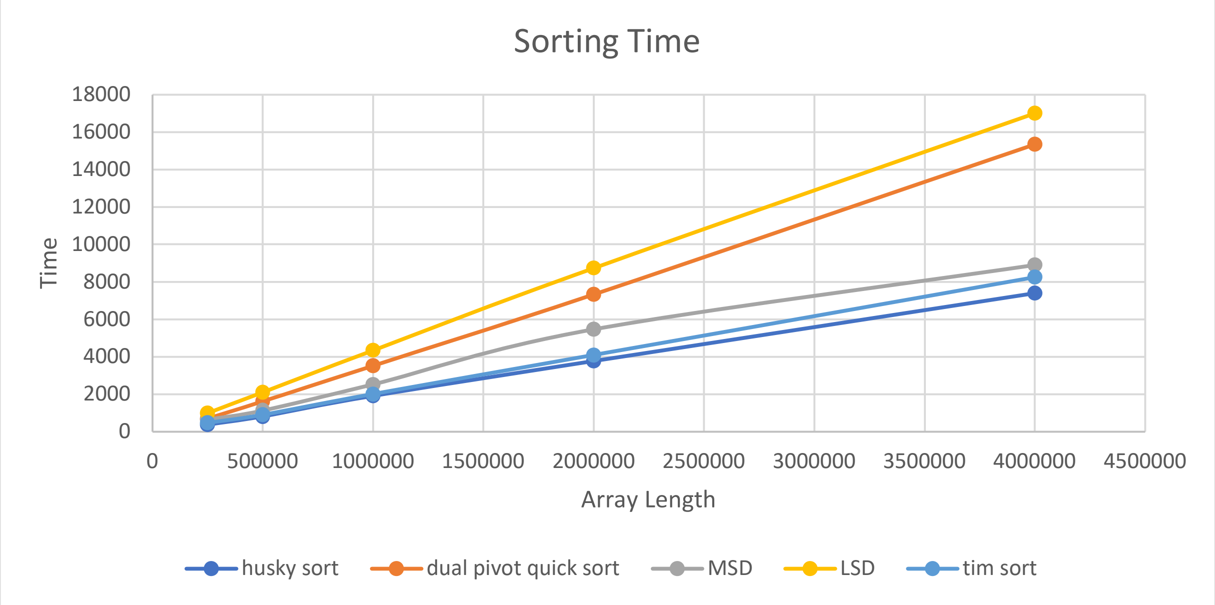
In Husky sort, the fastest algorithm of our 5 different sorting algorithms, they reduce the number of expensive comparisons in the linearithmic phase as much as possible by using huskyCode to help compare the types of objects which are expensive to compare. There will be very few inversions (elements out of place) remaining after the dual-pivot quicksort phase [1]. Then using timsort to make all the data sorted which is very useful to sort the part-sorted data.

In the Figure 1, we can see that the Huskysort extends the advantage both of dual-pivot quicksort and Timsort.

Finding the part which waste a lot of time and replace it by efficient way is a very useful way to improve the data sorting process.

4. Conclusion

As the calculation time of different sorting methods, we found that times of all sorting methods increase linearly as the array length increases doubly. Husky sort uses least time to sort the array we passed in. Timsort, MSD radix sort, dual pivot quick sort gets the 2nd, 3rd and 4th place of the sorting competition. LSD radix sort is the slowest sorting algorithm of these 5 algorithms set.



5. Reference

[1] Hillyard, R., Liaozheng, Y. and Vineeth K.R, S., 2020. Huskysort. Professor. Northeastern University.

