Machine Learning: Applications and Practices
Lecture 1

Xu Yuan
University of Louisiana at Lafayette

Welcome!

- **Welcome all participants from four universities:**
  - University of Louisiana at Lafayette
  - Southern University
  - University of South Alabama
  - Western Kentucky University
  - Others

Course Information

- **Class Meeting Time:**
    - Wednesday: 10: 30am to 11:45am (Lecture series)
    - Friday: 10: 30am to 12:00am (Hands-on series)
- **Prerequisite:**
    - Have a Windows OS laptop
    - Know the basic of Python programming
- **Course Assistants:**
    - Mr. Jiadong Lou
    - Mr. Fudong Lin
- **Course Website:**
    - https://people.cmix.louisiana.edu/yuan/2023_Summer_Tutorial_Courses.html

What’s Our Goals?

We are not ambitious…

Our Goals

This is just an entry level of Machine Learning course!

No credits, no grading!

1. Learning the fundamental knowledge

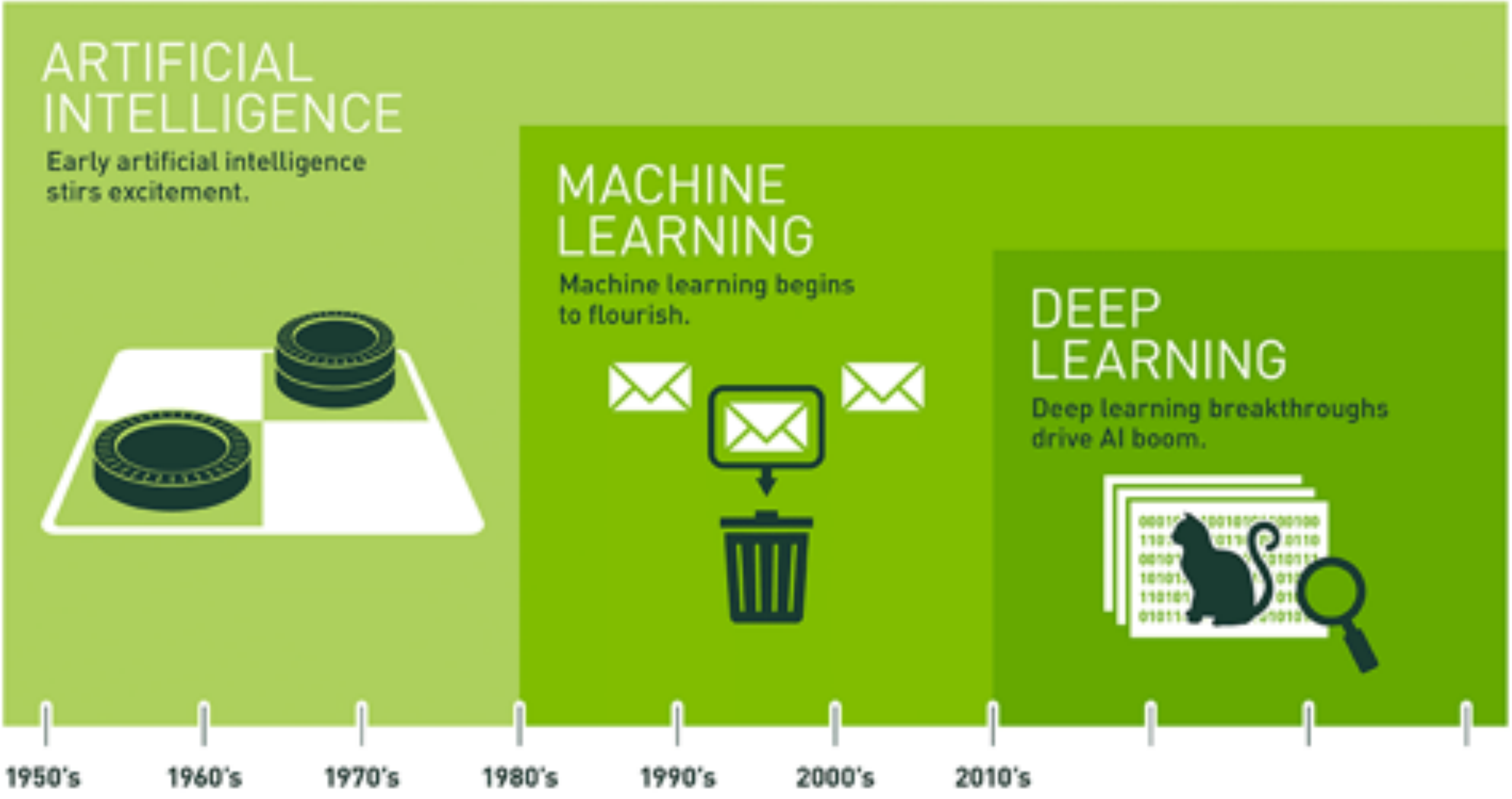
2. Coding practice for Python

3. Practicing on real-world data

My Suggestions

Please attend each lecture and hands-on;
Otherwise, you will be
lost!

AI History



ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.

MACHINE LEARNING

Machine learning begins to flourish.

DEEP LEARNING

Deep learning breakthroughs drive AI boom.

Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Source from: https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

AI and ML

- **Artificial Intelligence (AI)**
  - Role of Statistics: Inference from a sample.

- **Machine Learning (ML)**
  - Arthur Samuel (1959): Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.

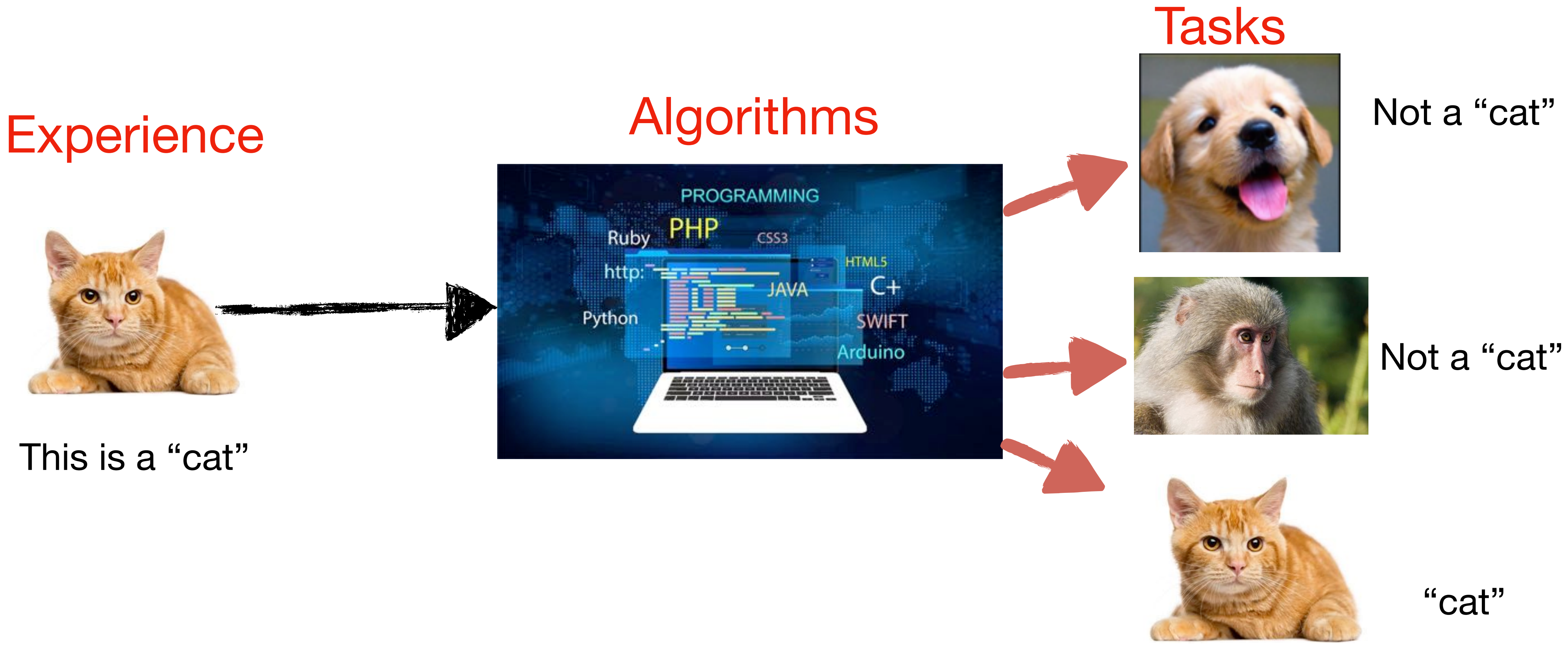
  - Tom Mitchell (1998): Well-posed Learning Problem: A computer program is said to learn from experience with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.

What is Machine Learning?

- Study of *Algorithms* that *improve* their *performance* at some *task* with *experience*.

- **Role of Computers:**
  - Having efficient algorithms to solve the optimization problems to learn models
  - Learning Models for unknown and changing worlds
  - Representing and Evaluating the model for inference.

What is Machine Learning?



