CIS 678 Machine Learning

Convolutional Neural Networks (CNNs)

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DeepSeek R1: 671 billion parameters

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It's challenging, but we will do it

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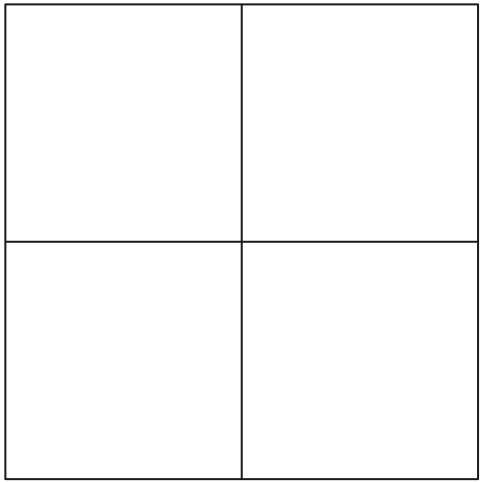
Why FF Networks don’t work well for Image Data?

- We ask you to write a “5”



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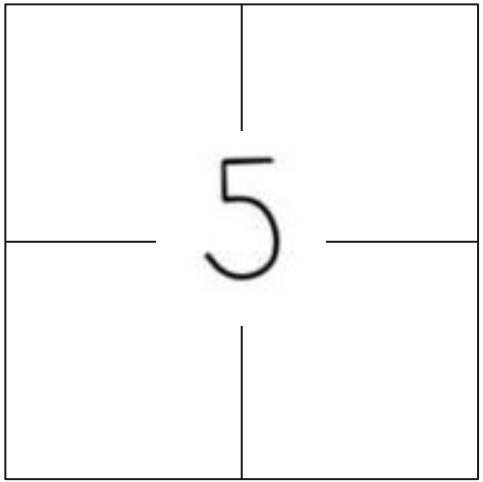

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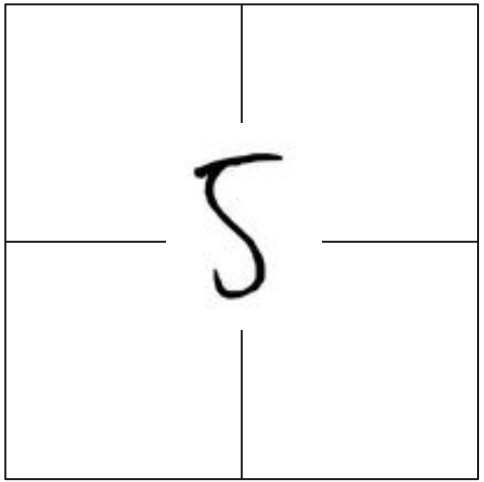
- **This is my "5", not good as yours but still at the center of the coordinate.**



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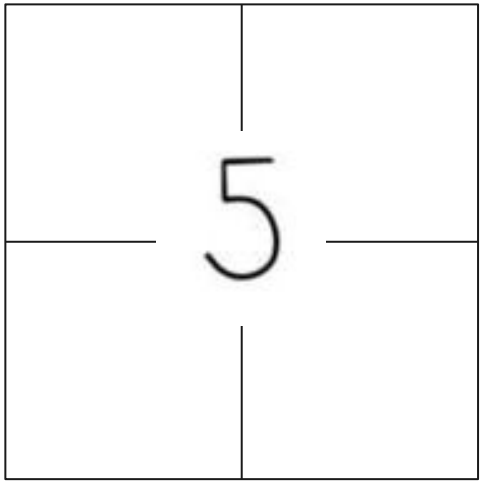

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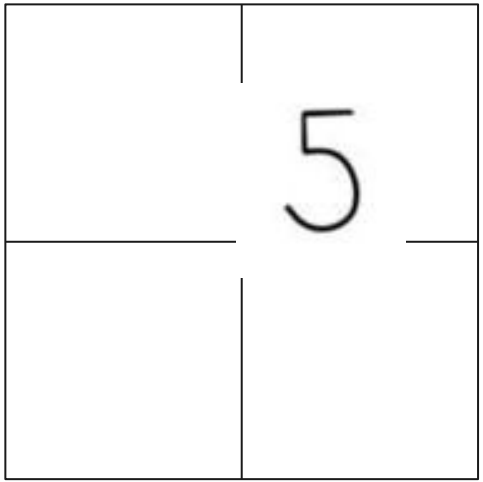

