



# IIT Madras

## ONLINE DEGREE

**Computational Thinking**  
**Professor Madhavan Mukund**  
**Department of Computer Science**  
**Chennai Mathematical Institute**  
**Professor G Venkatesh**  
**Department of Electrical Engineering**  
**Indian Institute of Technology Madras**  
**Concept of Variables, Iterators and Filtering**

So, now that we have all this data. Let us start looking at some properties of these cards. So, for instance I want to know how many students are there in this class. So, let me start counting them. So, we quickly count it.

Professor G. Venkatesh: How you are going to count it?

(Refer Slide Time: 00:29)



Professor Madhavan Mukund: Let me just count it 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28.

Professor G. Venkatesh: Are you sure? 28? You have miss something.

Professor Madhavan Mukund: Let me count it, 1, 2, 3, 4, 5, 6, 7, 8 they are sticking 9, 10, it is not very good way.

Professor G. Venkatesh: No, it is not a good way, better way.

Professor Madhavan Mukund: No I think I should, I think I should separate them. So, 1, 2, 3, 4, 5.

Professor G. Venkatesh: Hey wait.

Professor Madhavan Mukund: What?

Professor G. Venkatesh: Ok. Go ahead.

Professor Madhavan Mukund: I have to start again.

Professor G. Venkatesh: No, this does not work, you need to do something else.

Professor Madhavan Mukund: So, if I get stuck in the middle then I should not have to start again. So, let us do something, let us write down

Professor G Venkatesh: Keep track somewhere.

(Refer Slide Time: 01:21)





Professor Madhavan Mukund: So, let me write down. So, let me just mark each card because I guess if I have more than this many cards I might have to stop and continue. So, what I will do is, I will put a card down and then I will mark it. So, I will say for instance this is 1, 2, 3, 4 and then...

Professor G Venkatesh: You might want to cross it, yeah, you might want to cross it.

Professor Madhavan Mukund: Yeah, I will do this just to get bundles.

Professor G. Venkatesh: That is the normal way of doing it.

Professor Madhavan Mukund: 6, 7, 8, 9...

Professor G Venkatesh: Cross it again.

Professor Madhavan Mukund: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30. So, there were actually 30 card I think I had counted 28 I think 2 were stuck. So, now we are sure we have counted 30 cards and we can check that we have 1, 2, 3, 4, 5, 6 bundles of 5, so 6 times 5 is 30. But this is the bit tedious because again if we have 300 or 400 I do not know how many of these I would have to count. So, maybe I should just count, but then if I count, I have to write the track.

Professor G. Venkatesh: You have to keep track.

Professor Madhavan Mukund: So let us just count...

Professor G Venkatesh: Is it a better way to keep track?

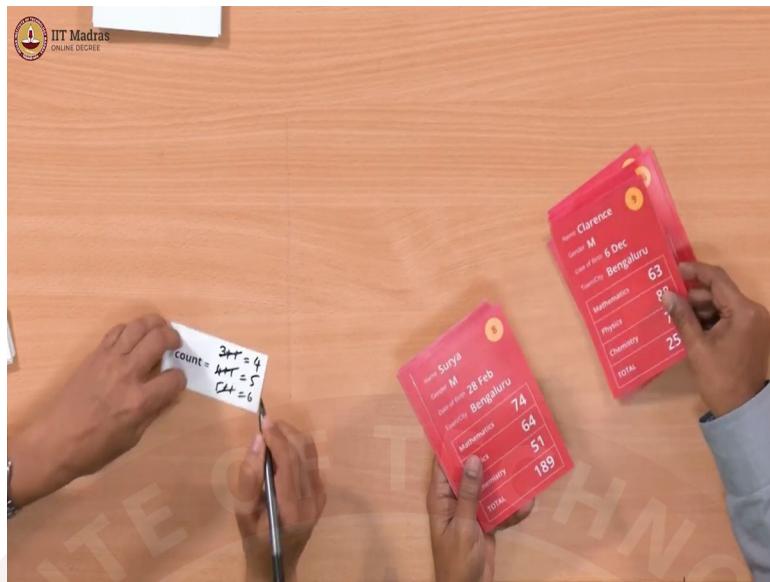
Professor Madhavan Mukund: Yeah, I think what we can do is we can just count and just keep writing the number and keep adding 1 to the number as we go along. So, let us start that again. So, maybe you move the cards aside and I will keep track of the count. So, what I will do is I will keep track of a number and I will keep adding 1 to the number, so you count the cards by moving them and I will keep track of the count so that...

Professor G. Venkatesh: You have to start somewhere, right? You have to start it somewhere, what you are starting...

Professor Madhavan Mukund: So, let us start with 0.

(Refer Slide Time: 03:26)





Professor G. Venkatesh: We will start with 0, because we not seen any card so far, so I am moving the first card, so I moved the first card.