Experience

This is a “cat”

Algorithms

Tasks

Not a “cat”

Not a “cat”

“cat”

Spam Classification Example

- *Suppose Twitter server watches which tweets marked as spam message. Based on this information, he will learn how to better filter spam.*

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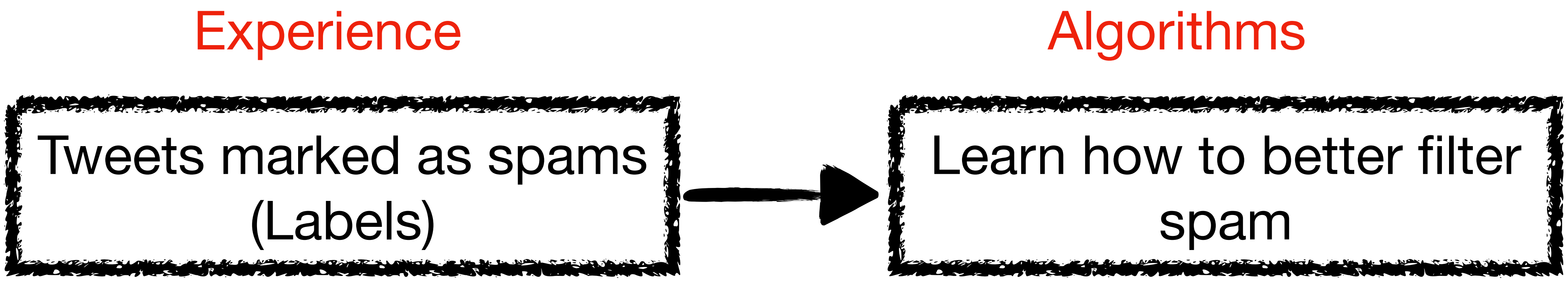


Experience

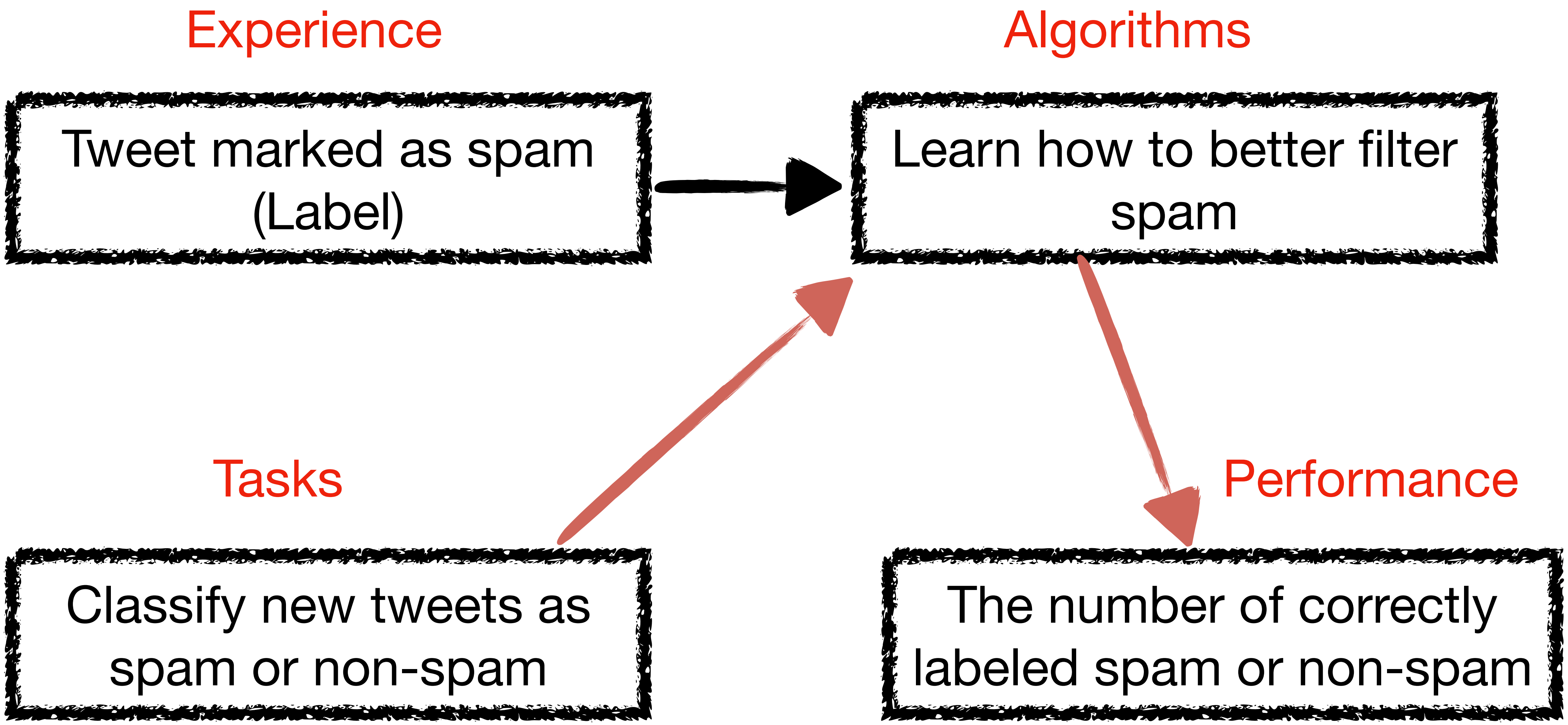
Tweets marked as spams (Labels)

Algorithms

Learn how to better filter spam

Spam Classification Example

- *Suppose a Twitter server watches which tweets are marked as spam messages. Based on this information, it will learn how to better filter spam.*



Experience

Tweet marked as spam (Label)

Algorithms

Learn how to better filter spam

Tasks

Classify new tweets as spam or non-spam

Performance

The number of correctly labeled spam or non-spam

Weather Prediction Example

- *Suppose a Mesonet station monitors the weather conditions for the past several years, then based on this information, a computer program can learn and predict the weather conditions in next several days.*

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Past several years' observation

Experience

Algorithms

Weather Prediction Example

- *Suppose a Mesonet station monitors the weather conditions for the past several years, then based on this information, a computer program can learn and predict the weather conditions in next several days.*

Past several years' observation

Last one week's observation

Tasks

Next week

Machine Learning ~ Looking for a Function

- Image recognition

f( ) → “Cat”

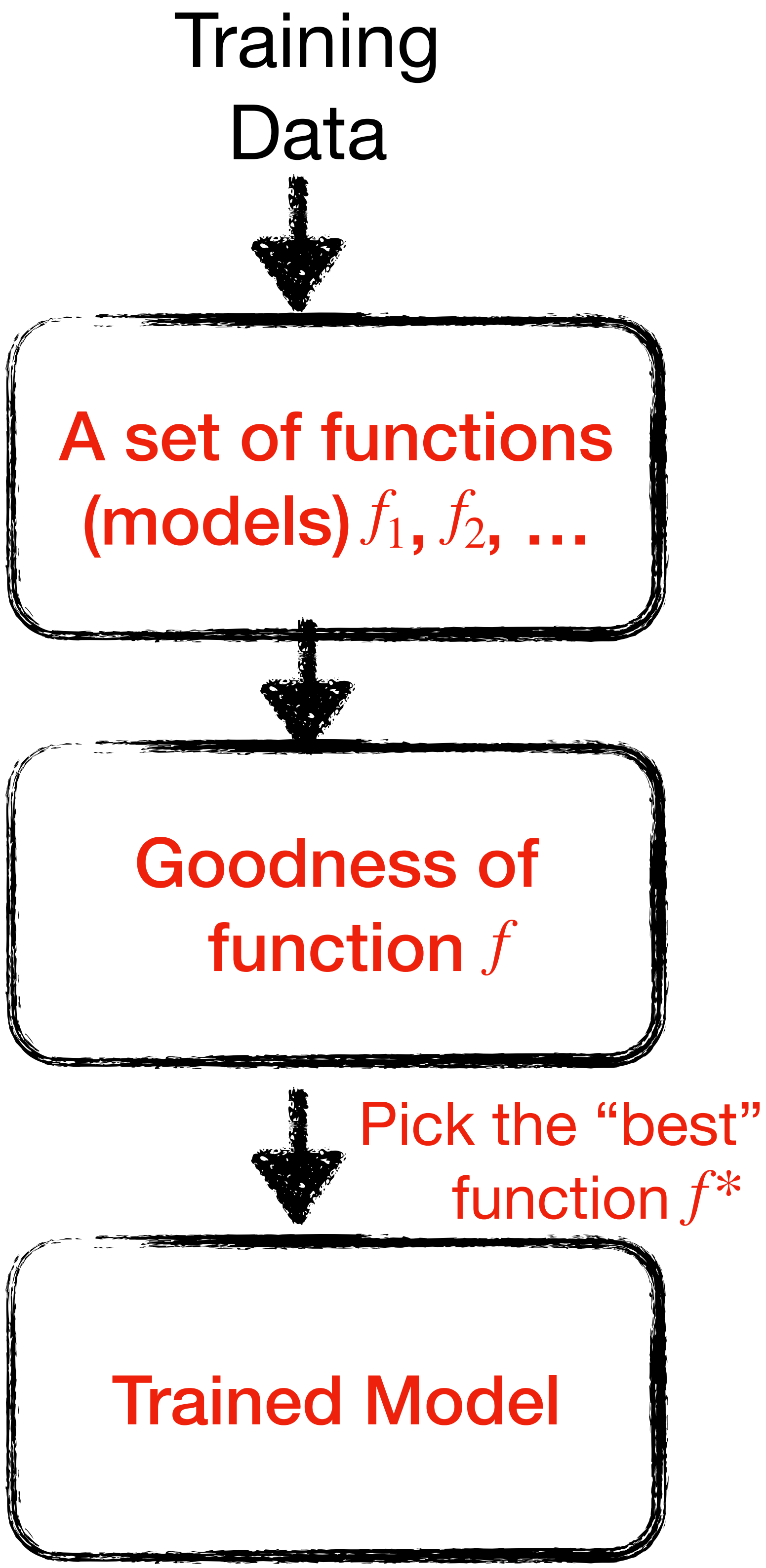
- Spam classification

f(“Tweets”) → a spam message

- Weather prediction

f(“*Observed Weather Conditions*”) → Future weather condition

Machine Learning ~ Training Framework



Training Data

A set of functions (models) f_1, f_2, …

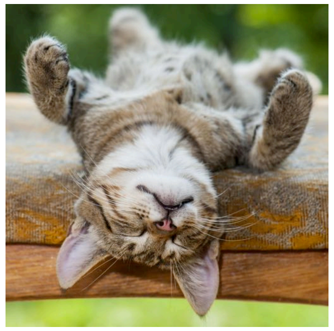
Goodness of function f

Pick the "best" function f^*

Trained Model

Machine Learning ~ Testing Framework

?