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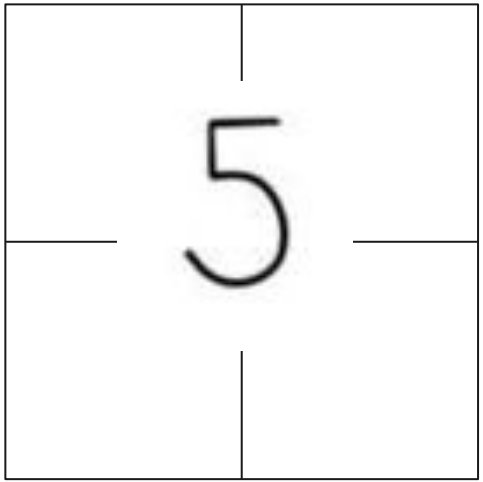

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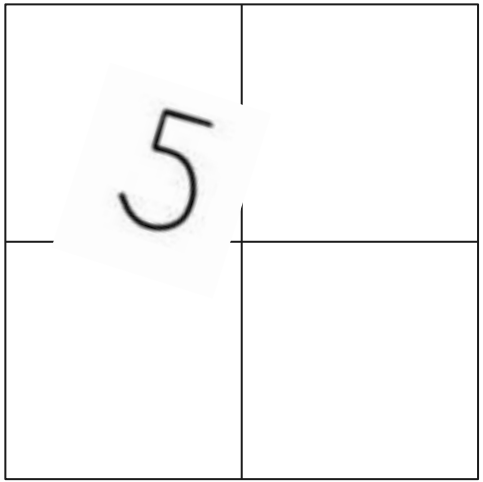

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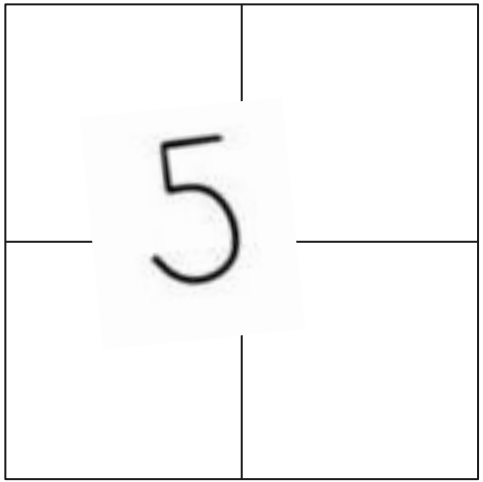

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- We ask you to write a "5"
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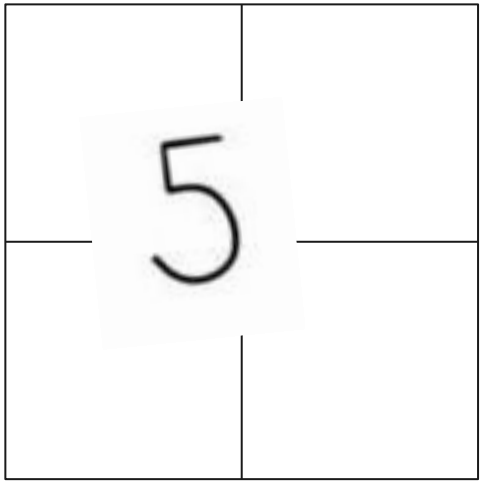
- **Your "5" still will have a lots of variations and each definition is unique in the vector space**



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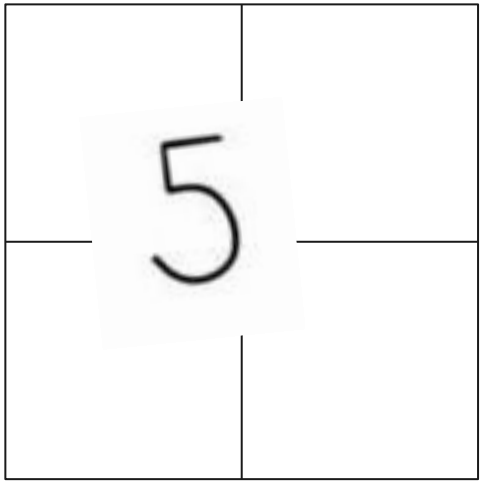
- Your "5" still will have a lots of variations and each definition is unique in the vector space
- **How many different "5"s we will need provide the model to learn a perfect model?**



Convolutional Neural Networks (CNNs)

- State of the Art for CV and some other problems
- Filters/Convolutional Kernels

Convolutional NNs

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Examples:

