IIT Madras

ONLINE DEGREE

Programming in Python
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Matrix Multiplication – 2

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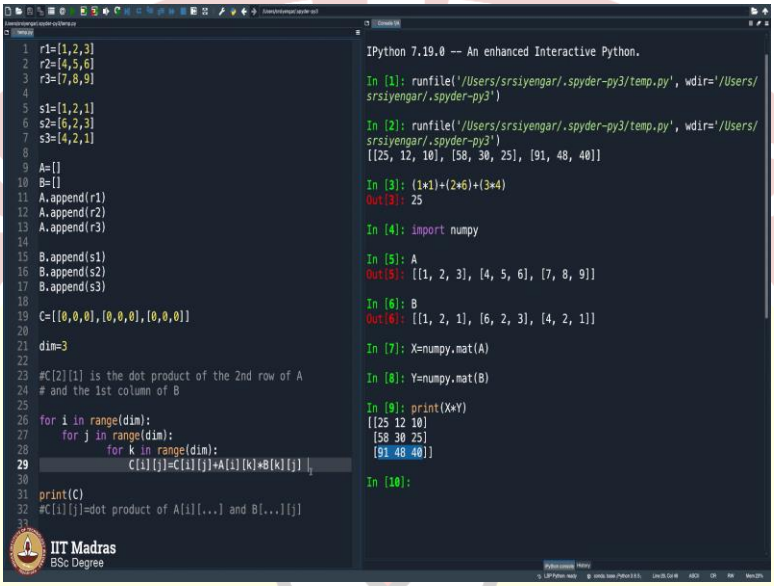

So, I am back to the same example with A being 1, 2, 3, 4, 5, 6, 7, 8, 9 and B being whatever you see here, 1, 2, 1, 6, 2, 3 and 4, 2, 1. So, I would like to go ahead and then find the product of these two matrices, the old high school way. So, my dimension here is going to be 3 because the matrix is 3 cross 3, I am going to put dim equals 3 and go ahead with the same logic as I did with matrix addition, just that, this is not going to be addition but multiplication as I continuing my little joke from the previous few videos, multiplication how I wish it was component wise just the way addition was.

Unfortunately, it is not and the reasons are very deep, if you understand some amount of matrix theory or linear algebra, you will realize the very requirement of this kind of a weird multiplication with ith row multiplied with the jth column and then finding the dot product and making an entry in cij. That sounds a little complicated, so I would like to make a comment, I put a hash, then say, C of i, j, i, j is written this way, is the dot product of, we have seen what is a dot product, dot product of the ith row of A and the jth column of B. That is all.

Stare at this very two lines for some time. I will repeat it because this should sync into our minds, unless the sync is in, we will not be able to write the code. I do not know how to write the code, so I am trying to make this two line sync into my mind. So what is it? So, I am trying to see that, I am sort of talking to myself. See if i, j should be the dot product of the ith row of A. So I picked ith row of A and then jth column of B and take the dot product and fill in the one, fill in just one entry in C, which is i, jth entry.

So, as I was explaining before, the 0, 0th entry in C will involve zero, zeroth row of A and zeroth column of B. Please note, it is the zeroth row of A and zeroth column of B. So, C of 2, 3 let me just write that down, just so that I practice it. Second row and first column of C will be the second row of A and first column of B. I need to take the dot product.

Now, here we have everything in pieces, I told you how to find the dot product of two vectors rather lists. Here, we have lists as you can see, this is matrix A and this is matrix B and we will go ahead and find the product. So, let me try my luck here. So, the damage with the matrix is 3, the dimension is 3 as you can note, so I will say, for i in range dimension, what does it even mean? For j in range dimension, I need to find out all entries of C. So, I go through from i from 0 to 2, 0, 1, 2, j from 0, 1, 2 and I should fill in the values of C of i, j which by the way, is initiated to 0 here.

So, what I should now do is, I will simply say C of i, j is, what is it? Dot product of ith row of A and jth column of B. How do I put the jth column of B, column is, it comes in the right side. Row comes in the left side. So, of course, how I wish it understood English like this, dot product of A i and B j. A i, where column varies, ith row and this can be anything and Bth column where the row can be anything. By that I mean row varies from 0, 1, 2, 3 up to the dimension, in this case 2 and j is fixed here, please note j and i are fixed.