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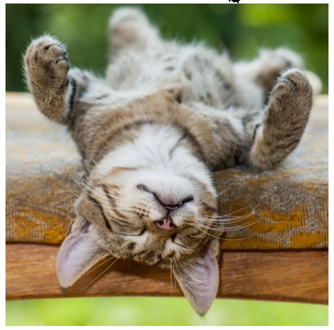
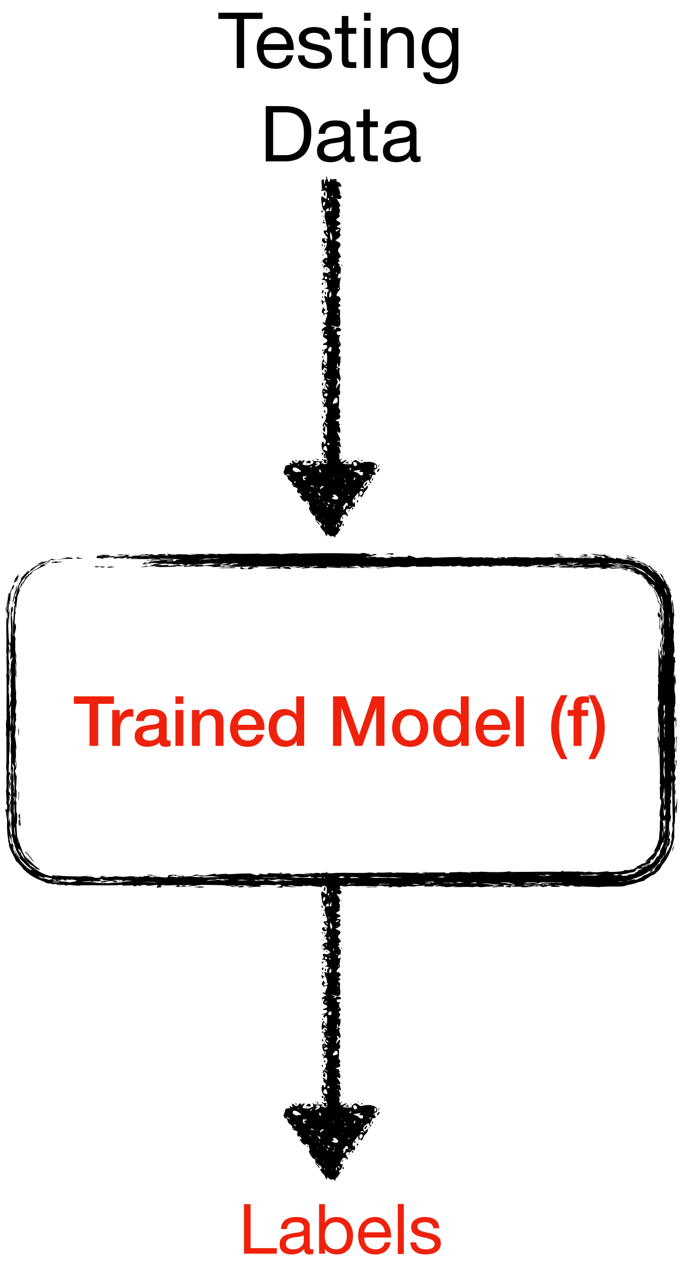
"Cat" (95%)



"Cat" (95%)

"Cat" (85%)



Testing Data

Trained Model (f)

Labels

Machine Learning ~ Testing Framework

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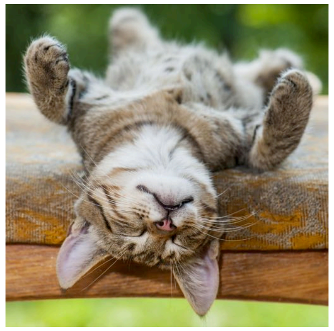

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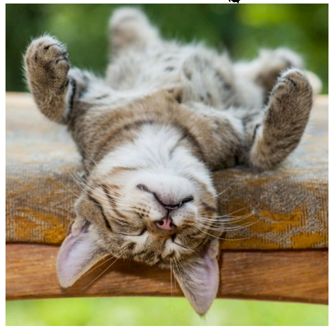

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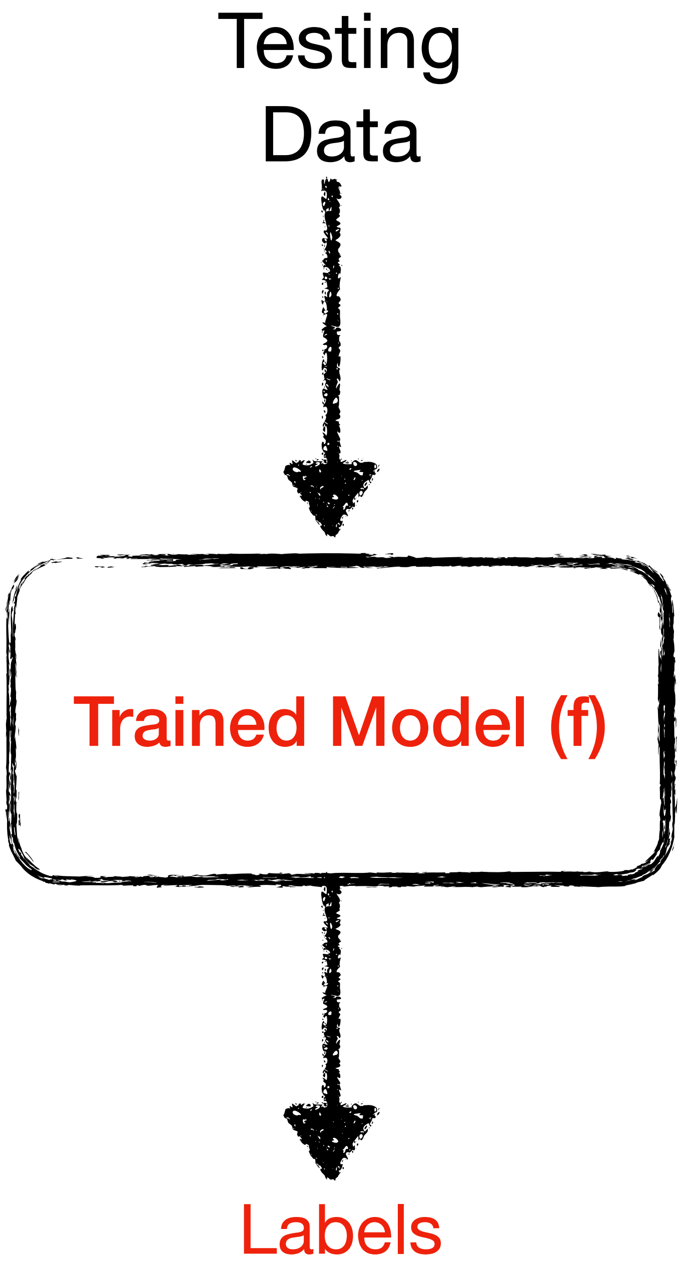

Testing Data

Trained Model (f)

Labels

Machine Learning ~ Testing Framework

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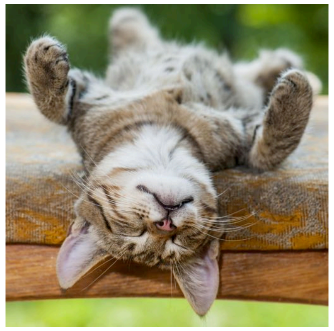

