# MACHINE LEARNING IN PHYSICS
## TUTORIAL 4 / CNN

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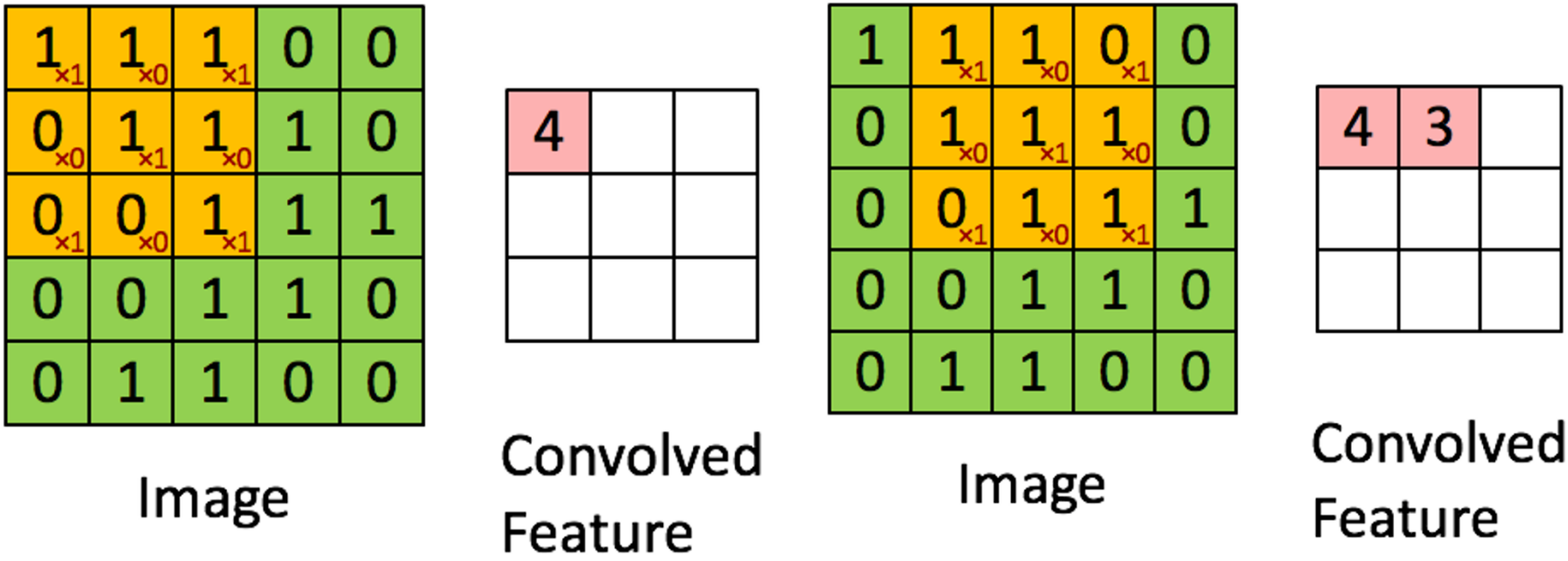
# Recap

A standard CNN comprises three types of processing layers:
1. convolution, 2. pooling, and 3. classification.

