Applied Machine Learning

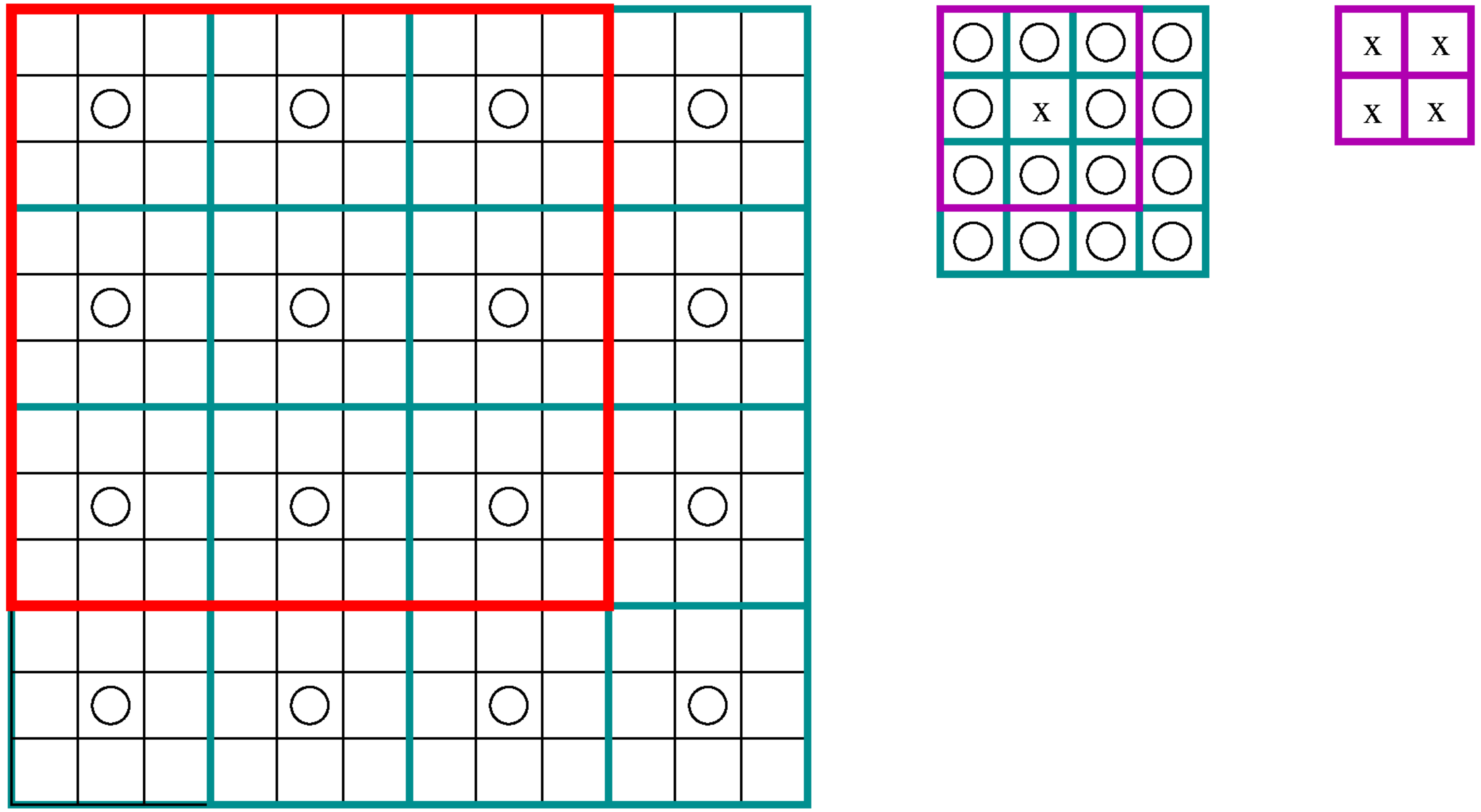
Convolutional Neural Networks

Convolutional Neural Networks

- Receptive field
- Deep Convolutional Neural Network for Image Classification
- Preprocessing images