For a given i, j here, I need to compute this. Here is the time when you should pause the video and think how do you code this particular thing. So, what I will do is, I will comment this or maybe put it down here just so that you are not confused on what I am going to type next. So, this very thing needs to be translated onto a program. So, just watch. All I am trying to do is this will be another variable, this will be another variable. Remember the video that I just explained before this video clip?

It was k here, the variable k here. If it is confusing here, then probably you must watch the video that I just now recorded and then come back here once again. So, C of i, j is equal to A of i k. So, k keeps varying, you see, into B of k j, am I right? Yes, i and j here, once it enters here, i and j are fixed but then k varies, k varies from what? k must vary for k in range dim, dimension. I must put another tab here.

So, C of i j is A of i k times B of k j. But then, you know how we computed the dot product? We took sum equals, dot products equals dot product plus A of i into B of j, whatever we did there with the lists. So, this C of i j, you keep getting the value A i k into B k j, this you multiply and you should keep doing this across different values of k and keep adding that to C of i j which means, think for a minute, maybe there is a confusion point. Do not worry, if you stare at it for a few minutes you will get through.

I should write C of i j equals C of i j plus A of i k into B of k j. Things appear very complicated but trust me, mathematics is common sense made complicated. It is like going one step ahead, one step ahead from simplicity and boom, you fall into complexity. So, this is very clear, I somehow console you people by telling that things are easy but it is appearing difficult. But I genuinely do not know how to break this even simpler.

Do not worry, we always have our forums to discuss which exact minute, which exact second do you have a question and you can post the question and I will be happy to answer, me or my TAs, my instructors will be happy to answer.

So, this should do the trick now, I will go ahead and execute this. If my luck serves good today, I will be able to get an answer. So, I got the answer but I am not displaying the answer. So, I should say print C and there I go, 12, 25, let me check this. First row with first column, 1 into 1, let me just type that here and see. 1 into 1 plus anyway operator precedence is always there. You can put this but still let me put this 1 into 1 plus 2 into 6. 2 first row and first column. I think it is clear to you people. I will go ahead.

2 into 6, first row and first column, first row of A and first column of B, what is the dot product plus three times four. What is this? Let me check, it is 25 and I am indeed getting 25 here, wonderful. Now, I will tell another way in which you check whether it is right or wrong. Bear

with me, after this, you all will leave a sigh of relief and probably punch me on my face if I am around. I will tell you why.

Look at this, I will say import numpy. And then, I have my matrix A here already, here. I executed the code. So, A is already stored here. I have my matrix B here, it is a list. If I say, M, a matrix M, let us matrix X is equal to numpy mat of A, what this does? It converts the matrix A into the numpy mat format. What is numpy? Numpy is a very brilliant library function in which 90 percent of the machine learning that I have learnt, I have tried coding in my days, in my student days, I have used numpy 90 percent.

It does everything that you need to do some good amount of machine learning and image processing and computer vision and what not. It also has some very beautiful matrix routines. So, I say X equals numpy mat A and then, Y equals numpy mat B, this is just converting the list A onto a matrix type where it is understood that A is list of list.

Now, you say print X times Y, boom, It shows you the matrix; 25, 12, exactly the same matrix as you can see. 58, 30, 25, 91, 48, 40, 91, 48, 40 and now you know why you want to punch me on my face. It is because if it is so easy to multiply, why on earth are you doing such a big circus? I go back to my same old logic. You should learn how to code from first principles.

I hope you understood how matrix multiplication is carried out by this complicated three for-loops. If you do not understand, do not worry at all, even I took some time. I remember in my student days, when I first encountered this long, long, long back, when I first was introduced to a programming language, I was asked to multiply two matrices, addition was so easy but multiplication took many, many folds more time.

I will not be surprised if you get it, if you are getting it right in the first it itself, then you have misunderstood it. You should struggle, you must find it confusing. With time only you will understand this here it takes, a good tip as I have been giving you people is to keep doing the same program again and again.

Erase this entire thing and then type it again, erase it once more and then type it again. You will stumble, you will struggle, there will be hurdles, there will be humps and potholes but still, you will realize how to code it from first principles from your, right from your fingers onto the

keyboard. So, that is the way you should learn and not see and then type. Maybe you can see this and type once. But then close everything and write it in your own way.