Professor Madhavan Mukund: So, I will add 1 to it and I will make it 1.

Professor G. Venkatesh: So that is now count is now 1. So, now I am moving the second card.

Professor Madhavan Mukund: So, I will add 1 to that and I will now make count equal to 2.

Professor G. Venkatesh: So, I now move the third card.

Professor Madhavan Mukund: So, I will add 1 it and I will have 3, so I have 3. So, I will move to a new piece so that I have space. So, I have 3 so far.

Professor G. Venkatesh: Okay, here is a 4.

Professor Madhavan Mukund: 3 plus 1 that is 4.

Professor G. Venkatesh: 5th.

Professor Madhavan Mukund: 4 plus 1 is 5.

Professor G. Venkatesh: 6th.

Professor Madhavan Mukund: 5 plus 1 is 6.

Professor G. Venkatesh: 7th.

Professor Madhavan Mukund: So, we were at 6. So, 6 plus 1 is 7.

Professor G Venkatesh: The next card.

Professor Madhavan Mukund: 7 plus 1 is 8.

Professor G Venkatesh: Next one.

Professor Madhavan Mukund: 8 plus 1 is 9.

Professor G. Venkatesh: The next one.

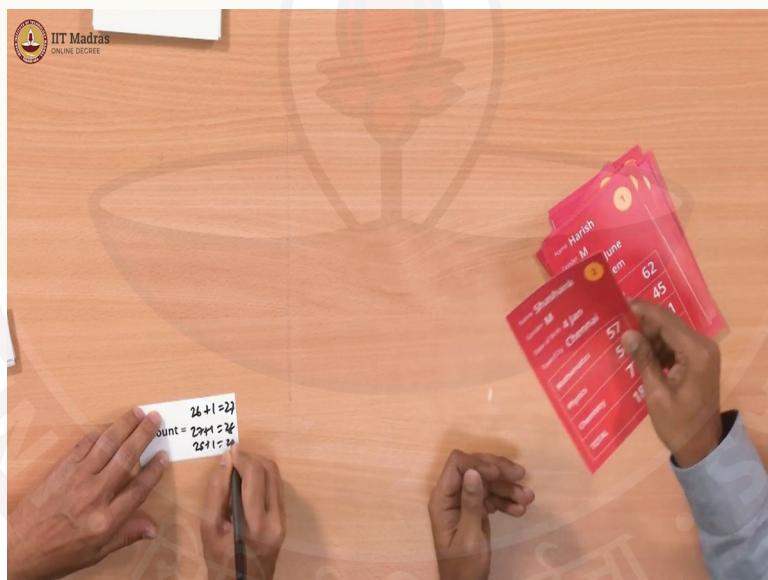
Professor Madhavan Mukund: So, we have 9 plus 1 is 10.

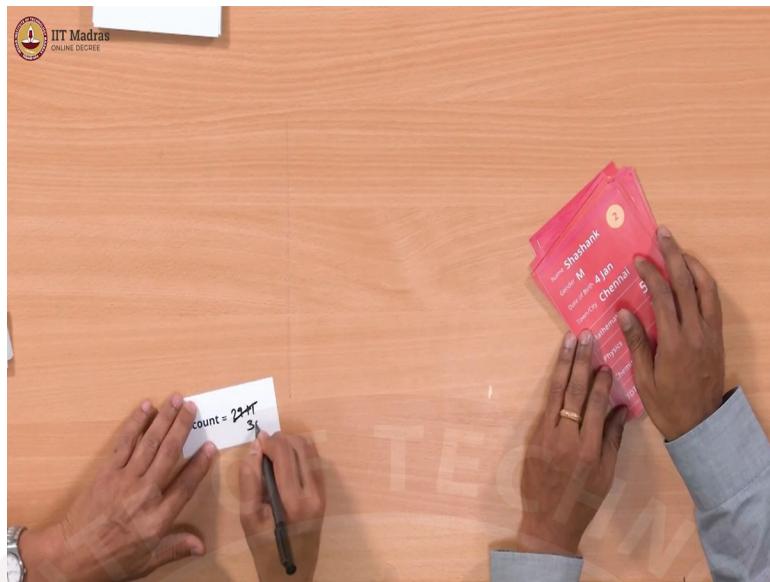
Professor G. Venkatesh: Next one.

Professor Madhavan Mukund: 10 plus 1 is 11, I guess we can keep going on and we know we have already counted 30, so when we get to the end, I guess...

Professor G. Venkatesh: So, it will come somewhere here.

(Refer Slide Time: 04:29)





Professor Madhavan Mukund: So, we have 4 cards left, so we would be say at 26, then I would say 26 plus 1 is 27. 27 plus 1 is 28...

Professor G Venkatesh: Next one.

Professor Madhavan Mukund: 28 plus 1 is 29...

Professor G Venkatesh: And then the last one.

