Deep Learning
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Lecture - 100
Deep Dream

So we will start so we were in the 3rd lecture on CNN's. Where we were looking at different visualization tools for understanding what your convolutional neural network is learning. And we did a bunch of things and now you move on to the next module where we talk about something known as Deep Dream very interestingly titled. But I am sure most of you have already seen this or read about this.

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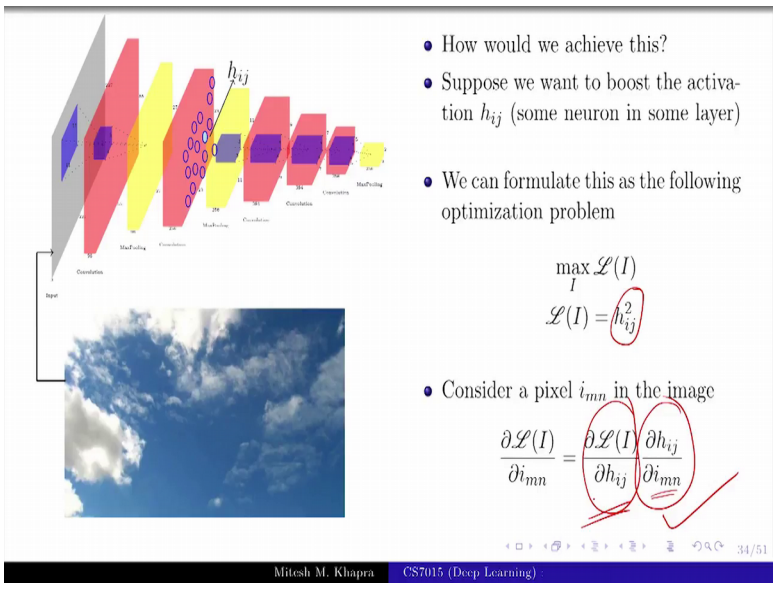

So, here is the idea right so, far we were seeing that if we start from a blank image, then we could suitably modify it by constructing an optimization problem whose parameters are the pixels of the image. And we can modify the image so that it starts looking like a certain class of interest right. But now suppose instead of starting with a blank image, I start with a natural image right, say a sky or any image that you have in your dataset.

I start with this and then I focus on neurons in some layer of the convolutional neural network. I am focusing on these neurons see any one of these neurons I am focusing on. And I want to change the image so that these neurons so when I say neurons I actually mean only a single neuron, but for illustration I will show multiple neurons. So, I want to

change the image so that this neuron fires even more. So, how would we achieve this? What will we do?

So, say this is the neuron which I want to fire even more. So, what is my optimization problem, first of all what are the parameters of the optimization problem?

Student: (Refer Time: 01:51).

The pixels of the image, that is clear. Now I want this to fire even more. So, what is the objective function, what you are going to maximize. Let us call this neuron as hij, what you are going to maximize.

Student: (Refer Time: 02:18).

Sorry.

Student: No (Refer Time: 02:21).

No I want this neuron to fire more.

Student: (Refer Time: 02:27).

Maximize hij right, I mean that is I mean why so that sort of a thing.

But of course, we will do something. So, that it is a neat differentiable thing and so on. So, you want to maximize the activation of one such neuron h ij. So, we could just formulate the following optimization problem that I want to maximize h ij square. And of course, the parameters of the optimization are the image pixels and if I consider one such pixel in the image then I essentially need to compute this gradient.

The gradient of the loss function, which is h ij square with respect to this image pixel and I can do it in these two parts the lead ability of the loss function with respect to h ij and the derivative of the h ij with respect to the image pixel. This we have seen a million times while doing back propagation of course, you are not going all the way back to i mn, but we saw last time that it is just one more term in the chain rule. And this again looks straightforward right the derivative of the loss function with respect to h ij looks straight forward. So, I have a very simple way of computing the derivative of the loss function with respect to any pixel of the image.

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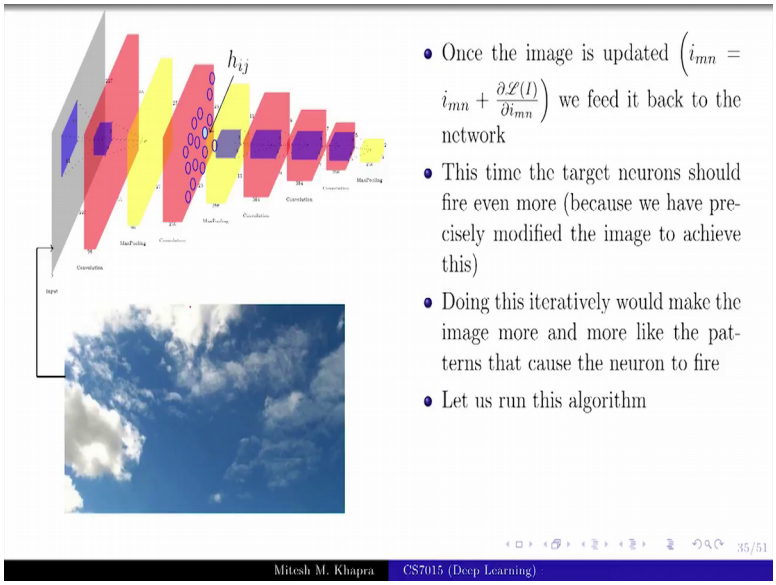

So, now, I can apply gradient descent and I can update the image. So, I started and now remember that the my original i mn was not blank or random or 0 or anything. It is actually the sky image so maybe it was blue or cloudy or whatever pixel that I have in my original image and that pixel I am changing.