6. Appendix

Code File Path:

MSD radix sort

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/MSDStringSort.java

Unit Test: INFO6205-Final-ZCL/INFO6205-Fall2021/src/test/java/edu/neu/coe/info6205/sort/finalProject/MSDStringSortTest.java

LSD radix sort

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/LSDStringSort.java

Unit Test: INFO6205-Final-ZCL/INFO6205-Fall2021/src/test/java/edu/neu/coe/info6205/sort/finalProject/LSDStringSortTest.java

Dual-pivot Quicksort

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/DualPivotQuickSort.java

Unit Test: INFO6205-Final-ZCL/INFO6205-Fall2021/src/test/java/edu/neu/coe/info6205/sort/finalProject/QuickSortDualPivotTest.java

Huskysort

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/huskySort/sort/huskySort/PureHuskySort.java

Unit Test: INFO6205-Final-ZCL/INFO6205-Fall2021/src/test/java/edu/neu/coe/info6205/sort/finalProject/huskySort/sort/huskySort/PureHuskySortTest.java

Timsort

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/TimSort.java

Unit Test: INFO6205-Final-ZCL/INFO6205-Fall2021/src/test/java/edu/neu/coe/info6205/sort/finalProject/TimSortTest.java

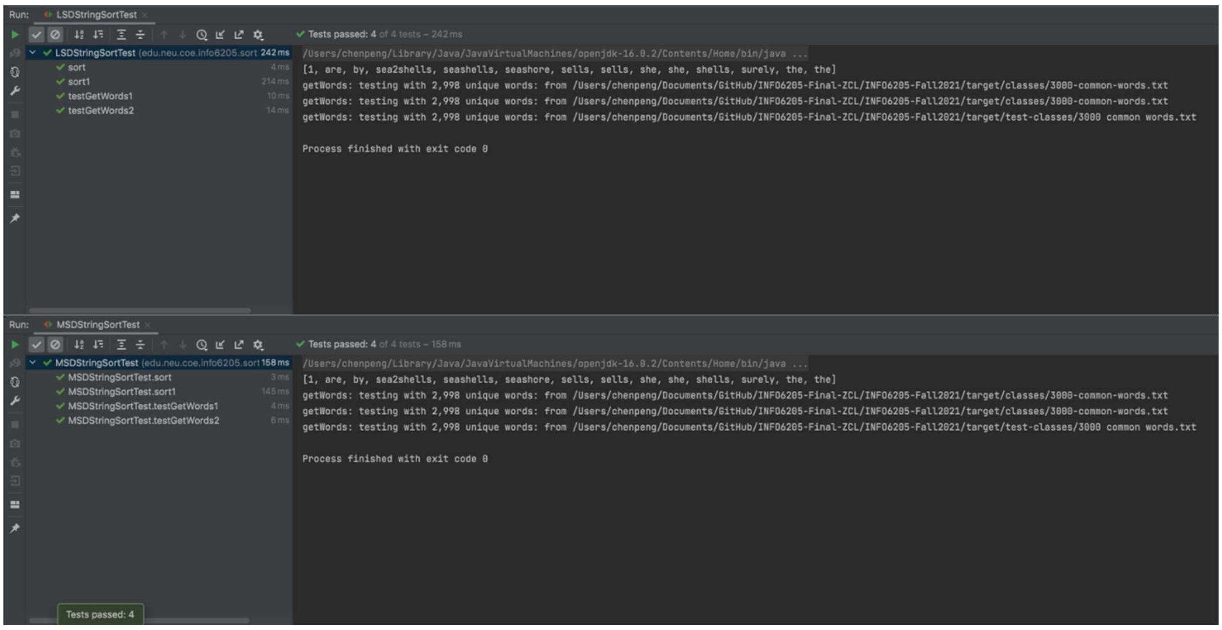
Benchmark

Code: INFO6205-Final-ZCL/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/sort/finalProject/SortingTest.java

Outputs:

MSD radix sort: INFO6205-Final-ZCL/MSDStringSorted.txt
LSD radix sort: INFO6205-Final-ZCL/LSDStringSorted.txt
Dual-pivot Quicksort: INFO6205-Final-ZCL/DualPivotQuickSorted.txt
Huskysort: INFO6205-Final-ZCL/PureHuskySorted.txt
Timsort: INFO6205-Final-ZCL/TimSorted.txt

Unit tests:

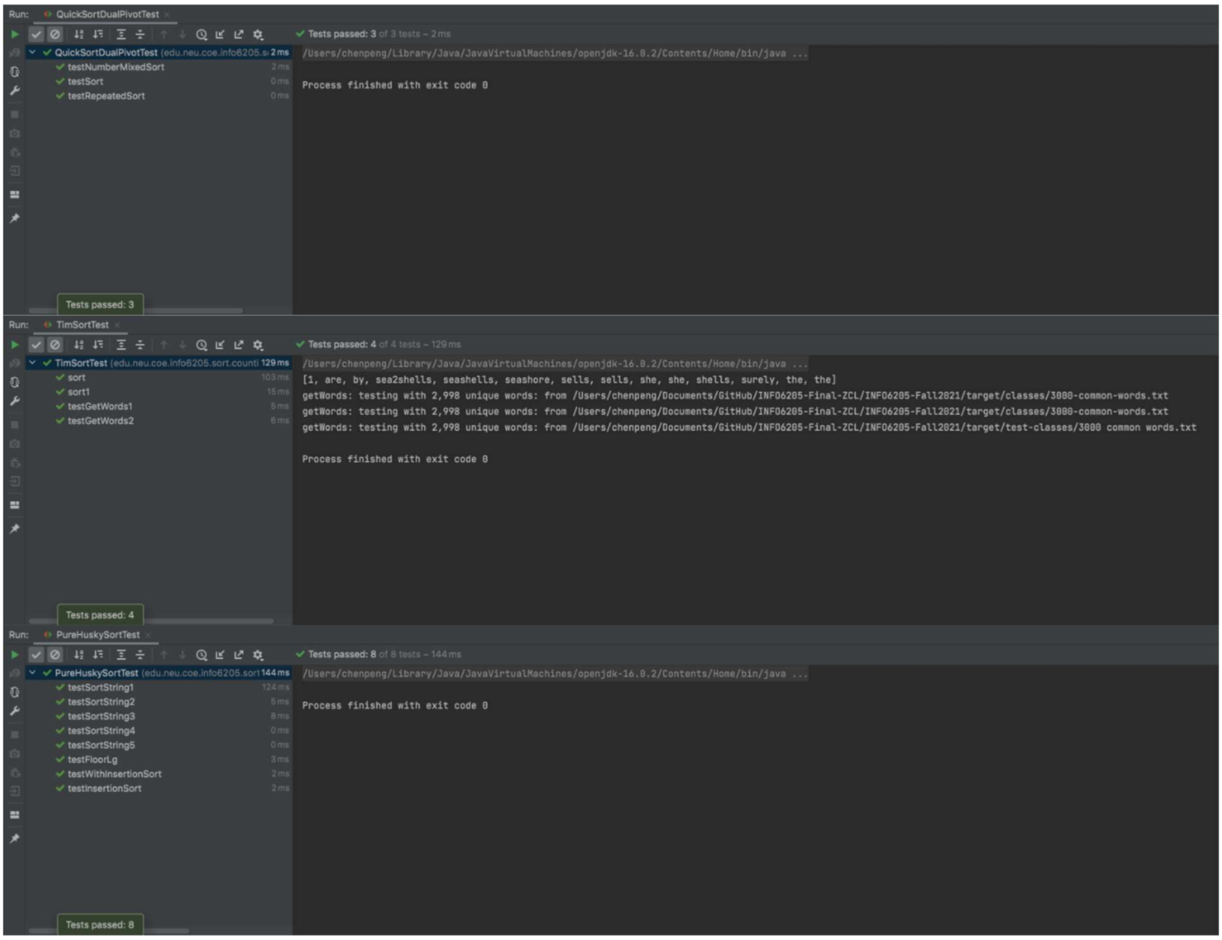


```
Tests passed: 4 of 4 tests – 242 ms
✓ LSDStringSortTest (edu.neu.coe.info6205.sort 242 ms
    ✓ sort                4 ms
    ✓ sort1             214 ms
    ✓ testGetWords1      10 ms
    ✓ testGetWords2      14 ms
```

```
/Users/chenpeng/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...
[1, are, by, sea2shells, seashells, seashore, sells, sells, she, she, shells, surely, the, the]
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/test-classes/3000 common words.txt

Process finished with exit code 0
```

```
Tests passed: 4 of 4 tests – 158 ms
✓ MSDStringSortTest (edu.neu.coe.info6205.sort 158 ms
    ✓ MSDStringSortTest.sort               3 ms
    ✓ MSDStringSortTest.sort1            145 ms
    ✓ MSDStringSortTest.testGetWords1      4 ms
    ✓ MSDStringSortTest.testGetWords2      6 ms
```

```
/Users/chenpeng/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...
[1, are, by, sea2shells, seashells, seashore, sells, sells, she, she, shells, surely, the, the]
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/test-classes/3000 common words.txt

Process finished with exit code 0
```



```
✓ Tests passed: 3 of 3 tests – 2 ms
✓ QuickSortDualPivotTest (edu.neu.coe.info6205.s 2 ms
    ✓ testNumberMixedSort   2 ms
    ✓ testSort              0 ms
    ✓ testRepeatedSort      0 ms
```

```
/Users/chenpeng/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...

Process finished with exit code 0
```