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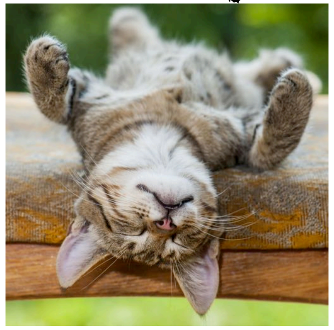
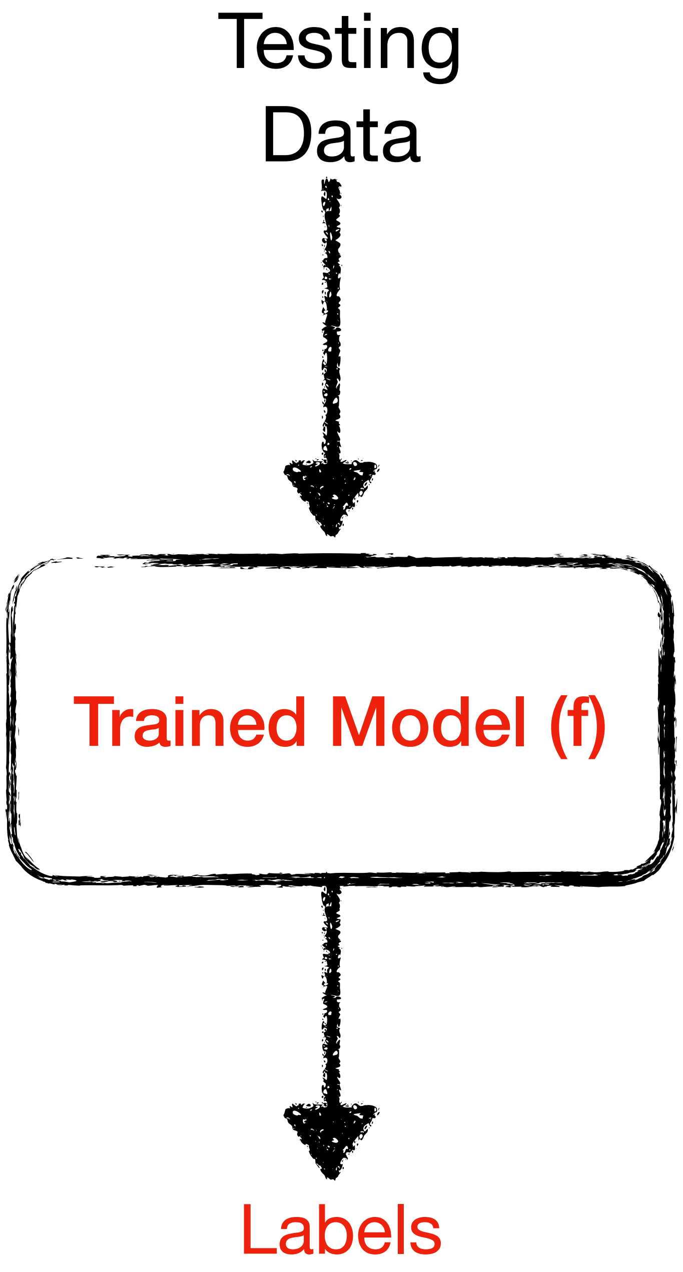
"Cat" (95%)



"Cat" (95%)

"Cat" (85%)

"Unknown" (what's this guy?)



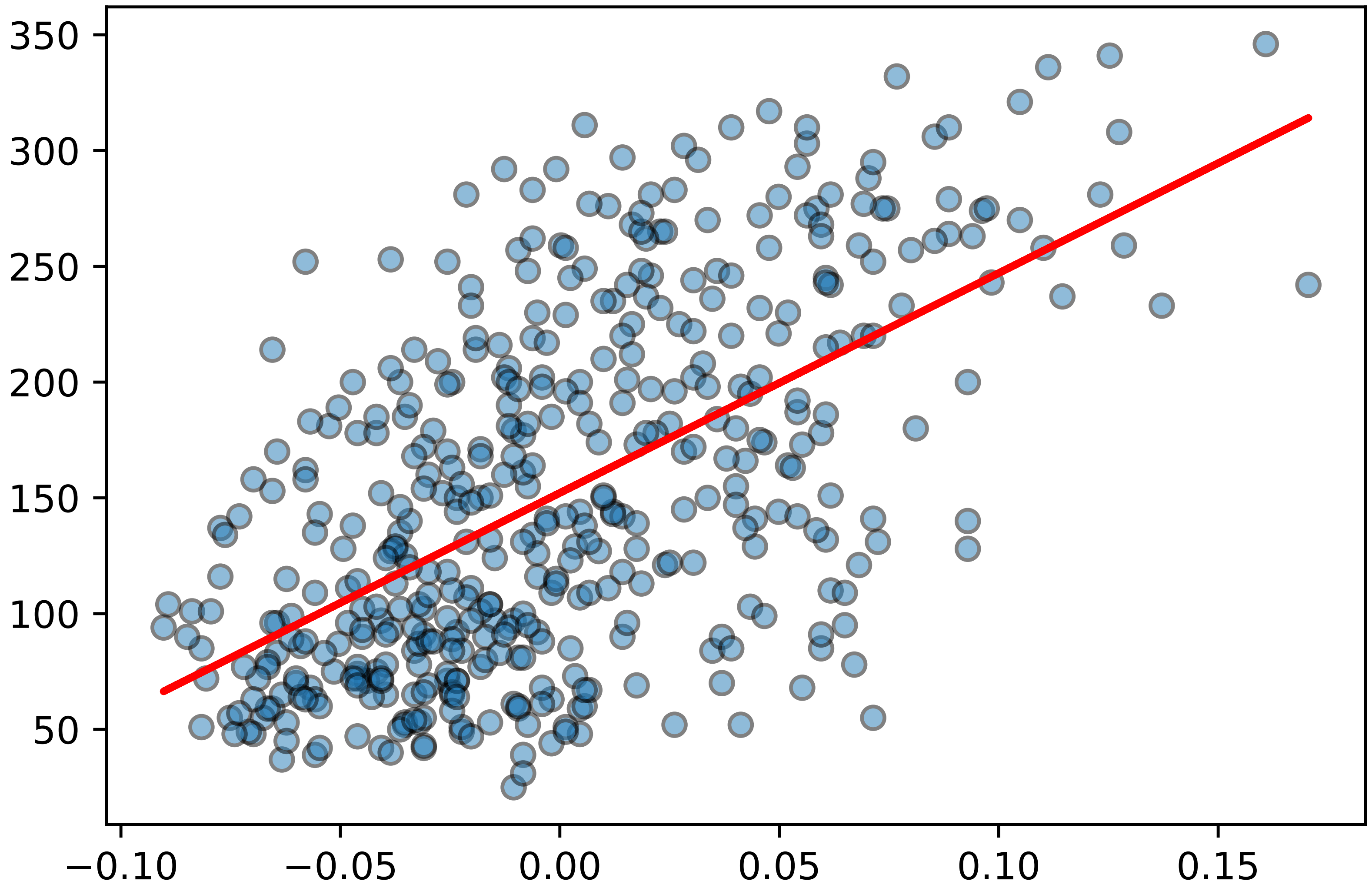
Testing Data

Trained Model (f)

Labels

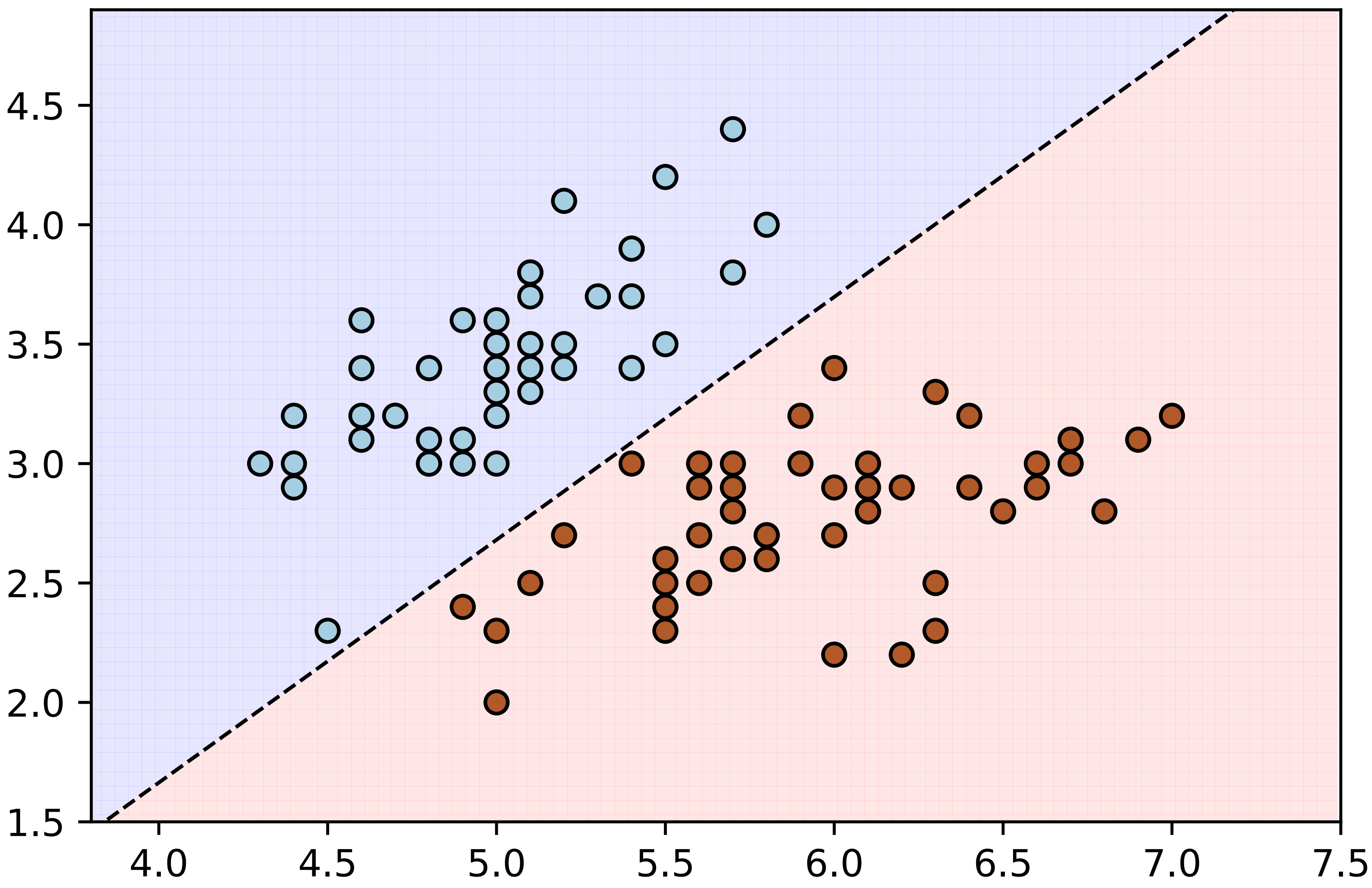
So far,
you can see finding a suitable function is the core of machine learning

