Machine Learning For Engineering and Science Application
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Introduction to Week 12

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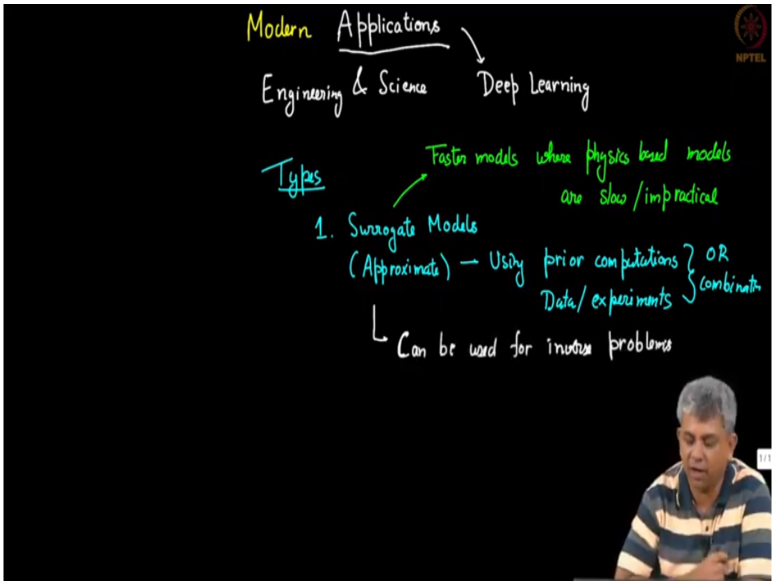

Welcome to week 12 of our course this is the final week as we had promised earlier we will be looking at applications of machine learning Dr. Ganapati had already shown you a few applications of machine learning within medical image analysis, so week will be primarily dedicated toward applications in engineering of course this are applicable to signs applications I will show you a quick applications towards Schrodinger's equation also. Now before we go forward I want emphasize that we will primarily be looking at deep learning applications there are of course applications to all the other algorithms that we discussed such as SVM, PCA, KNN etcetera.

And they have been used actually extensively used in engineering for quite some time over the last ten fifteen years in various field AVM etcetera used quite extensively we will not be covering those we will just be looking at modern applications except for just one I will be showing you a few very-very modern, modern meaning is the last two to three years success that machine leaning has had a specifically deep learning has had within some engineering applications what I will do is just give you a few hint of how this problems can apply to engineering etcetera.

Now we look at some specific types of application, so let me talk about this types of applications the first is what is called surrogate models, so surrogates models are typically faster models where physics base models are slow or in some cases in practical, so let me give you some example suppose you want to make a weather prediction tools actually weather prediction involves a lot of very-very complex physics but what can happens is if you have done a few weather predictions with the complex physics you can make up a sort of faster model approximate model a surrogate models is an approximate model using prior computations or prior data or experiments or a combinations of the tool.

So using this you can make approximate model, so I will show you a couple of example of surrogate models these are in some sense probably the most popular uses of machine learning now the surrogate model in turn can be used for inverse problems what is meant by inverse problems.

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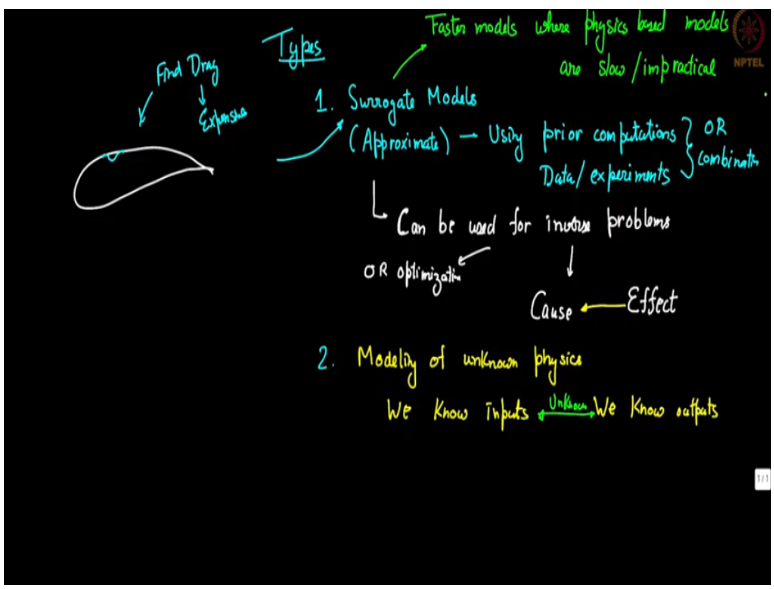

An inverse problem is a problem you know normally you go from cause of something to effect but in inverse problem is it goes from effect to cause, so I am just showing in terms here in case you are already using some of these cases somewhere within engineering were signs this would be a little bit more helpful to you hopefully you will also see a little bit of more use or sense to what I am saying as you be go through the examples.