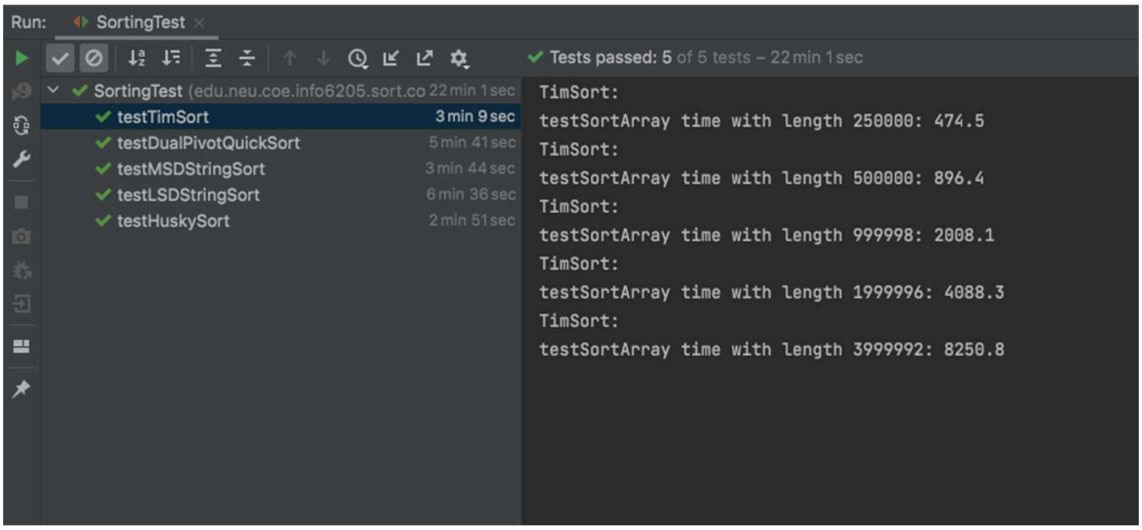
```
✓ Tests passed: 4 of 4 tests – 129 ms
✓ TimSortTest (edu.neu.coe.info6205.sort.counti 129 ms
    ✓ sort              103 ms
    ✓ sort1              15 ms
    ✓ testGetWords1       5 ms
    ✓ testGetWords2       6 ms
```

```
/Users/chenpeng/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...
[1, are, by, sea2shells, seashells, seashore, sells, sells, she, she, shells, surely, the, the]
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/classes/3000-common-words.txt
getWords: testing with 2,998 unique words: from /Users/chenpeng/Documents/GitHub/INFO6205-Final-ZCL/INFO6205-Fall2021/target/test-classes/3000 common words.txt

Process finished with exit code 0
```

```
✓ Tests passed: 8 of 8 tests – 144 ms
✓ PureHuskySortTest (edu.neu.coe.info6205.sort 144 ms
    ✓ testSortString1          124 ms
    ✓ testSortString2            5 ms
    ✓ testSortString3            8 ms
    ✓ testSortString4            0 ms
    ✓ testSortString5            0 ms
    ✓ testFloorLg                3 ms
    ✓ testWithInsertionSort      2 ms
    ✓ testInsertionSort          2 ms
```

