Medical Image Analysis
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Week 2
Lecture 06

Basic Image Processing Methods

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Hello and welcome back. This is week 2 of the Medical Image Analysis course. So last week, we were looking at the various medical imaging modalities, namely MRI, CT, ultrasound, and some nuclear medicine imaging. And we saw what the mechanisms are of image generation. So, either other than ultrasound, most of the other imaging systems require a reconstruction process. There is no direct image acquisition. And we looked at the nature of those images, the needs of contrast, what the pixel values mean, etc.

So this week we are going to continue to look at some of the basic image processing techniques that you will end up using pretty much every time you start on an imaging project. So this is necessary for a wide range of imaging, image types, starting from, even MRI, CT, or ultrasound whatever it might be. So some of these are a requirement in many cases.

So you will have to be familiar with some of them, so that you can use them, even if you are using let us say, machine learning or deep learning methods, as it is the state of the art. So in this

video, we will mostly only be looking at the contents of this week's lecture. Just to give you an overview of what we are going to look at this week.

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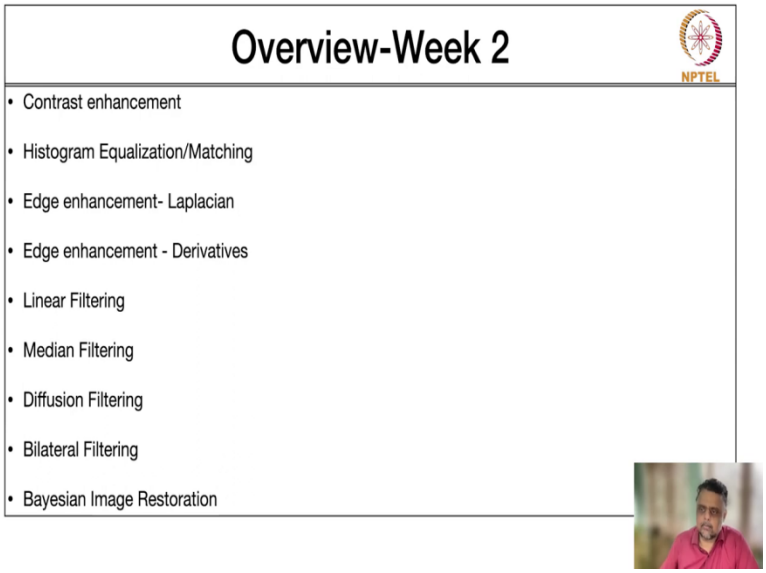

So our topics, the topics we are going to cover in this week or contrast enhancement. So in a lot of cases, when you display the medical image on the screen or on a radiologist monitor, the anatomies of interest are not necessarily highlighted. So there are various techniques to highlight a certain type of issue. And that is the technique that we are going to look at in terms of contrast enhancement window and level. So we will see what that is.

The next technique that we look at is called histogram equalization or matching. Once again, this is done to improve the appearance of the picture. So the first one is more trusted, the contrast enhancement, where we what we call the window and level, setting the window level is more often done, because it does not really change the meaning of the image, but histogram equalization can, isogram explanation is good if you are going to do further downstream tasks.

So we will see what that histogram equalization does when you look at the process. And the other techniques we are going to look at is the edge enhancement using Laplacian, the second derivative, you are familiar with as well as the derivatives. How can we compute derivatives on an image? Because the Laplacian, derivative, etc, are defined mostly on continuous function,

sorry, but the images are discretized to the matrix, so we will have to see how to use the Laplacian or the derivatives on images.

After that, we are going to look at a variety of techniques for filtering. Now these filters appear in the context of de-noising images. So, a lot of times the acquired image might not be of the quality that the clinician wants. In that case, we have to do filtering to remove that noise. Now when you do filtering, you have to be careful not to remove anatomical structures or distort anatomical structure so that there is a can happen.

