Neural Networks and Deep Learning: Success Deep Learning History

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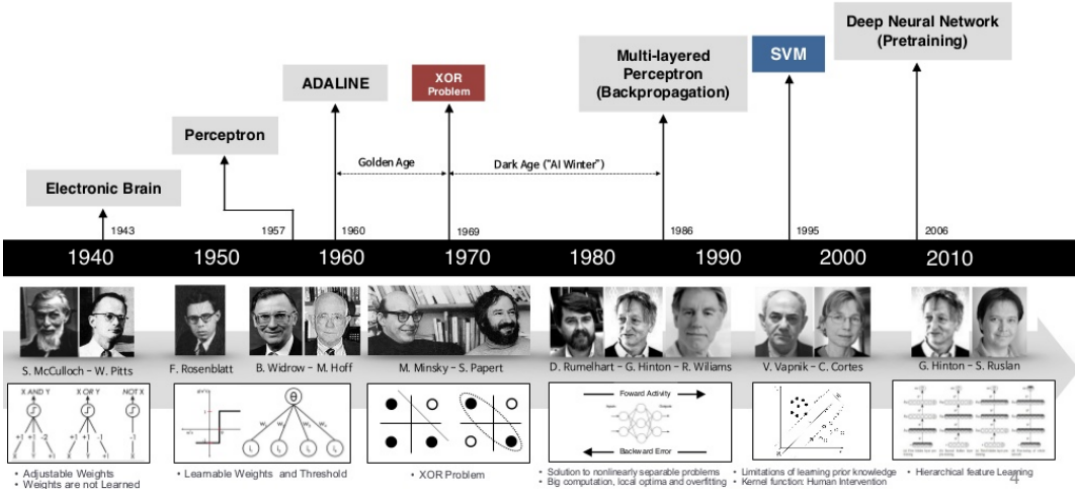
80's: 1st Convolutionnal Neural Networks

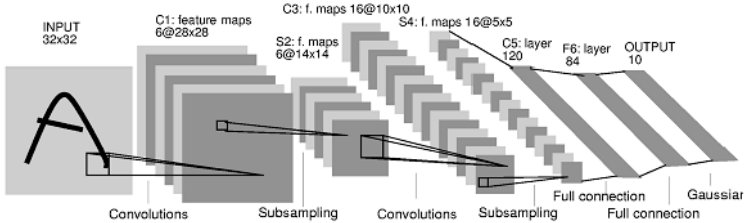


Slide credit:

https://www.slideshare.net/deview/251-implementing-deep-learning-using-cu-dnn

Case Study: LeNet 5 Model [LeCun et al., 1989]

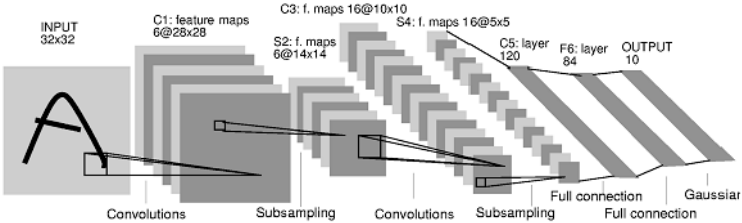
- **LeNet 5 Model, trained using back-prop**
- Input: 32x32 pixel image



- **Macro architecture:** [Convolution/Pooling] blocks Cx + Fully Connected layers Fx
- C5: convolution layer ~ fully connected

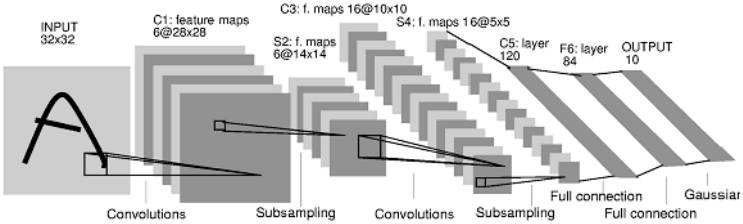
C1 Layer

- **Input: 32x32x1 tensor (image)**
- Convolutional layer with 6 5x5 filters
  $\Rightarrow$ **Output: 28x28x6 tensor**
- # Parameters: 5^2 per filer + bias
  $\Rightarrow (5 * 5 + 1) * 6 = 156$
  - If it was fully connected:
    (32*32+1)*(28*28)*6 parameters $5 \sim 10^6$!



