A/V Test

See my screen? Hear the bell?

Coding Machine Learning

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Neuro 140/240

Learning Outcomes

Main Goal: Get you set up and running for coding ML projects.

- How to set up your code?
- What tools/languages/frameworks can help make our life easier?
- How does it connect with the Theory?

Learning Outcomes

My Amazing ML Project

Files in that project

```python
import torch
from torchvision import datasets

def train_model():

def evaluate_model():
```

Code in these files

Learning Outcomes

My Amazing ML Project

How is this box organized?
Where is it stored?
How do I track changes?
How do I share it with someone else?

Files in that project

What kind of files would I have?
How would these be opened?
Which ones need to be shared and how?

```
import torch
from torchvision import datasets

def train_model():

def evaluate_model():
```

Code in these files

What language/frameworks should I use?

Part 1: The Box of Code

My Amazing ML Project

- **How is your project organized?**
- **Where is it stored?**
- **How do you track changes?**
- **How do you share it with someone else?**

Github

GitHub = Git + Hub

- Git: A system for tracking versions of files (Version Control)
- GitHub: Store your code + it tracks changes using git

Why do we need Git?

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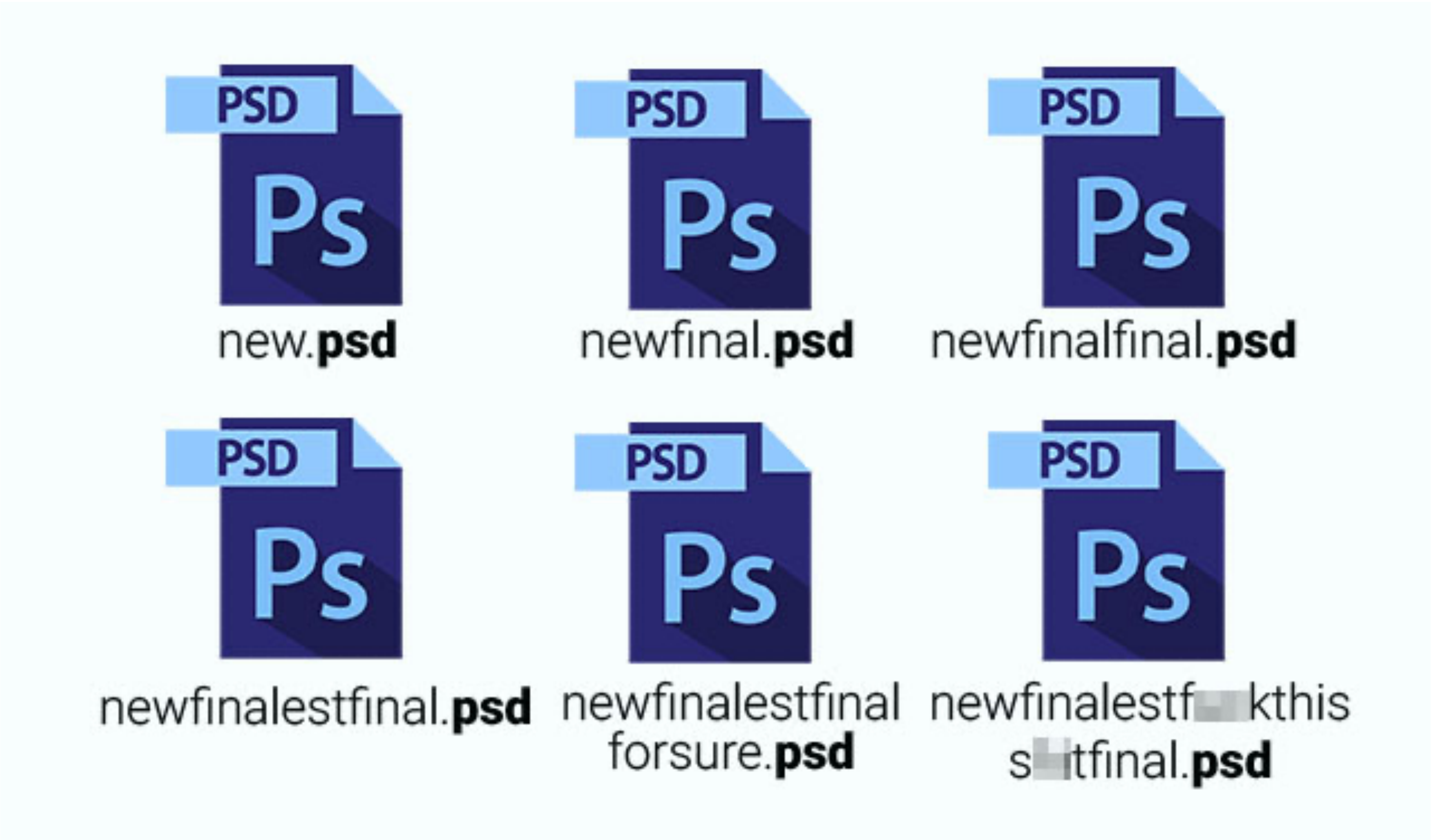
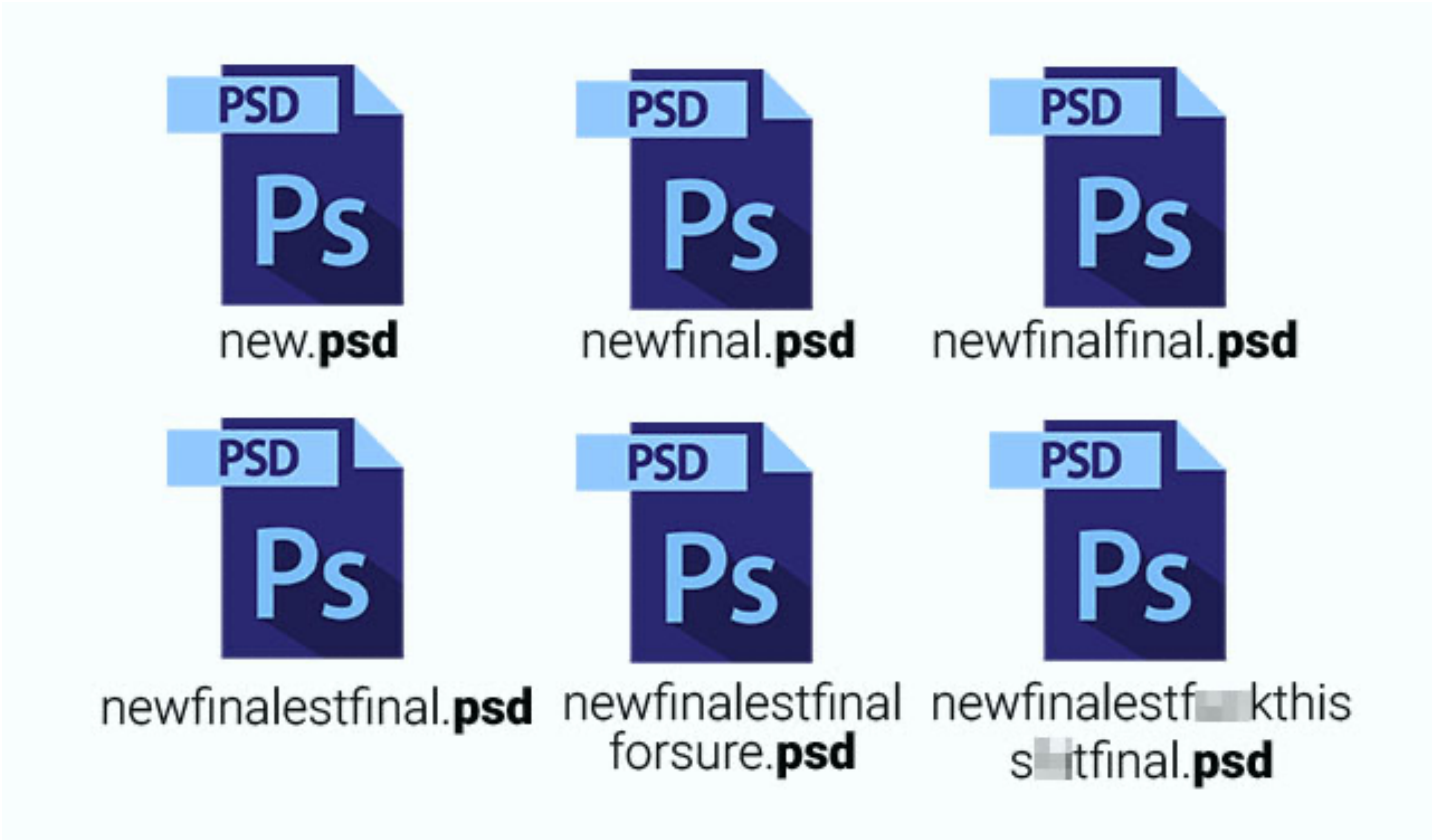
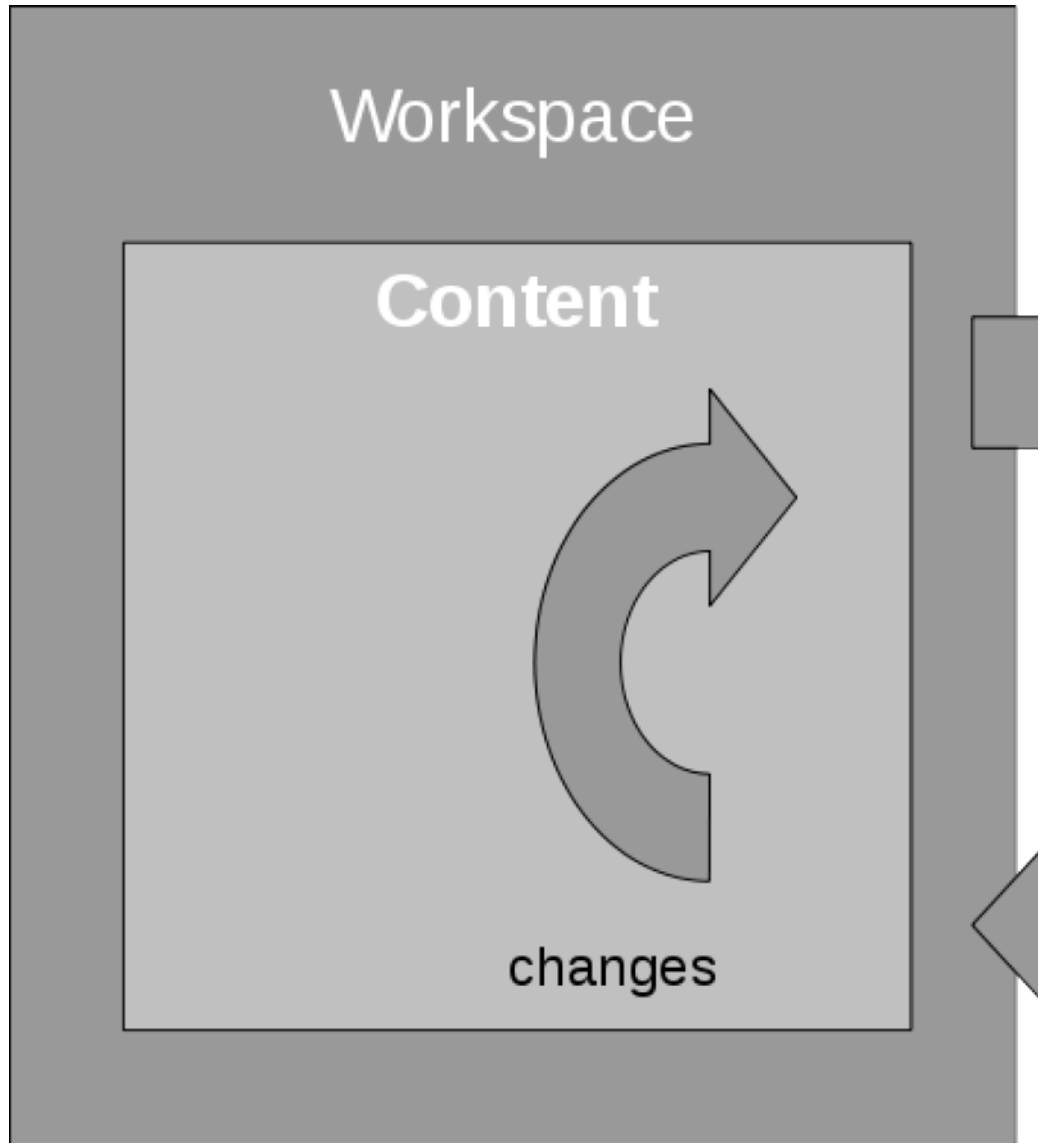


Why do we need Git?

