Deep learning

Introduction

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Sharif University of Technology

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Course Information

Course Information

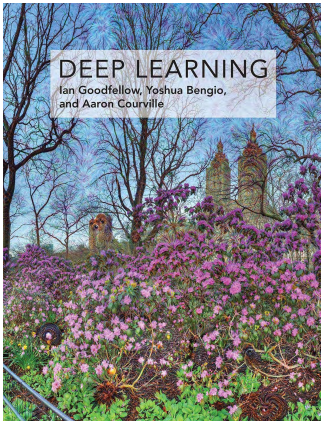
1. Course name : Deep learning
2. The objective of deep learning is moving Machine Learning closer to one of its original goals: Artificial Intelligence.
3. Instructor : Hamid Beigy Email : beigy@sharif.edu
4. Class : CE 201
5. Virtual class link: https://vc.sharif.edu/beigy
6. Course Website: http://sharif.edu/~beigy/14031-40719.html
7. Lectures: Sat-Mon (10:30-12:30)
8. Teaching Assistant : Reza Tavakoli Email: seyedreza.shiyade@gmail.com

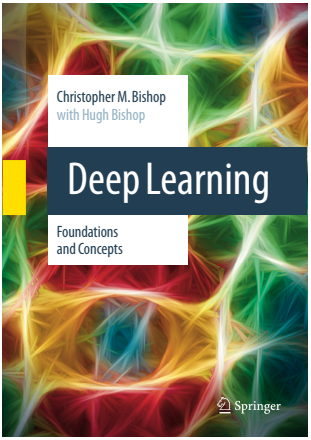
Course evaluation

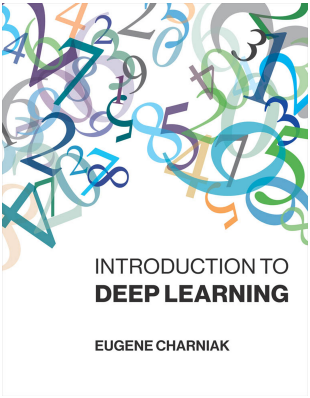
- Evaluation:

Mid-term exam	25%	1403-08-28	
Final exam	25%		
Practical Assignments	30%		
Quiz	15%		
Paper	5%	1402-08-28	Hard deadline for selection

Main reference







Relevant journals i

1. IEEE Trans on Pattern Analysis and Machine Intelligence
2. Journal of Machine Learning Research
3. Pattern Recognition
4. Machine Learning
5. Neural Networks
6. Neural Computation
7. Neurocomputing
8. IEEE Trans. on Neural Networks and Learning Systems
9. Annuals of Statistics
10. Journal of the American Statistical Association
11. Pattern Recognition Letters
12. Artificial Intelligence
13. Data Mining and Knowledge Discovery
14. IEEE Transaction on Cybernetics (SMC-B)

Relevant journals ii

15. IEEE Transaction on Knowledge and Data Engineering
16. Knowledge and Information Systems

Relevant conferences

1. Neural Information Processing Systems (NIPS)
2. International Conference on Learning Representations (ICLR)
3. International Conference on Machine Learning (ICML)
4. European Conference on Machine Learning (ECML)
5. Asian Conference on Machine Learning (ACML)
6. Conference on Learning Theory (COLT)
7. Algorithmic Learning Theory (ALT)
8. Conference on Uncertainty in Artificial Intelligence (UAI)
9. Practice of Knowledge Discovery in Databases (PKDD)
10. International Joint Conference on Artificial Intelligence (IJCAI)
11. IEEE International Conference on Data Mining series (ICDM)

Relevant packages and datasets

1. Packages:
   - Keras `https://keras.io`
   - TensorFlow `http://www.tensorflow.org/`
   - Cafe `http://caffe.berkeleyvision.org`
   - PyTorch `https://pytorch.org`
2. Datasets:
   - UCI Machine Learning Repository `http://archive.ics.uci.edu/ml/`
   - MNIST: handwritten digits `http://yann.lecun.com/exdb/mnist/`
   - 20 newsgroups `http://qwone.com/~jason/20Newsgroups/`

Introduction

What is deep learning?

Deep learning has various closely related definitions or high-level descriptions.

