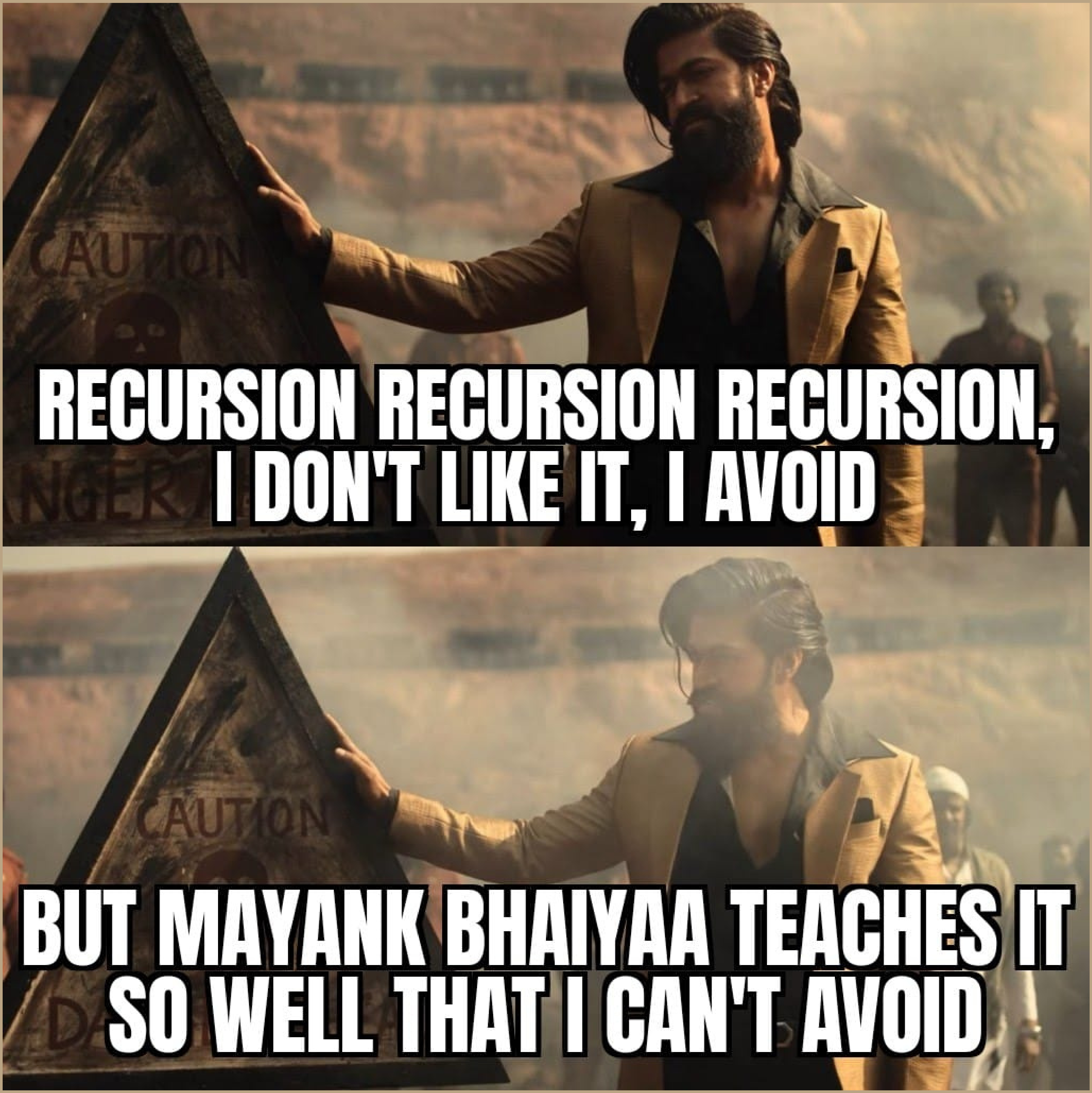

CAUTION
RECURSION RECURSION RECURSION,
I DON'T LIKE IT, I AVOID
CAUTION
BUT MAYANK BHAIYAA TEACHES IT
SO WELL THAT I CAN'T AVOID

OKAY, so now I got your attention, here is something important that you would have missed if you haven't followed me (LIKE the post rightnow, so it reaches to max. audience)

After my Binary Search CrashCamp SlideDeck, I'm now on a mission to make Recursion as easy as Binary Search(Guys just loved my way of teaching Binary Search)

Yesterday, dropped an introductory episode on Recursion, so the frequency of uploads will be every alternate day