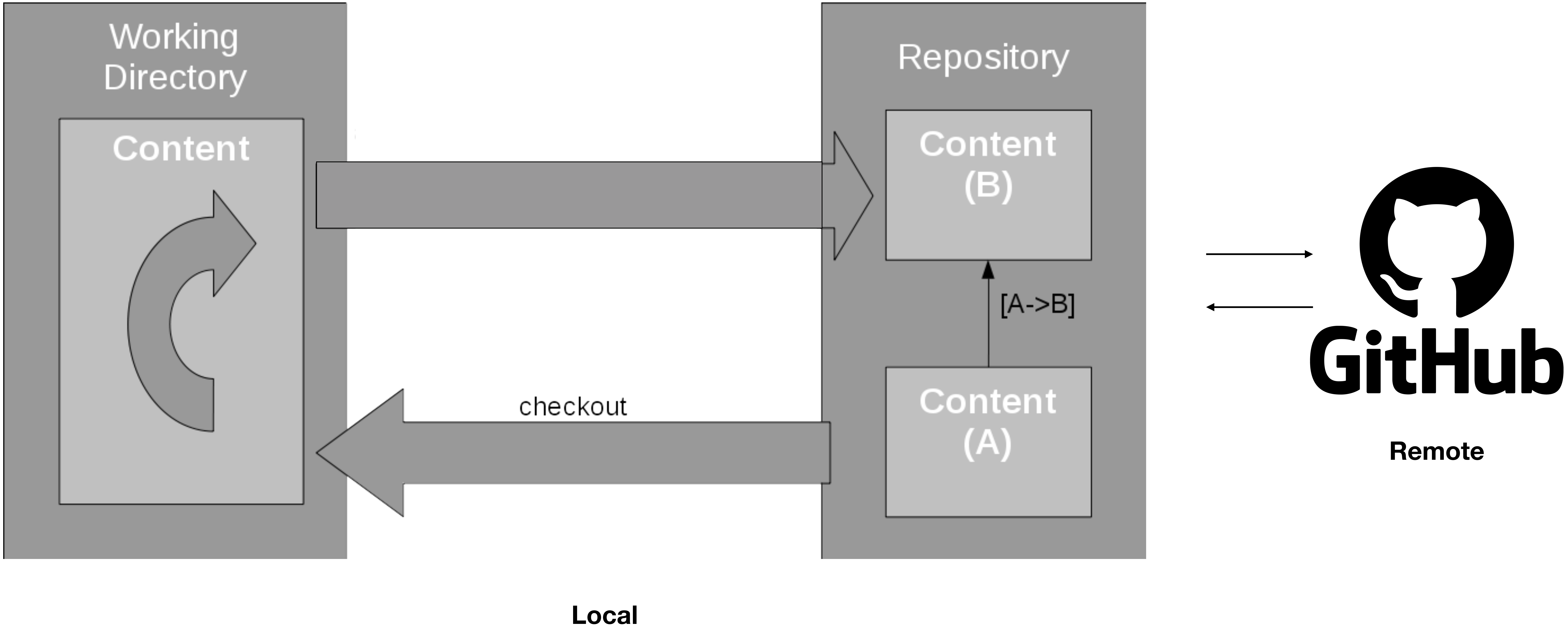


- Managing versions is important.
- Especially when multiple people are working on the same code-base.
- Combined with GitHub - Great way to store/manage/share your projects.

How version control works



How git works



Few useful commands

<u>Group 1: Getting stuff from github</u>
git clone - Copy from GitHub to local.
git fetch - get changes from remote
git merge - merge changes into local
git pull = git fetch + git merge

<u>Group 2: Reflecting your local changes on github</u>
git add - add a changed file to staging area
git commit - commit the change i.e. create snapshot
git push - upload new snapshot to github

<u>Group 3: Branches etc</u>
git checkout - switch or create new branch (Assignment 2)

More advanced git

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- How to resolve merge conflicts.
- Pushing too large a file - undoing added files.
- Undoing a commit i.e. moving to previous commit.

Summary Part 1

- Git = Management system for your files
- GitHub = a place where code is stored and managed using git snapshots

My Amazing ML Project

Files in that project

```
import torch
from torchvision import datasets

def train_model():

def evaluate_model():
```

