**20181123数据结构作业**

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**我承诺诚实作业，没有抄袭他人！**

1. **第2题**：**请查看可执行代码项目，代码使用JetBrain开发的Clion书写。**
2. **第3题**：试给出采用增量序列的Shell排序的时间代价为Θ的推理过程。

**解**：

**说明**：以下证明中以实数来确定时间复杂度的推算，不考虑取整的处理，因为无论是否取整对结果都没有影响。

1. **引入引理**：如果一个数组以增量g已经有序，以增量h已经有序，并且g和h互质，都是d的常熟倍(Θ(d))，则以增量d对a排序的时间复杂度为Θ(nd)。
2. 我们从增量序列中找到一个最接近的，来考察该增量序列下时间复杂度的上下界，即对k≤t和k＞t的情况下的时间复杂度。k为序列的数量。
3. **k**≤**t**：对于，容易看到，因此对于增量，其排序的时间复杂度为，那么对于所有的1≤k≤t，其总时间复杂度为，而和一个数量级，因此总是时间复杂度为。
4. **k＞t**：对于，需要对长度为的子序列分别排序，由于对于长度为n的序列进行直接插入排序的时间代价是，因此对个长度为排序的时间复杂度为即，那么对于所有k＞t，其总时间复杂度为，根据等比数列性质，他与一个数量级，所以总时间复杂度为，即。

**综上，采用增量序列的Shell排序的时间代价为Θ。**

1. **第7题**：在堆排序中采用的堆是基于二叉树的，因此时间代价是Θ(n log n)。如果基于三叉树的堆来实现堆排序，时间代价是否会变为Θ()？是编写出基于三叉树的堆排序算法，并分析时间代价。

**解**：**算法请查看可执行代码项目，代码使用JetBrain开发的Clion书写**

**分析时间代价**：

算法与二叉树相差不大，核心部分首先是建立初始大顶堆，然后进行n次大顶堆的调整。建立大顶堆所需时间为Θ(n)，调整n次大顶堆所花费的时间代价都是Θ()，所以总的时间代价是Θ()。因为三叉树的树高只在级别，共n次操作，从而时间代价就是Θ()。但要注意的是其本质上和Θ(n log n)等价，因为。

1. **第25题**：在下列情况下，你会选择那种排序算法？请说明理由。
2. **需要对1000个数字进行排序，程序只需运行一次**

**解**：采用归并排序或堆排序。1000个数字是一个规模较大的数据集，因此适用O(n log n)的算法。不采用快速排序是因为数字的初始状态不知，快速排序有可能达到最坏的情况，这两种排序虽然比平均上比快拍慢，但是速度稳定，最好和最差都是O(n log n)级别。

1. **只需要对50个数字进行排序，程序只需运行一次。**

**解**：选择直接插入排序。50数字属于小规模数据，因此O(n log n)的算法没必要采用。不采用选择排序和冒泡排序是因为他们的速度没有直接插入排序快，他们有过多的时间浪费在了比较上面。

1. **在编写一个很庞大的程序中需要编写一个对5个记录进行排序的函数，而且该函数将被反复调用很多次。**

**解**：采用直接插入排序或归并排序。从教材P231页表8.4可知，对于这种小规模数据，这两种算法的效率最佳。

1. **需要对1000个大型的记录进行排序，记录本身存储在外存中，在内存中只保存了所有记录的排序码。排序码之间的比较非常快，但是移动代价大，因为一旦移动一个排序码，相应的外存中的记录也要移动，将涉及上百个磁盘块的移动。**

**解**：采用直接选择排序。1000个数字是大数据，但是由于O(n log n)算法的移动次数无法估量，因此风险保守考虑不采用。三个简单排序算法中移动次数只有直接选择排序的平均情况是O(n)的代价，其他两个平均状况都是O(n²)，因此采用直接选择排序。

1. **在图书馆中里计算机类书籍区，一共有12列书架，书架上的书本都是按照编目号排列好的，但其中有些书被读者放错了地方，但通常不会偏离超过一个书架。试设计一个算法将这些数重新放回正确的位置。**