I'm attaching yesterday's Deck here but what I want from you guys is to find a recurrence relation in below problems (easy to hard, mostly on Leetcode), in coming Slides I'll be focussing on them

- Sum of an array
- Sort the array
- Reverse a Stack
- Mid element of Stack
- Pow(x,n)
- String Permutations
- Binary Search on Array (using Recursion)
- Kth Symbol of Grammar
- Longest Common Subsequence
- Longest Palindromic Subsequence (don't use LCS way)
- Matrix Chain Multiplication
- Decode String
- Reverse Nodes in K groups
- Wildcard Matching

...many more

ON A MISSION TO MAKE YOU LOVE DSA

CRASH CAMP

RECURSION

Introduction

LET'S THINK

RECURSIVLEY

Ruyank: Bhaiyaa can you help me to overcome 'fear' of 'Recursion' pls ?

Bhaiyaa: Okay, tell me what you know about 'Recursion' !

Ruyank: When a function calls itself, it is Recursion

Bhaiyaa: So you just know the definition part, let me help you in visualizing it once.

Ruyank, you are given following array nums[], calculate sum of all elements

0	1	2
2	1	3

Ruyank: Simple, define a variable sum = 0 & iterate from 0th index to last in a loop and do sum += nums[i]

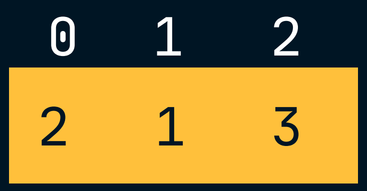
Bhaiyaa: Okay that was pretty simple and also the intuitive solution but can you think of some other approach ?

Ruyank: No bhaiyaa, I can only come up with the iterative solution.

Bhaiyaa: Ruyank, now onwards whatever I say just believe it's true(hypothetical situation) & we will prove it someday but not now

Ruyank: Sure, bhaiyaa !

Bhaiyaa: I'm giving you below array & make a function which returns me sum of this array

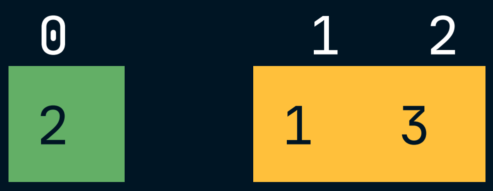


Ruyank: I'll make a function sum1(nums, l, h) which takes array, lowest index & highest index & returns sum.

Bhaiyaa, let me write the definition for sum1()

Bhaiyaa: Wait wait, don't define it yet there's going to be something magical, just do what I say

Let me take away 1st value of nums[] so you are remaining with below array now write a function to calculate sum of array from idx = 1 to idx = 2

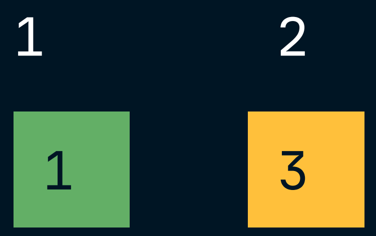


Ruyank: Bhaiyaa, I'll make another function sum2(nums, l, h) where I'll pass nums, idx=1, idx=2 & returns me the sum

Bhaiyaa: Can you see similarity b/w sum1() & sum2() that you wrote ?

Ruyank: Yes bhaiyaa, they are taking same arguments(arr, l, h) & their working is also same i.e. calculating sum.

Bhaiyaa: Great, now let me take out idx=1 from previous array, so you will make sum3(nums, 2, 2) to calculate rest of sum

