Image Single Processing
Professor. A. N. Rajagopalan
Department of Electrical Engineering
Indian Institute of Technology, Madras
Lecture No. 68
Impulse Noise Generator

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So, in the last clause last class, we saw what is called a Gaussian noise, which we also referred to as AWGN. And we also saw how to filter this kind of noise which comes under the under the image enhancement framework. And we saw that you could use a simple spatial averaging filter which will be local in nature and then we also saw an extension of that what is called a non local means filter which had this, this which had this nice capability that it could keep your edges reasonably intact.

Whereas, a local averaging filter will tend to smooth edges whereas an NLM, NLM has this, has this very strong feature that it can actually keep your edges intact. And then along with that, we also saw, saw what is called what is called a bilateral filter, a bilateral filter is again something that that actually employs that that not only looks at looks at the looks at the neighborhood information in terms of spatial locations, but it also looks at intensity differences and therefore, it also has the capability to keep edges intact. Now, moving on, we will look at what is called Impulse Noise.

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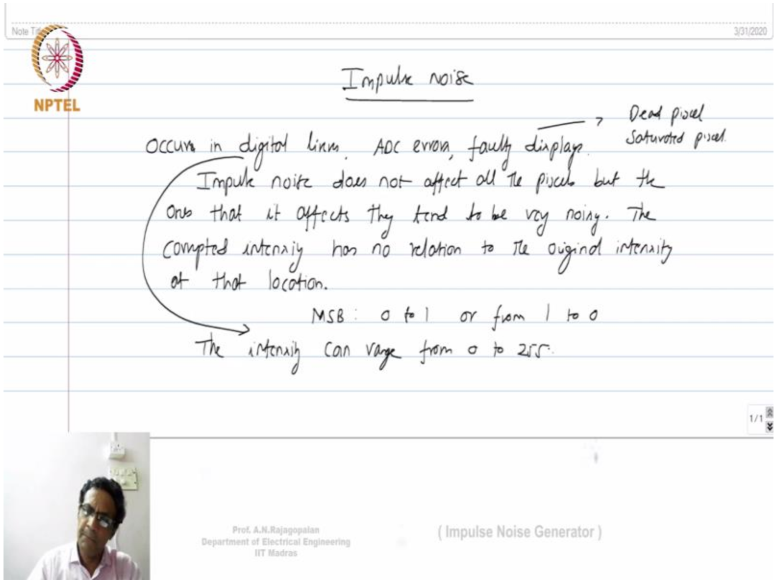

And some people even refer to refer to it as impulsive noise. An impulse noise something that occurs in like, I like, I like all I said occurs in, in what are called Digital links, ADC errors, this could be due to ADC errors, faulty displays and so on for the displays and so on. Now, now, a property a kind of a feature that sets it apart from either the GNA and all is that now the impulse noises is the impulse noise effects, does not affect, affect all the pixels does not affect all the pixels in the sense that some of the pixels could be simply noise free, they are not even affected by it.

Does not affect all the pixels, does not affect all the pixels but the ones that it affects but the ones that it affects they tend to be very noisy, they tend to be very noisy, they tend to be very noisy and tend to be very noisy. And the corrupted intensity, and the corrupted intensity has no relation whatsoever, has no relation with the underlying with the has no relation with the signal strength at that location has no relation, no relation to the original intensity at the location to the original intensity at that location, at that location.

One example for example, when we when we talk about an on a digital link we can think about the MSB the, the most significant bits not changing from 0 to 1 or from 1 to 0 for example during a transmission error, when you talk about a faulty kind of a display, it could simply mean that you have a dead pixel in your in a display which, which means that it always outputs a 0 irrespective of the signal strength or you could have a saturated pixel which seems to be always on, irrespective of the, of the incoming intensity.

A dead pixel or a saturated picture does not kind of seamlessly mean that the intensity that is 0, for example, but it is dead or it is too saturated will also be at some value in between because of the influence of neighboring intensities. But then the general idea is that in impulse noise only some pixels get affected not all of them are affected, but the ones that are affected turned out to be very noisy, and the intensity levels could in fact range from anywhere and then typically read in a general sort of scenario, the intensity, intensity could range could be intensity can range from any can range anywhere from 0 to 0 to 255 at any level between 0 and 255.

Now, there is a special case called the salt pepper noise where the intensity that where for example, salt would correspond to a high intensity or 255, pepper noise would, would mean an intensity of 0 level, those are going especially those are extreme cases, but otherwise impulse noise in general does not have to limit itself to 0 or 255 can take anywhere between 0 to 255. But the point is it is going to be completely independent of the signal strength and, and no and this is not true that it will affect all the pixels.