**解**：根据题目开始要求（选择那种排序算法并说明理由），这里不考虑算法的具体实现。**应当选择插入排序**。这里类似索引排序中每个小分组选择的排序，在分组内选择插入排序就可以，因为数据规模比较小。

1. **需要将500张随机排列的图书卡片按照字母顺序排好序**。

**解**：选择快速排序。对于随机排列且数据规模较大的情况下，快速排序有着最佳的优势。

1. **已知一个包含了5000个单词的列表已按照字母顺序排好列，需要再进行一次检查，确保所有单词已经排好序。**

**解**：选择冒泡排序。由于列表中单词已经基本有序，只需要进行一次检查，那么冒泡排序可以用于检查，即在有序的情况下，冒泡排序只需检查一次就可确定是否有序。

1. **第26题**：某整型数组A的10个元素值依次为{6,2,9,7,3,8,4,5,0,1}用下列各排序方法，将A中的元素有小到大排序。
2. 取第一个元素值为6作为分割数，试写出快速排序第一次分隔后A中的结果。

**解**：使用表格来看一下第一次快速排序的操作过程。其中6为分割数，将它从位置0暂时拿出来，并从数组末端即指针j开始查找。

1. **初始状态**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** | ↓ |  |  |  |  |  |  |  |  |  |
| **数组** |  | 2 | 9 | 7 | 3 | 8 | 4 | 5 | 0 | 1 |
| **指针j** |  |  |  |  |  |  |  |  |  | ↑ |

1. **第一次查找，发现1小于6，将它放置在下标0，并将**。

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  | ↓ |  |  |  |  |  |  |  |  |
| **数组** | 1 | 2 | 9 | 7 | 3 | 8 | 4 | 5 | 0 |  |
| **指针j** |  |  |  |  |  |  |  |  |  | ↑ |

1. **第二次查找，发现9大于6，将它放在下标9，并将指针j--。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  | ↓ |  |  |  |  |  |  |  |
| **数组** | 1 | 2 |  | 7 | 3 | 8 | 4 | 5 | 0 | 9 |
| **指针j** |  |  |  |  |  |  |  |  | ↑ |  |

1. **第三次查找，发现0小于6，将它放置在指针i所对位置下标2，并将i++。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  | ↓ |  |  |  |  |  |  |
| **数组** | 1 | 2 | 0 | 7 | 3 | 8 | 4 | 5 |  | 9 |
| **指针j** |  |  |  |  |  |  |  |  | ↑ |  |

1. **第四次查找，发现7大于6，将它放置在j所指位置下标8，并将j--。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  | ↓ |  |  |  |  |  |  |
| **数组** | 1 | 2 | 0 |  | 3 | 8 | 4 | 5 | 7 | 9 |
| **指针j** |  |  |  |  |  |  |  | ↑ |  |  |

1. **第五次查找，发现5小于6，将其放在i所指位置下标3，并将i++。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  |  | ↓ |  |  |  |  |  |
| **数组** | 1 | 2 | 0 | 5 | 3 | 8 | 4 |  | 7 | 9 |
| **指针j** |  |  |  |  |  |  |  | ↑ |  |  |

1. **第六次查找，发现8大于6，将其放在j所指位置下标7，并将j--。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  |  |  | ↓ |  |  |  |  |
| **数组** | 1 | 2 | 0 | 5 | 3 |  | 4 | 8 | 7 | 9 |
| **指针j** |  |  |  |  |  |  | ↑ |  |  |  |

1. **第七次查找，发现4小于6，将其防止在i所指位置下标5，并将i++。**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  |  |  |  | ↓ |  |  |  |
| **数组** | 1 | 2 | 0 | 5 | 3 | 4 |  | 8 | 7 | 9 |
| **指针j** |  |  |  |  |  |  | ↑ |  |  |  |

1. **第八次查找，发现i与j相遇，代表第一次的分隔结束，将6放置在i所指位置下标6结束。所得到最终序列如表中数组所示{1,2,0,5,3,4,6,8,7,9}**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **下标** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **指针i** |  |  |  |  |  |  | ↓ |  |  |  |
| **数组** | 1 | 2 | 0 | 5 | 3 | 4 | 6 | 8 | 7 | 9 |
| **指针j** |  |  |  |  |  |  | ↑ |  |  |  |