So, I have started with the sky image, I have changed in a bit based on this gradient update rule; gradient descent update rule. And now I feed it back to the network, what will happen to h ij?

Student: Fire a bit.

It will fire a bit more because that is exactly how you have changed the image with exactly that objective function right.

And now if I keep doing this what will happen? So, remember what does h ij actually capture now this is where. So, if you understand this right you will really understand and appreciate everything about convolutional neural network. And I will be sure that you are actually understood the details and not just these boxed architectures right. So, what if this happens right then what does actually h ij capture. It captures certain.

Student: Patterns.

Patterns in the image right. Now if h ij is firing; that means, these patterns have started.

Student: (Refer Time: 04:57).

Appearing in the image we started with a sky image.

And now hij is firing more and more; that means, it is now the image is suddenly becoming more and more or containing more and more patterns for which h ij should fire; does that make sense? So, let us run this algorithm we will start with this image and we will run this algorithm. So, I will run it before that I want some guesses; what kind of patterns do you think will start appearing here and this is deep dream is the title right so fine.

So, let us see, so I will run this algorithm so what I am doing is I am starting with this image and running exactly what I showed you that I will compute the gradient with respect to one of the neurons. And I will keep updating the image so, that it becomes more and more like the patterns that I am trying to capture. So, let us run this and observe carefully it is almost a magic trick. I hope this does not disappoint, what do you see.

Student: (Refer Time: 05:51).

Most of them are what?

Student: (Refer Time: 05:53).

They are dreaming so they are literally building castles in the air right. So, what is happening, why is this happening? Everyone sees castles right that is the first thing either is.

Student: [laughter].

Good; why is this happening? Have you seen the Disney logo the castle what does it have in back background. How many of you find this interesting how many think this is expected. So, why is this happening? Think about training data, think about what would have happen or you missed the magic show. So, what is the convolutional neural network actually trying to do.

Student: (Refer Time: 06:32).

I will give you a hint its being over enthusiastic. How many of you get that so here is what is happening right should I explain it or no, I am not going to ask you a quiz question I am just saying that I have some more images to show, I will explain it first. So, this is what is happening right.

So in the training data whenever the castle appears it is typically has the sky as the background ok. So now the convolutional neural network started drawing these correlations. So, whenever it sees a sky it is trying to find a castle somewhere, but because it knows that most of the times whenever I see a sky there is a castle in the foreground.

So, those neurons are firing a bit and then now you are trying to fire them even more and more. So, that keep trying to change the image till this castle actually appears on the image. How do you how many if you get this explanation please raise your hands ok. So, let us see some more examples right. So, now guess what will happen here ships, again a generation which thinks of.

Student: (Refer Time: 07:38).

Ships is I should not comment on that.

Student: Birds.

Fishes (Refer Time: 07:43).

Student: Birds.

Birds, orders but there are also mountains.

Student: (Refer Time: 07:47).

Ice, interesting.

Student: (Refer Time: 07:50).

Now our expectations are in case let me just run this and see what happens oops oh no.

Student: (Refer Time: 07:56).

I have my final trick ok.

Student: [laughter].

The prestige is gone yeah. So, what do you see here? So, actually if you go back and look at it carefully right this is very interesting a lot of fish eyes actually start appearing here and some shapes like fishes actually start appearing here. Go back and look at it carefully and all on the mountains and the green regions a lot of birds and animals start appearing right which is again expected. Because in your data set you would have seen birds and animals with a green or this kind of a background right whatever you call it a mix of green and brown background right.

So, now it is trying to find those things even though they do not exist and as it try to force it more and more it starts creating those images as you start asking to dream more and more right and since this is about dreams I could not let this go it has to had inception in that. So, what will happen here now?

Student: (Refer Time: 08:51).

There is actually nothing interesting is this for my own sake that I put this. Unfortunately nothing interesting happened with this.

Student: Oscars.

Wow.

Student: [laughter].

If only, but that is the point right this is so data set specific that it cannot really generalize it cannot dream beyond the data set actually nothing interesting happens. It is just a lot of these men are wearing brown suits and in the data set unfortunately all brown things were dogs. [laughter] So this is what will happen, we will start seeing dogs appear everywhere you see one here.

Student: [laughter].

You see many here actually

Student: (Refer Time: 09:31).

It is like a few more and this would have turned into [laughter] something unpleasant right. So, that is what is happening actually see a lot of dogs here in many places right.

So, this is still running. So, what exactly is happening here the same thing that I had detected right the network has been trained to detect certain patterns dogs, cats, birds etcetera which appear frequently in the ImageNet data and with these backgrounds that I am trying to do or these textures that I have in my images. It starts seeing these patterns even when they hardly exist and now as I start focusing on these neurons which are firing and try to modify the image to make them fire even more. It will start producing these pixels or these images in the original image right.

So, you can read this explanation which is from the Google blog on this they have some realize some code and something on this. So, you can just read this explanation if a cloud looks a little bit like a bird. So, that will make it look more like a bird, this in turn will make the network recognize the bird even more strongly on the next pass and so forth until out of nowhere a bird actually starts appearing in the image right. So, that is exactly what is happening so this is deep dream.