Code in these files

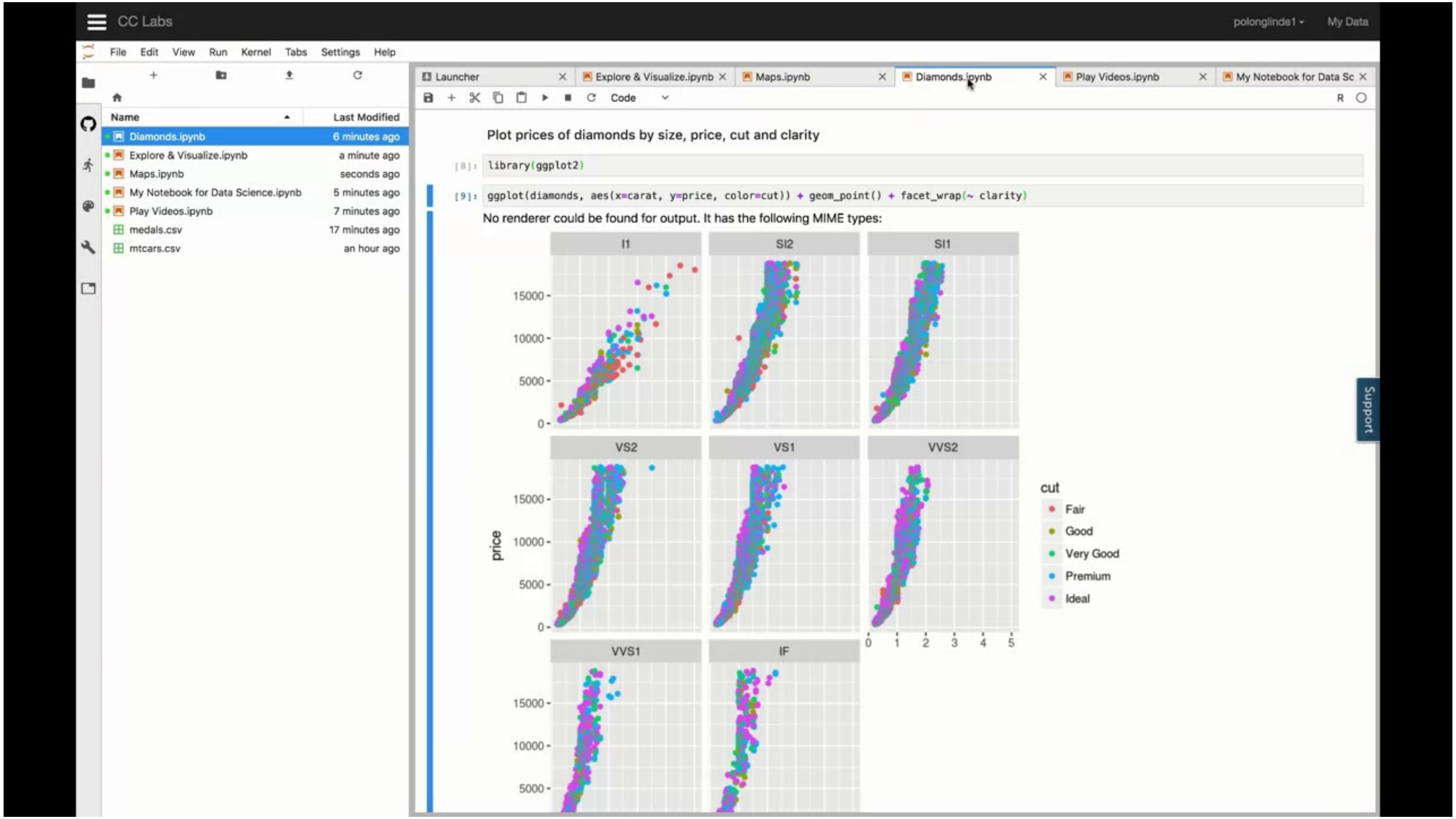
Part 2: Files in the Box

Files in that project

- **What kind of files would I have?**
- **How would these be opened?**
- **Which ones need to be shared and how?**

Jupyter

What is Jupyter?



Google Colab

Summary of Part 1 and 2

GitHub

Jupyter Notebooks

Part 3

```
import torch
from torchvision import datasets

def train_model():

def evaluate_model():
```

- What language/framework should we use to write code in our files?
- We will use PyTorch.

PyTorch

- Facebook's framework for ML/DL research.
- Easy to install.
- Easy to prototype.
- Resource for PyTorch: https://pytorch.org/tutorials/beginner/deep_learning_60min_blitz.html

A very brief introduction to ML/DL

...and how PyTorch allows us to code for ML

What is Machine Learning?

- Very elusive to define.

- Tom Mitchell (CMU): “A machine for which <u>*performance improves*</u> for some <u>*specific task*</u> with <u>*experience*</u>”.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Corporate Structure
TOTAL's Story
Upstream Strategy
Downstream Strategy
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At TOTAL, we draw our greatest strength from our fast-growing oil and gas reserves. Our strategic emphasis on natural gas provides a strong position in a rapidly expanding market.

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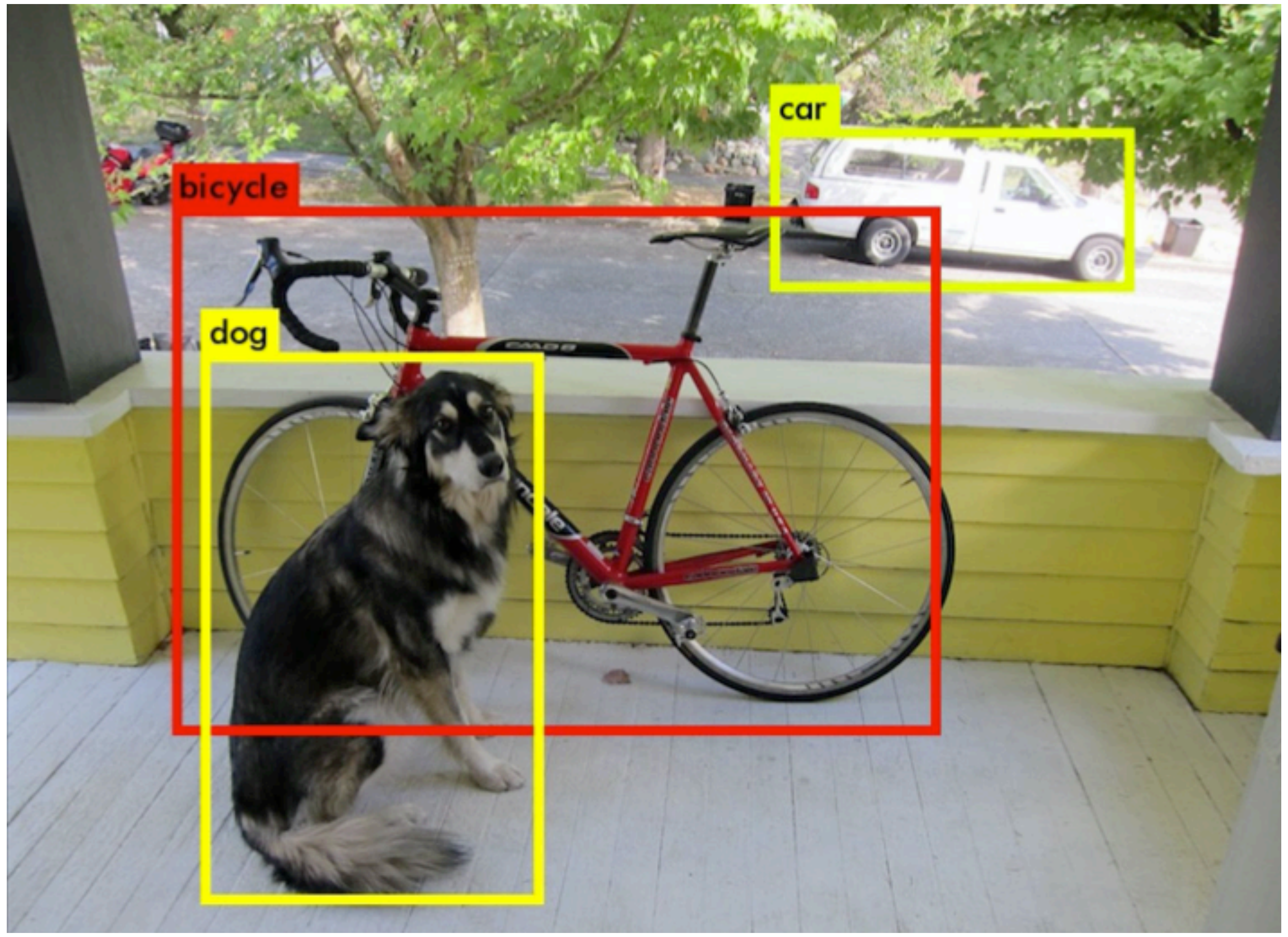

