Machine Learning for Engineering and Science Applications
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Summary and road ahead

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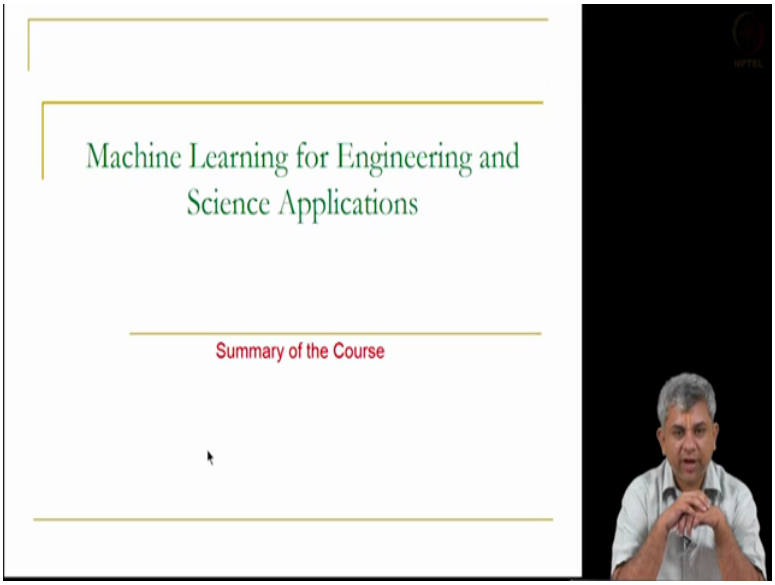

Welcome back in this final video for the course I will just summarize what we were able to do within the course, also what we were not able to do within this course and how you can move forward within your journey in machine learning.

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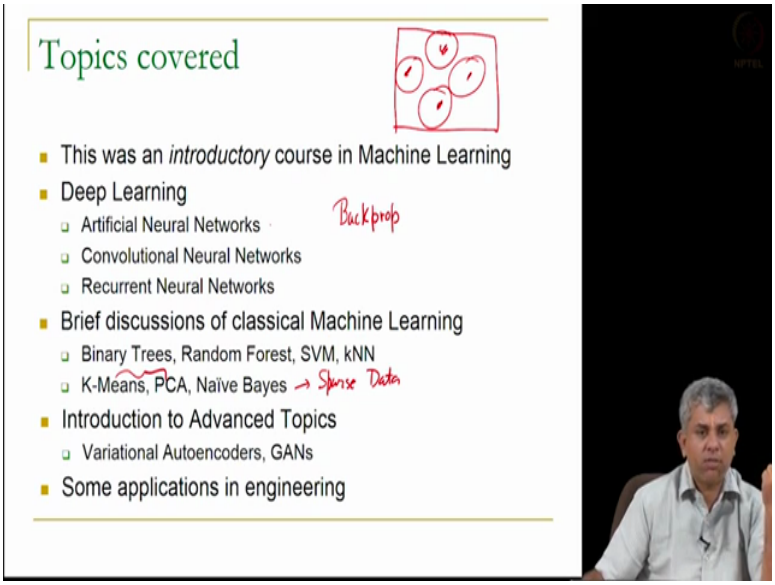

So the topics that we covered primarily apart from mathematics was basically introductory machine learning so this is just sort of a brief taste you got of machine learning, we just had

30 hours, we also (looked like) looked at some few applications, okay. So please do not take this course as being a thorough course in machine learning you just got an overview, machine learning is a vast subject, but hopefully you got some idea of what things are happening within this field.

The first part of the course was deep learning and specifically we looked at ANNs, CNNs and RNNs, once again all our discussions were kind of preliminary here we only looked at backprop very very briefly, thorough courses and machine learning will actually go into it our point was to be able to give you a flavour of what these things are, why they get into trouble and how they work and how maybe you can play around with them so that when you want to apply it a lot of black box tools are nowadays available even tensorflow and when you want to apply it hopefully you should have some background in what these methods are.

So that is what we covered that was a good portion of the course, deep learning itself was a good solid portion of the course. We also had brief discussions of classical machine learning (binat trees) binary trees, random forests unfortunately we did not have time to discuss applications of that Doctor Ganapathy's team itself has done a lot of work on binary trees and random forests within medical imaging, they have publications there too.

SVM are classic algorithms they are slowly going out of fashion, but as has happened throughout history within not only machine learning but also in general numerical methods there are things that go out of fashion and then come back, but unfortunately we did not have too much time to discuss SVM, it is a very interesting algorithm in itself, very different from the kind of algorithms that we saw, again we saw a brief introduction KNN and then of course we had unsupervised learning algorithms such as K-means and PCA.