Linear Regression



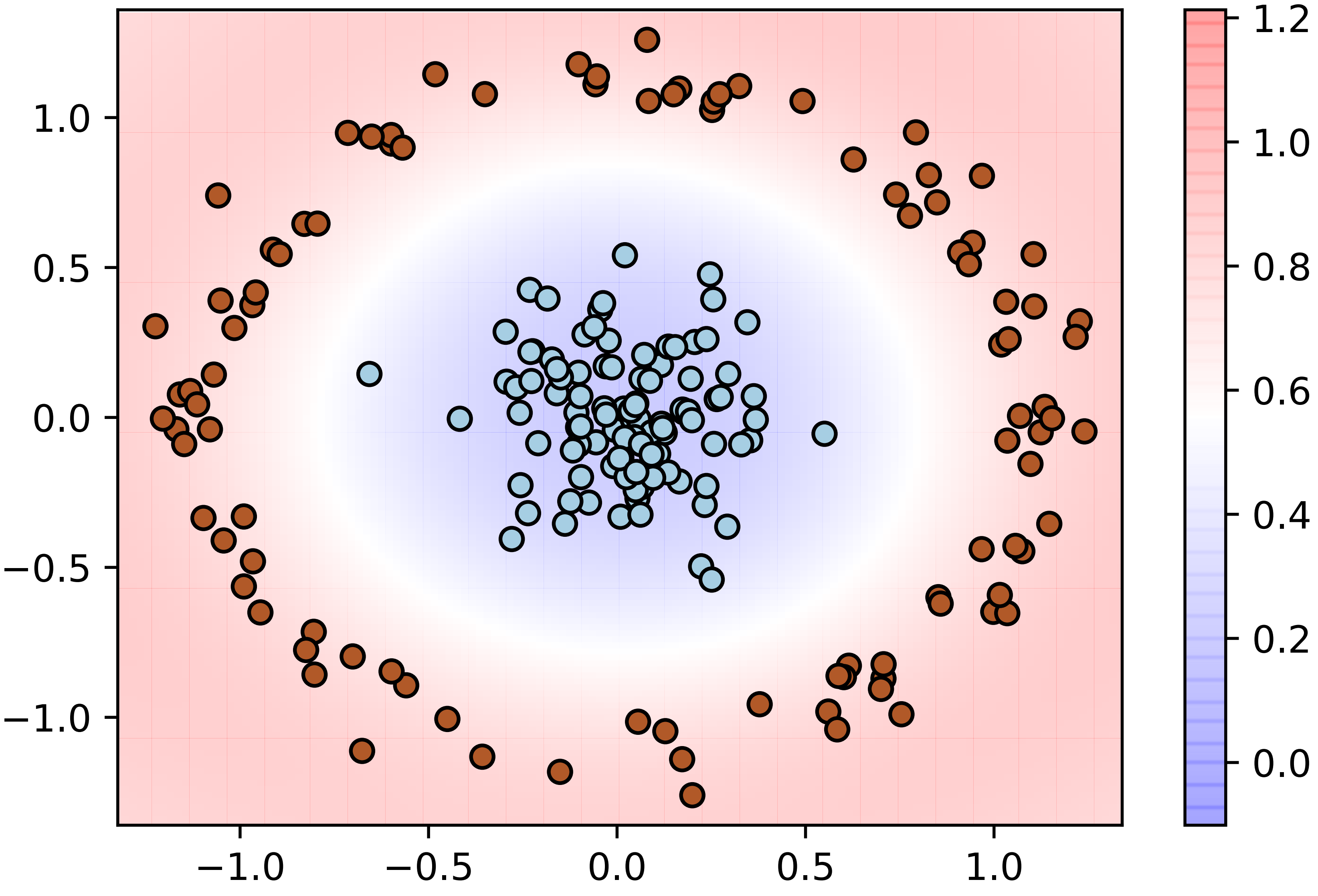
Finding a function that best fits the curve

Logistic Regression



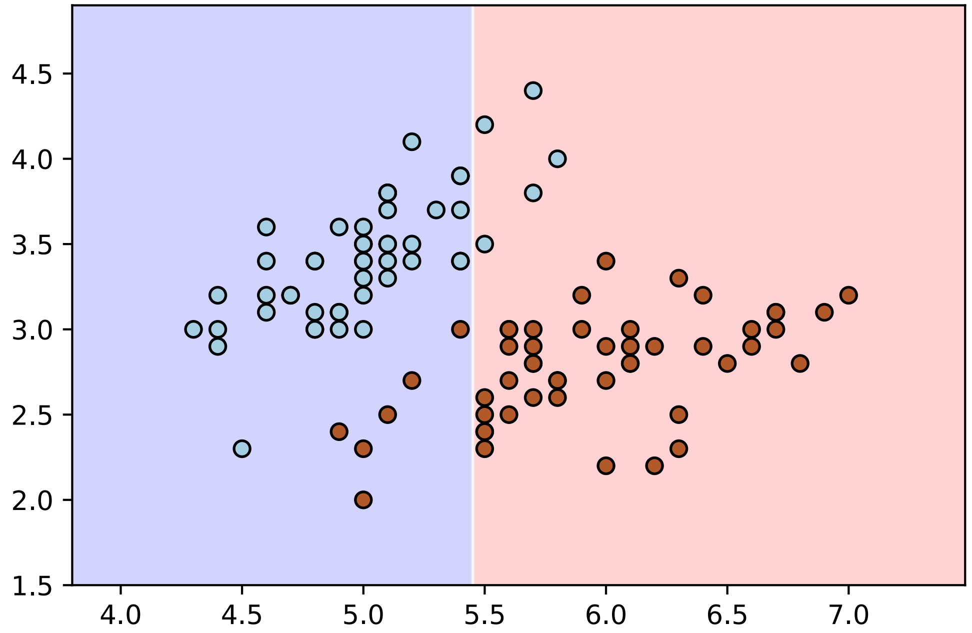
A function is used to define the boundary line

Supported Vector Machine (SVM)

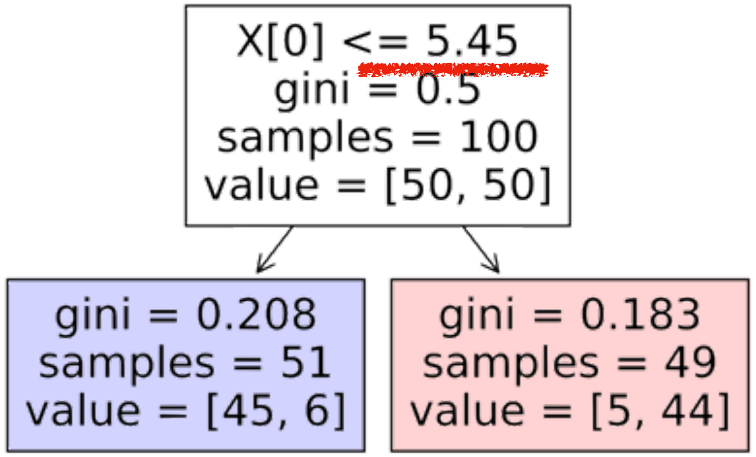


The boundary curves are non-linear.

Decision Tree



tree height = 1

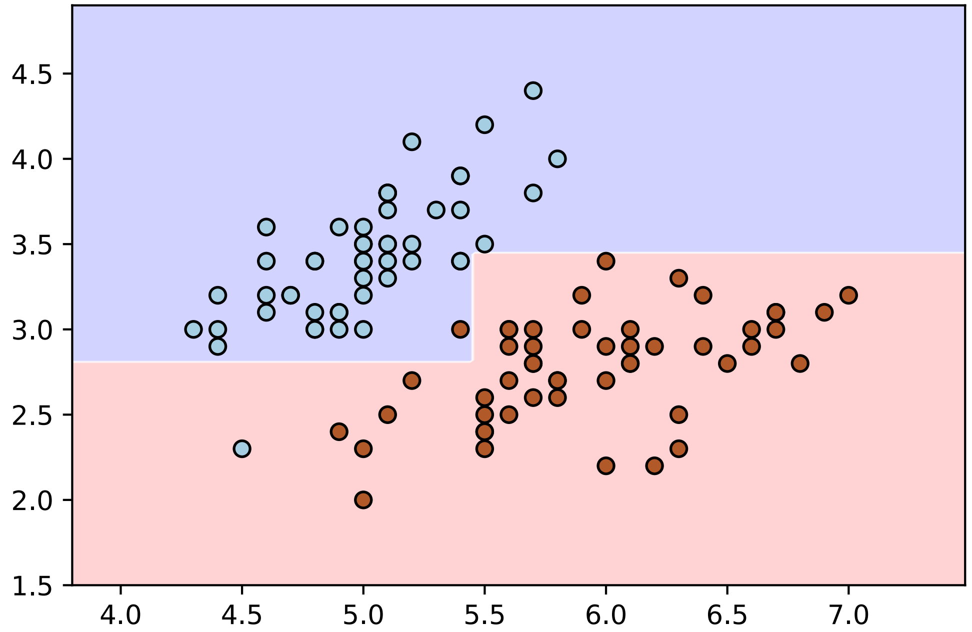


X[0] <= 5.45
gini = 0.5
samples = 100
value = [50, 50]

