

CU
University of Colorado
Boulder

Deep Learning Applications for Computer Vision

Lecture 11: Object Recognition and Image
Classification with Neural Networks

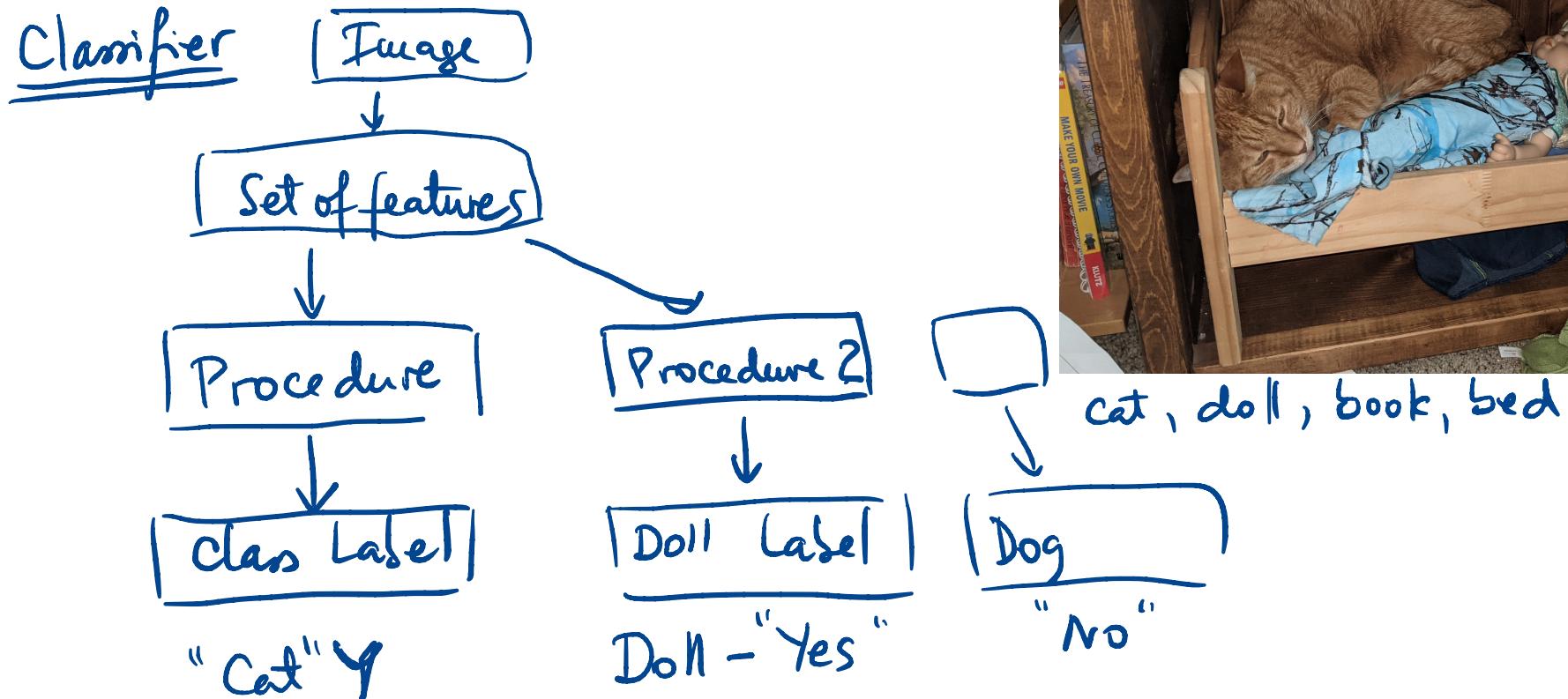


University of Colorado **Boulder**

Object Recognition vs Image Classification

- Often used interchangeably

$$IC = \text{label}(s)$$



cat, doll, book, bed



University of Colorado **Boulder**

Classification



We need:

- Data = set of labeled examples (images) (x_i, y_i)
- Rule/procedure: generates label for new image