Professor Madhavan Mukund: And finally the last one I would have had 29 and then when I see the last card, I will get 30. So, now we are just keeping a number and we are just adding 1 to this number as we go along. So, at any point we have the actual count we do not have to go back and then count all the tick marks and the crosses and how many bundles of 5.

Professor G. Venkatesh: So, there is the pattern that we are seeing here which I think is called an iterator.

Professor Madhavan Mukund: Yes, yes...

Professor G. Venkatesh: In programming...

Professor Madhavan Mukund: So, this is what is call iteration, so basically you go through the sequence of objects that you have and for each object you keep a count...

Professor G Venkatesh: You do something.

Professor Madhavan Mukund: You do something with that object here we are just keeping count. So, we are maintaining a count which starts with 0 and then as we go object, one

object at a time we keep incrementing that count by 1. So, at the end the count is actually equal to the total number of objects we have seen.

(Refer Slide Time: 05:40)



Professor G. Venkatesh: So, we have things that we are discuss here one is the iterator. The iterator itself has a initialization in this case count equal to 0 is the initialization and then at each step in the iteration we are moving the card into another pile and as we move the card into another pile we are adding 1 to the count that is a step. And when do we stop this process?

Professor Madhavan Mukund: Well I guess we started with 1 pile and we are moving the pile, the second pile has those which we have already counted. So, when we run out of things we are done. So, all the things have been counted...

Professor G. Venkatesh: So, everything has move to another pile...

Professor Madhavan Mukund: So, the first pile is empty the second pile is got everything that is when we are done.

Professor G. Venkatesh: That is when we stop. Is there, are there better ways or are there different ways in which one can pick cards from this I mean should we always have to pick the top card in this?

(Refer Slide Time: 06:11)



Professor Madhavan Mukund: I guess it should not matter as long as each time you move one card from here to there you can do it in any order.

Professor G. Venkatesh: So, I can pick a random card like this and keep moving into a pile, right? It should work?

Professor Madhavan Mukund: Yes, I think so. I mean if you just count it should definitely because finally you are moving things from left to right, from one pile to another and all that matters is that you move everything from here to there and you count once.

Professor G. Venkatesh: So, I can pick a card randomly, I can pick the last card I can pick the first card I can go between the first and the last card.

Professor Madhavan Mukund: Exactly, you can go from...

Professor G Venkatesh: Any of these?

Professor Madhavan Mukund: We did it from beginning to end, you can go from end to beginning you can do every alternate one and come back and do every alternate one or you could just put your hand and so supposing you have a sack of balls for example, if you have counted in the same way, you could have...

Professor G. Venkatesh: Yeah, there is no first time...

Professor Madhavan Mukund: Yes, you can put a hand into the thing pull out and put it the second, then it does not matter on what order you pull it out when the first sack is empty and the second sack is full you have counted them all.

Professor G. Venkatesh: Counted them all. So, this is an iterator pattern and there is a thing that we have kept on the side, an additional thing we have kept on the side this is called a variable.

(Refer Slide Time: 07:05)



Professor Madhavan Mukund: Yes, yes, so this is a variable. So, this we have called it given it a name ‘count’. So, count is a quantity and its quantity is a number which just keeps changing as we go along. So, we started with an initialization setting it to 0 and then as we went along, we added 1 to it because that is what we were intending that variable to mean. It was intended to be the number of cards we have seen. So, each time we see a new card we add 1 to it.

Professor G. Venkatesh: So, I presume that it is called the variable because its value keeps changing unlike for example the name Sofia or the marks, mathematics marks was 89...

Professor Madhavan Mukund: Exactly.

Professor G. Venkatesh: Which is not changing, these are constants.

Professor Madhavan Mukund: So, this as the process of our computation goes on. These values will keep changing and that is what we are using somehow to keep track of things.

Professor G. Venkatesh: Keep track of things. And at the end, the value of it mean something. The middle it does not mean anything but at the end of it the value of the variable count is 30 which means something and that meaning is the number of cards.

Professor Madhavan Mukund: Actually, even in between it means something if goes it tells us how many cards we have move to this side, but we are actually interested in this case and the final value. So, we wait till the end and then we look it up and that gives us a summary of something about the cards, some quantity about the cards.

So, last time we saw how to systematically count the cards by going from one stack to another stack and keeping track of variable but surely counting is a very simple thing to do and we should be able to do something more complicated than that with this information that we have on this cards. So, what do you suggest the good thing to check?

(Refer Slide Time: 08:37)



Professor G. Venkatesh: Suppose, I want to find out what the average marks in mathematics is. There are these 30 cards so they all have different card maths scores. I want to find the average score of mathematics for all these students in this class.

Professor Madhavan Mukund: So, the average would be that we have to then find out by adding up all the maths marks of all the students and divide by the total number of students which we have already done. So, you know the total is 30 we do not have to count that again but we just have to do some addition now. So how do we do...