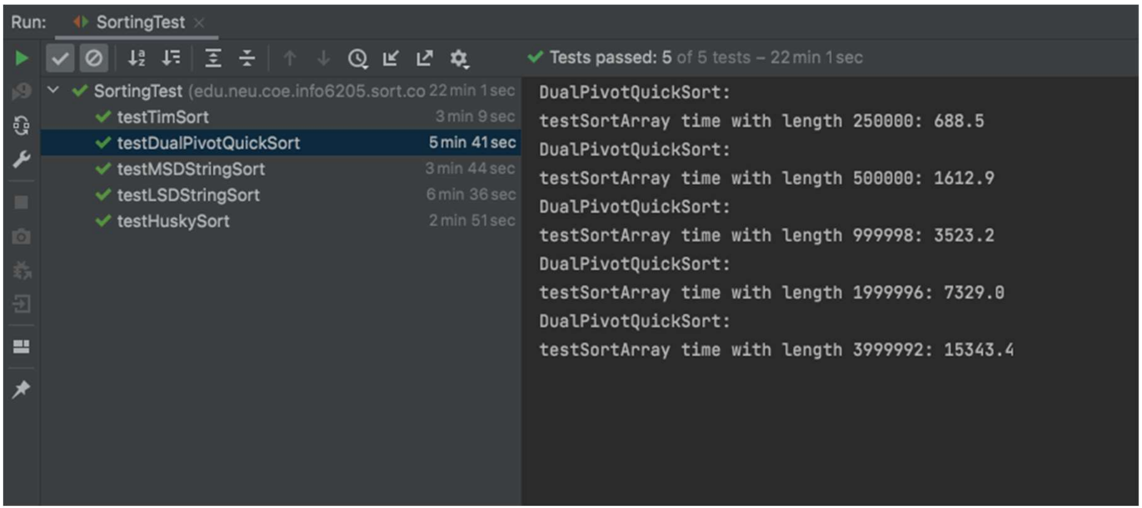
```
/Users/chenpeng/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...

Process finished with exit code 0
```

Benchmarks:



```
✓ Tests passed: 5 of 5 tests – 22 min 1 sec
✓ SortingTest (edu.neu.coe.info6205.sort.co 22 min 1 sec
    ✓ testTimSort                3 min 9 sec
    ✓ testDualPivotQuickSort     5 min 41 sec
    ✓ testMSDStringSort          3 min 44 sec
    ✓ testLSDStringSort          6 min 36 sec
    ✓ testHuskySort              2 min 51 sec
```

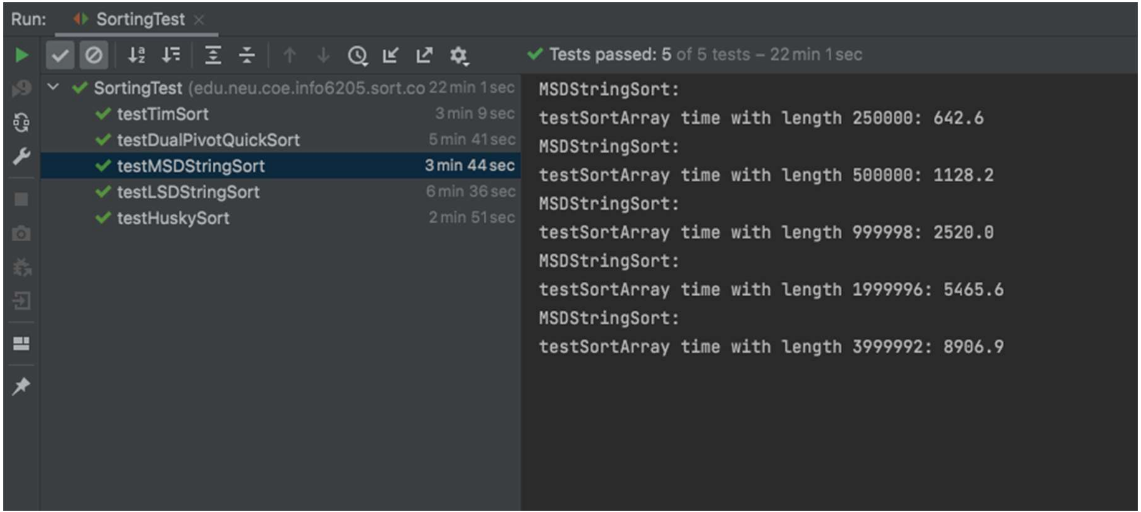
```
TimSort:
testSortArray time with length 250000: 474.5
TimSort:
testSortArray time with length 500000: 896.4
TimSort:
testSortArray time with length 999998: 2008.1
TimSort:
testSortArray time with length 1999996: 4088.3
TimSort:
testSortArray time with length 3999992: 8250.8
```