## 1. Convolution

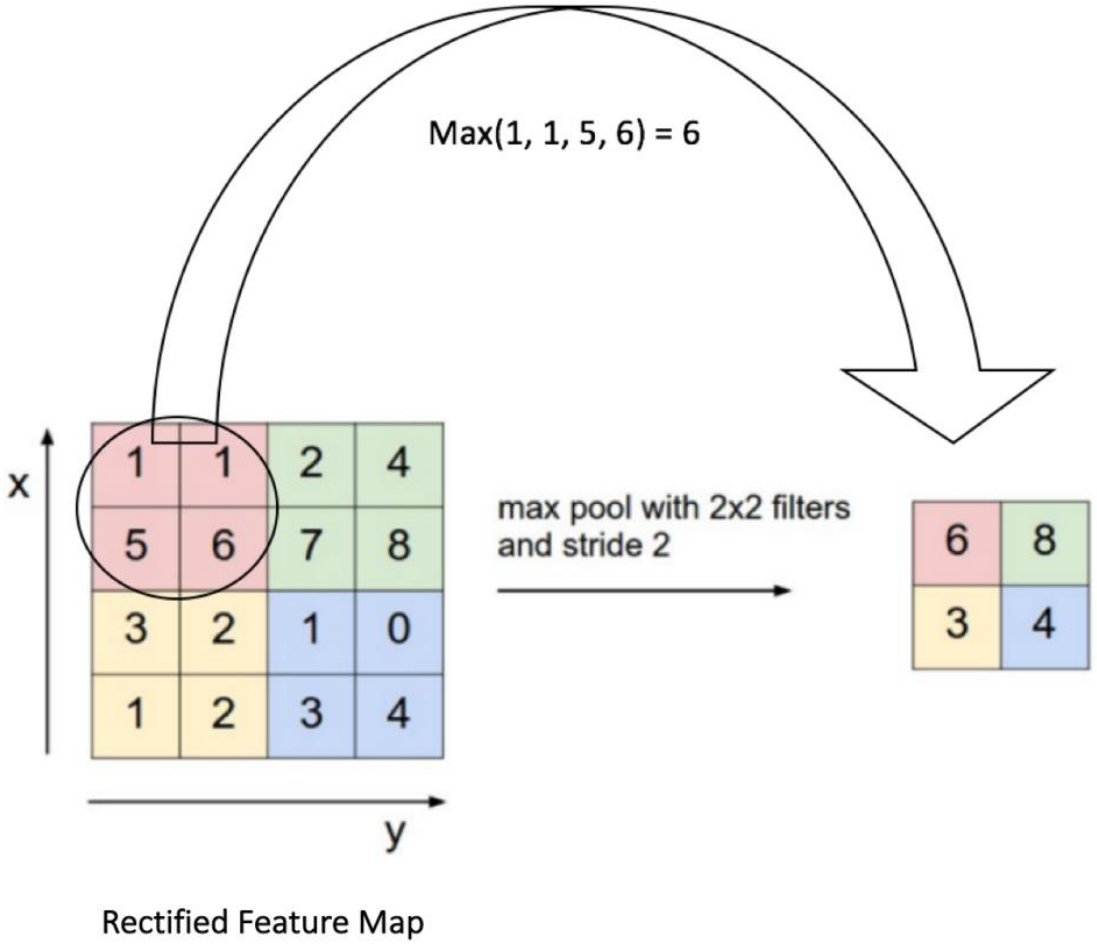


# Recap

## 2. Pooling

MaxPool2d

AvgPool2d



# Recap

## 3. Classification

$$p(k|x) = \frac{p(x|k)\,\pi(\mathrm{k})}{\sum_{j=0}^{K-1} p(x|j)\,\pi(\mathrm{j})}$$

In our galaxy classification example,

- $K = 7,$
- $\pi(k) = 1/K$

# Recap

Since this is a multi-class problem, we'll train a model, $f_k(x)$, with $K$ outputs that satisfy

$$\sum_{k=0}^{K-1} f_k(x) = 1$$

by minimizing the empirical risk

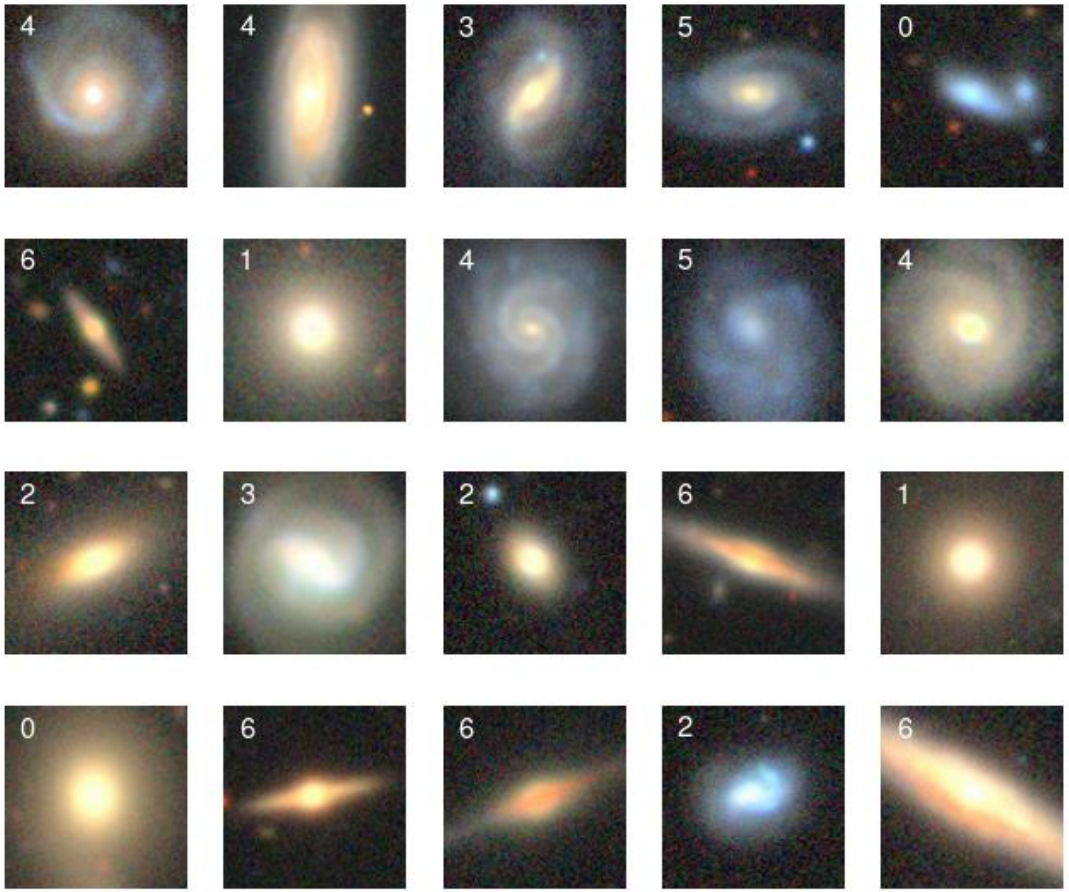
$$R\,(\omega) = -\frac{1}{N}\sum_{i=1}^{N} \log f_{y_i}(x_i)$$