So, so some of the pixels could still stay, stay noise free. Of course it would be hard to know which ones are affected by it impulse noise and which ones are not, there are of course algorithms that try to figure that out. But anyway that is kind of beyond the scope scope of this of this course.

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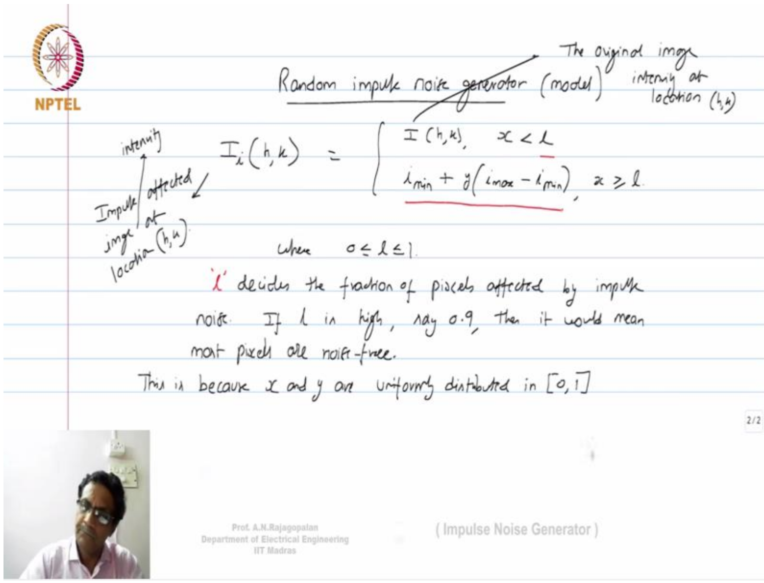

Now, let us first understand, How about how do I even generate an impulse noise, AWGN we all know how to generate now what is not very clear and so, how does one generate impulse noise because once you can once you know how to generate impulse noise and again look at what kind of filters and how well do they work on these kind of images and so on. So on. So, let us first look at what is called random impulse noise generator, impulse noise generator.

Now I am going to I am going to write down, this is simply a model, there is simply a model for actually generating an impulse noise. You can have other models also but the Standard Model, what this says is that the impulse, the impulse affected image, let us call this I subscript i, let us just call the spatial location of some h comma k is equal to I of h comma k that means original intensity itself. So, this is the impulse, impulse affected image, impulse affected image, add location, image intensity at location. Let us say you made intensity at location h comma k.

Well h comma k, let us have a look at it is strange to you get for using it for image location, but that is okay. I h comma k is really the original intensity, the original image intensity at original image intensity at location h comma k, at location h comma k and so, this is equal to I h comma k when x is less than l, I will tell you what x and l r and if not, that means if x is greater than or equal to l then the value that you assign at pixel location hk in the pulse affected image.

It is i min plus y into i max minus i min provided x is greater than or equal to l. Now, l itself is the number where l is a number between 0 and 1. So, this l that you have here is simply a number between 0 and 1 and l decides l in fact, decides the fraction of pixels that are affected by the sides the fraction of pixels, fraction of pixels affected by impulse noise, pixels affected by impulse noise, by impulse noise.

So, for example, if l is high, if l is high that is say, 0.9 suppose we can suppose we said l through a high value then, then, then, then it would mean that it would mean that most pixels are, are noise free that is most pixels are our most pixels noise free. Why? This is because, this because x and l, this is because, because x and l are simply numbers it is because x and l are simply random x and y, not l x and y, x and y are uniformly distributed random numbers that are uniformly distributed, uniformly distributed, distributed in the range 0 to 1.

So, what so what this really means is that at every pixel location, what it is you draw a random number x, which is uniform in the interval 0 to 1, x gets a value, if x is the number x is less than l. Now l is something that you would fix for this image let us say l equal to 0.9 in this case, then what will happen is if x is a number which is, which is uniform in the range 0 to 1 and when you draw a sample of x for some location h comma k and if x is, x turns out to be less than l then in that case, you simply retain the original intensity value at that location h comma k.