Prediction function

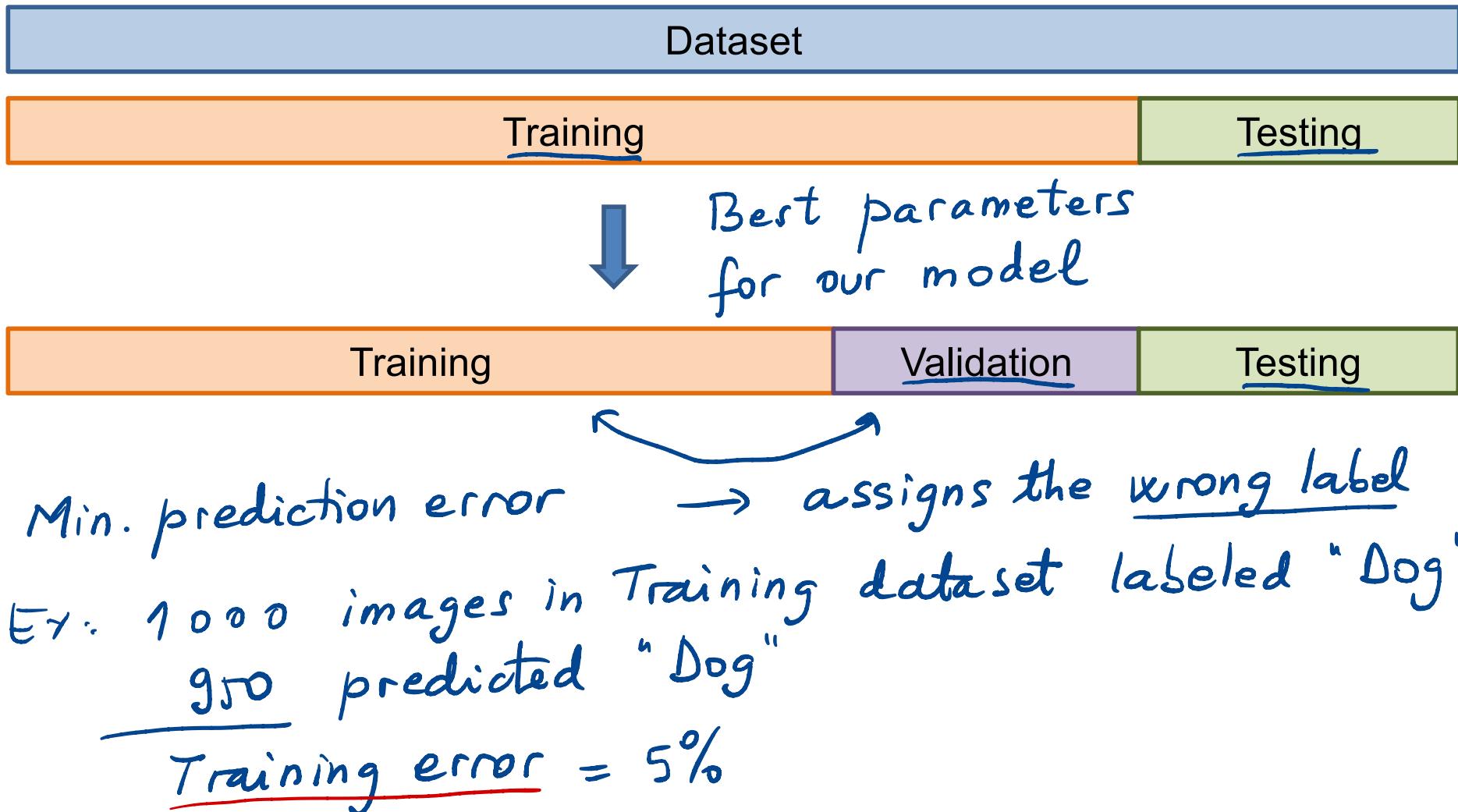
$$f \left(\boxed{\text{cat}} \right) = \text{"cat"}$$

$$f(x) = y$$



University of Colorado **Boulder**

The Data

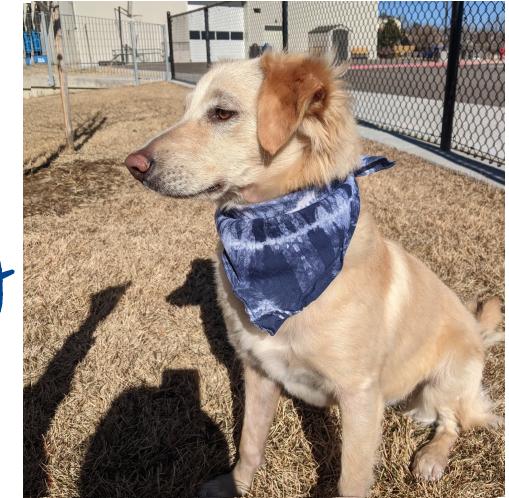


Confusion Matrix

Assumption: two-class classifier

- OL = original label
- PL = predicted label

Dog
Cat / Not Dog



		Predicted Condition		Model Predicts
		Positive (PP) ^{"Dog"}	Negative (PN) ^("Not Dog")	
Actual Condition	Positive (P) "Dog"	True Positive (TP) "Dog" labeled as "Dog"	False Negative (FN) "Dog" → "Not dog"	
	Negative (N) "Not Dog"	False Positive (FP) "Not Dog" → "Dog"	True Negative (TN) "Not Dog" → "Not dog"	