S2 Layer

- Subsampling layer = pooling layer

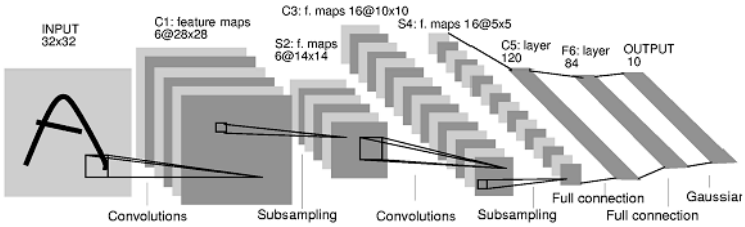


- **Input: 28x28x6 tensor**
- Pooling parameters: area (2x2 in C1), stride 2
  - $p(\mathbf{x}) = w \cdot \sum_{i=1}^{4} x_i + b \Rightarrow$ 2 parameters per channel
- **Output: 14x14x6 tensor**
- Total # Parameters: $2 * 6 = 12$

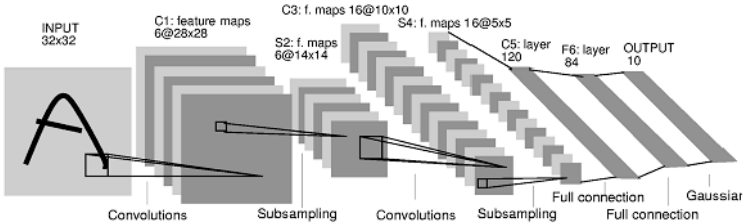
C3 Layer: Convolutional

- **Input: 14x14x6 tensor**
- C3 Convolutional, 16 filters of spatial size 5x5
  - **Sparse depth connection to a subset of S2 maps**
    ⇒ 0-5 connected to 3, 6-14 to 4, 15 connected to 6
  - **Sparse connection goal?**
- **Output: 10x10x16 tensor**
- # Parameters?

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	X				X	X	X			X	X	X	X		X	X
1	X	X				X	X	X			X	X	X	X		X
2	X	X	X				X	X	X			X		X	X	X
3		X	X	X			X	X	X	X			X		X	X
4			X	X	X			X	X	X	X		X	X		X
5				X	X	X			X	X	X	X		X	X	X

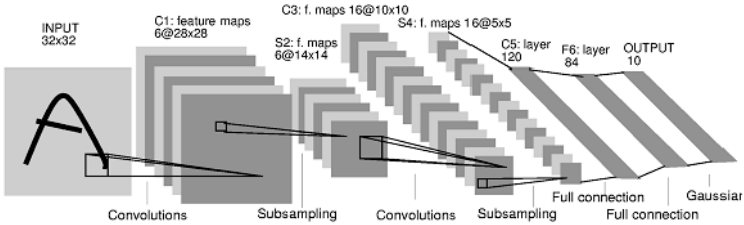


S4 Layer



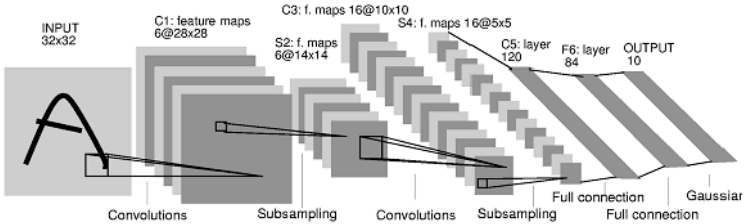
- Subsampling layer = pooling ~ S2
- **Input: 10x10x16 tensor**
- **Output: 5x5x16 tensor**
- Total # Parameters: $2 * 6 = 12$

C5 Layer: Convolutionnal



- **Input: 5x5x16 tensor**
- C5 Convolutional, 120 $5x5x16$ filters
  $\Rightarrow$ whole depth of $S4$ ($\neq C3$)
- **Output: 1x1x120 tensor** = vector!
  $\Rightarrow$ C5 $\sim$ FC layer on flattened tensor!
- Total # Parameters?