1. 用堆排序，试写出将第一个选出的数据放在A的最后位置上，将A调整成堆后的A中结果。

**解**：题目中是“写出”，并没有要求过程，因此直接给出堆排序的答案。

**建立初始大顶堆**：{9,7,8,5,3,6,4,2,0,1}

**将第一个放置最后位置**：{7,8,5,3,6,4,2,0,1,9}

**再次调整**：{8,7,6,5,3,1,4,2,0,1,9}，此为最终答案

1. 用基数为3的基数排序法，试写出第一次分配和收集后A中的结果

**解**：由于本题的元素非常特殊，因此第一次分配和收集后A中结果为{0,1,2,3,4,5,6,7,8,9}

1. **第27题**：已知一组元素的排序码为{46,74,16,53,14,26,40,53’,86,65,27,34}
2. **利用直接插入排序的方法写出每次向前面有序表插入一个元素后的排序结果**

**解：已经就位的元素以浅绿色底色标记，每次被操作的元素以边框标记**

1. **第1次**：46是第一个元素，不需要动：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第2次**：74大于46，不需要动：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第3次**：将16插入到下标0，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 16 | 46 | 74 | 53 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第4次**：将53插入在下标2，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 16 | 46 | 53 | 74 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第5次**：将14插入下标0，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 46 | 53 | 74 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第6次**：将26插入到下标2，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 46 | 53 | 74 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第7次**：将40插入到下标3，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 40 | 46 | 53 | 74 | 53’ | 86 | 65 | 27 | 34 |

1. **第8次**：将53’插入到下标6，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 40 | 46 | 53 | 53’ | 74 | 86 | 65 | 27 | 34 |

1. **第9次**：86大于74，因而不需要挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 40 | 46 | 53 | 53’ | 74 | 86 | 65 | 27 | 34 |

1. **第10次**：将65插入到下标7，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 | 27 | 34 |

1. **第11次**：将27插入到下标3，并将其他已就位元素向后挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 | 34 |

1. **第12次**：将34插入到下标4，并将其他已就位元素向后挪动。

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

**第12次所得序列即为最终的使用插入排序所得序列。**

1. **利用直接选择排序方法写出每次选择和交换后的排列结果**

**解：每次就位的最大元素以浅绿色底色标记。采用每次选择最大的方法**

1. **第1次**：从下标0-11中选出最大的元素即86与下标11的元素34交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 34 | 65 | 27 | 86 |

1. **第2次**：从下标0-10中选出最大的元素即74与下标10的元素27交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 27 | 16 | 53 | 14 | 26 | 40 | 53’ | 34 | 65 | 74 | 86 |

1. **第3次**：从下标0-9中选出最大的元素即65，发现不需要挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 27 | 16 | 53 | 14 | 26 | 40 | 53’ | 34 | 65 | 74 | 86 |

1. **第4次**：从下标0-8中选出最大的元素即53（注意是从下标0开始查找）与下标8的元素34交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 27 | 16 | 34 | 14 | 26 | 40 | 53’ | 53 | 65 | 74 | 86 |

1. **第5次**：从下标0-7中选出最大的元素即53’，发现不需要挪动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 27 | 16 | 34 | 14 | 26 | 40 | 53’ | 53 | 65 | 74 | 86 |

1. **第6次**：从下标0-6中选出最大的元素即46与下标6的元素40交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 40 | 27 | 16 | 34 | 14 | 26 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第7次**：从下标0-5中选出最大的元素即40与下标5的元素26交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 26 | 27 | 16 | 34 | 14 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第8次**：从下标0-4中选出最大的元素即34与下标4的元素14交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 26 | 27 | 16 | 14 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第9次**：从下标0-3中选出最大的元素即27与下标3的元素14交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 26 | 14 | 16 | 27 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第10次**：从下标0-2中选出最大的元素即26与下标2的元素16交换

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 16 | 14 | 26 | 27 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第11次**：从下标0-1中选出最大的元素16，发现不需要挪动，而此时就是最后的操作，剩余一个元素不要再比较。**第11次所得序列即为最终的排序序列**。

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 | 34 |

1. 利用最大堆排序写出在构成初始堆和利用堆排序的过程中，每次过筛(代码5.1中的函数ShiftDown)运算后的排列结果，并画出初始堆所对应的完全二叉树
2. ­**第1次**：初始堆

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 86 | 74 | 40 | 53’ | 65 | 34 | 16 | 46 | 53 | 14 | 27 | 26 |