Definition (Deep learning)

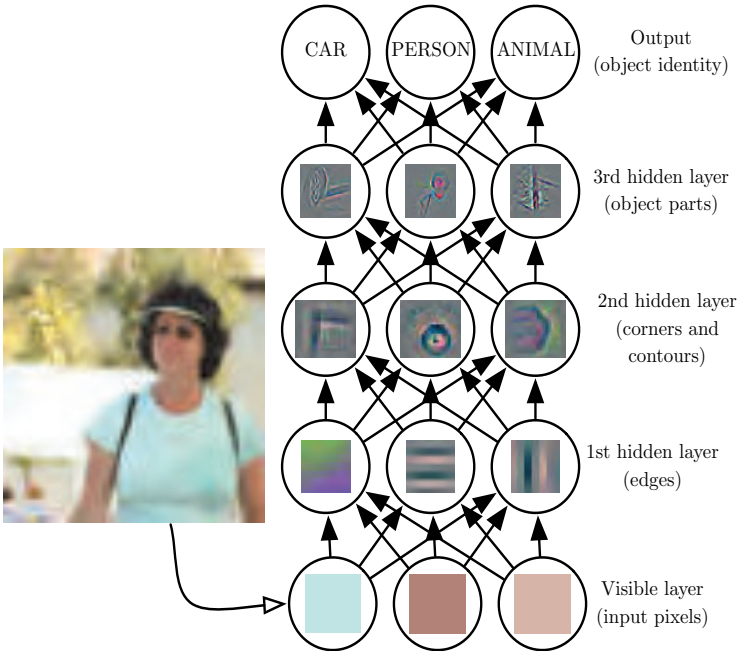
A sub-field of machine learning that is based on

- learning several levels of representations, corresponding to a hierarchy of features or factors or concepts,
- where
  - higher-level concepts are defined from lower-level ones, and
  - the same lower-level concepts can help to define many higher-level concepts.

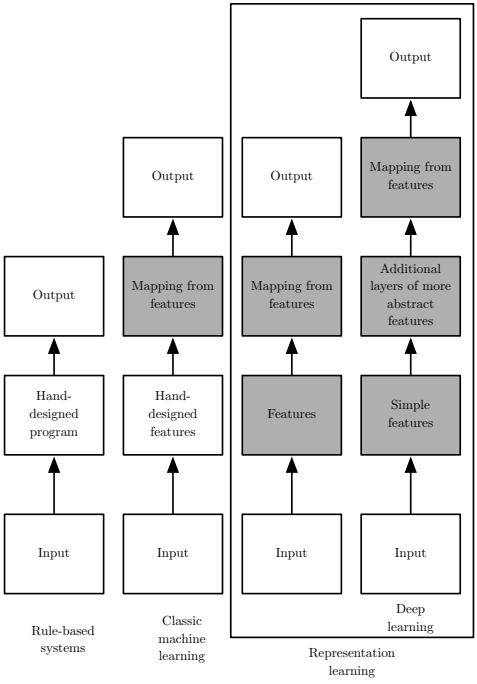
Definition (Deep learning)

- Deep learning is part of a broader family of machine learning methods based on learning representations.
- An observation (e.g., an image) can be represented in many ways (e.g., a vector of pixels), but some representations make it easier to learn tasks of interest (e.g., is this the image of a human face?) from examples, and research in this area attempts to define what makes better representations and how to learn them.

An Example


CAR
PERSON
ANIMAL
Output
(object identity)
3rd hidden layer
(object parts)
2nd hidden layer
(corners and
contours)
1st hidden layer
(edges)
Visible layer
(input pixels)

An Example


Output
Output
Output
Output
Mapping from features
Mapping from features
Mapping from features
Additional layers of more abstract features
Hand-designed program
Hand-designed features
Features
Simple features
Input
Input
Input
Input
Rule-based systems
Classic machine learning
Representation learning
Deep learning

What is deep learning?

Common among the various high-level descriptions of deep learning are two key aspects:

1. Models consisting of multiple layers/stages of nonlinear information processing
2. Methods for supervised or unsupervised learning of feature representation at successively higher, more abstract layers.

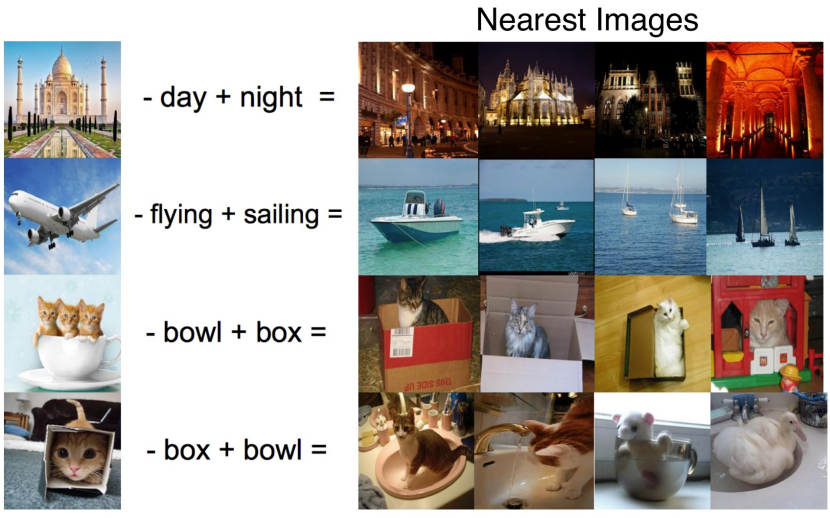
Deep learning is in the intersections among the research areas of

