**Medical Image Analysis**
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**Lecture 07**

# Contrast Enhancement

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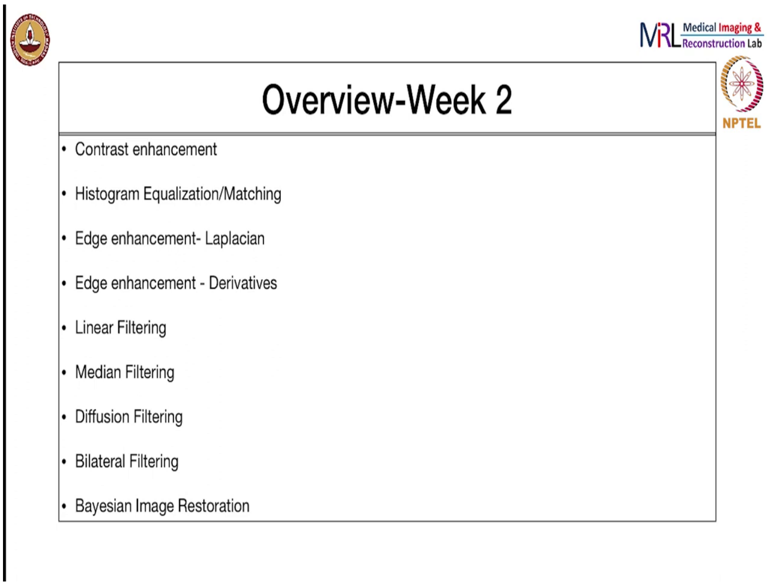


Hello and welcome back. So, in this video we are going to look at contrast enhancement technique

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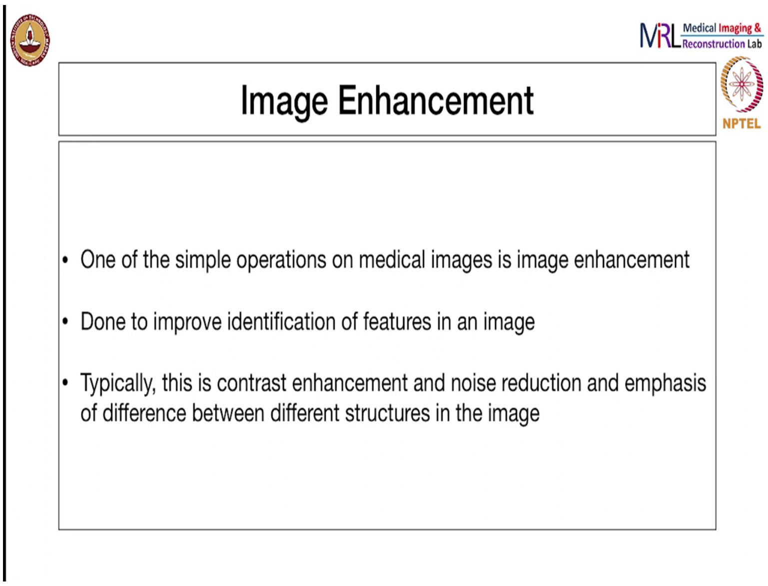


So, contrast enhancement is basically a form of innate image enhancement and it is one of the most simple operations that is used in medical image analysis. And this is primarily done to improve the identification of a particular feature in an image, basically to make something appear more bright or more distinctive from the background. So, you call it contrast enhancement because contrast if you want to define contrast it is basically how different residues from the background.

And it is also of contrast enhancement noise enhancement noise reduction together and with in combination with like you mentioned earlier emphasis of different structures on the image. So, we like we also like we had also like had also mentioned earlier we will just look at the formulation of these techniques and I will show them through the results in a separate class.

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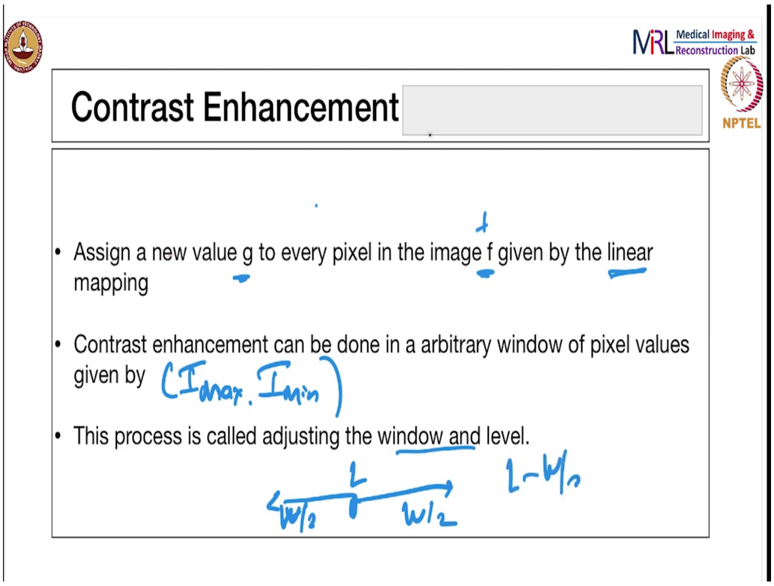