$$\underline{\text{Sensitivity}} = \frac{TP}{P}$$

$$\underline{\text{Specificity}} = \frac{TN}{N}$$



University of Colorado **Boulder**

Cost → Loss Function

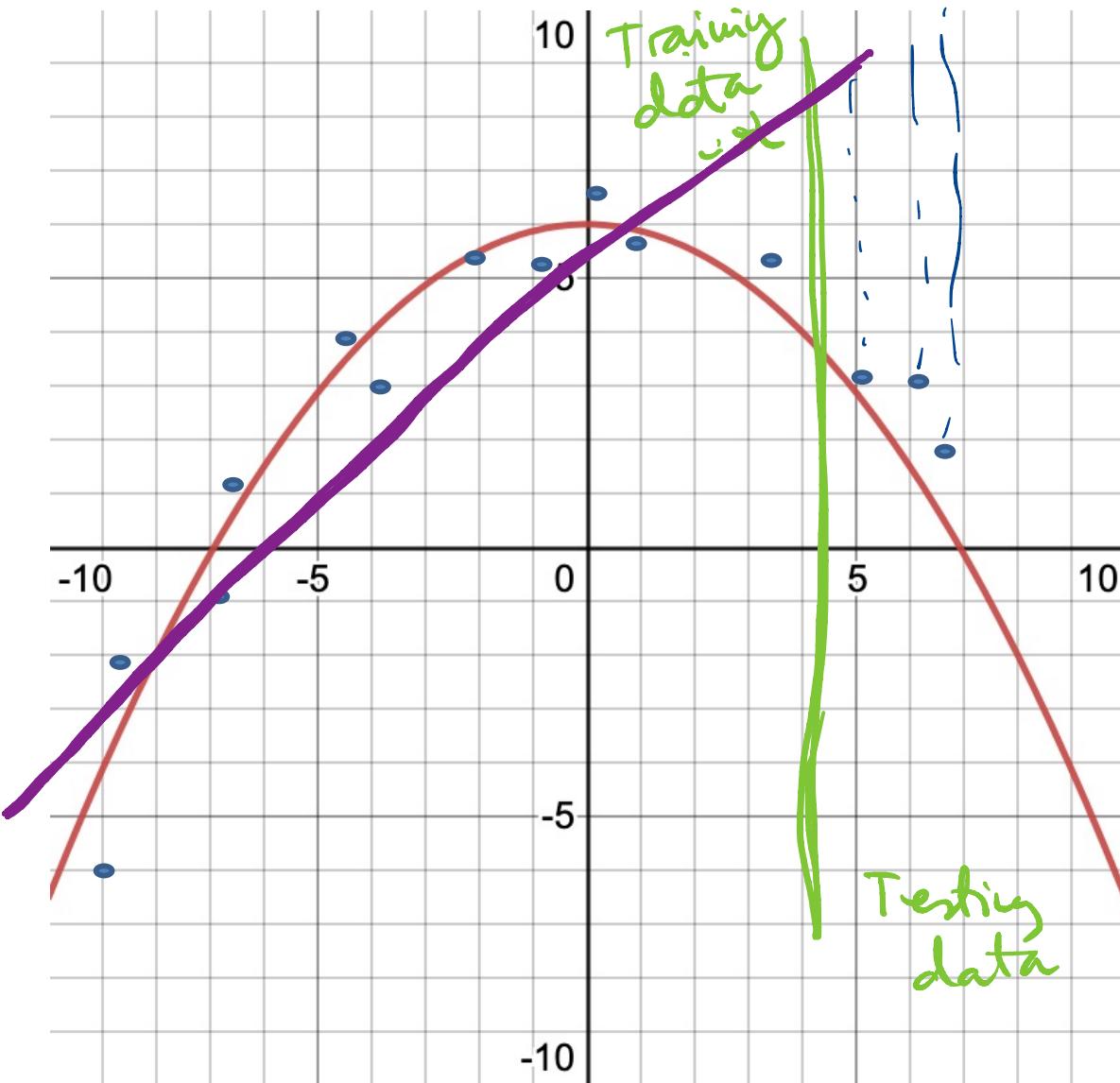
What if the image is labeled incorrectly?