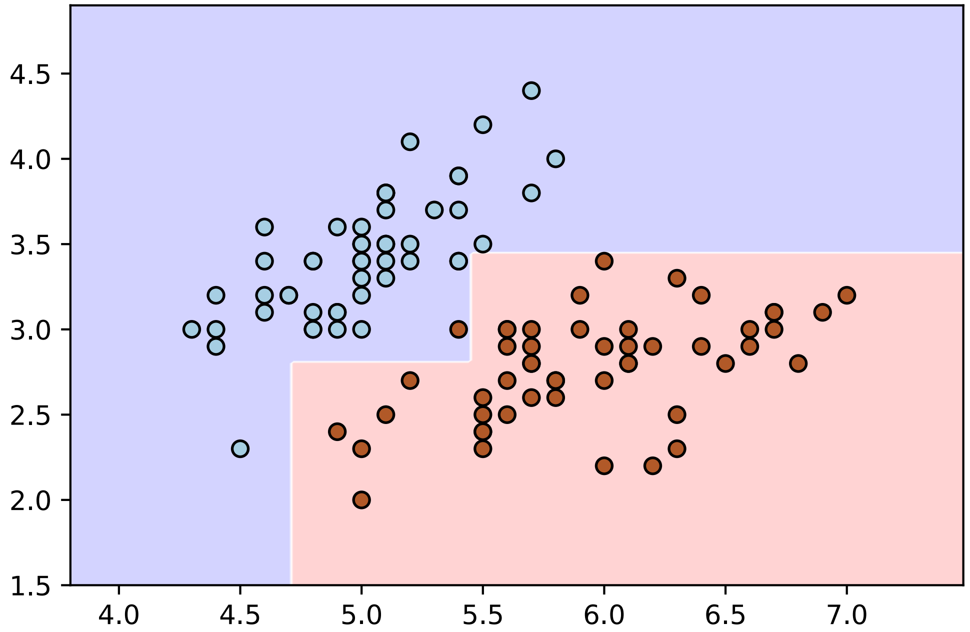
gini = 0.208
samples = 51
value = [45, 6]

gini = 0.183
samples = 49
value = [5, 44]

Decision tree with height 1

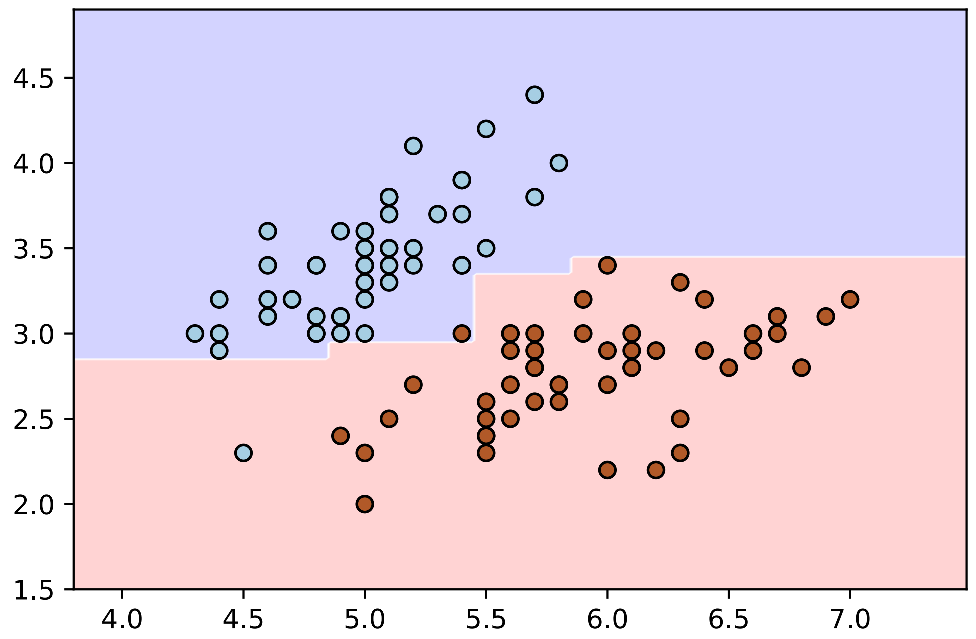


tree height = 2

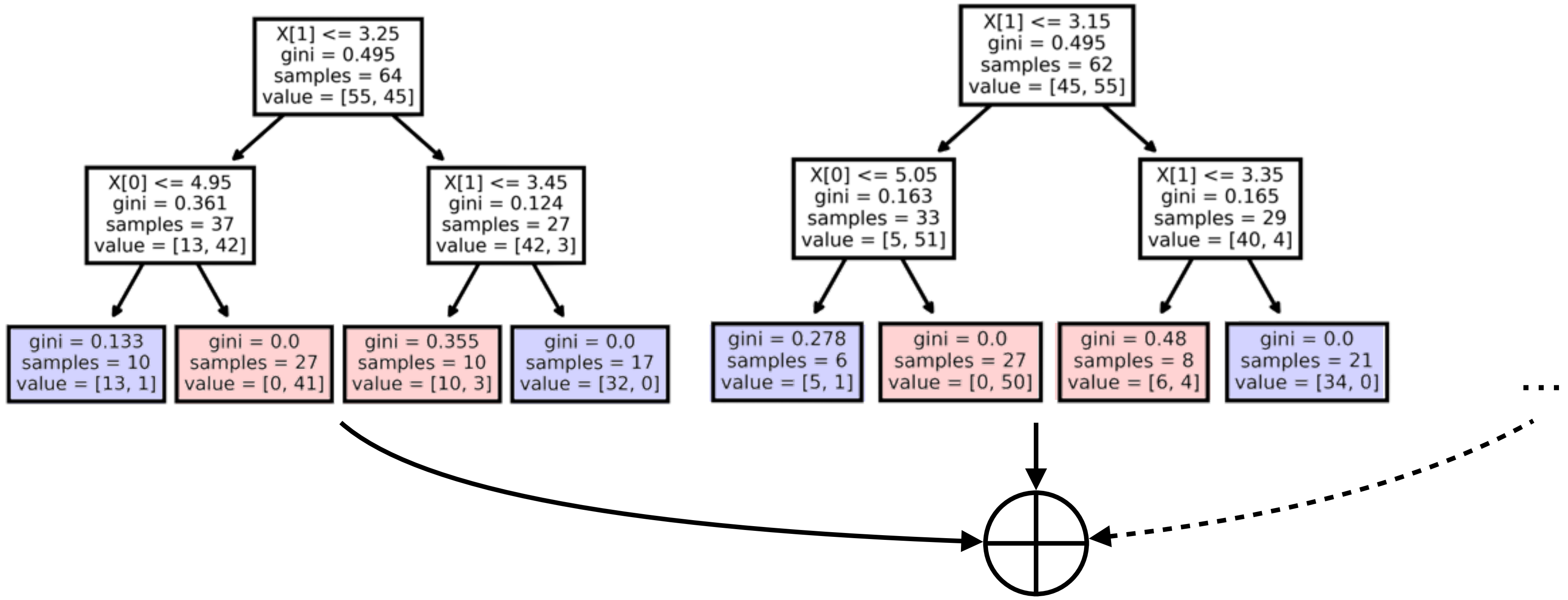


tree height = 3

Random Forest



number of trees = 10, tree height = 2



X[1] <= 3.25
gini = 0.495
samples = 64
value = [55, 45]

X[0] <= 4.95
gini = 0.361
samples = 37
value = [13, 42]

X[1] <= 3.45
gini = 0.124
samples = 27
value = [42, 3]

gini = 0.133
samples = 10
value = [13, 1]

gini = 0.0
samples = 27
value = [0, 41]

gini = 0.355
samples = 10
value = [10, 3]

gini = 0.0
samples = 17
value = [32, 0]

X[1] <= 3.15
gini = 0.495
samples = 62
value = [45, 55]

X[0] <= 5.05
gini = 0.163
samples = 33
value = [5, 51]

X[1] <= 3.35
gini = 0.165
samples = 29
value = [40, 4]

gini = 0.278
samples = 6
value = [5, 1]