1. **第2次**：第1次ShiftDown，86已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 74 | 65 | 40 | 53’ | 27 | 34 | 16 | 46 | 53 | 14 | 26 | 86 |

1. **第3次**：第2次ShiftDown，86、74已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 65 | 53’ | 40 | 53 | 27 | 34 | 16 | 46 | 26 | 14 | 74 | 86 |

1. **第4次**：第3次ShiftDown，86、74、65已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 53’ | 53 | 40 | 46 | 27 | 34 | 16 | 14 | 26 | 65 | 74 | 86 |

1. **第5次**：第4次ShiftDown，86、74、65、53’已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 53 | 46 | 40 | 26 | 27 | 34 | 16 | 14 | 53’ | 65 | 74 | 86 |

1. **第6次**：第5次ShiftDown，86、74、65、53’、53已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 27 | 40 | 26 | 14 | 34 | 16 | 53 | 53’ | 65 | 74 | 86 |

1. **第7次**：第6次ShiftDown，86、74、65、53’、53、46已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 40 | 27 | 34 | 26 | 14 | 16 | 46 | 53 | 53’ | 65 | 74 | 86 |

1. **第8次**：第7次ShiftDown，86、74、65、53’、53、46、40已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 34 | 27 | 16 | 26 | 14 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

1. **第9次**：第8次ShiftDown，86、74、65、53’、53、46、40、34已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 27 | 26 | 16 | 14 | 34 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

1. **第10次**：第9次ShiftDown，86、74、65、53’、53、46、40、34、27已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 26 | 14 | 16 | 27 | 34 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

1. **第11次**：第10次ShiftDown，86、74、65、53’、53、46、40、34、27、26已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 16 | 14 | 26 | 27 | 34 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

1. **第12次**：第11次ShiftDown，86、74、65、53’、53、46、40、34、27、26、16已经就位

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53 | 53’ | 65 | 74 | 86 |

此时堆排序结束，所得序列就是最终的序列

**初始堆对应的二叉树如下**：

**在下一页**

86

40

74

53’

65

16

34

53

14

26

27

46

1. 采用快速排序，每次都取子序列的最左元素为轴值，写出每一层划分后的排列结果，并画出由此快速排序

注，**这里的快速排序每次从数组最末端开始**。

1. **第1次划分结果**：轴值为46

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 34 | 27 | 16 | 40 | 14 | 26 | 46 | 53’ | 86 | 65 | 53 | 74 |

1. **第2次划分结果**：轴值为34和53’

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 26 | 27 | 16 | 14 | 34 | 40 | 46 | 53’ | 86 | 65 | 53 | 74 |

1. **第3次划分结果**：轴值为26、86，其中40由于元素只有一个，因此不需要再动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53’ | 74 | 65 | 53 | 86 |

1. **第4次划分结果**：轴值为14、16、74，其中27由于元素只有一个，因此不需要再动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

1. **第5次划分结果**：轴值为53，由于16元素只有一个，因此不需要再动

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |

**到此，快速排序到达最底层，已经全部结束。**

**二叉搜索树在下页，浅绿色底色为每层的轴值**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 34 | 27 | 16 | 40 | 14 | 26 | 46 | 53’ | 86 | 65 | 53 | 74 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 14 | 16 | 26 | 27 | 34 | 40 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 53’ | 74 | 65 | 53 | 86 |

|  |  |  |  |
| --- | --- | --- | --- |
| 53 | 65 | 74 | 86 |

|  |  |  |  |
| --- | --- | --- | --- |
| 14 | 16 | 26 | 27 |

1. **利用归并排序的方法写出每一趟二路归并排序后的结果**
2. **初始状态**：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 86 | 65 | 27 | 34 |

1. **第1次归并结果**：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 46 | 74 | 16 | 53 | 14 | 26 | 40 | 53’ | 65 | 86 | 27 | 34 |

1. **第2次归并结果**：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 16 | 46 | 53 | 74 | 14 | 26 | 40 | 53’ | 27 | 34 | 65 | 86 |

1. **第3次归并结果**：

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 40 | 46 | 53 | 53’ | 74 | 27 | 34 | 65 | 86 |

1. **第4次归并结果**：直接合并

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 下标 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 元素 | 14 | 16 | 26 | 27 | 34 | 40 | 46 | 53’ | 53 | 65 | 74 | 86 |