Deep Learning - Introduction

Syllabus

Syllabus:	Teaching Hours
UNIT I Review of Artificial Neural Networks: Perceptron Learning, Feed Forward Neural Networks, Backpropagation, Unstable Gradient Problem, Limitations of Feed Forward Neural Networks for Computer Vision Problems	**6**
UNIT 2 Convolutional Neural Networks: Convolution & Pooling, Dropout, Batch Normalization, State-of-the-art CNNs	**9**
UNIT 3 Transfer Learning & Domain Adaptation: Transfer Learning Scenarios, Applications of Transfer Learning, Transfer Learning Methods, Fine Tuning and Data Augmentation, Supervised, Semi Supervised and Unsupervised Deep Learning	**5**
UNIT 4 Convolutional Neural Networks for Computer Vision: Image Classification, Image Classification with Localization, Semantic Segmentation, Object Detection	**9**
UNIT 5 Sequence Models: Recurrent Neural Networks (RNN), Language Modeling, Long-Short Term Memory Network, Gated Recurrent Unit, Bi-directional RNN, Deep RNN, Applications of Sequence Models	**9**
UNIT 6 Miscellaneous: Auto encoders and Stacked Auto encoders, Generative Adversarial Networks, Deep Reinforcement Learning	**10**

purpose

Referencess

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press

2. Charu C. Aggarwal, Neural Networks and Deep Learning – A Textbook, Springer

3. Adam Gibson, Josh Patterson, Deep Learning, O'Reilly Media, Inc.

4. Duda, R.O., Hart, P.E., and Stork, D.G., Pattern Classification, Wiley.

5. Theodoridis, S. and Koutroumbas, K., Pattern Recognition. Academic Press

6. Russell, S. and Norvig, N. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence

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7. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press.

8. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning, Springer

9. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press

10. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer

11. Research Papers and Web Links

Blog and Course Site

Course Site:
https://sites.google.com/a/nirmauni.ac.in/it7f4---deep-learning/

Teaching & Evaluation Scheme

Teaching Scheme:

Theory	Tutorial	Practical	Credits
3	0	2	4

Evaluation Scheme:

	LPW	SEE	CE
Exam Duration	Continuous Evaluation + 2 Hrs. End Semester Exam	3.0 Hrs.	Continuous Evaluation
Component Weightage	0.2	0.4	0.4