where $y_i$ is the class label associated with image $x_i$.

# TUTORIAL 4

# Tutorial 4

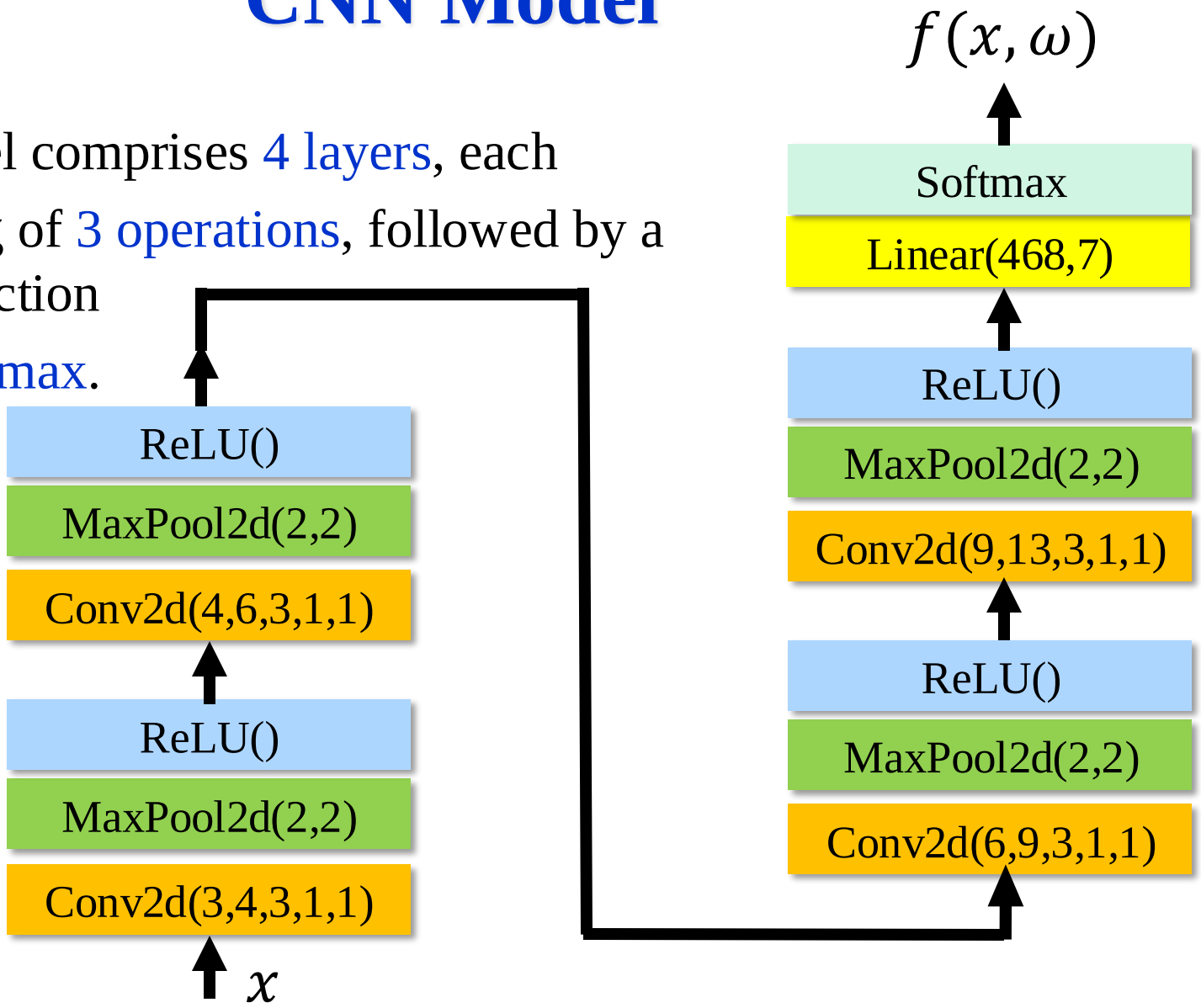
Goal: classify galaxies into 7 morphology classes using a CNN.



