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What are the best resources to learn about deep learning?

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33 Answers

Subhasis Das, Learning Machine Learning
Written Mar 25, 2015

There are a lot of very good resources on the net to learn about deep learning.

1. Neural networks and deep learning is a great website that goes step by step into neural network architectures, loss functions used etc. It should be very easy to read if you have a bit of math background.
2. CS231N lecture notes from here: CS231n Convolutional Neural Networks for Visual Recognition (notes), and CS231n: Convolutional Neural Networks for Visual Recognition (lecture slides)
3. Once you are familiar with the basics and the terminology (which is not much I should say), you can read tutorials of deep learning software such as Caffe (Caffe | Deep Learning Framework , read through the Example section), and Theano (Deep Learning Tutorials).
4. If you are feeling adventurous, you can also look through the proceedings and submitted papers for conferences such as ICLR and NIPS. Deep learning being a fast growing area, once you understand the basics it should not be much of an effort to understand what is being talked about in most of the papers.
5. Last of all, one of the pioneers of deep learning, Yoshua Bengio is also here on Quora. I am not sure how active he is but you can probably ask questions to him.

Also, there is another course on neural networks for NLP that is coming up: CS224d: Deep Learning for Natural Language Processing . In case you are interested in this area, I would also recommend keeping up-to-date with this. You can participate in a reddit group about this course at CS224d: Deep Learning for NLP • /r/CS224d .

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David Barber, machine learning researcher: AI, bayesian reasoning, deep learning
Written Apr 13, 2016

I think it depends on where you're coming from. If you already have a background in machine learning, then I think it's OK to dive into some of the more current technical literature.

There's a good list of resources here Tutorials " Deep Learning and a really great tutorial at Unsupervised Feature Learning and Deep Learning Tutorial which covers an intro to deep learning.

If you don't yet have this background, then I think it's good to spend a bit more time on the basics. One of the reasons for this is that deep learning is a field with a huge amount of design choices -- what deep learning architecture to use, what training algorithm to use, etc. Navigating this ocean of possibilities is difficult, especially when each experiement might take days if not weeks. Building insight into what architectures might work and why deep learning might be preferable to some more classical methods for your problem is important.

overfitting. Looking back I think the field was perhaps mesmerised by these incredibly powerful neural network tools that could in principle do anything -- everthing was a neural network, and everything could be solved by a neural network. In this sense there appeared little incentive to look at what other communities (for example in statistics) were doing. There were certainly some enlighted researchers from outside the neural net community looking in, but I think we got a poor reputation for not being outward looking enough.

In the 2000s we went through a tremendous maturation period in which the connections to a range of different communities (information theory, optimisation, statistics) became much better understood and I think the ML field benefitted enormously from that.

During this period though I think the field lost sight of its goal and lost focus. Indeed, a common question was ``What's the difference between machine learning and statistics?'' For me it's very clear -- ML is data driven AI, but this wasn't at all clear if you looked at the papers from the leading journals and conferences in the 2000s.

One of the great things about the rebirth of neural nets in deep learning is that the community has refocussed on the AI goals. There's renewed hope that we are at a stage to make progress in some of these core challenges and that's very exciting. This naturally has encouraged a large number of people to join the field. However, we certainly don't want to go back to the dark ages we were in before we gained these insights into machine learning and its relation to other fields. We're in a much better position now to understand what the benefits of deep learning might be compared to alternative approaches since we know much better how non deep learning approaches behave on AI tasks.

It's extremely important therefore to understand the basics, not just of neural nets, but of machine learning in general. Without this, there are many potential pitfalls in the way. Even today there are deep learning tutorials online that are deeply misleading, largely because the authors don't understand the basics of machine learning and statistics.

I would therefore strongly encourage anyone who wants to get into deep learning, but doesn't have a strong ML background, to first learn the basics of ML. Andrew Ng's coursera course https://www.coursera.org/learn/m... is excellent in this respect, and also touches on deep learning as well.

Yoshua Bengio's book Deep Learning looks very nice since it contains, in addition to a nice intro to deep learning, some material on the basics of machine learning as well.

An older, but still classic book is Chris Bishop's book Neural Networks for Pattern Recognition and provides a good intro to some of the theory.