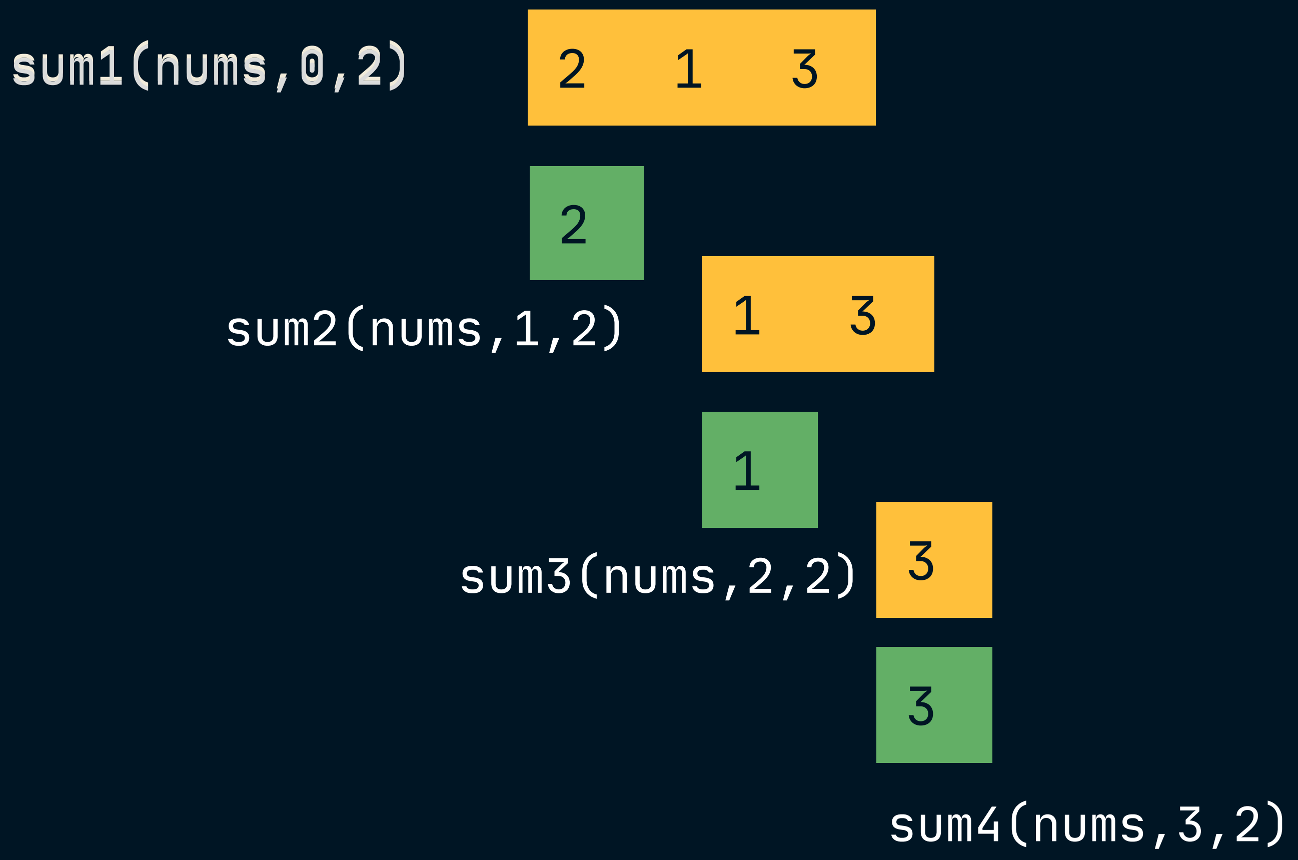


Ruyank: Now bhaiyaa, if you take away idx=2 out as well then we aren't remaining with any array, what to do then?

Bhaiyaa: Don't worry about that now, we will see that later BTW you will make sum4(arr, 3, 2) finally and since l(3) > h(2), you can say- you traversed entire array & you can return 0

To give you some idea, your sum4() was handling base case in terms of Recursion, but we will see later.

Ruyank: Bhaiyaa, before it becomes too confusing let's write down all the functions in 1 place