- Alexnet
- VGG
- ResNet
- GoogLeNet
- ..

ref

Convolution

- Is a mathematical operation

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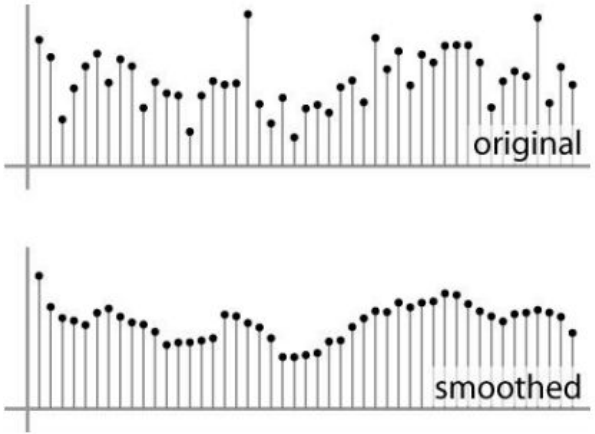
- Let’s learn through a practical example

Convolution

Moving average:

- Replaces each pixel with an average of all the values in its neighborhood
- Moving average in 1D: **[1, 1, 1, 1, 1] / 4**

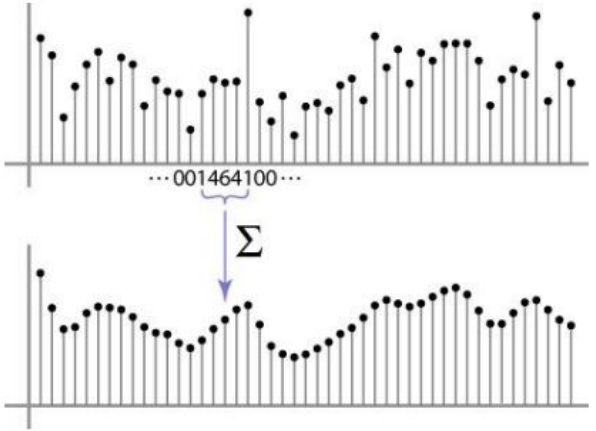


ref

Convolution

Weighted Moving average:

- Non-uniform weights **[1, 4, 6, 4, 1] / 16**



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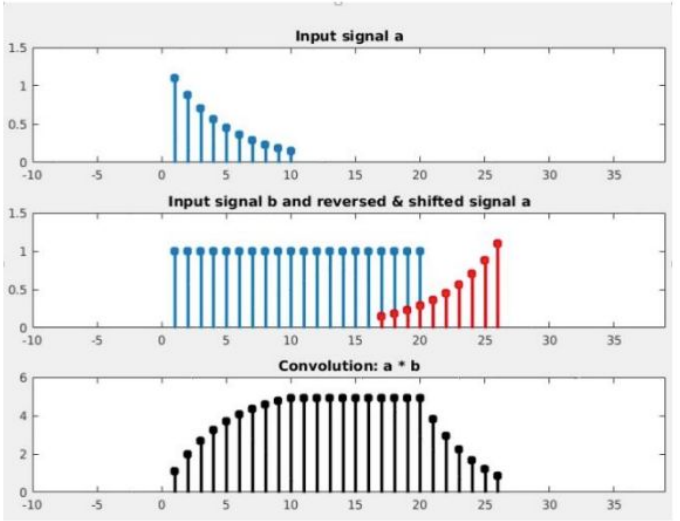
Convolution

This operation is call Convolution

Example of convolution of two sequences (or “signals”)

- One of the sequences is flipped (right to left) before sliding over the other
- Notation: a * b
- Nice properties: linearity, associativity, commutativity, etc.