Stacking Convolutional Layers

- Stacks of convolutional layers
  - Input: $x \times y \times 1$ $12 \times 12 \times 1$
  - Layer 1: Convolutional + ReLU
    - strides 3, kernel $3 \times 3 \times 1$
    - Output $\frac{x}{3} \times \frac{y}{3} \times 1$ $4 \times 4 \times 1$
    - Receptive field: 3×3
  - Layer 2: Convolutional + ReLU
    - strides 2, kernel $3 \times 3 \times 1$
    - Output: $\frac{x}{2} \times \frac{y}{2} \times 1$ $2 \times 2 \times 1$
    - Receptive field: 9×9



Stacking Layers and Receptive Fields

- The size of the Receptive Field
  - depends on kernel size and stride length at all previous layers
- Resolution:
  - from finer grain to coarser grain
- Receptive field in Pooling Layer is similar
  - stride length and patch size
- Frequently
  - Layer 1: stride lenght of 1, kernels: n
  - Next layers: stride length of 2 or more, kernels: increase by some factor, at least 2

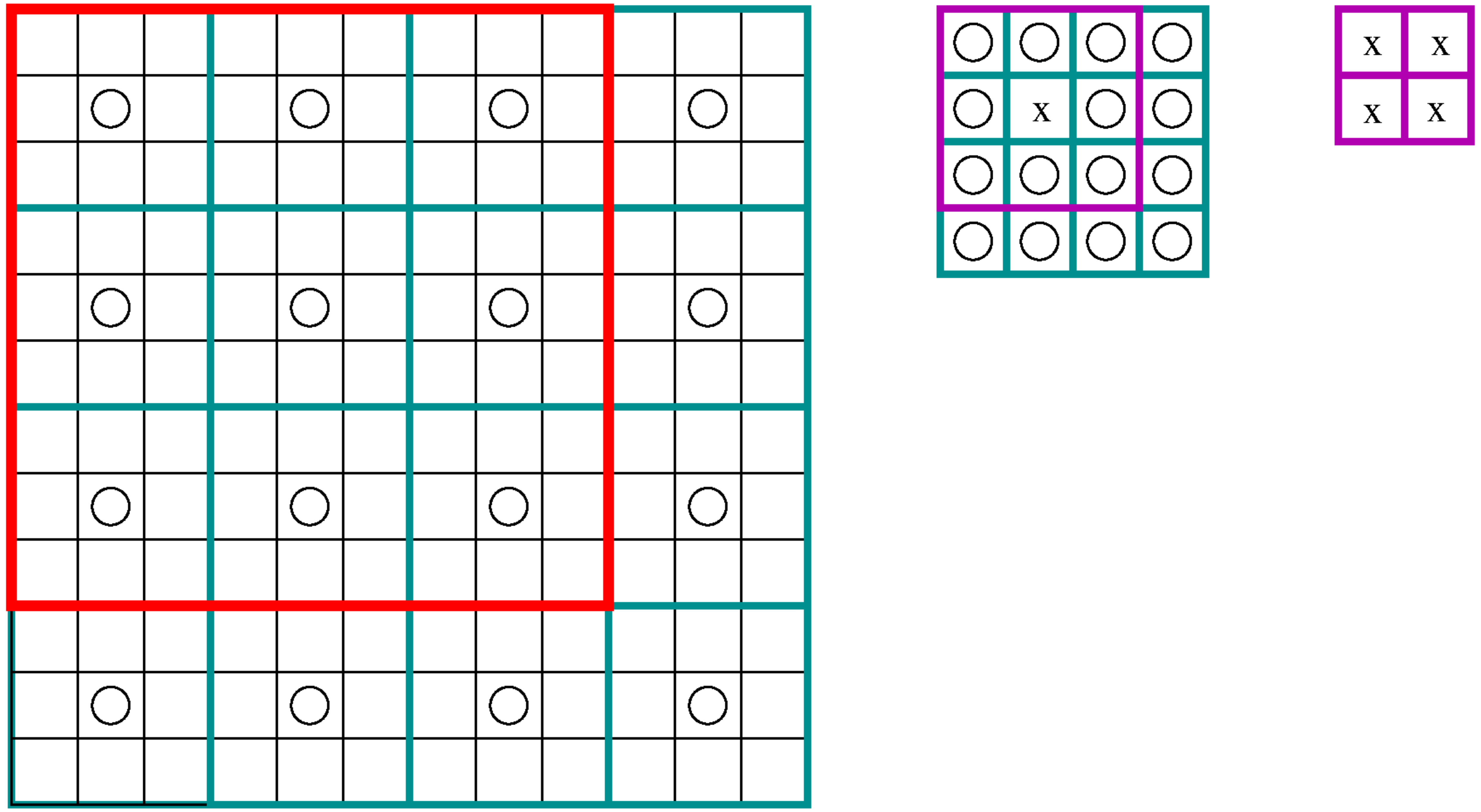
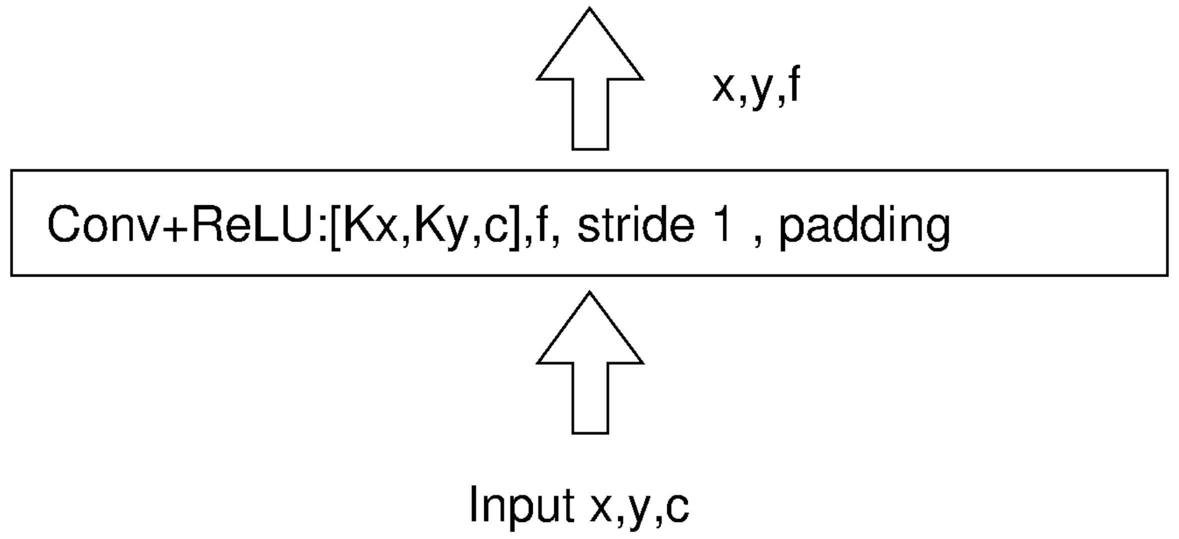