Bhaiyaa: Ruyank, now let's write definitions for all functions

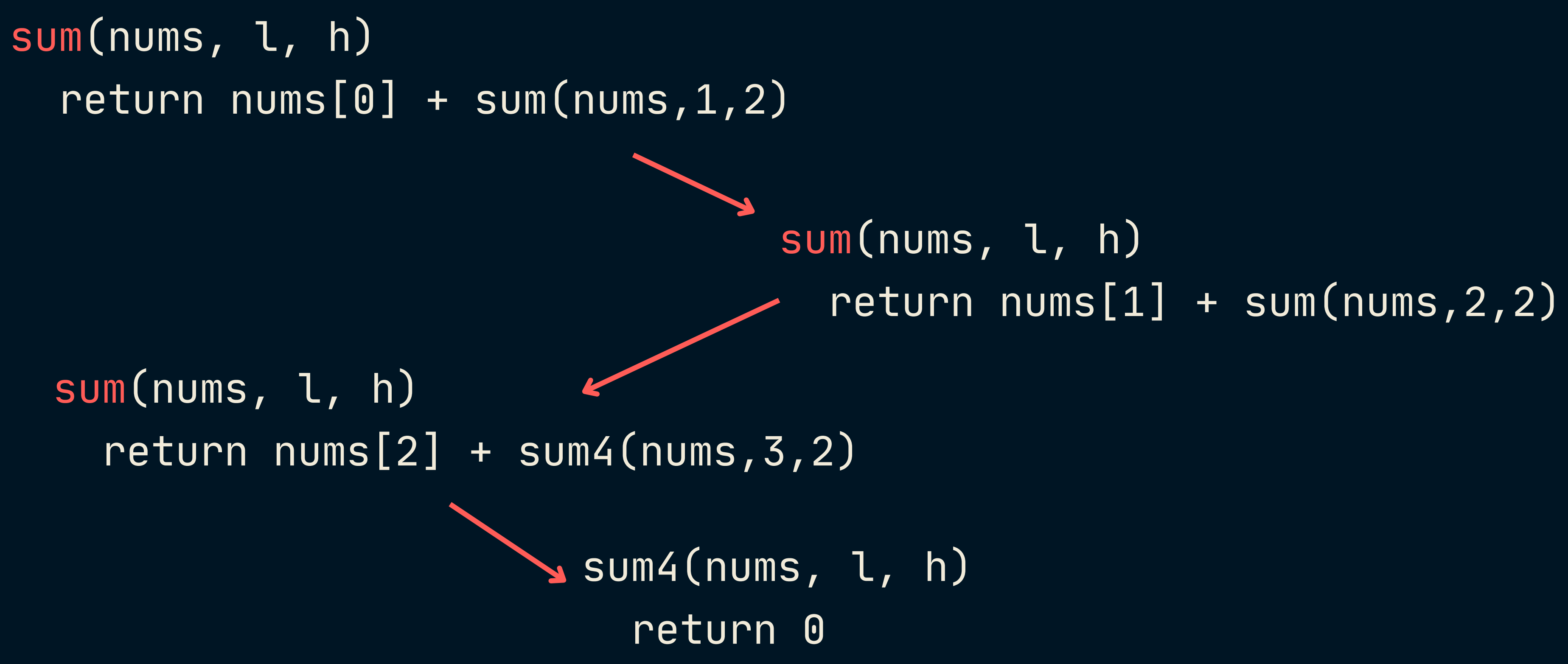
```
sum1(nums, l, h)
  return nums[0] + sum2(nums,1,2)

                                    sum2(nums, l, h)
                                      return nums[1] + sum3(nums,2,2)

  sum3(nums, l, h)
    return nums[2] + sum4(nums,3,2)

                            sum4(nums, l, h)
                              return 0
```

Bhaiyaa: Ruyank, why do we make functions ?

Ruyank: To reuse same piece of code & avoid redundancy

Bhaiyaa: Can you see in prev. slide sum1(), sum2(), sum3()
are doing exactly same work i.e.
-> taking input of array, low index, high index
-> computing sum b/w low & high index

So, let's make a function sum(nums,l,h) which does
the same thing that sum1,2,3 are doing & we will
reuse it everytime needed & replace all instances of
sum1,2,3 with sum()



```
sum(nums, l, h)
  return nums[0] + sum(nums,1,2)

                                    sum(nums, l, h)
                                      return nums[1] + sum(nums,2,2)

  sum(nums, l, h)
    return nums[2] + sum4(nums,3,2)

                             sum4(nums, l, h)
                               return 0
```

Ruyank: Bhaiyaa, I can see that now instead of writing
sum1(), sum2(), sum3() separately their work will be
done by sum() but what about sum4() ?