We can also use surrogate models for optimizations for example let us say you have a shape optimization problem you want to find out what shape of an air foil of a wing will give you the maximum lift or the minimum drag or maximum what is called del by D ratio etcetera, now people what they do is they will change a shape little bit and then find out drag etcetera, drag means the force that is applied on the air file as it moves through air now typically this is very expensive that is each time you shape change the shape of little bit if you want to find out what the drag is you have to do the long computation and that is one other place where you can use surrogate models.

So surrogate models would be the strongest case for neural networks etcetera within deep learning now the other thing is direct modeling of physics modeling of unknown physics means let us say like I give you the example of weather problem let us say you have a really-really complex problem but you know that the output, so we know inputs we know outputs but we do not know the connection, so the map itself is actually unknown in such cases you will use neural networks deep learning.

So let me slightly distinguished between surrogate models versus let us say modeling directly surrogate models are you might know the model it is just that it is very-very expensive to actually use it, so in such case you use surrogate models or the uses called the surrogate models and either case you will use neural networks, now there a few other cases where you can use neural networks.

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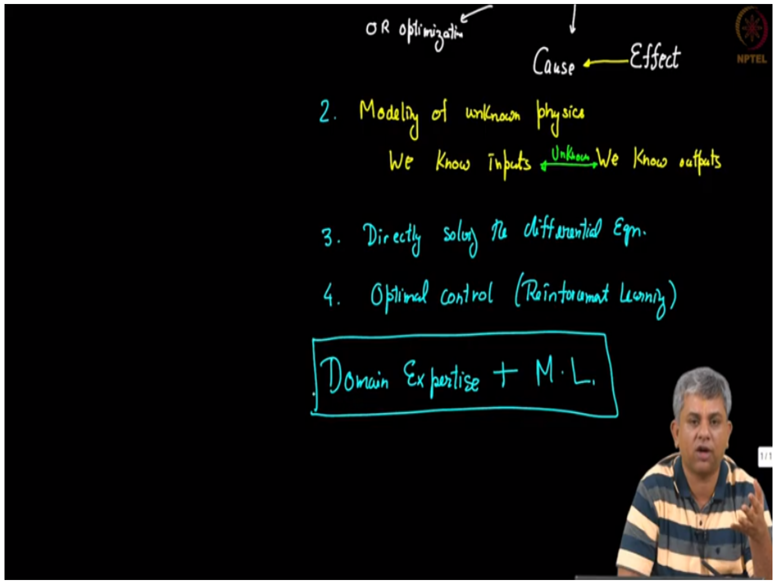

Which is directly solving the differential equation, so I will show an example of this we you can have a neural network actually solve a differential equation by itself now this is just a hint of what are neural networks can do of this are very standard this we can tend to do again an again within engineering and science but this is just a hint of what neural networks can do you can actually have control problems here typically reinforcement learning useful for example a prof Andrew Yang a several years ago had done control of a sort of model helicopter using deep learning ideas.

Now these are some of the uses you can have within engineering and science I show you a few examples now a quick note of advice for how to approach this particular week this kind of different from all of previous weeks the theory portion is going to be less I will just show a problem and it solution and in fact most of the solution I am going to show are by the people, now in order for you to maximize for learning the best way for you is to I will describe the problem first in a separate video and once I describe the problem I would like you to think about what kind of structure would be ideal for this problem what kind of neural architecture would it be a ANN, would it be a CNN etcetera.

What would be ideal for this problem how would you pose the input how would pose the output how would you make the network structure, so please think about the problem before you look at the solution as offered by the other people some of this solutions are actually quite elegant, so this will actually exercise you mental muscle so that when you actually have a practical problem you wish to solve because throughout this course we got several questions how would I solve problem XYZ in some field now most of those fields neither of us actually know but if you actually get into the idea of how this problem is actually solved by other people and where you can use your domain expertise.

So this is a key word how this problem is actually requires some amount of domain expertise plus some amount of knowledge of machine learning, so it is this two domain expertise means if I am solving a fluid mechanics problems I should know something about fluid mechanics typically it is useful in how you are going to pose there problems machine learning algorithm, so as we go through some of these problems through this week please think about how you would have solve them if you did not know the solution already and then come to the next video where the solution will be discuss, thank you.