- **Loss function:** $L(i \rightarrow j)$ object of type i classified as type j
 - $L(\text{dog} \rightarrow \text{dog}) = 0$
 - $L(\text{cat} \rightarrow \text{dog}) = \dots ?$
- Risk function, **Total risk** – for strategy s
$$R(s) = \underbrace{p(\text{dog} \rightarrow \text{cat} \mid \text{using } s)L(\text{dog} \rightarrow \text{cat})}_{FN} + \underbrace{p(\text{cat} \rightarrow \text{dog} \mid \text{using } s)L(\text{cat} \rightarrow \text{dog})}_{FP}$$



University of Colorado **Boulder**

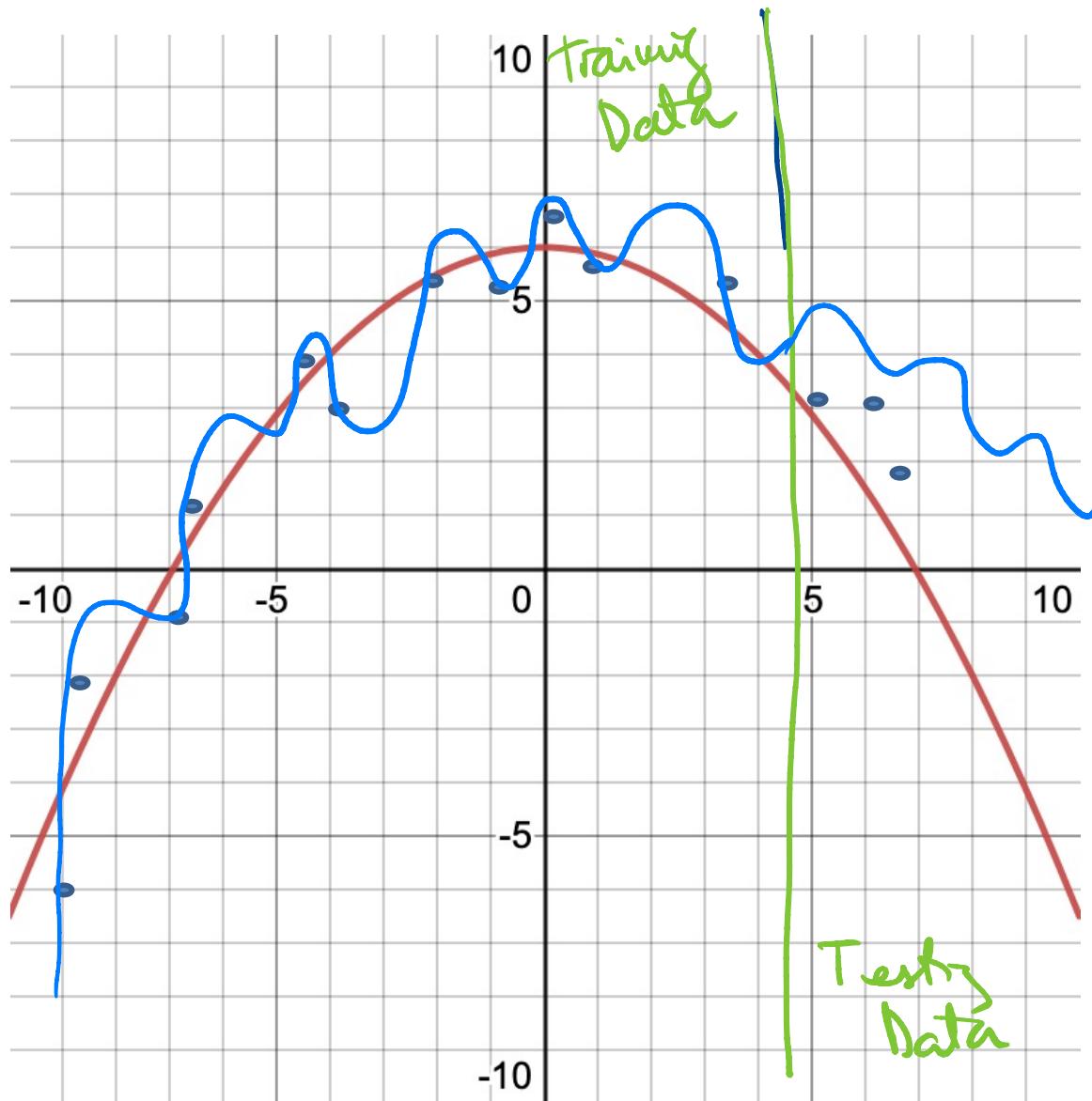
Generalization: Overfitting, Underfitting