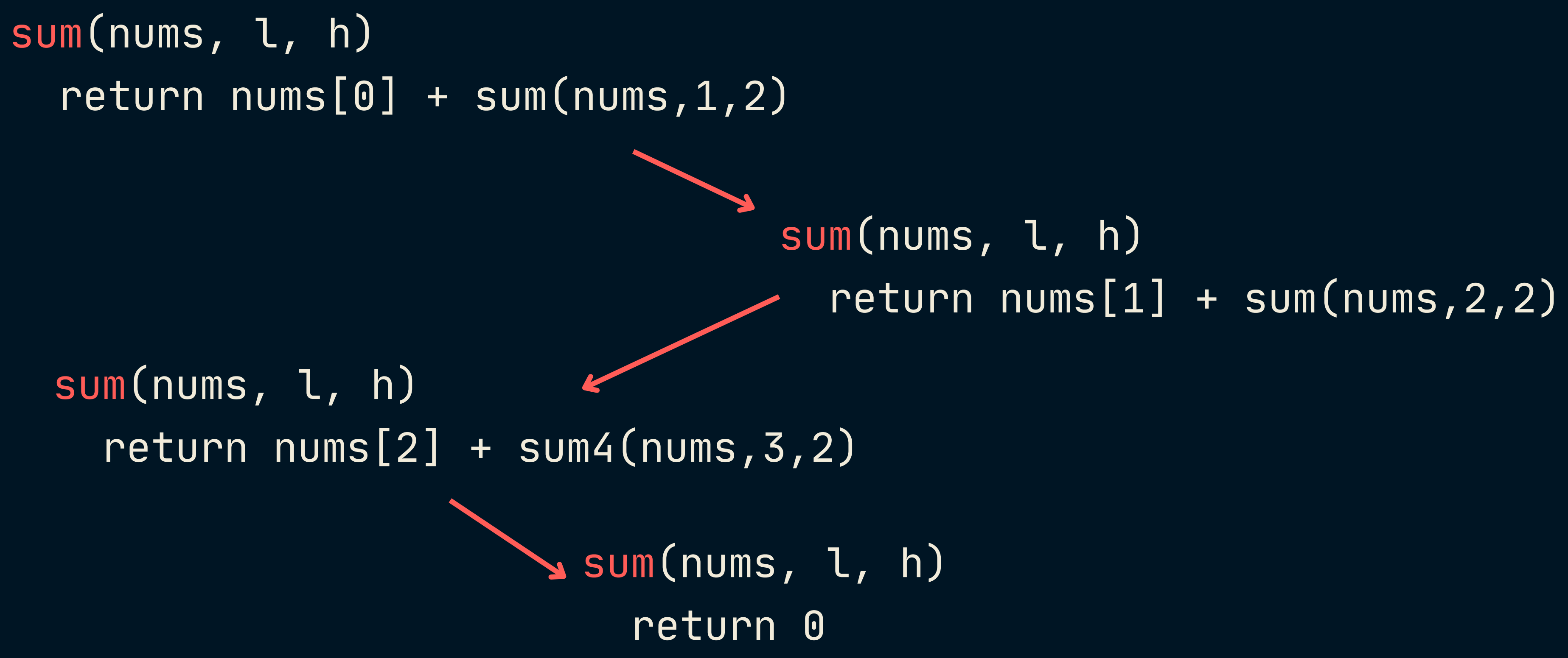
Bhaiyaa: sum4() or final function is used for something special, which we call base case & can you tell when will we encounter base case ?

Ruyank: When our test case crosses it's valid boundary, here it was valid till l <= h & as soon as l becomes > h, we know we are done with array so we just did

```
    return 0; // when nothing left in array sum = 0
```

great bhaiyaa, I can observe that we can replace sum4() from sum() just with below condition

```
   if(l > h)
      return 0;
```



```
sum(nums, l, h)
  return nums[0] + sum(nums,1,2)

                                sum(nums, l, h)
                                  return nums[1] + sum(nums,2,2)

  sum(nums, l, h)
    return nums[2] + sum4(nums,3,2)

                        sum(nums, l, h)
                          return 0
```

Bhaiyaa: Ruyank, can you see above diagram now and get some idea that what exactly we did ?

Ruyank: Earlier we used sum1(),sum2(),sum3(),sum4() to calculate the sum of array but now we just have sum() & we are reusing it all the time

Bhaiyaa: We are resuing it or I can say we our sum() is calling to itslef all the time and that's what we call RECURSION

Ruyank: Great Bhaiyaa, so their is nothing to fear about recursion, either we can make multiple new functions or we can just reuse same function which is recursion.

Bhaiyaa: Ruyank, there is still a long long journey in mastering recursion & in coming days we will get to know about following stuff

-> Induction, Base, Hypothesis approach
-> Choice Diagram approach
-> Different ways of creating Induction
-> Getting recurrence relation
-> Handling base cases etc...

Ruyank: Bhaiyaa, atleast now I know what 'Recursion' exaclty is all about & I hope in coming days you will help me master that properly

2	1	3

```
sum1(nums, l, h)
  return nums[0] + sum2(nums,1,2)

                               sum2(nums, l, h)
                                 return nums[1] + sum3(nums,2,2)

  sum3(nums, l, h)
    return nums[2] + sum4(nums,3,2)

                       sum4(nums, l, h)
                         return 0
```

Either you can make many new functions()

```
sum(nums, l, h)
  return nums[0] + sum(nums,1,2)

                               sum(nums, l, h)
                                 return nums[1] + sum(nums,2,2)

  sum(nums, l, h)
    return nums[2] + sum(nums,3,2)

                       sum(nums, l, h)
                         return 0
```

OR

```
sum(nums, l, h)
   if(l > h) return 0
  return nums[l] + sum(nums,l+1,h)
```

Or you can reuse one function all the time

I know I took way more time to explain a simple concept but as a beginner it becomes tough to actually visualize what exactly is recursion & then many times you see people telling to believe in your function() it will do it's work just handle your induction step.

Now all these hypothetical things mess around in mind so I just tried to go from scratch & I hope you would have got something new in Recursion

There is much more exciting things in Recursion I'll be posting but those things will be possible only if you like, comment and share these posts