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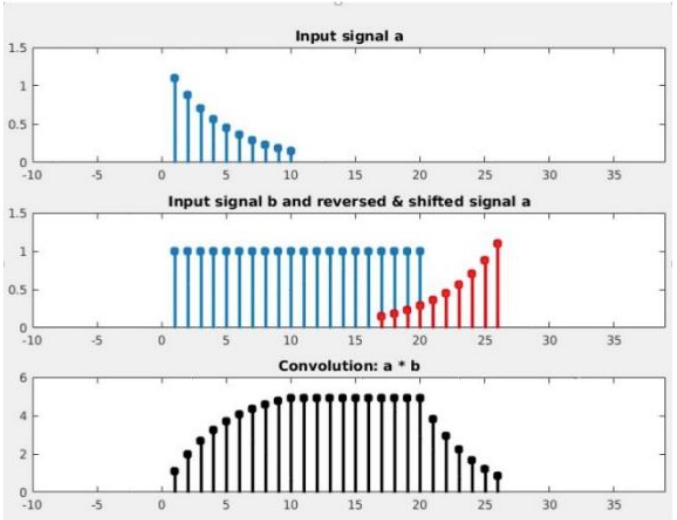
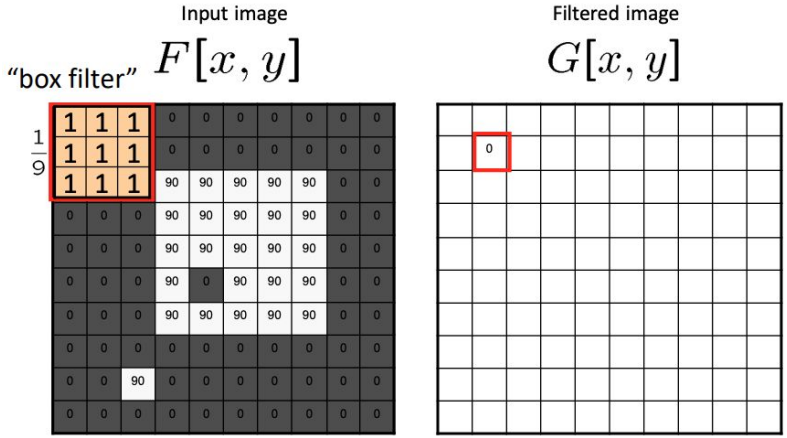


Image Filters

Moving Average in 2D

- 2D convolution operation



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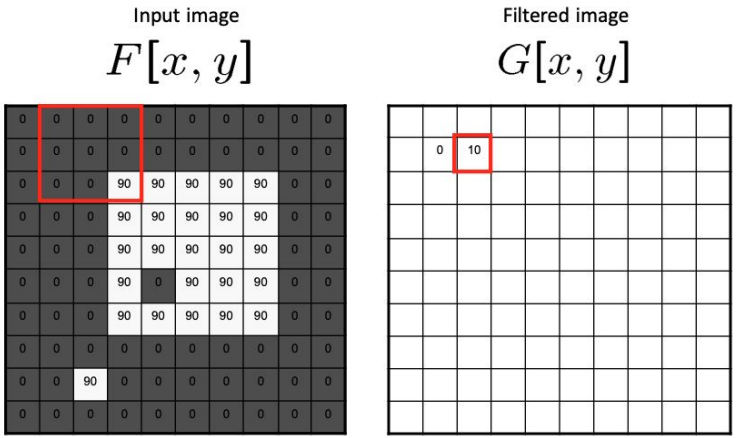


Image Filters

Moving Average in 2D

- 2D convolution operation
- Practical application (smoothing)

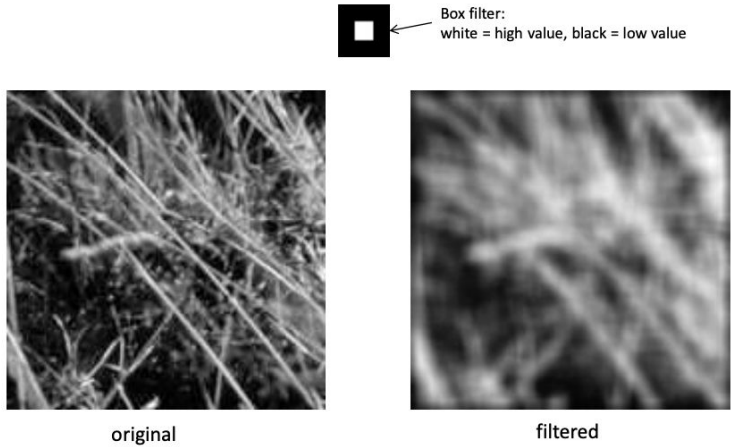


Image Filters

High Pass Filter

“If you take an image and blur it you only keep the "low frequencies". High pass makes the opposite, it only lets the "high frequencies" pass, or what most people call "**the details**". Any image can be deconstructed into these two components.”[ref]