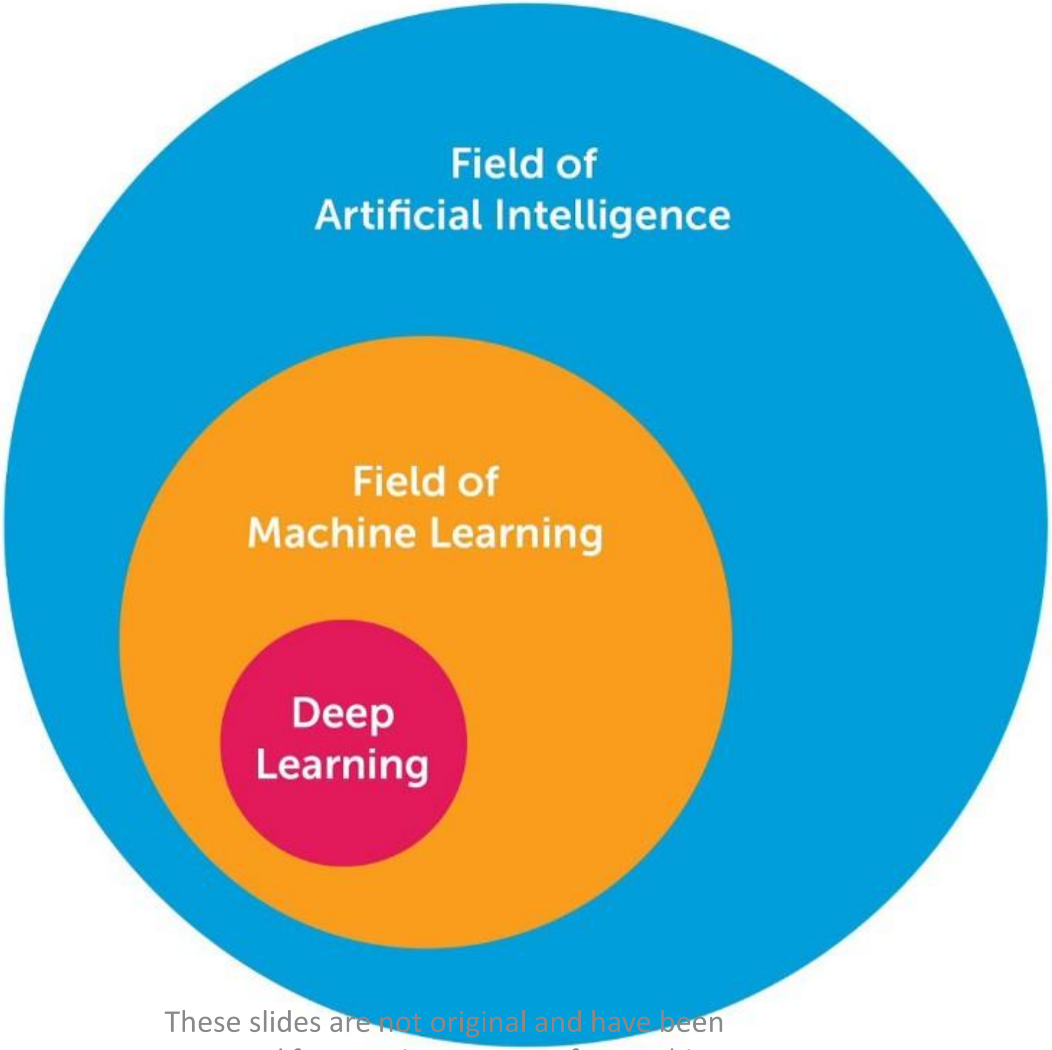
Teaching & Evaluation Scheme

Breakup of CE

	Unit 1	Unit 2	Unit 3
Exam	Class Test	Sessional Exam	Assignments
Inter Component Weightage	0.35	0.35	0.3
Numbers	2	1	1
Marks of Each	35	35	30