Image Classification

- Image classification
  - Input: Image $x \times y \times c$
  - Input Layer: Convolutional + ReLU, stride 1
  - Intermediate Layers:
    - Convolutional: stride 2 or more, occasionally 1
    - Non-linear (ReLU or others)
    - Pooling: stride 2, patch $[2 \times 2]$
    - One last fully connected layer + ReLU to flatten
  - Output Layer: Fully Connected + ReLU + softmax
    - One output per class
    - dropout probability

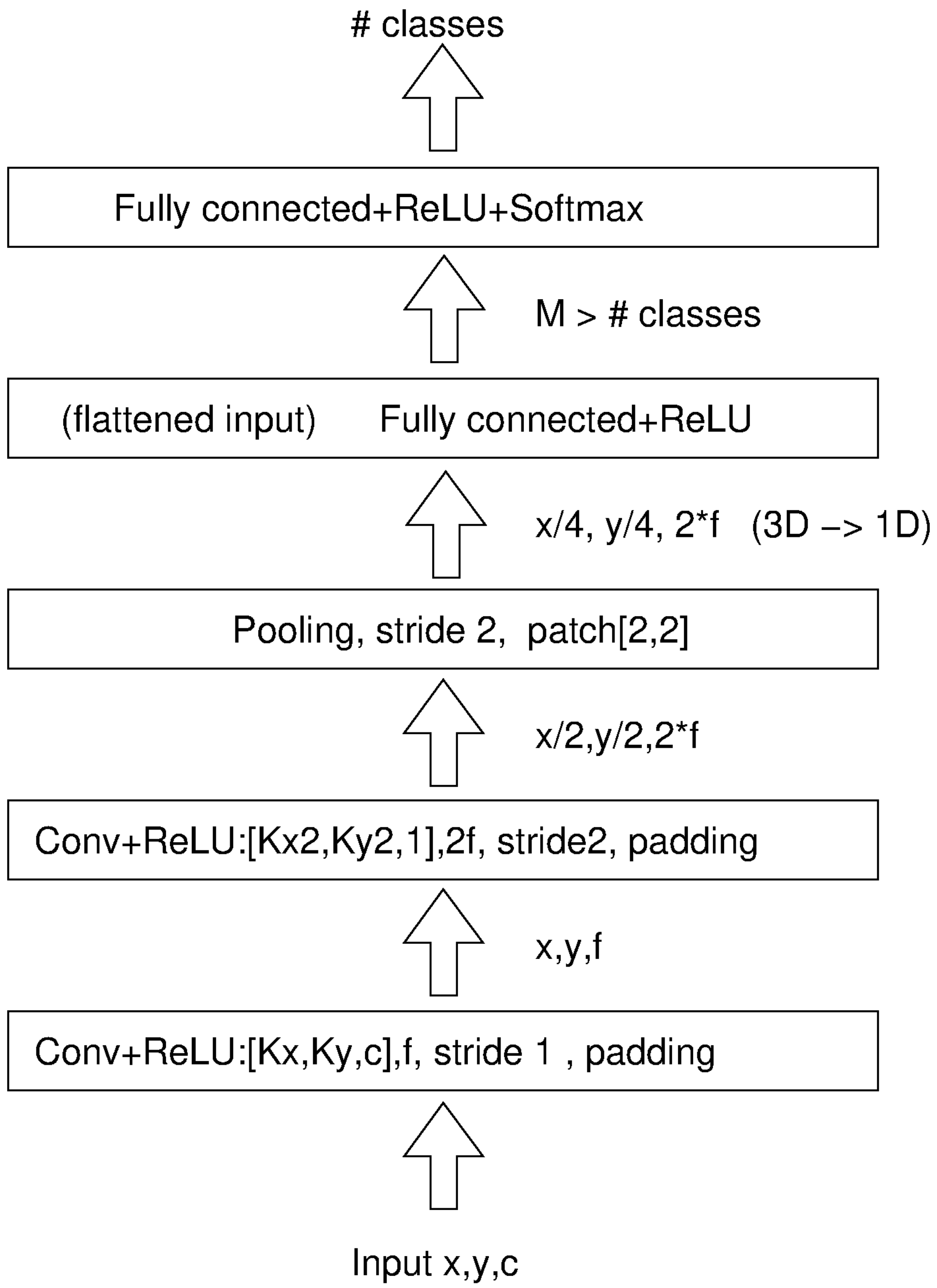

x,y,f

Conv+ReLU:[Kx,Ky,c],f, stride 1 , padding

Input x,y,c

Image Classification

- Training
  - Input dataset
    - large and representative
    - if different networks will be compared, they should be trained with the same dataset
  - preprocessing input
    - size
    - normalization
    - channels
    - brightness
    - images with dominant colors
      - $\text{pixel}_{i,j} - \text{mean}_{i,j}$
  - hardware: GPUs allow parallelization


# classes
Fully connected+ReLU+Softmax
M > # classes
(flattened input)
Fully connected+ReLU
x/4, y/4, 2*f (3D –> 1D)
Pooling, stride 2, patch[2,2]
x/2,y/2,2*f
Conv+ReLU:[Kx2,Ky2,1],2f, stride2, padding
x,y,f
Conv+ReLU:[Kx,Ky,c],f, stride 1 , padding
Input x,y,c

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