Professor G. Venkatesh: We have to sum up all the math marks and then divide it by the total number of students, yes that is correct yes. That is what we have to do.

Professor Madhavan Mukund: So, again we want to do the systematically.

Professor G. Venkatesh: Systematically we want to sum all the math marks. So, do we use the same method that we did last time?

Professor Madhavan Mukund: Yeah, so we can use the same iterator idea except that this time instead of keeping track of the count we want to keep track of the total sum of all the maths marks. Because at the end we want the total sum.

Professor G. Venkatesh: So, good idea would be to start with the card, let us call it ‘sum’.

(Refer Slide Time: 09:23)



Professor Madhavan Mukund: So, we will initialize it to 0...

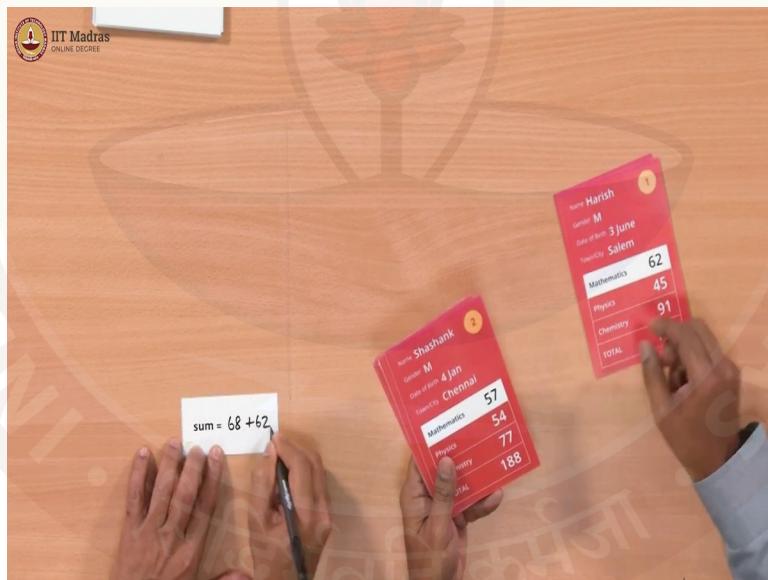
Professor G. Venkatesh: So, I shall read out the maths marks and as I read it out, I will move it into a different pile like we did last time and you will keep track of the total maths marks we have seen so far. So, the first card is 68.

(Refer Slide Time: 09:39)



Professor Madhavan Mukund: So, let me just go slowly because I have to add now it is not just a plus 1, so I have now 68.

(Refer Slide Time: 09:48)



Professor G. Venkatesh: Now, second card is 62.

Professor Madhavan Mukund: So, 68 plus 62, so I have 130.

(Refer Slide Time: 09:55)



Professor G. Venkatesh: The next one is 57.

Professor Madhavan Mukund: So, that is now 187.

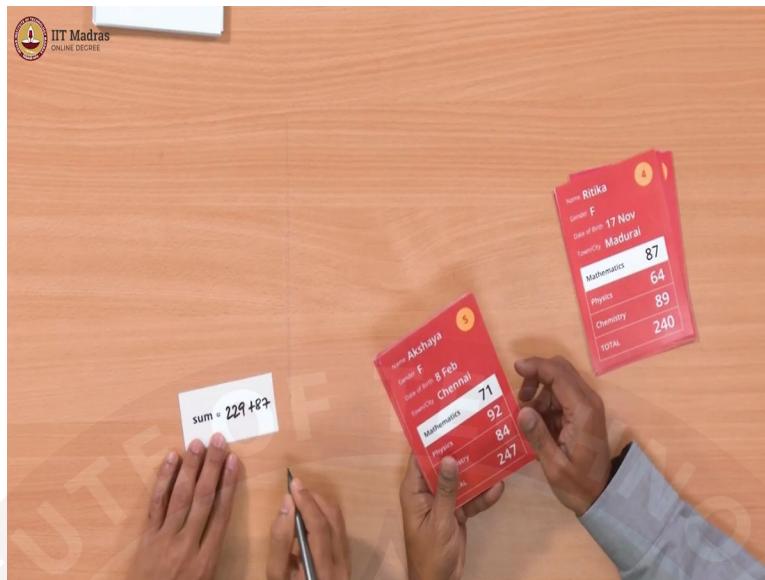
(Refer Slide Time: 10:00)



Professor G. Venkatesh: Next one is 42.

Professor Madhavan Mukund: Now, it getting complicated. That is 229 I think.

(Refer Slide Time: 10:08)



Professor Madhavan Mukund: So, we have seen 4 cards and we have 229 so far.

(Refer Slide Time: 10:11)



Professor G. Venkatesh: 87 is a next one.

Professor Madhavan Mukund: So, that makes 316. So, we can...