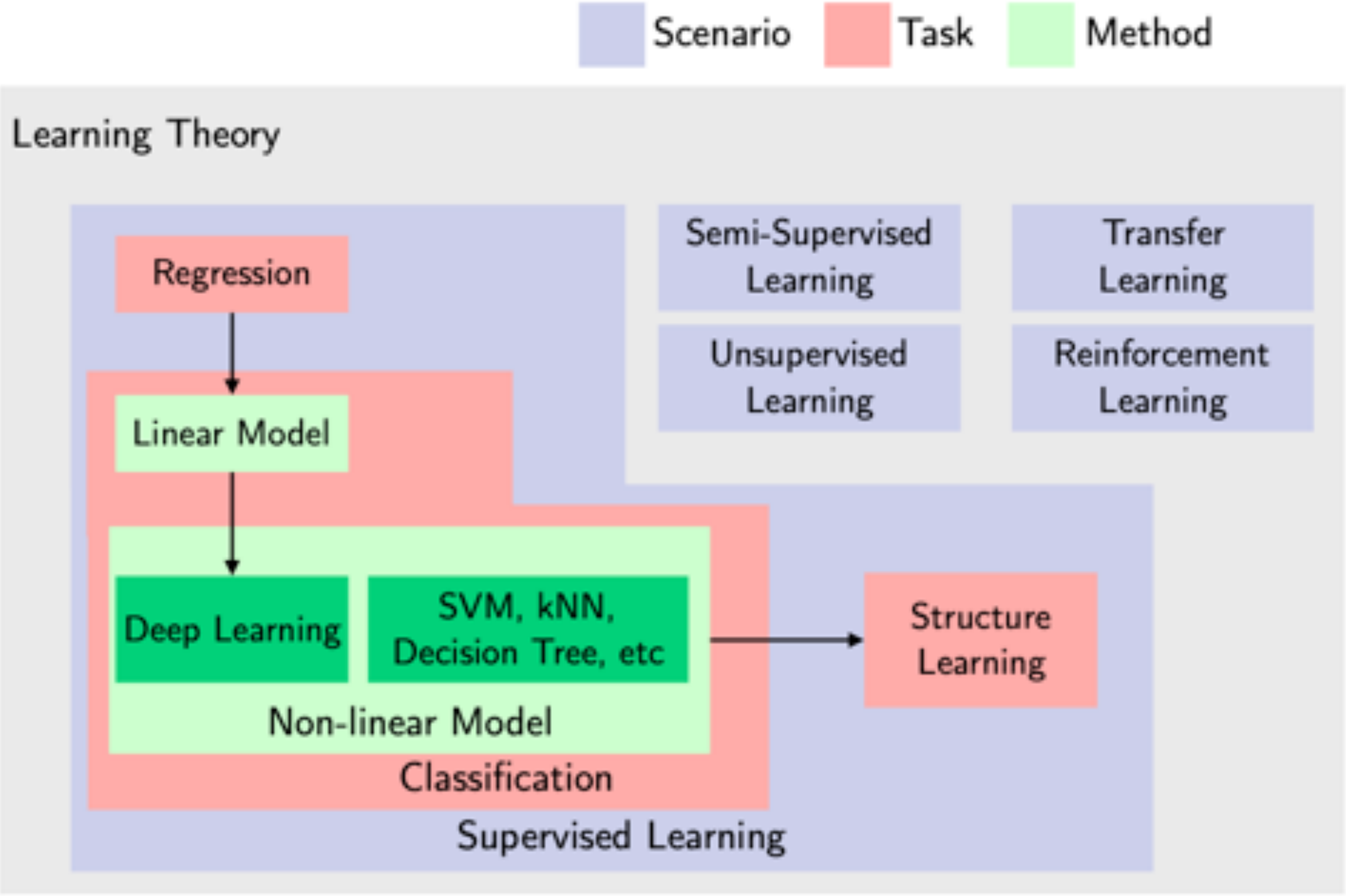
gini = 0.0
samples = 27
value = [0, 50]

gini = 0.48
samples = 8
value = [6, 4]

gini = 0.0
samples = 21
value = [34, 0]

...

Learning Map



Supervised Learning

- **Classification**
  - Each element in the sample is labeled as belonging to some class. No order among classes.

$$\text{“Tweet message”} \rightarrow f(*) \rightarrow \begin{cases} 1,\ \text{Yes} \\ 0,\ \text{No} \end{cases}$$

Binary Classification
(Spam detection)

- **Prediction**
  - Elements in the sample have the inherent relationships to weather condition at some time point.

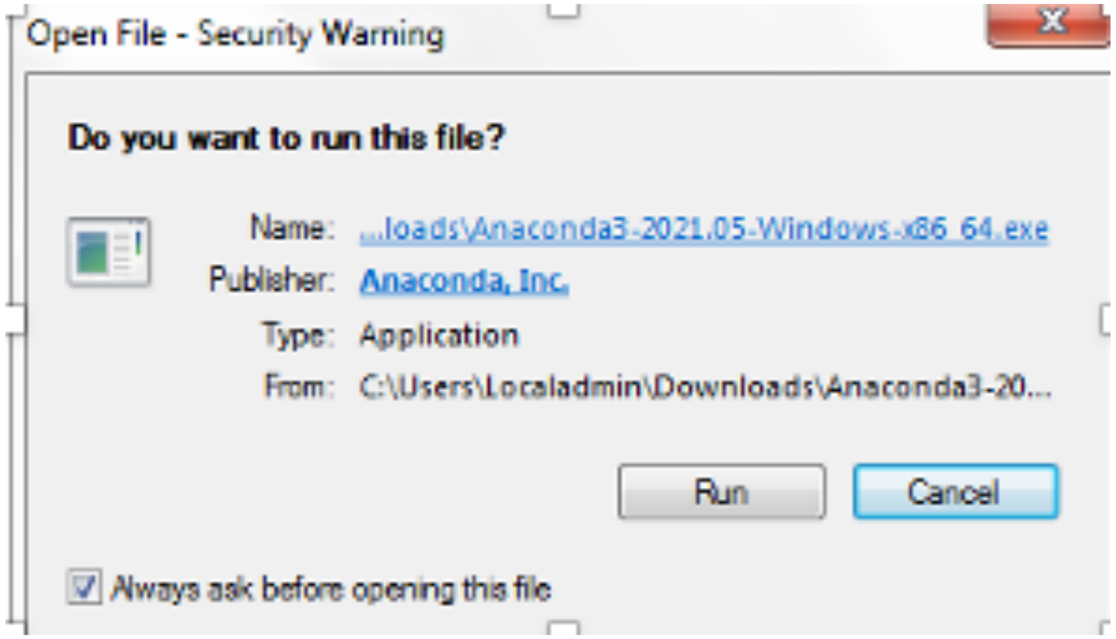
$$\text{“Observation”} \rightarrow f(*) \rightarrow \text{Weather conditions in next time point”}$$

Before starting, we need to know Python

- Python provides a set of libraries including different ML packages
- Standard libraries provide the ready-to-use implementation of algorithms
- The scikit-learn is the one we will use in this course

Installing Anaconda Navigator

1. Browse https://docs.anaconda.com/anaconda/install/windows/
2. Click on Download the Anaconda installer
    - Check your OS bit version: Start button->Settings->System->About: Device specification System Type
    - Click on (your_OS_bit_version)-Bit Graphical Installer, e.g., 64-Bit Graphical Installer, and click on save (will take a while for downloading)
3. Double click the installer to launch and click on Run for installation
4. Click on Next -> I Agree -> Next ->Next->Install (for default settings)



Open File - Security Warning

Do you want to run this file?

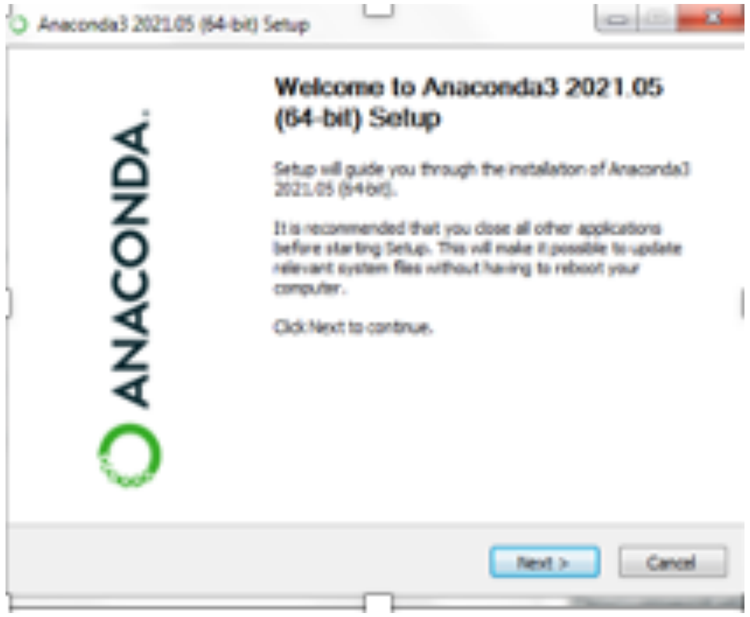
Name: ...loads\Anaconda3-2021.05-Windows-x86_64.exe

Publisher: Anaconda, Inc.

Type: Application

From: C:\Users\Localadmin\Downloads\Anaconda3-20...