Introduction

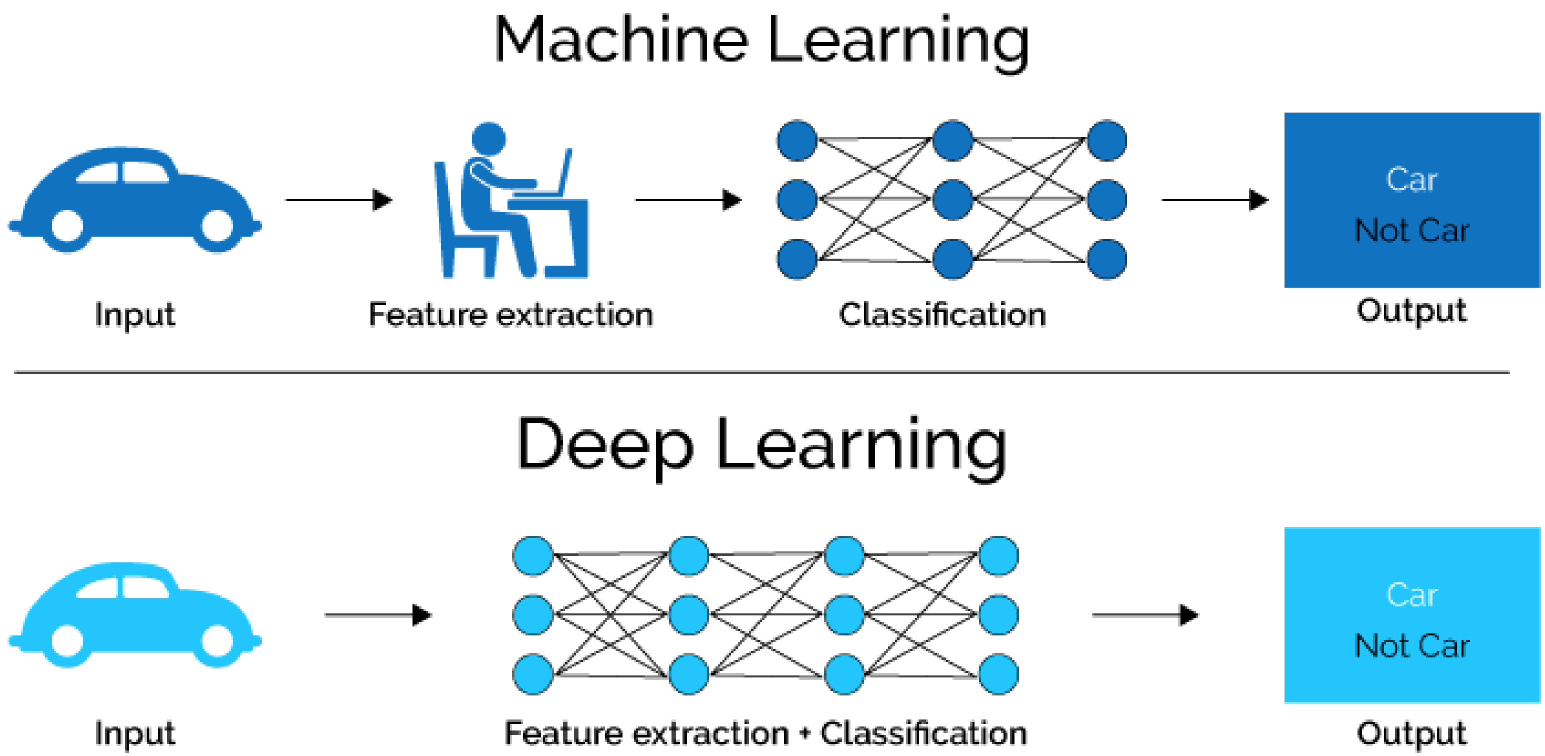
- AI, ML and DL



Source: [1]

Introduction

- Machine Learning vs Deep Learning



Source: [2]

Major Architectures of Deep Networks

- Four Major Architectures:
  - Unsupervised Pretrained Networks (UPNs)
  - Convolutional Neural Networks (CNNs)
  - Recurrent Neural Networks
  - Recursive Neural Networks

Major Architectures of Deep Networks

- Four Major Architectures:
  - Unsupervised Pretrained Networks (UPNs)
    - Autoencoders
    - Deep Belief Networks (DBNs)
    - Generative Adversarial Networks (GANs)

    - Use Cases:
      - Feature Extraction
      - Initialization
      - Synthesizing

Source: [3]

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Major Architectures of Deep Networks

- Four Major Architectures:
  - Convolutional Neural Networks (CNNs)
    - Lenet-5
    - AlexNet
    - VGGNet
    - GoogleNet (Inception)
    - ResNet
    - ResNext
    - DenseNet
    - RCNN (Region Based CNN)
    - YOLO (You Only Look Once)
    - SqueezeNet
    - SegNet

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Major Architectures of Deep Networks

- Four Major Architectures:
  - Convolutional Neural Networks (CNNs)
  - Use Cases:
    - Computer Vision
    - Natural Language Processing

Major Architectures of Deep Networks

- Four Major Architectures:
  - Recurrent Neural Networks
    - Hopfield Network
    - Long Short-Term Memory (LSTM)
    - Gated Recurrent Unit (GRU)
  - Use Cases:
    - Sentiment Classification
    - Image Captioning
    - Language Translation
    - Video Captioning

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Major Architectures of Deep Networks