Professor G. Venkatesh: We can go like that, we can go that way and keep adding 71, 81, 84 and so on and if you go like this keep on adding and we reach.

Professor Madhavan Mukund: So, then finally we come to the last card.

Professor G. Venkatesh: You have 2099 and then last card is 72.

Professor Madhavan Mukund: Then we have 72. So, our total now is 2171. So, this is the total maths marks across the entire group of students. We know there 30 of them.

Professor G. Venkatesh: 30 students. Yeah.

Professor Madhavan Mukund: So, now we want to compute the average. So, we have that the sum is 2171 and the count is 30. So, we divide these two and we get 72.36666.

Professor G. Venkatesh: OK.

Professor Madhavan Mukund: So, this is the average maths marks of the entire class for 30 students. So, added up these maths marks systematically by going through all the cards and then when we got the total, we had already counted that the 30 students

Professor G. Venkatesh: In previous round we already counted 30 students.

Professor Madhavan Mukund: So, now we divide than and we get the average

Professor G. Venkatesh: Average. Alright.

Professor Madhavan Mukund: So, instead of adding up just one at a time we are actually adding up some information which is on the card, so we are actually...

Professor G. Venkatesh: So, we have another variable which is sum, that we kept track of. The sum variable basically instead of just incrementing we are accumulating the value of mathematics in the sum variable, is that there?

Professor Madhavan Mukund: Exactly.

Professor G Venkatesh: So, basically at the end of the iteration over 30 cards we got the total value of this mathematics. And then we computed the average by dividing the two variables. And then we divided the 2 and we got the average marks. Is it possible that instead of doing two iterations one for a count and the other to find the sum we could do both in a single iteration?

(Refer Slide Time: 12:28)



Professor Madhavan Mukund: Yes, I mean I guess so. Because what we could do is, we could just have to begin with they could say keep track of both quantities. So, we can say count is 0 and we can say sum is 0...

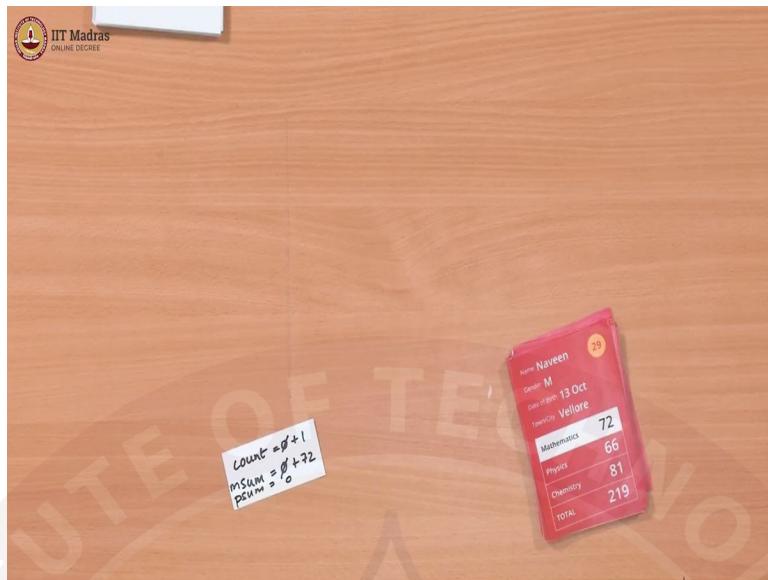
Professor G Venkatesh: And then as we go through the cards...

Professor Madhavan Mukund: Then when we see the first card we make count as plus 1 and say sum is 72 or whatever this maths marks. And then each time we add 1 to the top and the actual marks to the bottom and so we keep track of both quantities at the same time in the end we have...

Professor G. Venkatesh: So in the single iteration, in a single round we will be able to at each step keep track of two variables one is count and the other is sum. At the end of it you will get the total number of cards and count and the sum of all the mathematics marks in sum and then you could divide one by the other and get the average.

Professor Madhavan Mukund: Yes, we could have also done this for another subject we done physics at the same time for instance. We could have track of so...

(Refer Slide Time: 13:04)