✓ Tests passed: 5 of 5 tests – 22 min 1 sec

```
✓ SortingTest (edu.neu.coe.info6205.sort.co 22 min 1 sec
   ✓ testTimSort                            3 min 9 sec
   ✓ testDualPivotQuickSort                 5 min 41 sec
   ✓ testMSDStringSort                      3 min 44 sec
   ✓ testLSDStringSort                      6 min 36 sec
   ✓ testHuskySort                          2 min 51 sec
```

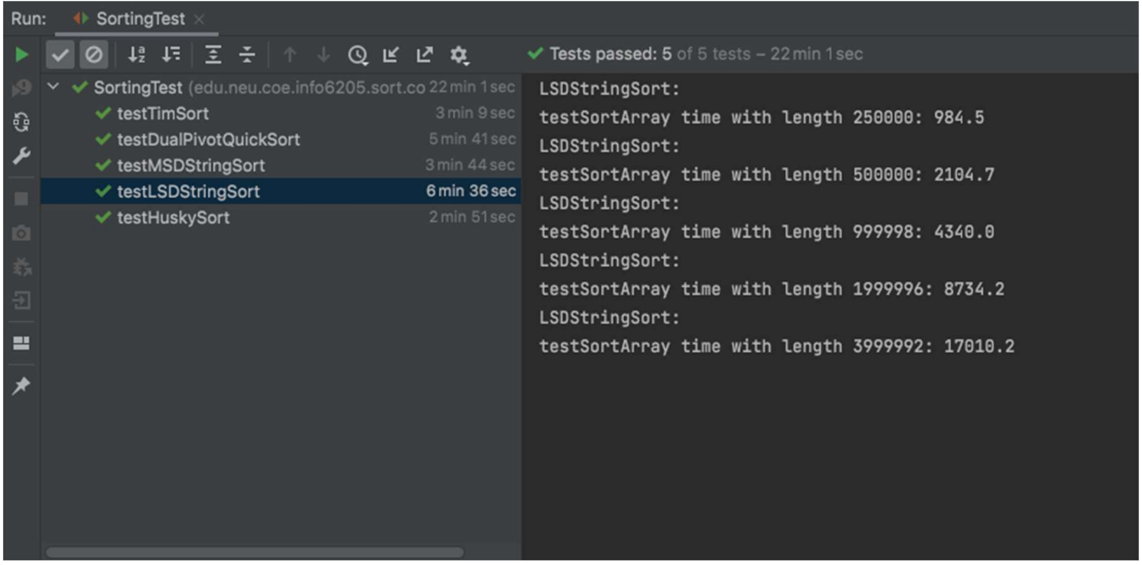
```
DualPivotQuickSort:
testSortArray time with length 250000: 688.5
DualPivotQuickSort:
testSortArray time with length 500000: 1612.9
DualPivotQuickSort:
testSortArray time with length 999998: 3523.2
DualPivotQuickSort:
testSortArray time with length 1999996: 7329.0
DualPivotQuickSort:
testSortArray time with length 3999992: 15343.4
```



✓ Tests passed: 5 of 5 tests – 22 min 1 sec

```
✓ SortingTest (edu.neu.coe.info6205.sort.co 22 min 1 sec
   ✓ testTimSort                            3 min 9 sec
   ✓ testDualPivotQuickSort                 5 min 41 sec
   ✓ testMSDStringSort                      3 min 44 sec
   ✓ testLSDStringSort                      6 min 36 sec
   ✓ testHuskySort                          2 min 51 sec
```