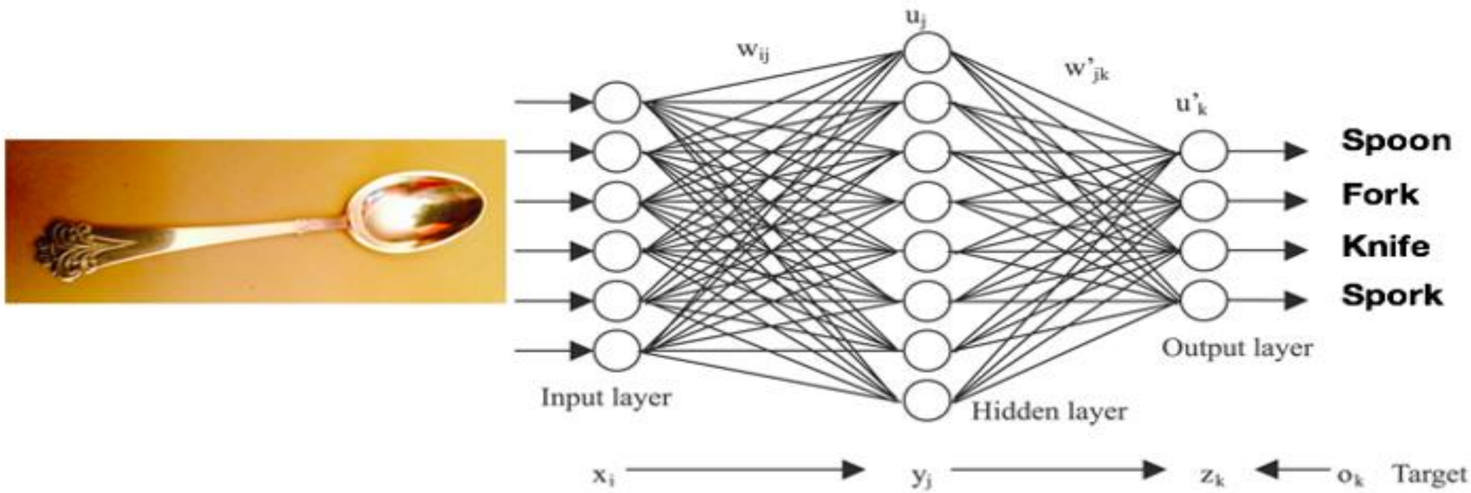
- Four Major Architectures:
  - Recursive Neural Networks
    - Recursive Autoencoder
    - Recursive Neural Tensor Network
  - Use Cases:
    - Image scene decomposition
    - NLP
    - Audio-to-text transcription

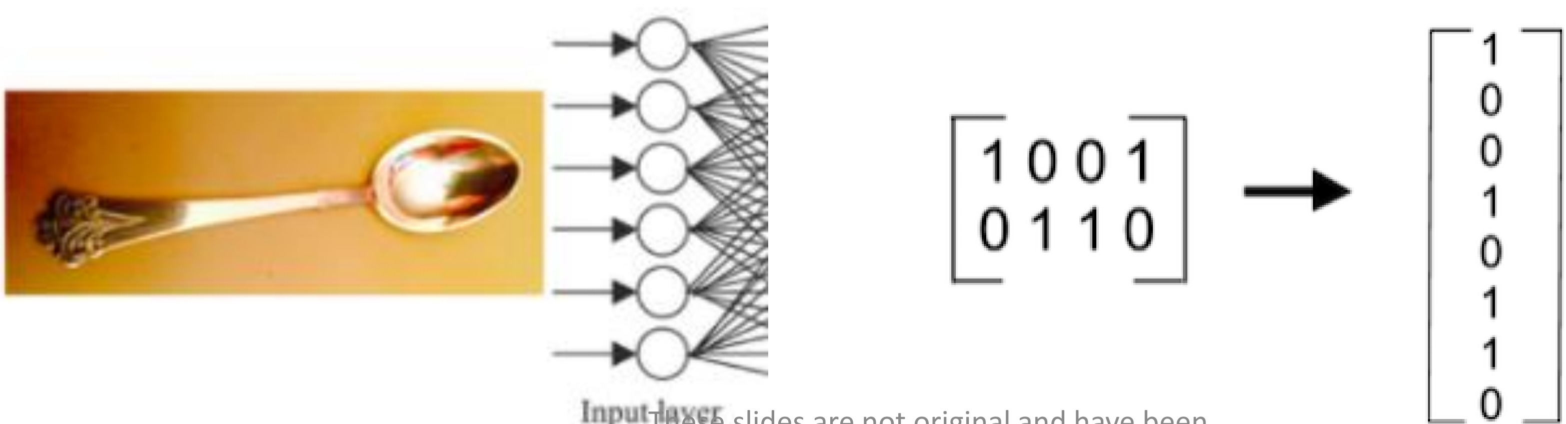
Computer Vision & Vanilla Neural Networks