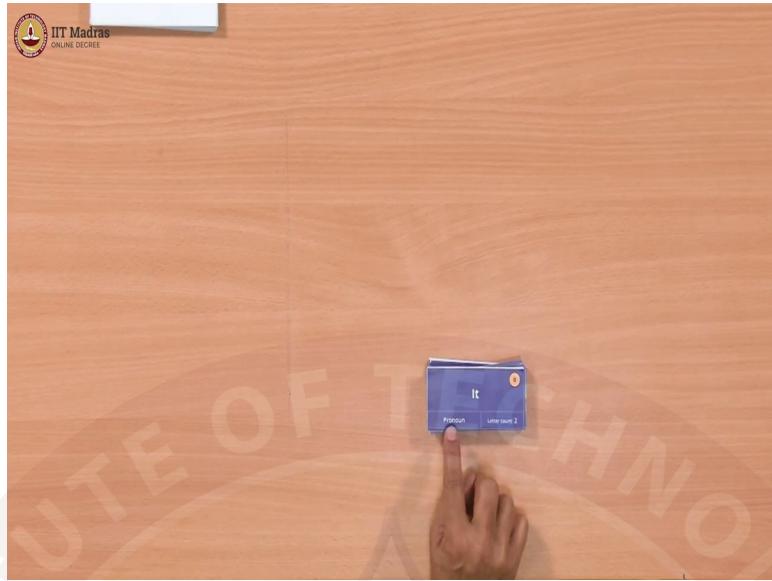
Professor G. Venkatesh: We could have track of so that means we can keep track of...

Professor Madhavan Mukund: So, we could have had an mathematics sum and the physics sum 3 variance. So, any number of variables that we want to keep track of we could keep track of as long as we make sure that we systematically update them with each card. At the end we can do all of this overlapping in one iteration.

Professor G. Venkatesh: So, the pattern we are seeing here, the important pattern we have seen here is iteration which has an initialization step in this case putting the variables to 0 was initialization step and at each stage we are moving the card into a different pile and updating the value of these variables, depending on what we have seen on the card and then at the end of it, at end we basically is when all the cards are exhausted. At the stage we can basically take all the variable values and do some operations on them, in our case we did the computation of average dividing one by the other.

Professor Madhavan Mukund: So, in the last two examples we did iteration over the entire stack of data and we kept track of some quantity. But sometimes we are only interested in specific cards or specific items which are special to us and not in all the items. So, for instance here we have this data which consist of words from a paragraph.

(Refer Slide Time: 14:12)



So, each card has one word one it and if you remember it has the word, it has the type weather it is a pronoun or noun or verb or an adverb and it has a number of letters in the word. So, supposing we have the stack and what we want to do is count the number of verbs in it. So, we are only interested in some cards those cards where the word is a verb.

Professor G. Venkatesh: So, which so we should be use the same method which means that we go through the cards systematically?

Professor Madhavan Mukund: Yes, but maybe we can just do something simpler maybe we can first go through the cards and pull out all the verbs, take out all the verbs and then we can just count it.

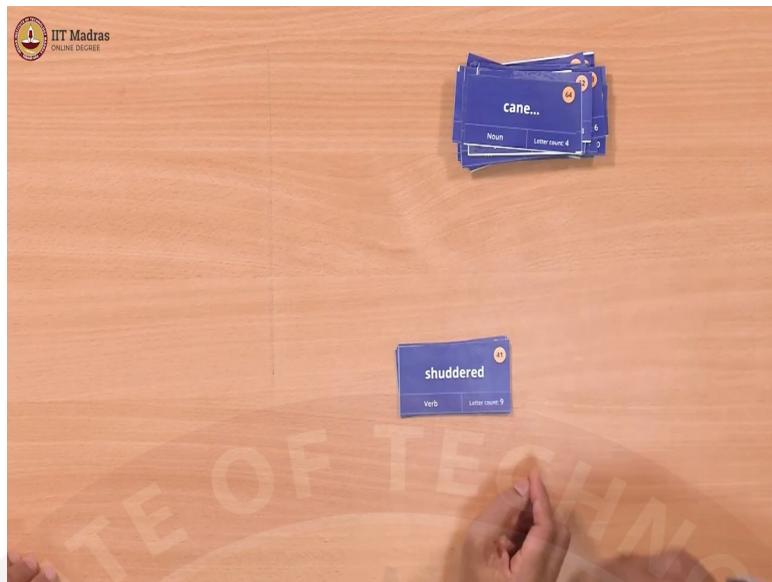
(Refer Slide Time: 14:54)





considered

Saturd



Professor G. Venkatesh: So, let me inspect the card. So, the first one is ‘it’ which is a pronoun, so I put it in one pile. The second one is a verb, so I should separate the verbs...

Professor Madhavan Mukund: So, keep all the verbs separately and everything else separately.

Professor G. Venkatesh: So, I am moving this here, this here, this is going here, this also is a verb ‘was’, so this comes here

Professor Madhavan Mukund: Adjective.

Professor G. Venkatesh: Adjective.

Professor Madhavan Mukund: Preposition, verb put it down.

Professor G. Venkatesh: Okay, ‘his’ is a pronoun. ‘Eyes’ is a noun, ‘he’ is a pronoun, ‘considered’ is a verb, ‘Monday’ is a noun, ‘specialty’, ‘unpleasant’, ‘in’, ‘the’, ‘calendar’, ‘after’, ‘the’, ‘delicious’, ‘freedom’, ‘of’, ‘Saturday’, ‘and’, ‘Sunday’, ‘it’, ‘was’.

