Two Pointers October

Date: October 4th, 2021

→ Two pointer

X ← → pointer

A: [| | |]

pt → stop traversing the rest of the array!

1) When to place the 2 pointers initially?

2) When to update the 2 pointers.

Q Given a sorted array A and integer K. Find a pair (i,j) $\boxed{A_i + A_j = K}$

2.2.18

A: [1 | 3 | 5 | 14 | 25 | 34]

$K = 39$ $25+14$ $i \to A_i$ $A_j = K - A_i$ $(1,4)$ $39 - 25 = 14$

1) Brute force

$f(i: 0 \to n)$

$f(j: 0 \to n)$

if $(A_i + A_j = K)$

$\to (i,j)$

TC: $O(n^2)$

SC: $O(1)$

2) Binary Search

$f(i: 0 \to n)$

for A_i: $O(\log n)$

B_S find $K - A_i$

(i,j)

TC: $O(n \log n)$

SC: $O(1)$

3) Hashing

hm

$f(i: 0 \to n)$ $O(n)$

$hm[A_i] = i$

$f(i: 0 \to n)$ $O(n)$

for A_i:

find $K - A_i$ in HM $O(1)$

TC: $O(n)$

SC: $O(n)$

4) Two pointer

$k = 25$

A: [1 | 3 | 5 | 14 | 25 | 34]

$3 + 5 = 25 == 25$!

$i = 0$, $j = n-1$

while $(i < j)$ {

$sum = A[i] + A[j]$

if $sum == k$

$i++$

$j--$

}

(i,j)

TC: $O(n)$

SC: $O(1)$

Q Given a sorted array. Find a pair (i,j) $\boxed{A_j - A_i = K}$

$k = 15$

A: [1 | 3 | 5 | 14 | 17 | 23 | 29]

1) BF

TC: $O(n^2)$

SC: $O(1)$

2) BS

$A_j - A_i = K$

$A_j = A_i + K$

for $i \to n$: A_i

find $K + A_i$ using BS

TC: $O(N \log N)$

SC: $O(1)$

3) HM

TC: $O(n)$

SC: $O(n)$

for $i \to n$

find $K + A_i$ in HM

4) Two pointer

$(3,5)$

$k = 15$

A: [1 | 3 | 5 | 14 | 17 | 23 | 29]

i

$3 + 5 = 15 + 3 = 18$

$2.4.4$

TC: $O(n)$

SC: $O(1)$

Q Find a triplet (i,j,k). Such that $\boxed{A_i + A_j + A_k = K}$

2.2.18

A: [1 | 3 | 5 | 14 | 23 | 29]

$k = 38$

$(1,3,5)$

1) BF

$O(n^3)$

2) BS

$A_i + A_j + A_k = K$

$A_k = (A_i + A_j)$

$f(i: 0 \to n)$ $O(n)$

$f(j: i \to n)$ $O(n)$

find $K - A_i - A_j$

if $A_k \in A$

find $K - (A_i + A_j)$ using BS

$O(n \log n)$

TC: $O(N^2 \log n)$

SC: $O(1)$

3) HM

for A_i: A_j $O(n^2)$

TC: $O(n^2)$

SC: $O(n)$

find $K - (A_i + A_j)$ $O(1)$

HM

4) Two pointer → $(3,5)$

$k = 38$

A: [1 | 3 | 5 | 14 | 23 | 29]

$29 - 5$

$24 > 5$

TC: $O(n^3)$

SC: $O(1)$

$38 - 29$

$9 < 5$

K-Sum $O(N^{k-1})$

Q Given an array of size 10^5. Find a subarray whose sum $= K$. $k = 33$

A: [1 | 10 | 15 | 20 | 25 | 3]

$(1,4)$

1) BF

$O(n)$

for subarray

for $i \to n$

$O(n)$

TC: $O(n^2)$

SC: $O(1)$

$O(n^2)$

2) BF + P.S

$O(n)$

for subarray

$O(n)$

$N + N^2 + N$

TC: $O(N^2)$

SC: $O(N)$

$O(1)$

A: [1 | 3 | 5 | 14 | 15 | 3]

$k = 33$

PS: [1 | 15 | 25 | 39 | 32 | 35]

$ps[j] - ps[i-1] = k$

$A: 1 \; 3 \; 5 = 5$

$PS: 1 \; 4 \; 9 = 1$

TC: $O(N)$

SC: $O(N) \to O(1)$

$k = 7$

A: [1 | 10]

PS: [0 | 1 | 11]

$0 < 7$

$1 < 7$

$11 > 7$

A: [1 | 3 | 14 | 10 | 15 | 2]

$k = 18$

$\boxed{\text{if } S == 18}$

$S = \cancel{1} \; \cancel{4} \; \cancel{18}$

$\cancel{2} \; \cancel{17} \; 18$

TC: $O(N)$

SC: $O(1)$

Q Rain Water Trapping

max h

$2, 6$

$(6-2) \times 5$

$4 \times 5 = 20$

$(5,1)$ $= \boxed{(j-i) \times \min(A_j, A_i)}$

A_i

$(j-i) \times \min(A_j, A_i)$

$(5-1) \times 5$

$= 4 \times 5$

$= 20$

$(5-3) \times 6$

$= 2 \times 6$

$= 12$

$(5-4) \times 5$

$= 1 \times 5$

$= 5$

$(5-5) \times 2$

$= 0$

$(j-i) \times 2$

$= 0$

A_j

A_i

$\max(A_i, A_j)$

$\boxed{\text{if } (j < i)}$

$O(n)$

TC: $O(n)$

SC: $O(1)$

Q Given a sorted array of distinct integers. Count the no. of triplets with distinct indexes s.t. $a + b < K$

$L \neq 0$ can be any of values from the array!

A: [2 | 3 | 5] → $L \neq 0$

$K = 15$

$2 + 3 < 15$

$2 + 5 < 15$

$3 + 5 < 15$

$3 + 2 < 15$

$5 + 2 < 15$

$5 + 3 < 15$

$2 + 3 < 15$

$2 + 5 < 15$

$3 + 5 < 15$

$3 + 2 < 15$

$5 + 2 < 15$

$5 + 3 < 15$

A: 3

$A_i + A_j < K$

$K = 15$

A: [2 | 3 | 5 | 7 | 8 | 9]

i

$L \neq 2$, $L \neq 3$

$L \neq 5 = 12 < 15$

$= \boxed{\text{any} - 2}$

$2 \times (j - i + 1) - 1$

$2 \times 2 - 1$

$A_i + A_j < K$

N^2

TC: $O(n^2)$

SC: $O(1)$