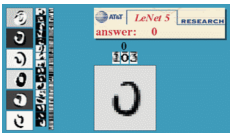
F6-F7 Layers: Fully Connected

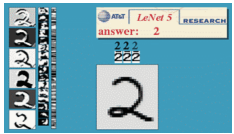


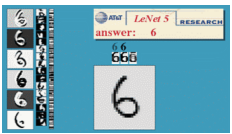
- F6 Layer
  - 84 fully connected units.
  - # Parameters: 84*(120+1)=10164
- F7 Layer (output): Fully Connected layer
  - 10 (# classes) fully connected units.
  - # Parameters: 10*(84+1)=850

LeNet 5 Model: Performances on MNIST

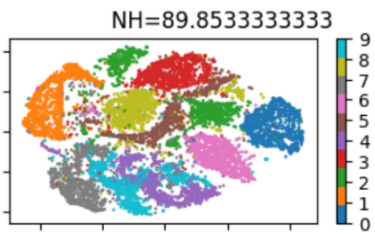
- Evaluation on MNIST
- Total # parameters ~ 60000
  - 60,000 original datasets: test error: 0.95%
  - + 540,000 artificial distortions ⇒ test error: 0.8%
- **Successful deployment for postal code reading in the US**

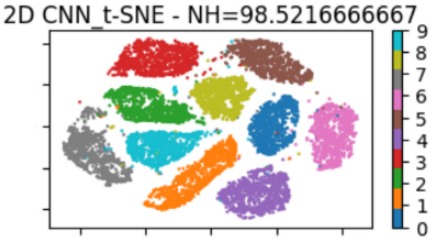


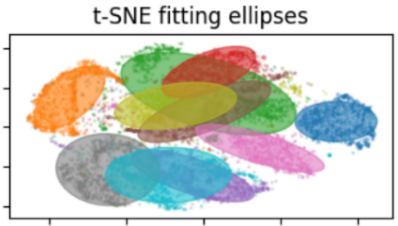




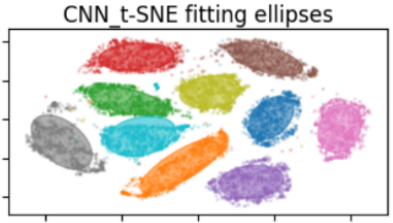
LeNet 5 Model: Manifold Untangling





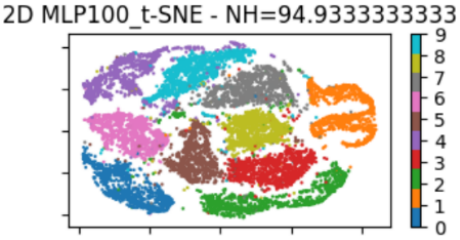


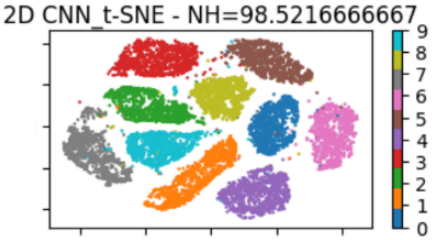
Input space

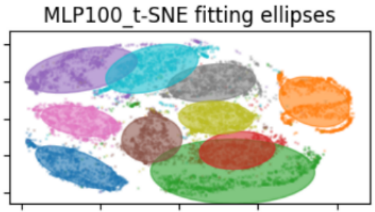


Latent space

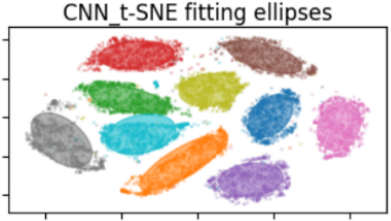
LeNet 5 Model: Manifold Untangling







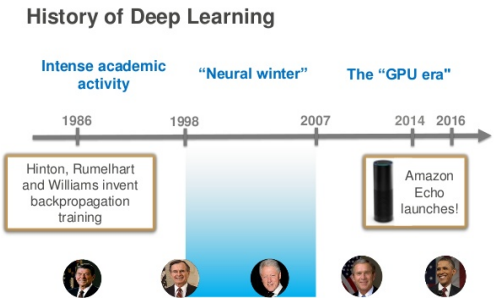
Latent space MLP



Latent space LeNet

80's: Deep Learning Sucees

- ConvNet trainable with backprop, able to untangle class manifold
- Very good performances for digit classification, industrial transfer
- **2nd winter of Deep Learning**
  ⇒ following!



Source: Amazon

References I


LeCun, Y., Boser, B., Denker, J. S., Henderson, D., Howard, R. E., Hubbard, W., and Jackel, L. D. (1989).
Backpropagation applied to handwritten zip code recognition.
Neural computation, 1(4):541–551.