Why is ML everywhere?

Machine Learning

Unprocessed things

The toolkit perspective

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INFORMATION GOES IN → MACHINE LEARNING MODEL → MORE USEFUL INFORMATION COMES OUT

x_i f y_i

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EXAMPLES

→ Machine Learning System → Chair YES/NO

What is f?

- Assumption: Underlying relationship. We have reason to believe that:

$$y_i = g(x_i) \quad \forall x_i \in X$$

- But, g is very, very complex/hard to pin point. Ex: protein folding, music preference, voting preference, and so on.

- Solution: Let’s approximate g with f.

Typically learning setups

- **Supervised:** Both y (labels) and x (inputs) are given.
    - Ex: Is this a picture of chair? Can you translate this from English to Hindi/Mandarin/French?
- **Unsupervised:** Discovering patterns in x, independent of a y.
    - Ex: Anomaly detection in a subset of pictures, or predicting next word in a sequence.

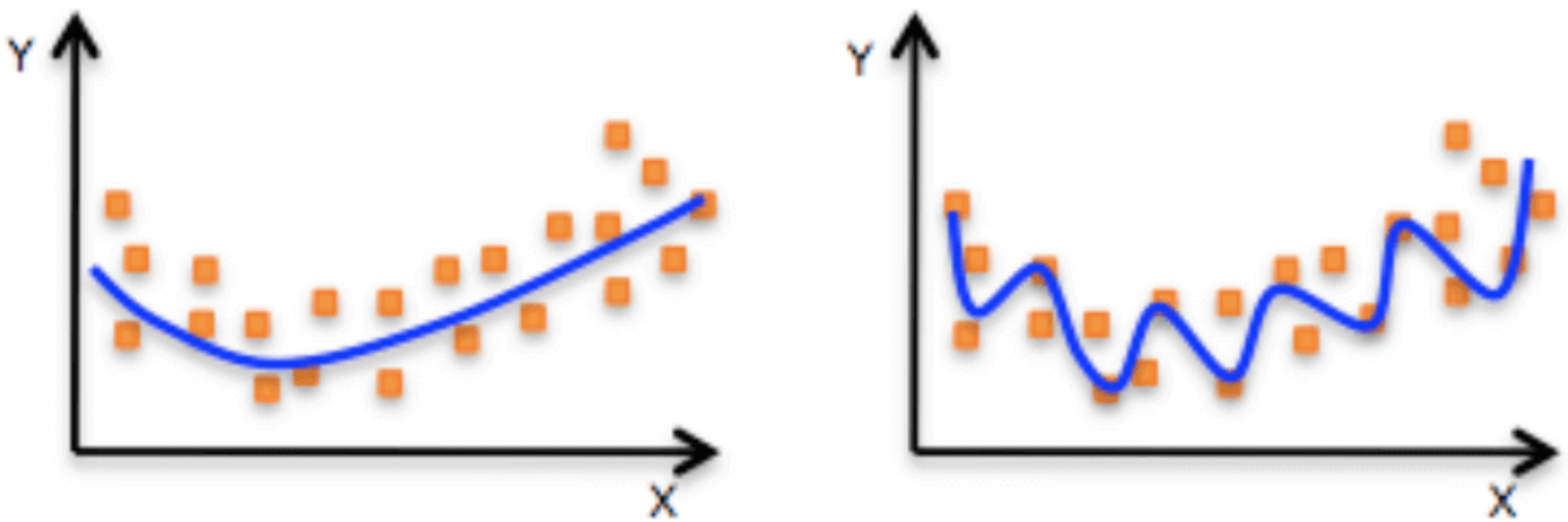
Typically learning setups

- **Semi-supervised:** Supervised + Unsupervised components.
  - Ex: MRI, CT scans - mixing vision + small, labeled doctor feedback.
- **Reinforcement:** Really shouldn't be on the same list. Specifically cast for settings where multiple actions are taken in a sequence.

Supervised Learning

$$y_i = g(x_i) \sim f(x_i)$$

- Goal, finding f which best approximates g.
- Let $x_i \in X_{train}, y_i \in Y_{train}$, is the goal to find the best fit f on (X_{train}, Y_{train})?



Overfitting

Empirical Risk Minimization

- f and g should be similar on all possible X,Y you will get.