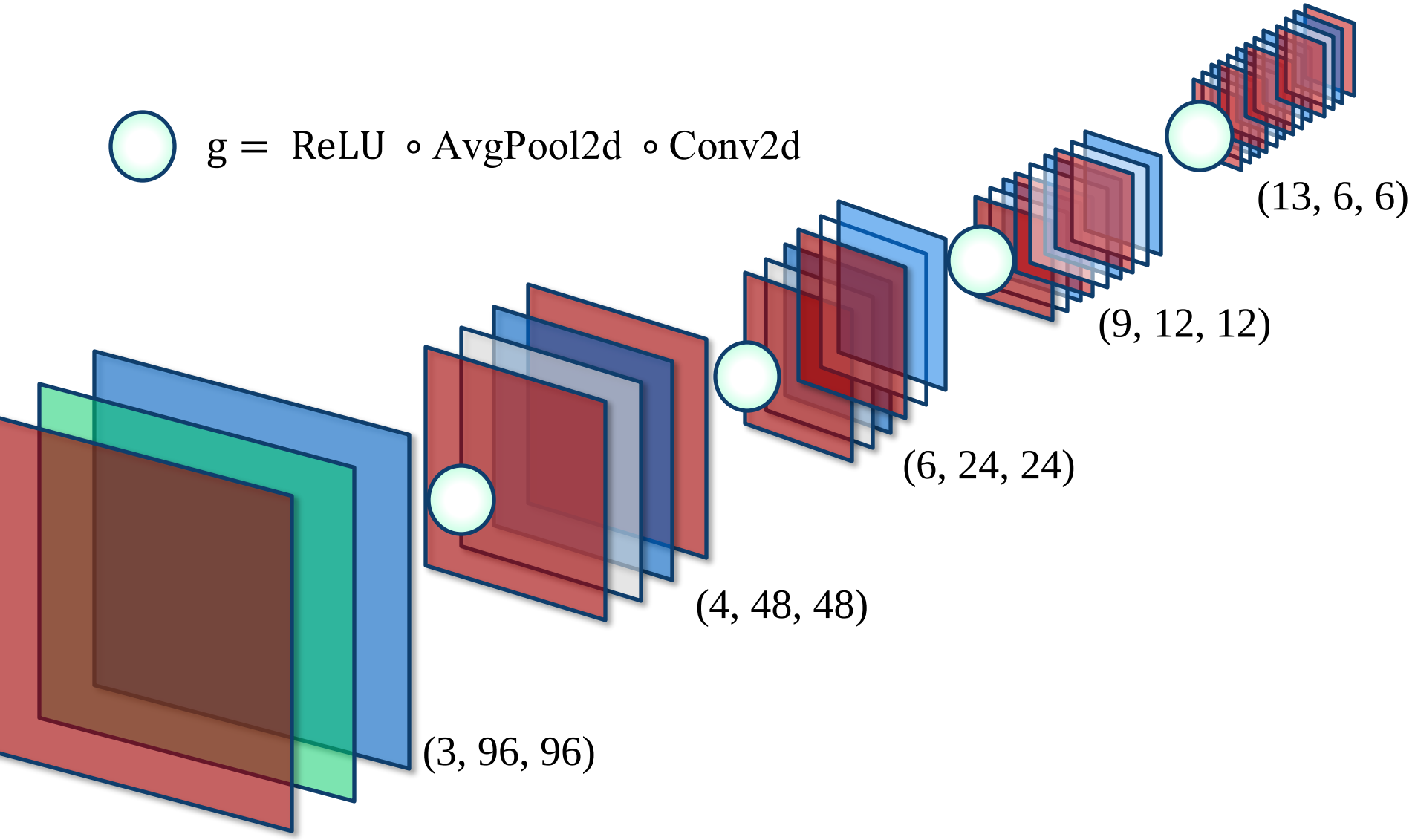

https://astronn.readthedocs.io/en/stable/galaxy10.html

# CNN Model

Our model comprises 4 layers, each consisting of 3 operations, followed by a linear function and a softmax.



# CNN Model



# CNN Model: Training

## Samples

1. Training sample size: 10,000
2. Validation sample size: 1,600
3. Testing sample size: 1,000

## Training hyperparameters

1. Number of iterations: 10,000 (200 epochs)
2. Batch size: 200
3. Learning rate: $10^{-3}$

# CNN Model: Results

Accuracy: 71.2%