Professor Madhavan Mukund: ‘Was’ is a verb.

Professor G. Venkatesh: Okay, ‘difficult’, ‘to’, ‘get’ here is another verb. ‘Into’, ‘the’, ‘Monday’, ‘mood’, ‘of’, ‘work’, ‘and’, ‘discipline’, ‘he’, ‘shuddered’ is a verb.

Professor Madhavan Mukund: ‘Shuddered’ is a verb.

Professor G. Venkatesh: ‘Shuddered’ is a verb, sorry, yes, yes, yes, so that should go here. ‘At’, ‘the’, ‘very’, ‘thought’, ‘of’, ‘school’, ‘the’, ‘decimal’, ‘yellow’, ‘building’, ‘the’, ‘fire-

'eyed', 'Vedanayagam', 'his', 'class-teacher', 'and', 'headmaster', 'with', 'his', 'thin', 'long', 'cane', that is it?

Professor Madhavan Mukund: Okay.

Professor G. Venkatesh: So, we got all the verbs, separated the verbs.

Professor Madhavan Mukund: So, now we will have to count the verbs so we would have to do our usual thing...

Professor G. Venkatesh: There is, this thing I mean I guess there is a name for this, because you have taken out some subset of it, so this is a name for this in programming and what do we call this?

Professor Madhavan Mukund: So, it is a like a bit like when you pour tea out of the pot and the leaves stay behind. So, you want to keep something...

Professor G. Venkatesh: So, this is filtering.

Professor Madhavan Mukund: Yeah, so this is called filtering. So, basically you take your data you pass it through a filter and anything which is caught by the filter stays behind and all the other thing pass through, so here the filter was to catch all the verbs and then we left all the other card through the filter and we are not really interested in them, they are only interested in what is caught by the filter.

(Refer Slide Time: 17:11)



And now what we want to do first of all we just count this. So, we basically now we have collected these things and we have to separately count it. So, we will do our usual thing of saying you know 1, 2, 3, 4, 5, 6, 7.

Professor G. Venkatesh: Keeping track I guess in the count variable.

Professor Madhavan Mukund: So, basically we have filtered it and then we are counting but we could also do this while we were, we do not have to separately count this, we could have counted it while we were filtering. So, we could have done this kind of iteration that we were doing selectively, instead of doing it for every card...

Professor G. Venkatesh: So, how do we do that? I mean just, that you can illustrate...

Professor Madhavan Mukund: If we just put it here say in the middle, let us do something else in this time, so let us do not verb but say pronouns. So, let us count to pronouns. So, I will keep a card.

(Refer Slide Time: 19:29)



Professor G. Venkatesh: So, you will keep a count but this count means it is not same as...

Professor Madhavan Mukund: So, this is the pronoun...

Professor G. Venkatesh: Earlier the count represented the total number, now this count means something else?

Professor Madhavan Mukund: So, now this is just a pronoun count...

Professor G Venkatesh: This is variable, pronoun count...

Professor Madhavan Mukund: And it is initially is 0.

Professor G. Venkatesh: It is initially is 0, so I should move the cards one at a time to another pile...

Professor Madhavan Mukund: And whenever you see...

Professor G. Venkatesh: And I am not separating it into two piles, I am just separate, putting it all in a different pile one by one.

Professor Madhavan Mukund: And whenever you see a pronoun tell me and I will increment this.

Professor G. Venkatesh: Okay, I shall do that. So, we have all the verbs which we found earlier. So, this is a noun, this a noun, there is an article, this a noun, it is an adjective, it is an adjective, so we found the first pronoun.

Professor Madhavan Mukund: so, I make 0 into 1.

Professor G. Venkatesh: Then a preposition, a noun, a conjunction, a noun, a noun, another pronoun.

Professor Madhavan Mukund: So, now I make the 1 into 2.

Professor G. Venkatesh: Here is a noun, adjective, article, noun, adjective, adjective, article, noun, preposition, preposition, adjective, preposition, here is another pronoun.

Professor Madhavan Mukund: That is 3 now.

Professor G. Venkatesh: Noun, adverb, article, preposition, here is a pronoun.

Professor Madhavan Mukund: Okay, 4.

Professor G. Venkatesh: Noun, conjunction, noun, preposition, noun, conjunction, noun, preposition, noun, adjective, article, preposition, noun, article, preposition, adjective, adverb, noun, here is another pronoun.

Professor Madhavan Mukund: Okay, 5.

Professor G. Venkatesh: Noun, pronoun.

Professor Madhavan Mukund: Okay, 6.

Professor G. Venkatesh: Preposition, adjective, noun, noun, noun, verb, verb, finally here is another pronoun.

Professor Madhavan Mukund: So, we have 7 pronouns.

Professor G. Venkatesh: So, we have a pronoun count and this time we did not separate out, we cannot filter it, but I guess this filtering going on here also.