- **Underfitting:**
 - too few parameters
 - not enough flexibility
- $f(x) = 6 - \frac{x^2}{8}$
- Red \rightarrow perfect fit
- Blue dot \rightarrow data + noise



Generalization: Overfitting, Underfitting



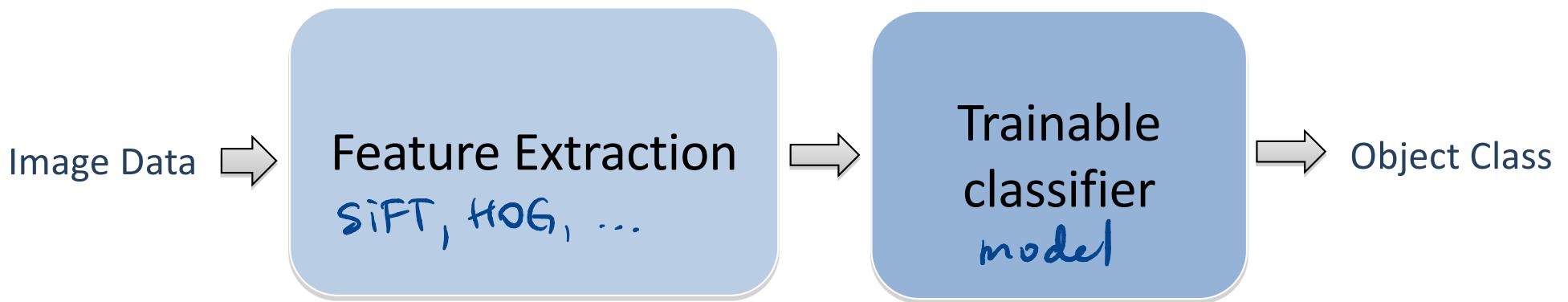
- **Overfitting:**
 - too many parameters
 - trying too hard to have 0 loss for every testing sample



University of Colorado **Boulder**

Classification – Traditional Approach

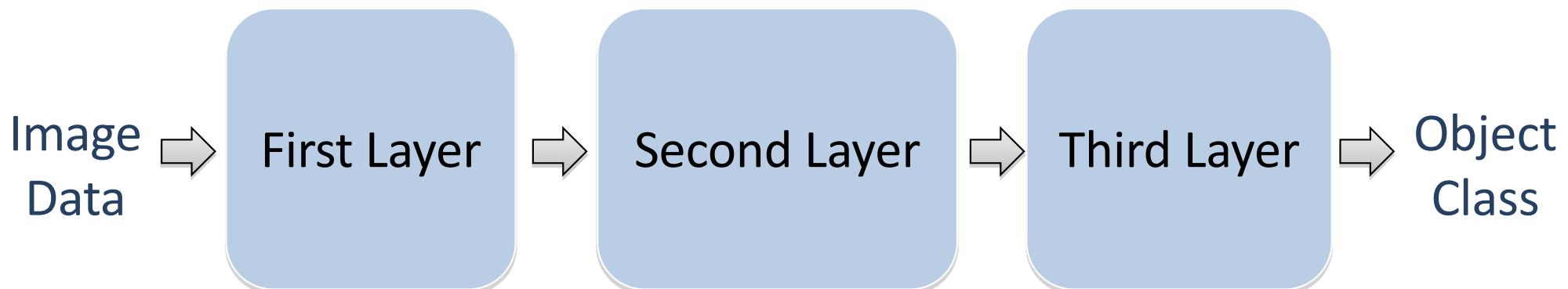
- relies on hand-designed feature extraction



Classification – Can we learn the features?

- Each layer learns from the output of the previous one
- Training is done for all layers together

Layer hierarchy



- How many layers???

*Shallow
vs.
deep* \ architecture



University of Colorado **Boulder**

Summary

- Image classification two-class vs multi-class
- Data and the cost of misclassification
- Shallow vs Deep architecture



University of Colorado **Boulder**