- Feature Engineering
- Loss of Structural Information
- Difference in Indented Part, Orientation, Backdrop, Size, Location
- Noise
- Scalability

Computer Vision & Vanilla Neural Networks

- Loss of Structural Information

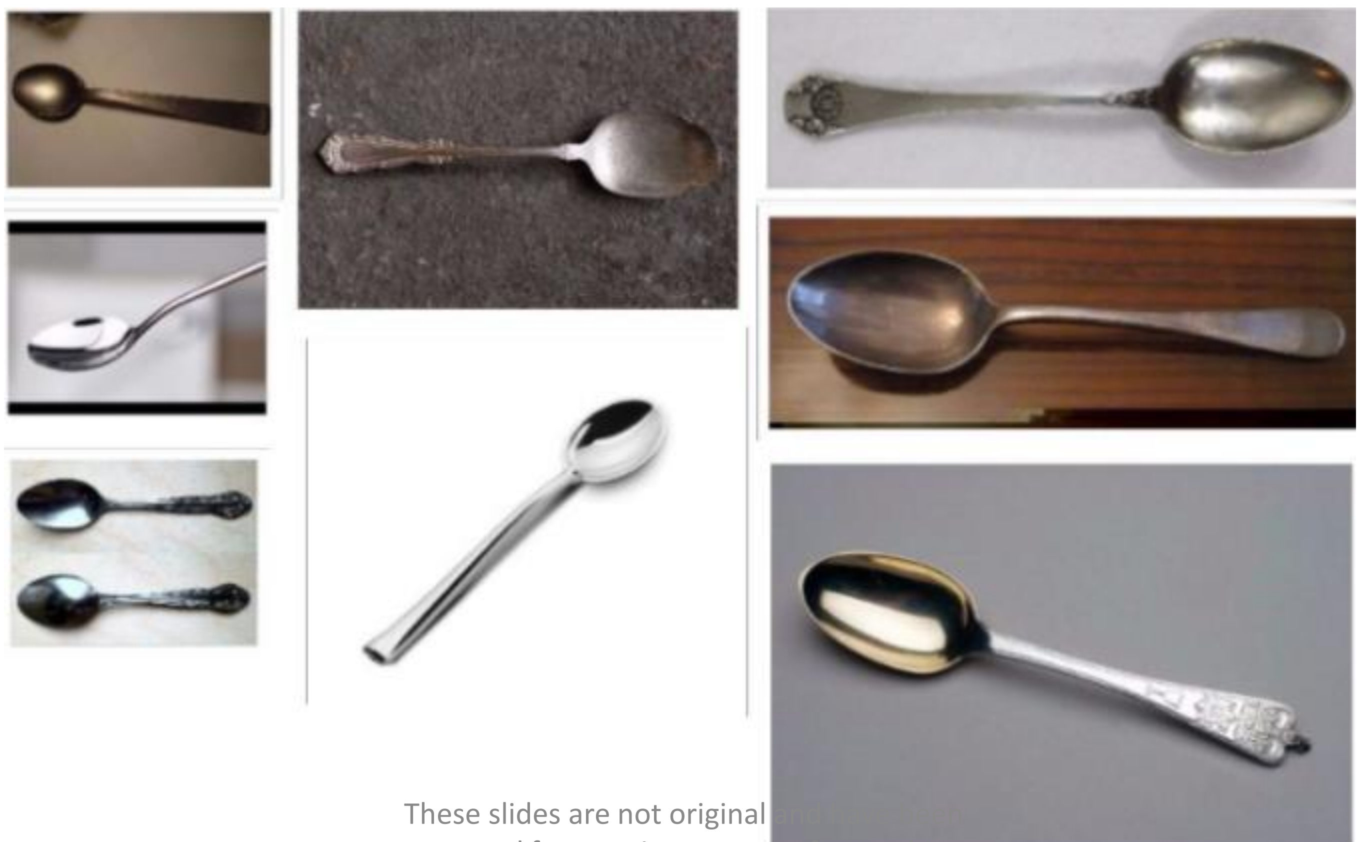




Pixel Vector

Computer Vision & Vanilla Neural Networks

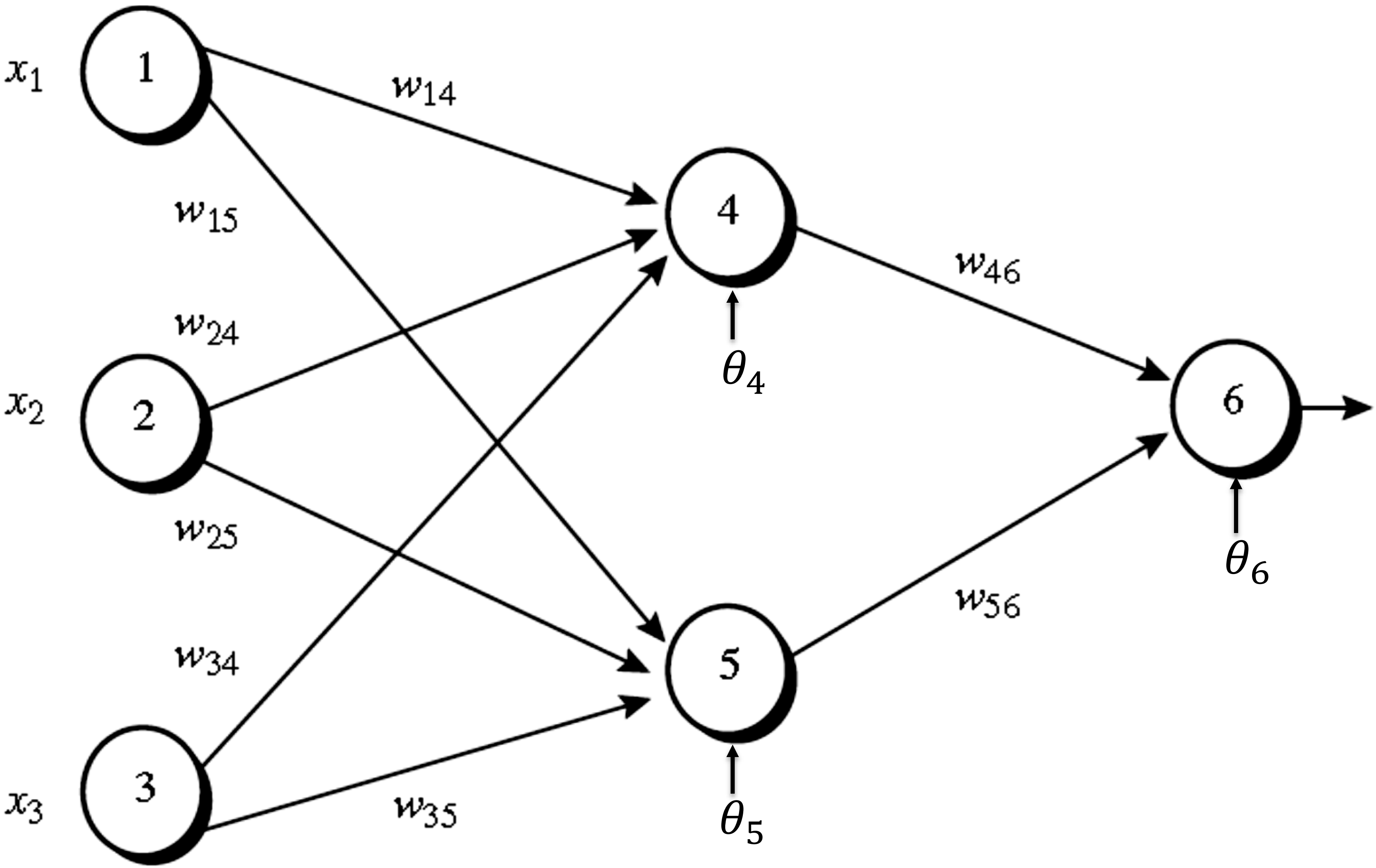
- Difference in Indented Part, Orientation, Backdrop, Size, Location
- Noise