1. Neural networks
2. Artificial intelligence
3. Graphical modeling
4. Optimization
5. Pattern recognition
6. Signal processing.

Success stories

Success stories[1]

1. Finding nearest images



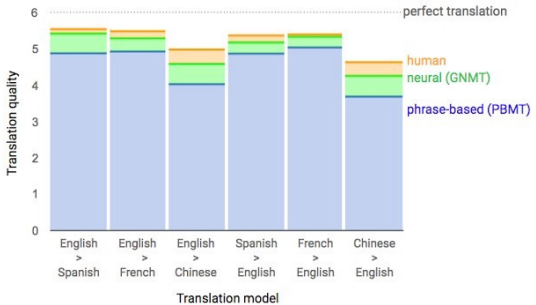
[1] This slide is taken from Prof. Ghodsi's slides.

Success stories

1. **Word2vec** (Mikolov et al. 2013).

   king – man + woman = queen

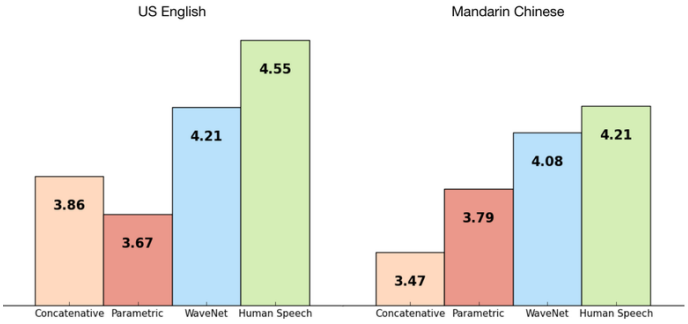
2. Google neural machine translation[2]



[2]Borrowed from https://blog.statsbot.co/deep-learning-achievements-4c563e034257

Success stories

1. Wavenet : Generating voice [3]



2. Lip Reading

[3] Borrowed from https://blog.statsbot.co/deep-learning-achievements-4c563e034257

Success stories

1. **LeNet-5**

   LeNet-5 is designed for handwritten and machine-printed character recognition

   Live demo : `http://yann.lecun.com/exdb/lenet/index.html`

2. **Sentiment Trees**

   Predicting the sentiment of movie reviews.

   Live demo : `http://nlp.stanford.edu:8080/sentiment/rntnDemo.html`

Success stories of Deep RL

1. TD-Gammon
2. DQN in Atari
3. Deep RL in Robotics
4. Alpha Go and Alpha Zero
5. Dota2 (Video Game)

Outline of course

Outline of course

1. Review of machine learning and history of deep learning
2. Multi-layer Perceptrons and Backpropagation (MLP)
3. Optimization and Regularization
4. Convolutional networks (CNN)
5. Recurrent networks (RNN)
6. Sum-Product networks (SPN)
7. Dual learning
8. Attention mechanism & Transformer family
9. Deep reinforcement learning (Deep RL)
10. Representation learning
11. Deep generative models
12. Graph convolutional networks (GCN)
13. Applications
    - Text mining and natural language processing
    - Computer vision
    - Social networks
14. Advanced topics

References

Readings

1. Chapter 1 of Deep Learning Book (Goodfellow, Bengio, and Courville 2016).
2. Chapter 1 of Introduction to Deep Learning (Charniak 2019).
3. Chapter 1 of Introduction to Deep Learning (C. M. Bishop and H. Bishop 2024).

References i

- Bishop, Christopher M. and Hugh Bishop (2024). *Deep Learning: Foundations and Concepts*. Springer.
- Charniak, Eugene (2019). *Introduction to Deep Learning*. The MIT Press.
- Goodfellow, Ian, Yoshua Bengio, and Aaron Courville (2016). *Deep Learning*. The MIT Press.
- Mikolov, Tomas et al. (2013). "Distributed Representations of Words and Phrases and their Compositionality". In: *Advances in Neural Information Processing Systems 26*, pp. 3111–3119.

Questions?