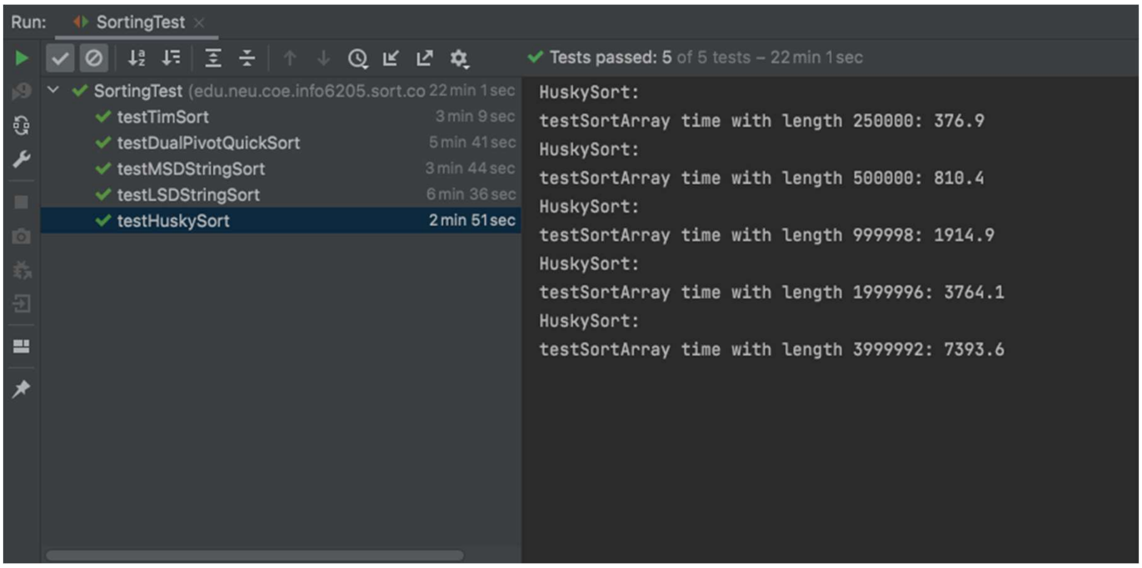
```
MSDStringSort:
testSortArray time with length 250000: 642.6
MSDStringSort:
testSortArray time with length 500000: 1128.2
MSDStringSort:
testSortArray time with length 999998: 2520.0
MSDStringSort:
testSortArray time with length 1999996: 5465.6
MSDStringSort:
testSortArray time with length 3999992: 8906.9
```



✓ Tests passed: 5 of 5 tests – 22 min 1 sec

```
✓ SortingTest (edu.neu.coe.info6205.sort.co 22 min 1 sec
   ✓ testTimSort                            3 min 9 sec
   ✓ testDualPivotQuickSort                 5 min 41 sec
   ✓ testMSDStringSort                      3 min 44 sec
   ✓ testLSDStringSort                      6 min 36 sec
   ✓ testHuskySort                          2 min 51 sec
```

```
LSDStringSort:
testSortArray time with length 250000: 984.5
LSDStringSort:
testSortArray time with length 500000: 2104.7
LSDStringSort:
testSortArray time with length 999998: 4340.0
LSDStringSort:
testSortArray time with length 1999996: 8734.2
LSDStringSort:
testSortArray time with length 3999992: 17010.2
```



Tests passed: 5 of 5 tests – 22 min 1 sec

```
SortingTest (edu.neu.coe.info6205.sort.co 22 min 1 sec
    testTimSort                    3 min 9 sec
    testDualPivotQuickSort         5 min 41 sec
    testMSDStringSort              3 min 44 sec
    testLSDStringSort              6 min 36 sec
    testHuskySort                  2 min 51 sec
```

```
HuskySort:
testSortArray time with length 250000: 376.9
HuskySort:
testSortArray time with length 500000: 810.4
HuskySort:
testSortArray time with length 999998: 1914.9
HuskySort:
testSortArray time with length 1999996: 3764.1
HuskySort:
testSortArray time with length 3999992: 7393.6
```