Computer Vision & Vanilla Neural Networks

- Scalability

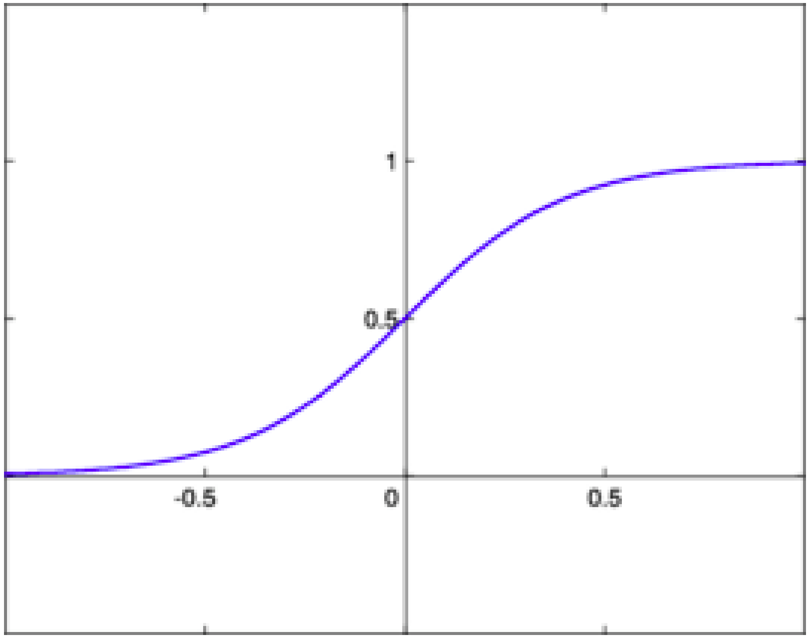
Backpropagation



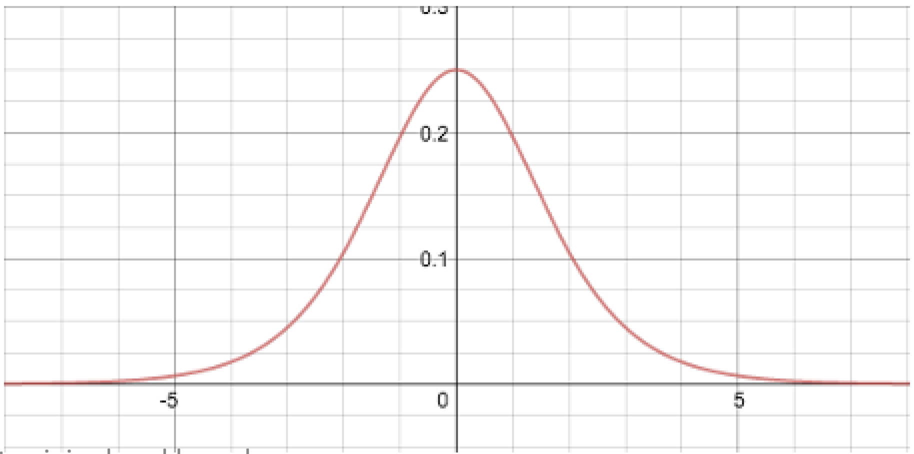
An example of a multilayer feed-forward neural network.