So in that context, you look at some very simple filtering techniques like linear filtering, which is nothing but an averaging, boxcar averaging as it's called; median filtering, diffusion filtering is slightly more complicated. So I will not spend too much time on diffusion filtering, I will just give you the general principle, maybe in week 3 or 4 when we are looking at related techniques, I might get into that.

But at this point in time, as far as diffusion filtering is concerned, we will just look at the overall concept of how it works. Just to give you an understanding of how there exists so many different techniques to do filtering. And the next one is the bilateral filtering, this we can go into slightly more detail as the formulation of this filter. And of course, this is also a widely used filter in the clinic.

It is a very slow filter in the sense they are, computationally it takes longer, but a lot of people have worked on improving the speed and making approximations etc. But we will only look at the basic method as it was described in the original paper and understand its strengths and weaknesses. The last topic is the Bayesian image restoration, which is again a probabilistic technique for removing noise from images where we actually propose probabilistic models for the image as well as for the noise.

And then I do this Bayesian image distribution. Once again, as far as the Bayesian image restoration is concerned, we are not going to go into great detail as to how it is done. Again, just show you the general principle, and if time permits maybe in the future weeks, after week 3 and 4, I will get into this in more detail. Just a note of warning, you will see a lot of formulas, some mathematics, you are not, I mean, but I think this mathematics is at the level of plus 1 or plus 2.

Now, if you are not comfortable with this, do not worry. There are lots of resources online, textbooks, carrying this information, after all, is a well researched subject. So there is a lot of material out there, I urge you to go and read them. So do not be intimidated, if you see a derivative, second derivative, Bayes formula, a bunch of exponential weighting schemes etc, or medium figures, etc.

Or if you use the term probabilistic models or things like that, do not get put off by it. At this point you can spend a lot of time understanding this pseudo code or how you take the formula and make it into a code. So you can spend time on that, that will help you understand this thing better. Also, at this point, I am not showing any demonstrations, I will definitely show you demonstrations of these techniques on some good images, and see what each of them do.

But once again, like I said, well researched subjects can find a lot of resources online about these filters etc, implementations of these filters will be available in Python, MATLAB. MATLAB as an Image Processing Toolbox, I tried all of them or you can just try it from your laptop, like many of them are not that computationally intensive in the sense that you can run it on a very simple workstation.

So I know, so even though it might be very mathematical to be I present the formulas for all of these techniques and I urge you again to be not intimidated, but rather try to understand what the techniques are in terms of working of the pseudo code trying to see how you would exactly do the computations, etc. I also mentioned it better I can and then that way you can understand the techniques better.

Now, once again, you might be wondering why we need all this, now there is deep learning, machine learning, etc. But if you look at a lot of these papers, in machine learning, or deep learning, there is usually a preprocessing step, especially for medical images, it is actually a requirement, I think. And it is good to know some of these techniques, because then you can apply them without worrying about what it does.

So it is important to understand what this technique does. There are two ways, one is to understand what the output is, what the limitations are. The other one is actually understand the process computation is involved. So now there are again, implementations available. So

understanding the computations is good for you. Maybe you want to code yourself and you are wondering, low level code for all these, that is great, go and develop your own image, like a fast library for all of these things in that context, please go and understand every little computation.

But in the context of, you want to do slightly more advanced things, but this becomes a basic step. And maybe you do not want to spend too much time on it, in that way you are going to understand; what each of these operations do today, do to the images. So broadly speaking, this is basically divided into, this contrast enhancement, this histogram equalization, matching, these are all I would call improving the, enhancing the image.

That is what this comes up, an image enhancement. The edge enhancement, except the Laplacian as well as the derivatives for edge enhancement, is more into processing. Because not too long ago, edge detection was a big thing. Even now it is, if you are very good, it is great. It is very useful.

So when, that is what this Laplacian and the derivatives fall under. The other things are again they also are concerned with improving the quality of the image without distorting the anatomical. So, now we go into each of these techniques one by one and show you what the basics are. Thank you.