Now one thing that you can do when you face a practical problem, let us say you are looking at just to give you an example weather prediction or monsoon prediction within India, okay. So India itself has you know you can see that maybe up north will be different from west, will be different from east, will be different from the south, but maybe there are other natural portions that kind of aggregate properly.

Now instead of trying to predict whole the whole of the monsoon in the country at one shot you could probably figure out that there are four different kind of networks that predict in a particular area well, now how could you figure this out? If you try to put (the gate) the data and try and get an unsupervised algorithm within there, okay when I say data I am being

deliberately vague this word data is overloaded but let us say you find out genuinely that there are four clusters four types of behaviours maybe K-means can help you there, may be PCA can help you there, you can think of unsupervised algorithms as sort of a precursor to even supervised algorithm so that is one thing. So that is one place where you can apply unsupervised algorithms.

Naive Bayes again we discussed only very very briefly but oftentimes when your data is sparse by sparse I mean it is you do not have too much of a data set, Naive Bayes can perform sometimes surprisingly well, even though the assumptions are all actually unphysical it tends to perform reasonably well. You also did several other topics there which I am NOT summarizing here, but apart from this Doctor Ganapathy also covered variational auto-encoder and grants which are right now the quote, unquote trending topic within machine learning this is what is known as generative models and generative models can be useful for many many many different fields, unfortunately once again we did not have time to discuss applications of that hopefully we will put up some extra videos after this course is over.

We also discussed a few applications in engineering and science specifically PDE based ones that we looked at hopefully you can apply it to almost any field that you have looked at atleast in terms of basic applications that you can do very quickly using machine learning we have discussed a few applications.

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Now unfortunately the topics we did not cover are larger than the topics which we covered that is going to be true of any course actually if you want you cannot have both breadth and

depth, so we actually sacrificed depth for breadth within this course. Now one common complaint and I guess it is not really a complaint but it is a suggestion and we do understand it, we did not cover coding, we specifically we did not cover coding in frameworks. For example how do you code in tensorflow, keras, Pytorch, etc we did not have time. And that was honestly speaking that was not the purpose of this course also, our purpose primarily was if you see some publication or if you see a paper and lot of people are sharing their papers online, most of this field currently as it is developing is there only in papers it is not there in a textbook a textbook takes too long to write and to summarize and by the time the (move) field has moved elsewhere.

We are ourselves planning to write a textbook based on kind of the material that we covered so that you have fundamentals, okay. So a textbook can only cover (friend up) fundamentals and this field as rapidly as it is growing is basically within papers. So our purpose and if you are able to succeed in this we will be very happy was that if you take a paper it does not look like all Greek and Latin to you and you are able to figure out you know at least 50, 60 percent of any publication the machine learning portions and then you are able to see how this person would have applied or why this person would have applied this method, now why did this person apply an LSTM here? Why why a convolutional LSTM here? Why a fully convolutional layer here? Why a segmentation type of architecture and why an encoder, decoder architecture?

This kind of idea if you are able to create both Doctor Ganapathy and I would be very happy because then we would have succeeded in the purpose of our course, okay. Because once you know this then you can implement practically anything because learning these frameworks does not take too much time, atleast atleast the preliminary functionality of this is not very hard it is not too hard for you to learn. People are putting up their codes it is the basics, it is the basic idea that is a little bit hard to get, okay.

So that is one other thing that we did not cover and hopefully we are planning to put on some extra videos and more about that later. We did not cover applications of many of the algorithms that we actually talked about, we went through them really rapidly. For example well convolutional LSTM I just talked about, Gans we did not discuss, we did not discuss you know (())(7:43) how do you actually apply them you have just seen them in theory, they have beautiful applications within inverse problems, I was planning on showing one such

application there but unfortunately time was too short and it would have become a little bit too complex for you.

Naive Bayes, (())(7:58), binary trees, random forests, SVMs, etc there are lot of them have actually got very very nice applications in engineering and science but this course was too short for us to cover that. One very important topic that we did not cover is reinforcement learning this is within engineering and science, it is extremely useful in what is known as controls, how to control something you know how to make sure that an inverted pendulum stays upright, controlling of an aircraft etc etc.

So reinforcement learning is slowly it is slowly coming into this field, it has always had heavy applications within the gaming sorry sort of video game playing that side Google has bought deep mind which started with doing heavy reinforcement learning for several problems. Now there is a full course by Professor Balaraman Ravindran on NPTEL, we would very highly recommend that you go through that course, okay the videos are up online he is the expert on this topic within India so we would highly recommend that you take a look at in case you are interested in this field it is a vast field in itself, it would have taken us about a week at least to give us give you the beginning ideas.