- This includes - (1) Train set, (2) Test set, **(3) Samples you don't have**

$$\epsilon(f) = \int_{X \times Y} f(x) \sim g(x)$$

- How should we quantify f ~ g?

$$L(f(x), y) \rightarrow [0, \inf)$$

Empirical Risk Minimization II

$$\epsilon(f) = \int_{X \times Y} f(x) \sim g(x)$$

$$\epsilon(f) = \int_{X \times Y} L(y, f(x))$$

$$L(f(x), y) \rightarrow [0, \inf)$$

The goal of supervised learning: $$\min_{f} \epsilon(f)$$

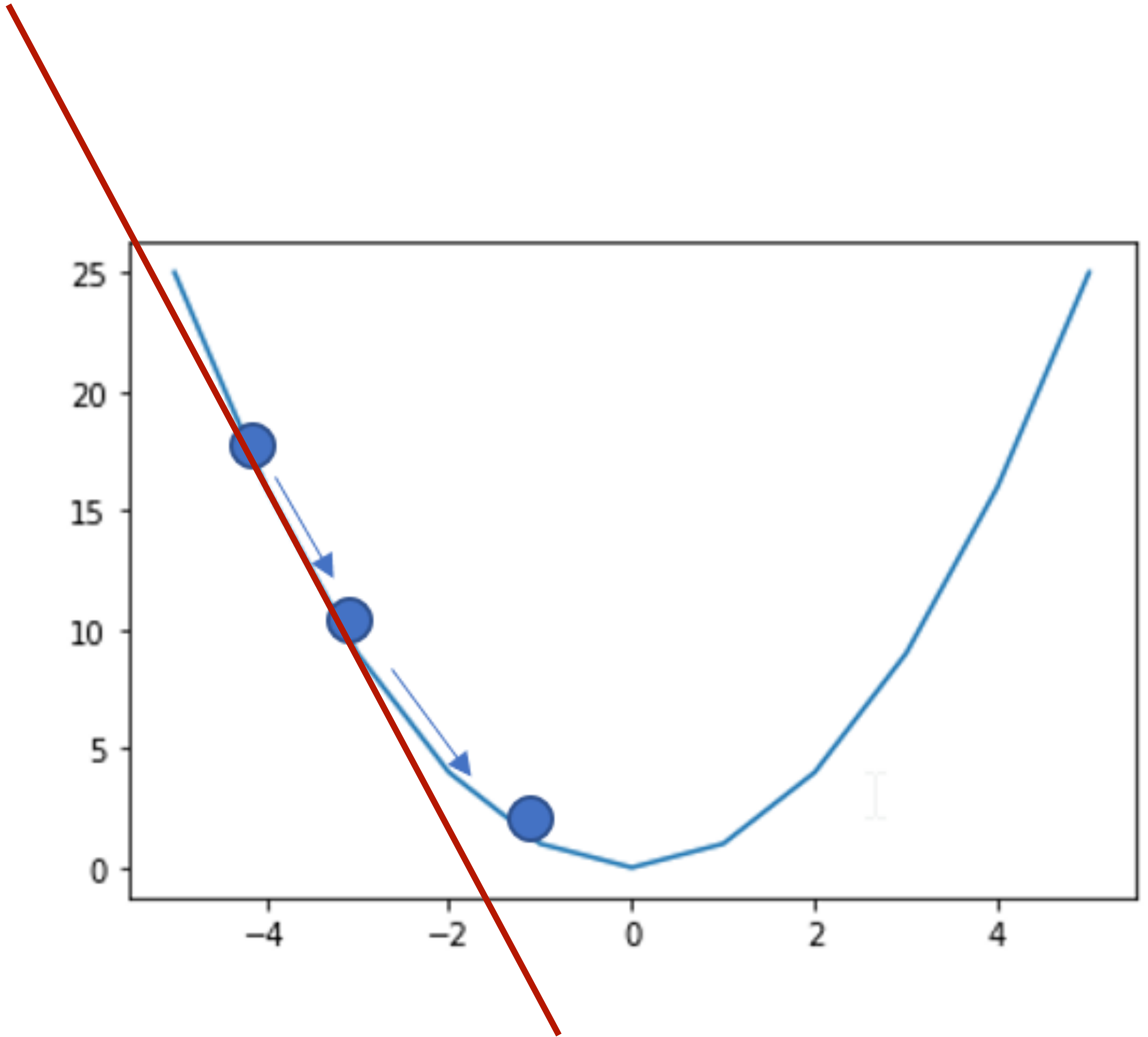
What all factors did we see?

- We are trying to minimize, the loss function (L) incurred by our chosen function f on dataset space (X,Y)
- Let's go over each one of these components

Minimization: How do we do it?