Vanishing Gradient Problem

$$Sigmoid = S(\alpha) = \frac{1}{1+e^{-\alpha}}$$



$$\frac{1}{1+e^{-\alpha}}\left[1-\frac{1}{1+e^{-\alpha}}\right]$$



Simply: S(1-S)

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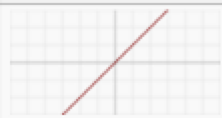
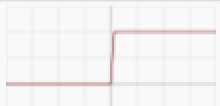
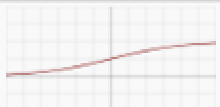
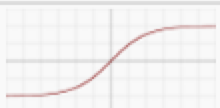
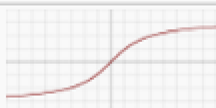
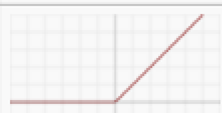
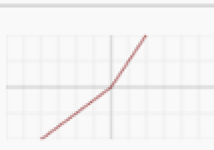
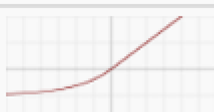
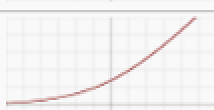
Note: Images are not original

Vanishing Gradient Problem

- How does ReLU solve (delay) the problem?
- Dead Neuron in case of RELU and its implication
- Leaky/Parameterized ReLU

Vanishing Gradient Problem

Name	Plot	Equation	Derivative
Identity		$f(x) = x$	$f'(x) = 1$
Binary step		$f(x) = \begin{cases} 0 & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} 0 & \text{for } x \neq 0 \\ ? & \text{for } x = 0 \end{cases}$
Logistic (a.k.a Soft step)		$f(x) = \frac{1}{1 + e^{-x}}$	$f'(x) = f(x)(1 - f(x))$
TanH		$f(x) = \tanh(x) = \frac{2}{1 + e^{-2x}} - 1$	$f'(x) = 1 - f(x)^2$
ArcTan		$f(x) = \tan^{-1}(x)$	$f'(x) = \frac{1}{x^2 + 1}$
Rectified Linear Unit (ReLU)		$f(x) = \begin{cases} 0 & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} 0 & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$
Parameteric Rectified Linear Unit (PReLU) [2]		$f(x) = \begin{cases} \alpha x & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} \alpha & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$
Exponential Linear Unit (ELU) [3]		$f(x) = \begin{cases} \alpha(e^x - 1) & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases}$	$f'(x) = \begin{cases} f(x) + \alpha & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$
SoftPlus		$f(x) = \log_e(1 + e^x)$	$f'(x) = \frac{1}{1 + e^{-x}}$

Disclaimer

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References

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2. https://semiengineering.com/deep-learning-spreads/
3. https://www.safaribooksonline.com/library/view/deep-learning/9781491924570/ch04.html

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5. Elements of Artificial Neural Networks, Kishan Mehrotra, Chilukuri K. Mohan, Sanjay Ranka. MIT Press, (1997)

6. Matlab Neural Network Tollbox Documentation

7. LeCun, Yann, et al. "Gradient-based learning applied to document recognition." Proceedings of the IEEE 86.11 (1998): 2278-2324.

8. Srivastava, Nitish, et al. "Dropout: A simple way to prevent neural networks from overfitting." The Journal of Machine Learning Research 15.1 (2014): 1929-1958.

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10. http://cs231n.github.io/convolutional-networks/

11. https://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets/

12. Xu, Bing, et al. "Empirical evaluation of rectified activations in convolutional network." arXiv preprint arXiv:1505.00853 (2015).

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