But professor Balaraman Ravindran scores there right now available on NPTEL we would highly recommend that. The last topic which is expected to get more and more popular in the future is probabilistic graphical models we do not have time for this.

Now since we did not have time for a lot of topics we are actually planning to upload more material which will be publicly available on YouTube or some such place if it is a video, otherwise you know just on our websites if it is a you know written material etc etc. If you are interested in this material or knowing whenever we put up this material whenever it is probably we will start doing this this summer May, June, July if you are interested please contact us on this form on this link here you will just be asked to put an email and if you are interested in some specific video you can put that.

We have also put up the same link on the forums for those of you who are there currently on the NPTEL forums. So please contact us here in case you are interested, okay.

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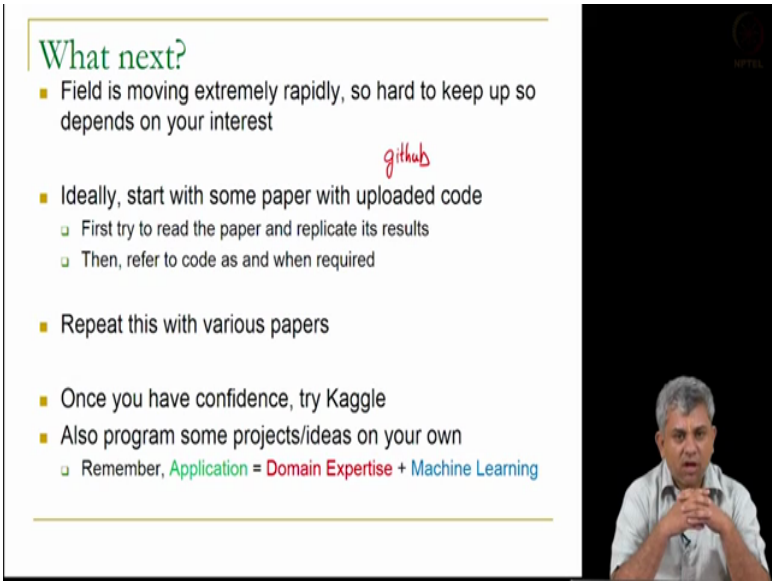

Finally for those of you who have finished this course, several of you have asked us both in our live sessions, as well as on the forum, on what should you do next? Okay, so first is of course that the field is moving extremely rapidly, if I tell you to solve problem A today it is quite possible that somebody might have already solved it by the time I finished speaking, okay so it it is important to know what your actual interest is.

Now our videos, our course was pitched towards people who are in engineering okay so something like Chemical Engineering, Mechanical Engineering, maybe even Electrical Engineering actually the course was neutral to all that except for the last few applications that we discussed or in physics, chemistry and they are not traditional computer science students, okay. So we are hoping that you already have some knowledge of some field reasonably well at the very least at the undergraduate level. In that case you can start thinking about oh this was the kind of application this person did for CFD, can I try something similar in my field?

Okay, so our experience with the live classes at IIT Madras have been that whenever we present this course usually several ideas automatically come from the students and we hope that some such ideas have come to your mind also, okay.

Now if you want to get better expertise in this ideally it is best to start with some paper that seems interesting to you that is the most important thing please start with something that actually looks interesting rather than something you know oh I would just like to do it just for the heck of it, okay so it is much better if you are actually interested with something. Find out some paper with interesting results and ideally since you are starting look at some paper who

has put up who have put up their code either on their website or typically most people will put up their codes on github and they would have given links to that within their paper.

In fact one of the applications we discussed right now have put up their code on github the PDE paper and that is a good place to start, you can just take a look at it and see how people have done it, okay. Try to read the paper and without looking at the code try and replicate its results, then as and when you get stuck that is when you should actually refer to how the people how the researchers are actually utilized it and put up put it up on there and I have put up on their website, okay.

So if you I iterate with this with multiple papers you will find yourself very rapidly gaining confidence in your ability to take an idea and actually execute it as code, okay so that is important. And once you have some confidence you can try Kaggle which is a sort of data science computation platform, you can also program some projects ideas of your own from scratch. Please remember something that we have been emphasizing multiple times any application comes with two things, you have to have some amount of domain expertise and you have to have some knowledge of machine learning at least enough to know that why something would work and why something would not work and what problems you would encounter during training.

So with this we will end this course, we apologize for all the glitches and hitches that happened during this course, there were several problems both on the forums as well as in the assignments, this is the first time that we are running this course on as a MOOC so there were some teaching troubles hopefully it did not completely spoil your experience of the course and hopefully you gained something. As I said in case you are able to find yourself understanding something that is either discussed online or while reading a paper we would be happy that we have actually succeeded in our aim for this course, thank you and good luck.