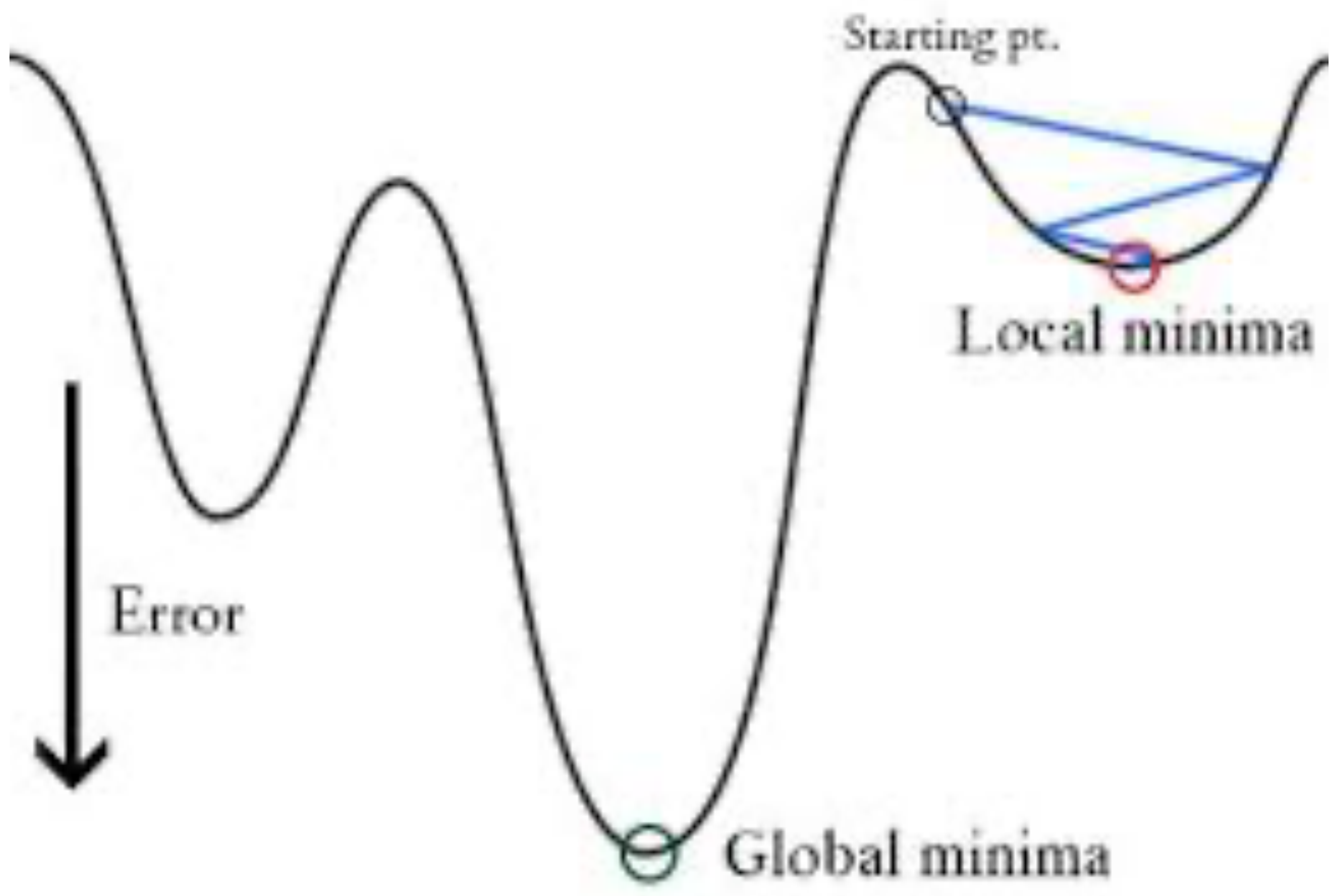
- Gradient Descent: (1) Measure gradient of loss w.r.t. parameter (say α),

  (2) change parameter as: $\alpha = \alpha + r * \dfrac{\partial L}{\partial \alpha}$



How about a more complex function?

- Gradient descent should not work.
- We have other variants which work better in practice.



So, we need to make the job easy.

- Components to play with - Loss function L, Data (X,Y), and architecture of the function f.
- Let’s see how we can modify each of them.

What is a good loss function?

- It should reflect what is important to us. For classification:- don’t penalize if prediction is same, and do penalize if classification is wrong.

- Should help optimization. Best to keep it continuous.

- For ex: Misclassification loss does not have good gradients. Hence, we use CrossEntropy loss for classification.

- If we have a custom use case, we can design a custom loss function.