If not, if x let say turns out to be 0.91 then you go to the next thing, which will mean that the, the location at the at the location h comma k, the the, the rates of the main intensity will be affected by impulse noise and, and then what will, what will happen at that location is that you will get a new intensity, the old intensity gets replaced by this, this new intensity where i max and i min are something like that we need to specify, what can be the maximum value of the impulse noise on one run on what can be the minimum value of impulse noise. So, you can automatically see that setting a value or setting a higher value for l will mean that will mean that the impulse is not going to be affecting all the pixels. In fact, it will have a sparse effect.

On the other hand, if you, if you choose if you set your l low than then what you will be effectively doing is you will be actually you will be actually introducing dense impulse noise into the image. So, this l is some kind of a leave it gives you a control over, over how many what fraction of the pixels it can get affected by impulse noise. So, it actually gives you that kind of a, that kind of a, that kind of a hold over, over impulse noise generation.

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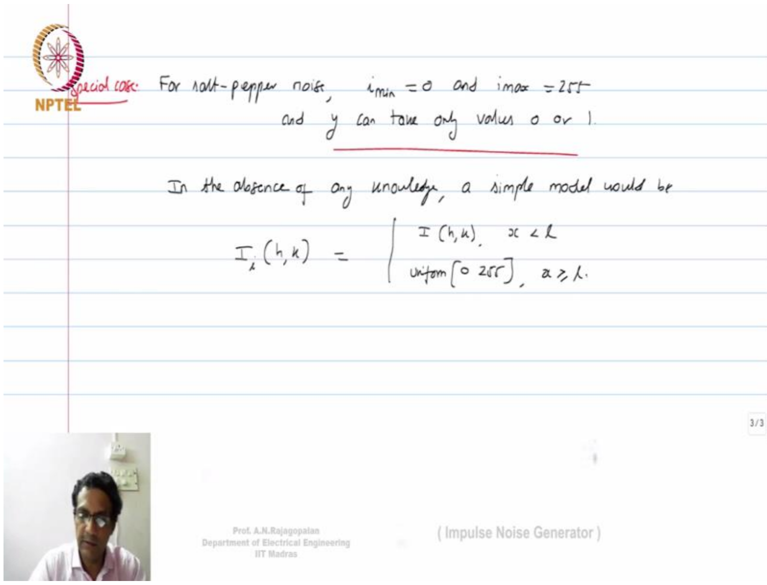

Now i min, i max, let us just write those down also. So, now you can you can set any value for for for i min and i max depending upon what you know about the noise for that situation, but typically now for salt pepper noise especially if you have for salt pepper noise, for salt peper noise okay we set i min is equal to 0 and i max equal to equal to 255. So, that so, that what will happen is so, when you set it like that i min is equal to 0 and i max equal to 255 then what will happen is whenever, whenever you come here.

And look here now for for the for salt pepper noise i min is equal to this and y can take only values 0 or 1, only values 0 or 1. So, this is a special case, this is a special case which is the salt pepper noise where y can take only, only a binary value either 0 or 1. So, maybe we can say that they will take it with equal probability in which case what will happen is, in which what will happen is when let us say y is 1 and let us say x turns out to be x is still between 0 and 1 it could take any value you found it in 0 and 1.

So, if you happen to be here and if and if some noisy pixel has to be introduced then if y is 0 then what will happen is you will get i min that means you will get actually, actually that intensity to be equal to 0 which should be pepper noise. On the other hand if y turned out to be 1 then what happened is i min and minus i min will cancel off and you will get to 255 which will be salt noise. So, the salt pepper noises so this model that we have here also allows you to generate what is called salt pepper noise.

So, so this model also allows you to generate salt pepper noise which will be a special case okay and in this case y of course going to takes up only values 0 or 1. Otherwise, otherwise depending upon what you know what situation you can set your i min, you can set your i max and then your y will then be anything between 0 and 1 and x will also be anything between 0 and 1. Now there are situations where let us say well if you do not know anything at all about the about what the min and max intensities can be like.

In the absence of any knowledge okay in the absence, of in the absence of, in the absence of, of any other knowledge of any, any other knowledge of i min i max excreta, in the absence of any knowledge, now a simple model, a simple model would be this, would be, would be Ii or h comma k is equal to I of h comma k again the same thing as we had earlier if x is less than l and uniform between 0 and 255 for x greater than or equal to l. So, so the absence of any knowledge and all requests the normal model is this.

But in case, in case let us say, you do not have any knowledge at all and you just want to okay then in that case, you could use, use a simple model like this. Now, this is as far as impulse noise generation is concerned. Now we want to get a say talk about how do you do filtering when we do the important thing is how do, how do you only filter?