Professor Madhavan Mukund: Yeah, so this is like a filtered iteration, so it is just kind of...

Professor G. Venkatesh: It is iteration with a filter inside it.

Professor Madhavan Mukund: So, we are overlapping and earlier we said we could overlap two different counts like a count and a sum, now we are saying we can do a overlapping of a filtering and a count. So, we are counting but only those which are filtered.

(Refer Slide Time: 19:57)

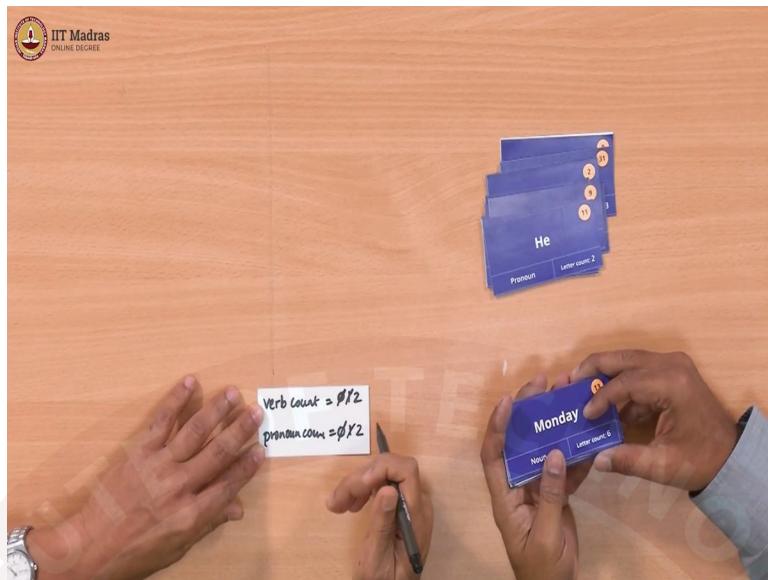


And I think we can actually do two filters at the same time. So supposing we had this and we also wanted to count the verbs...

Professor G. Venkatesh: We could start with both of them equal to 0.

Professor Madhavan Mukund: So, we could start with both. So, let us just see maybe just to, we will just start it we will not do the whole thing but we will just do this.

(Refer Slide Time: 20:49)



So, supposing we have the verb count and then we have the pronoun count.

Professor G. Venkatesh: Equal to 0 both, I guess.

Professor Madhavan Mukund: So, both are initially 0, and now what we do is when we see a pronoun...

Professor G. Venkatesh: So, we see a pronoun, so, you will add to the pronoun count.

Professor Madhavan Mukund: Then we add to the pronoun count.

Professor G. Venkatesh: Now, I saw verb, so I will add to the verb count, here is another verb.

Professor Madhavan Mukund: So, we will add to the verb count.

Professor G. Venkatesh: Here is a noun. Now what we do?

Professor Madhavan Mukund: So, I will add to nothing.

Professor G. Venkatesh: Nothing, you will not add it in. Here is another noun, here is another noun, here is an adjective, again nothing, preposition nothing, pronoun.

Professor Madhavan Mukund: 2.

Professor G. Venkatesh: Okay, noun and so on we can do the same thing exactly.

Professor Madhavan Mukund: So, now we are basically either we in this case everything is either a verb or a pronoun or something else. So, if it is something else, we do nothing we do

not adjust any of these counts. If it is a verb, we increment the verb count we add plus 1 to the verb count if it is a pronoun, we add plus 1 to the pronoun count.

And of course, we could also do it with 3, we can do nouns, pronouns verbs. We could do adjective, pronouns, so we can do as many of these in parallel just like we said earlier we could keep track of maths marks and physics marks or math marks and physics marks and some other marks. So...

Professor G. Venkatesh: So, here we have 2 variables, the verb count and the pronoun count and so what we are doing is each card we are actually inspecting that card and we are checking whether that card is a verb or a pronoun or it might be neither verb nor pronoun. So, these are the 3 possibilities, it cannot be anything else.

So, it is either a verb or a pronoun, neither of them, so if it is a verb then we are adding to the verb count, if it is a pronoun, we are adding to the pronoun count and if it is neither we are just ignoring the card.

Professor Madhavan Mukund: Exactly or we could have been kept a third count which was other...

Professor G. Venkatesh: Other count.

(Refer Slide Time: 21:52)



Professor Madhavan Mukund: And we could have done 0, 1, 2 whenever we saw another we could have add it to that and then we would have got across the 3 every card should either be a verb or a pronoun or another card.

Professor G. Venkatesh: So, if you add up, finally at the end the all the three count should add up to the number of cards, total number of cards...

Professor Madhavan Mukund: Total number of cards. Every card should have fall into one of these 3 categories.

Professor G. Venkatesh: One of these 3 categories.