−1	−1	−1
−1	8	−1
−1	−1	−1

Note: Only for demonstration

Image Filters

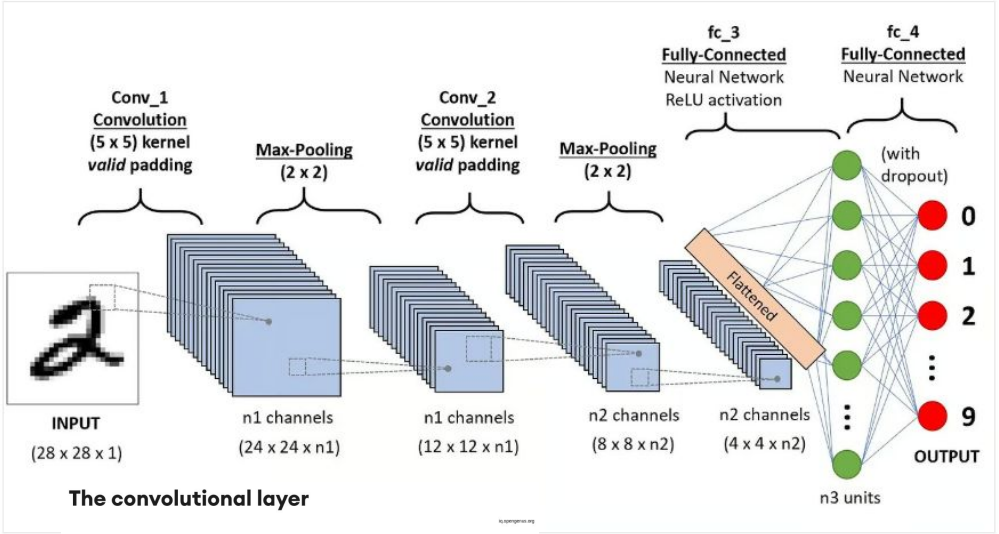
Other Filters:

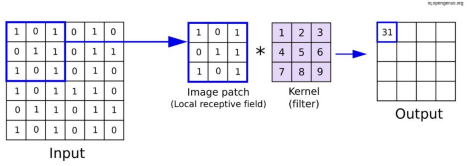
- Essentially these are convolution functions, we also call as convolution kernels

Prewitt filter $\mathbf{G_x} = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix}$ and $\mathbf{G_y} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix}$

Sobel filter $\mathbf{G_x} = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$ and $\mathbf{G_y} = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$

Convolutional NNs





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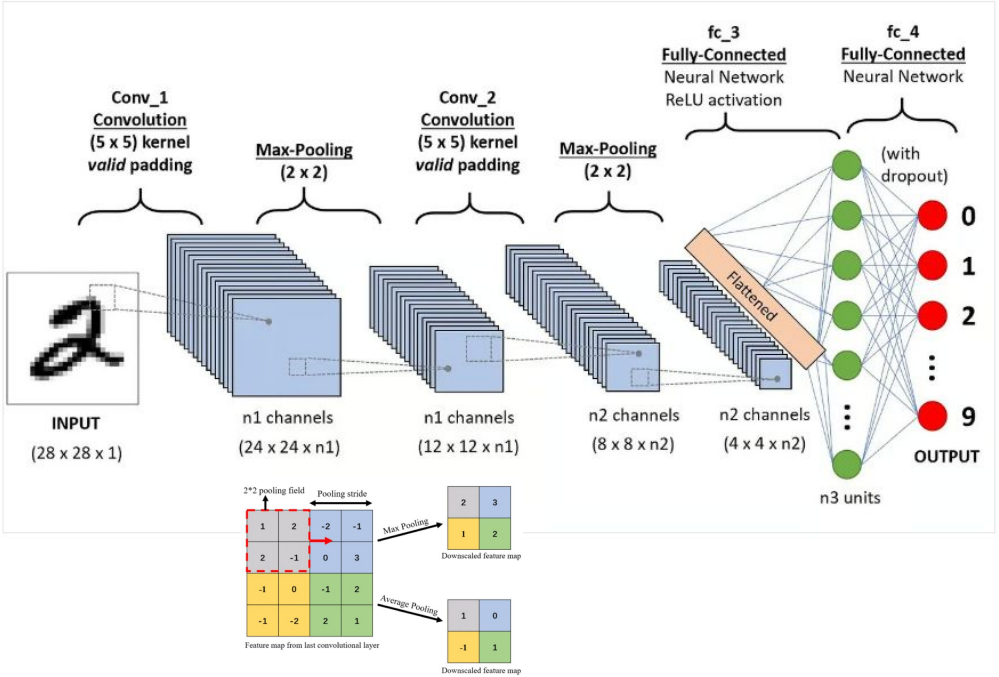

Coding!

Image classification (Convolutional Neural Network)