Algorithm Lab

Week 2: Non-Comparison Sort

Description

Classical sorting algorithms are algorithms rearrange the input list to a certain order defined by the comparison function. For some special domain (in most case, subdomain of natural numbers), we can design special sorting algorithms that working without generalized comparison functions, respectively, non-comparison sorting algorithms.

Instance: a list of non-negative integers $A = (a_1, a_2, \dots, a_n)$ *that for all* $1 \leq i \leq n, 0 \leq i < r^d$ *where* r *is radix and* d *is the position of most significant digit.*

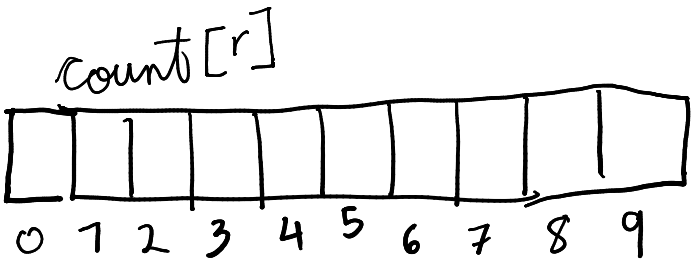
Result: a list $B = (b_1, b_2, \dots, b_n)$ *that* $\{a_1, a_2, \dots, a_n\} = \{b_1, b_2, \dots, b_n\}$ *and for all* $1 < i \leq n, b_{i-1} < b_i$.

Algorithm Design

1. Set processing position to least significant order.
2. Rearrange the list by digit at processing position.
3. Set processing position to next digit.
4. Repeat step 2, 3 until finished the most significant digit rearrangement.

Implementation

Language: C




```
void sort_by_digit(int *A, int n, int r, int p)
{
        int base = 1;
        while (p > 0)
        {
                --p;
                base *= r;
        }
        int count[r], B[n], m = 0;
        for (int j = 0; j < r; ++j)
                count[j] = 0;
        for (int i = 0; i < n; ++i)
                count[(A[i] / base) % r]++;
        for (int j = 0, psum = 0, sum = 0; j < r; ++j)
        {
                psum = sum;
                sum += count[j];
                count[j] = psum;
        }
        for (int i = 0; i < n; ++i)
                B[count[(A[i] / base) % r]++] = A[i];
        for (int i = 0; i < n; ++i)
                A[i] = B[i];
}
```

#of numbers

List of #

ex. 10

position of digit to be sorted

count to zero

count # of radix at lose position

Cummulative sum shifted 1 to the right

Puts A[i] into B[order] after that increments the number stored in count

Copies B into A

```
void radix_sort(int *A, int n, int r, int d)
{
        for (int i = 0; i < d; ++i)
                sort_by_digit(A, n, r, i);
}
```

Questions

- Function sort_by_digit is a stable counting sort. If we rewrite the function to an unstable version, can radix sort still work correctly?
- This radix implement is processing through least significant digit to most significant digit. Can't you design radix algorithm which start at most significant digit?
- Please design an algorithm to measure minimum usable d of list A and radix r.
- Please analysis the space complexity and the time complexity. (should be functions with arguments n, r, d)

1.) Yes as long as all the digit positions are sorted

2.) for (i = d-1; i ≥ 0; i--)

3.) int r=0, D=0, x=0, y=0;

```
for (int i=0; i<n; i++){
    x = to_string(A[i]).lenght
    if (x > D) D=x;
    while (x != 0){
        y = A[i] % 10;
        if (y > r) r=y;
        x /= 10;
        }
}
```

D will be the number of digits of the longest number
r will be the highest digit of all positions

4.) Time complexity $O(d(2r+3n))$

space complexity $O(n+r)$