One of the most important insights recently is the use of automatic differentiation (AutoDiff) in machine learning. This is tremendouly useful and it's quite amazing that we didn't really use this until relatively recently. See

http://web4.cs.ucl.ac.uk/staff/D...

for an introduction. Theano is probably the best tool currently avaiable for AutoDiff. Personally though I find it hard to warm to Python. For this reason I've developed my own Julia AutoDiff package davidbarber/AutoDiff It's early days, but I like the clean sytax of Julia and think a simple AutoDiff package would help to teach about deep learning.

Once you've understood the ML basics and AutoDiff, an understanding of some basic optimisation methods is important. You might like to start with
http://web4.cs.ucl.ac.uk/staff/D...

things, this book contains a great intro to numerical optimisation.

More modern resources including Stochastic Gradient Descent are discussed in the deep learning tutorial Unsupervised Feature Learning and Deep Learning Tutorial

Sebastian Raschka, Author of Python Machine Learning, researcher applying ML to computational bio.
Written Feb 21, 2016

The probably most gentle introduction would be Michael Nielsen's "Neural Networks and Deep Learning" online book: Neural networks and deep learning

Although the following to resources have already been mentioned in other answers, let me put them here for completeness:

As a follow-up, I'd recommend Geoff Hinton's Neural Net lectures on coursera, Neural Networks for Machine Learning https://www.coursera.org/course/ ...

Then, to cover certain topics in more detail, have a look at the manuscript of Ian Goodfellow, Yoshua Bengio, and Aaron Courville's Deep Learning

Bonus:

If you are specifically interested in deep learning for computer vision, I can recommend Stanford's course notes of CS231n: Convolutional Neural Networks for Visual Recognition (CS231n: Convolutional Neural Networks for Visual Recognition)

On the other hand, if you are more into natural language processing, have a look at this Stanford course (notes and videos): CS224d: Deep Learning for Natural Language Processing (CS224d: Deep Learning for Natural Language Processing)

Franck Dernoncourt, PhD student in machine learning at MIT
Updated Apr 3, 2015

In addition to Subhasis Das's great list:

- Geoffrey Hinton's course: Coursera Neural Networks for Machine Learning (fall 2012)
- Yoshua Bengio, Ian Goodfellow and Aaron Courville are writing a book on deep learning: http://www.iro.umontreal.ca/~ben...
- Hugo Larochelle's course (videos + slides) at Université de Sherbrooke: http://info.usherbrooke.ca/hlaro...
- Stanford's tutorial (Andrew Ng et al.) on Unsupervised Feature Learning and Deep Learning: http://ufldl.stanford.edu/wiki/i...

NLP-oriented:

- Tutorial given at NAACL HLT 2013 : Deep Learning for Natural Language Processing (without Magic) (videos + slides): http://nlp.stanford.edu/courses/...

Toolkit-specific tutorials:

- Machine Learning with Torch7: Machine Learning with Torch7 (in Lua)
- H2O Deep Learning (Java): H2O - Fast Scalable Machine Learning For Smart Applications

Language Processing?

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Chris Nicholson, co-founder of skymind and deeplearning4j
Written Nov 24, 2015

Originally Answered: What are the best deep learning tutorials?

We write a lot of deep learning tutorials on the Deeplearning4j website:

Restricted Boltzmann Machines
Long Short-Term Memory Networks (RNNs)
Eigenvectors, Covariance and Entropy
Word2vec

A longer list of online resources is here: Deeplearning courses and papers

Andrej Karpathy writes consistently good tutorials: Andrej Karpathy blog

Deeplearning.net also has a lot of great tutorials.

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Ismail Elezi, Computer Science student
Written Dec 1

By far, the best resource to learn deep learning that I have found so far is Andrej Karpathy's course in Stanford (technically, Fei-Fei Li was the main instructor, but Karpathy gave most of the lectures and he also made the notes).

Karpathy is a great 'teacher' and explained things as well as it could possibly be. He tried to make students learn the intuition, not just a bunch of formulas. The assignments were also done extremely well (though, I think that Justin Johnson was responsible for that). And he is quite funny.

Videos:

Lecture notes: CS231n Convolutional Neural Networks for Visual Recognition

Course page: CS231n: Convolutional Neural Networks for Visual Recognition

Unfortunately, I cannot recommend that much Hinton's course (which among other things, is a bit outdated now), and the preprint version of the book from Goodfellow, Courville and Bengio wasn't near as good as I hoped it will be (I hope the final version is better). However, when you go into recurrent networks and other more advanced topics, you will probably need to read it because Karpathy's notes are just up to convolutional neural network. Up to that topic though, nothing beats Karapthy's notes and lectures.

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