So, the idea behind this method is to have for every pixel in an image if you have to find a new value g through a linear mapping. So, the linear transformation is a linear transformation I will say linear mapping and typically what you do is you want to map all the pixel values into a range between I max and I mean.

So, this I max and I mean chosen by the user typically a clinician or radiologist who in his experience knows the best I max and I mean this process is also called adjusting the window and level primarily because you can choose a level L and from there you can go w/2 to the right w/2 to the left. So, which means you will be mapping between L-w/2 to L+w/2.

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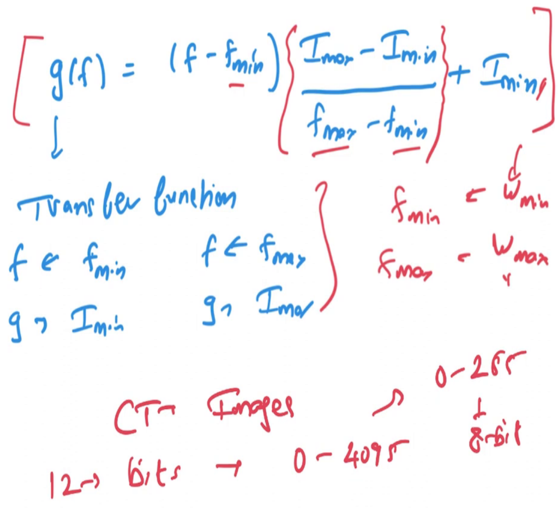


So, let us see how it is actually done. So, the formula write this down is g(f) that is the transformed intensity is $g(f) = (f - f_{min})\frac{I_{max}-I_{min}}{f_{max}-f_{min}} + I_{min}$. So, this g is called the transfer function. So, you can actually see that if you plug in the appropriate values you will get the desired result.

So, for instance when f you can try to see when f =f min and f = f max then this the g then goes to I min and in this case g goes to I max you can just plug the values in here and then verify that. Now, here what you are doing is taking every pixel value in f of course we are identifying the minimum and the maximum values in f and denote them as f max and f min and then you are trying to do a linear mapping.

So, think of this expression here as estimating the slope. So, doing a linear fit is estimating a slope here and then you can just use a straight line fit to go from f to g. So, this process is often done with CT images CT images are typically 12 bit images 12 bits. So, which means that they go from having 4096 values like 0 to 4095 this might be a very wide dynamic range wherein you might not be able to see very good contrast between let us say lesion or tumor and background small tumor and background.

So, you might want to map this into a slightly smaller range. Maybe you want to go to 0 to 255. So, this is an 8 bit range where maybe you get better contrast. So, this is one way of doing the transformation now once again knowing that f min and f max do not necessarily need to come from the maximum and minimum values in the image.

So, the maximum and minimum values in a given image might not be meaningful. So, you are also allowed to set your own instead of f_min and f_max instead of f_min you can go to w_min and instead of f_max you can go to w_max and because in the original image of anything less than w min might not be meaningful it could be some artifact some error anything greater than w max might not be meaningful also.

So, when you do this kind of mapping then you have to make sure you do a thresholding operation also find out all the pixel values less than w min and then turn them into I min which is what is here then find out all the pixel values greater than w max and find out and set it to I max but of course there is some conditions here which is basically you want to make sure that w min and w max are within the range I mean and I max that is one other condition from which then you can map easily.

So, again there are variations of this so this is the simplest version and often done. So, the window and level are often done on CT images. So, this is one of the simplest contrast enhancements and you will end up doing this often. So, for instance even if you are let us say doing deep learning and you have a bunch of CT volumes to process. So, it will be nice before you provide these CT images as inputs to a neural network a CNN for instance in order to have an outcome you might want to do the window and level on this image.

So, one of the strategies that people often use is to have an ensemble of networks wherein each network has an input adjusted to a different window and level. So, that it highlights different anatomies or structures of interest. So, this is a commonly used trick. So, that is all we have for contrast enhancement. So, in the next video we will look at other techniques. Thank you.