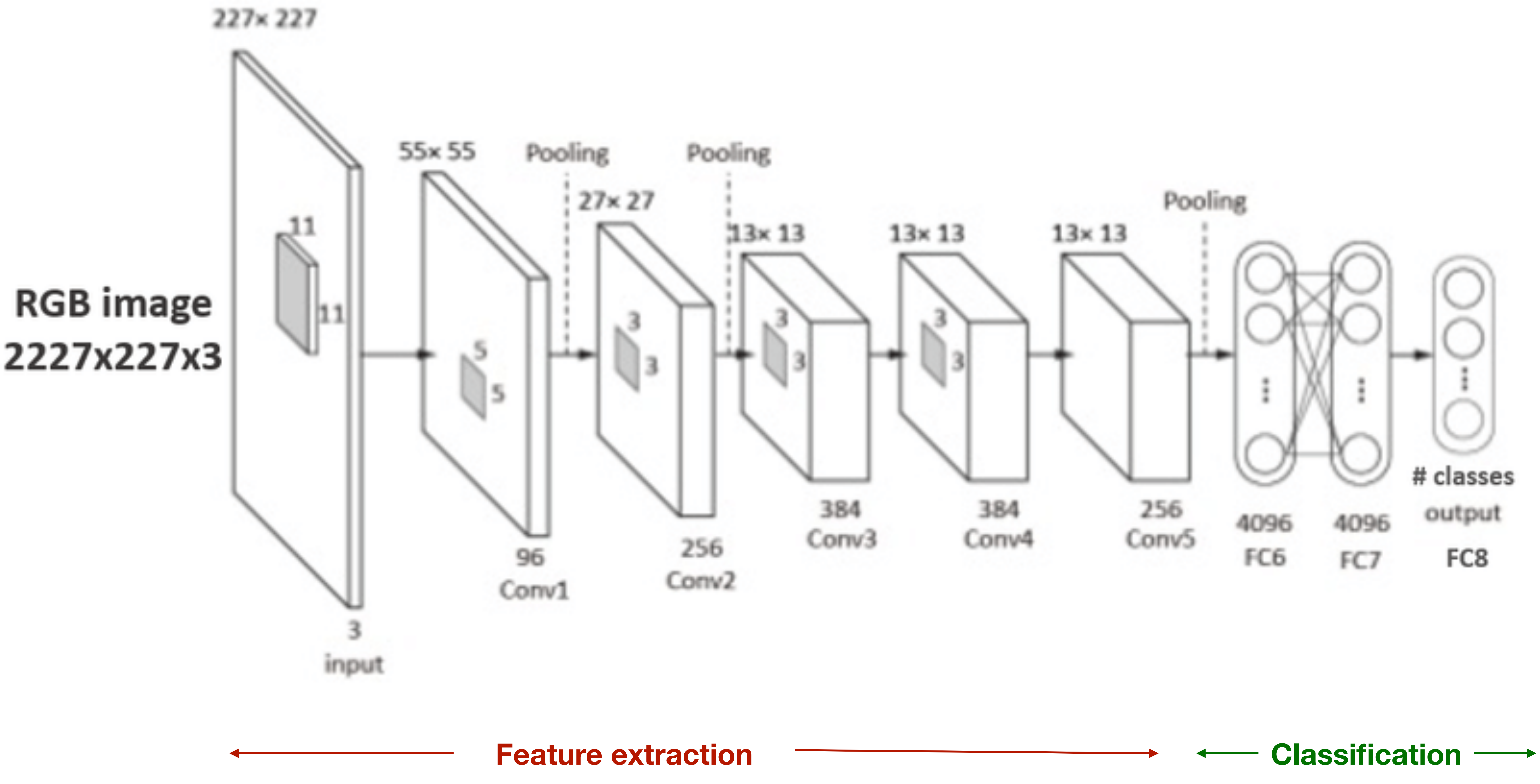
Making (X,Y) most useful

- Features = facets of your data. Ex: For picking best advertisement - age, shoe preference, favorite color.
- Conventional ML: features are everything.
- Finding the right features is very, very hard.

Making (X,Y) most useful

- Typical things done:- PCA, mean normalization. More fancy ones - whitening, sketching/streaming, random projections.
- Deep learning automates this search. First few layers = non-linear projection of your data.
- First few layers combine parts of input in non-linear way till they find something which is a good feature.

Deep Learning - automatic feature extraction



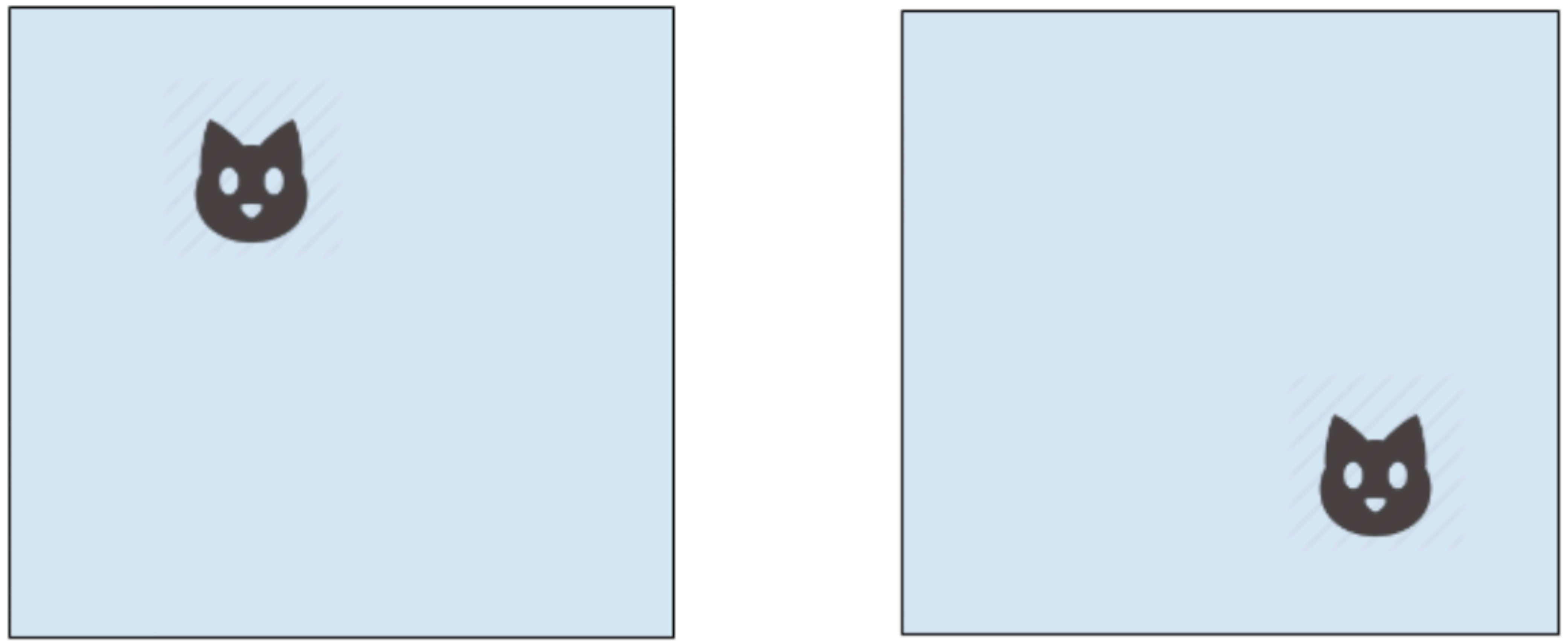
Important questions worth asking

- Are we sure a CNN can be the mathematically best f?
    - Yes, universal approximation theorem proves that.
- If we’re doing automatic search, why do certain architectures work better? Why CNNs, and not normal feed forward architectures?

Architectures to help automatic search

- Addition of inductive bias - i.e. exploiting the structure of the problem.

- For ex:



- CNNs, RNNs are designed so this structure can be exploited.

I am going to the _____ because I am hungry.

I am hungry, so I am going to the _____.

So, how do we code all this?

We were introduced to 4 components of Deep Learning today. These are:

1. Dataset: We want to load + Pre-Processing easily + fast.

2. Architectures: We may want to include specific structure of our problem.

3. Loss functions: Custom loss functions for our task are important.

4. Optimization: Variant of gradient descent used. So, gradient of loss w.r.t. NN parameters needs to be calculated.

PyTorch returns

PyTorch allows great control over each of these aspects

- Data-Loading: Automatically manages issues of memory and speed on GPU.
- Architectural expressivity: If you’ve ever used CAFFE, you would know.

libstdc++ installation

This route is not for the faint of heart. For OS X 10.10 and 10.9 you should install CUDA 7 and follow the instructions above. If that is not an option, take a deep breath and carry on.

- Easy definition of losses and custom losses.
- Autograd.
- Easy implementation of different gradient algorithms.

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Let’s see it in code?

https://colab.research.google.com/drive/125blGZwFZUm8g6YsRntzyJrrp-NjWkuW?authuser=1