☑ Always ask before opening this file



Anaconda3 2021.05 (64-bit) Setup

Welcome to Anaconda3 2021.05 (64-bit) Setup

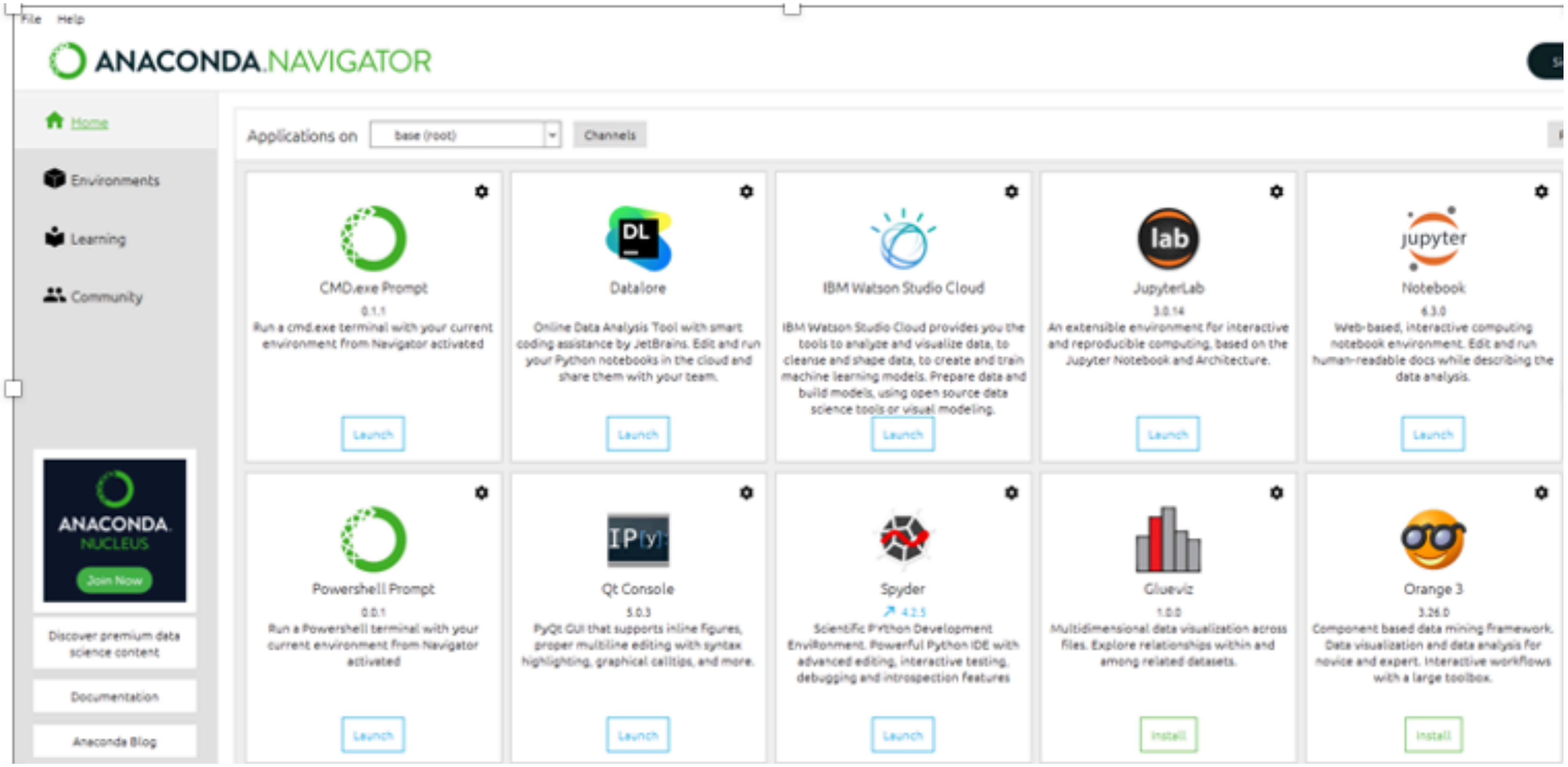
Setup will guide you through the installation of Anaconda3 2021.05 (64-bit).

It is recommended that you close all other applications before starting Setup. This will make it possible to update relevant system files without having to reboot your computer.

Click Next to continue.

Installing Anaconda Navigator (Continuing…)

5. Click Next->Next->Finish to complete the installation (registration is not essential for operation).
6. Open Anaconda Navigator: It will pop up an icon in the status bar.
7. Click on the icon and click on the launch button of Jupyter Notebook.



CMD.exe Prompt
0.1.1
Run a cmd.exe terminal with your current environment from Navigator activated

Datalore
Online Data Analysis Tool with smart coding assistance by JetBrains. Edit and run your Python notebooks in the cloud and share them with your team.

IBM Watson Studio Cloud
IBM Watson Studio Cloud provides you the tools to analyze and visualize data, to cleanse and shape data, to create and train machine learning models. Prepare data and build models, using open source data science tools or visual modeling.

JupyterLab
3.0.14
An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.

Notebook
6.3.0
Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.

Powershell Prompt
0.0.1
Run a Powershell terminal with your current environment from Navigator activated

Qt Console
5.0.3
PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.

Spyder
↗ 4.2.5
Scientific PYthon Development EnviRonment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features

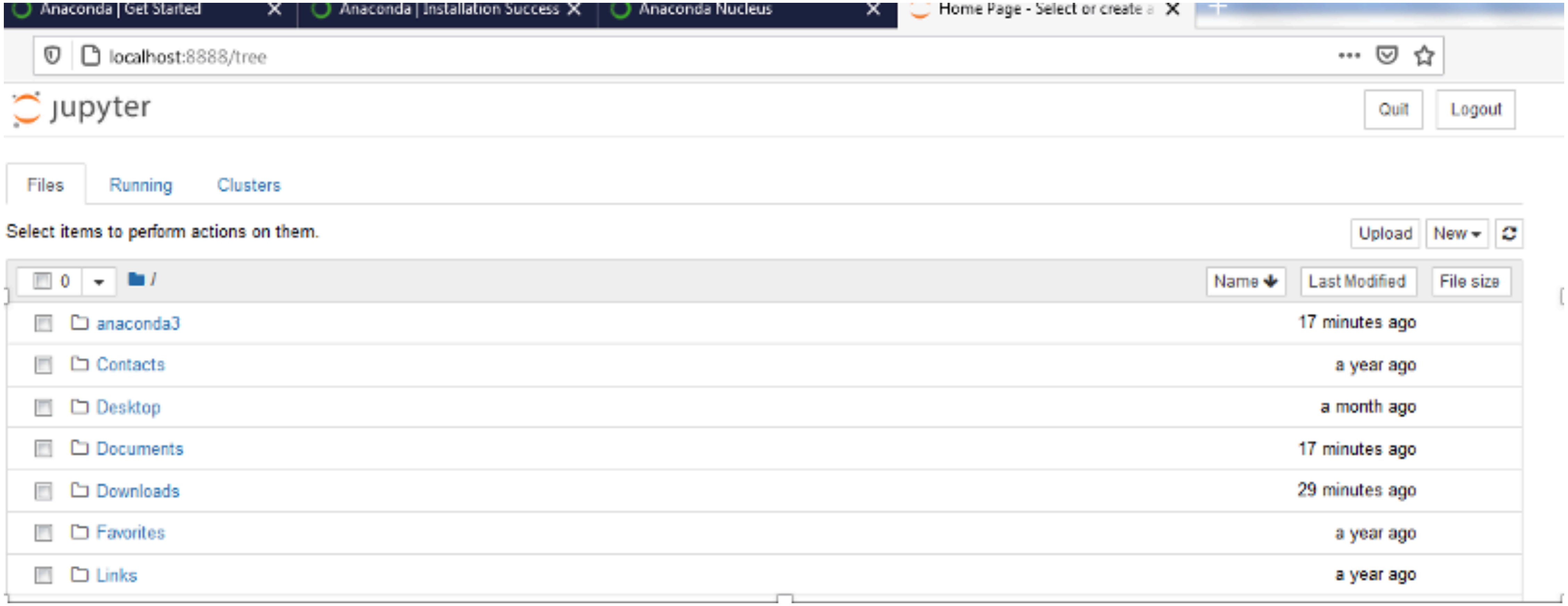
Glueviz
1.0.0
Multidimensional data visualization across files. Explore relationships within and among related datasets.

Orange 3
3.26.0
Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows with a large toolbox.

Installing Anaconda Navigator (Continuing…)

8. It will open the browser and show your files and directory (folders) from C:\Users\Your_user_account.

9. For the time being, create a working directory at C:\Users\Your_user_account\[yourWorkingDirectory]



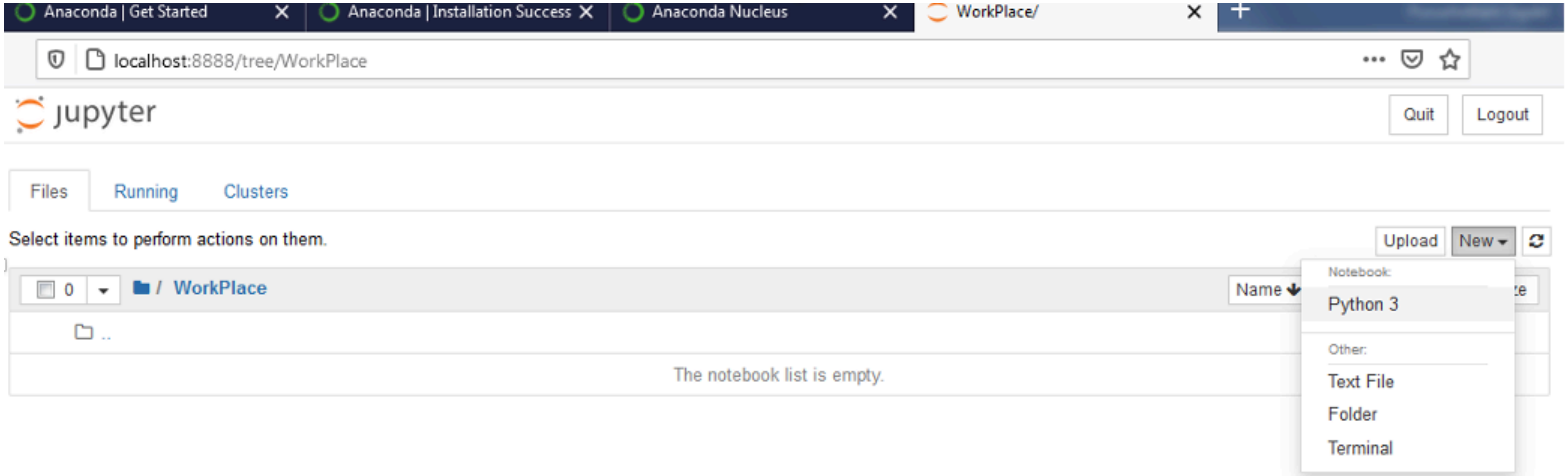
Select items to perform actions on them.

Name	Last Modified
anaconda3	17 minutes ago
Contacts	a year ago
Desktop	a month ago
Documents	17 minutes ago
Downloads	29 minutes ago
Favorites	a year ago
Links	a year ago

Installing Anaconda Navigator (Continuing…)

10. Click on your working directory (in my case, it is 'workPlace'). It will take you to a new window.

11. Click on the New dropdown button (on the right side) and click on the Python 3.

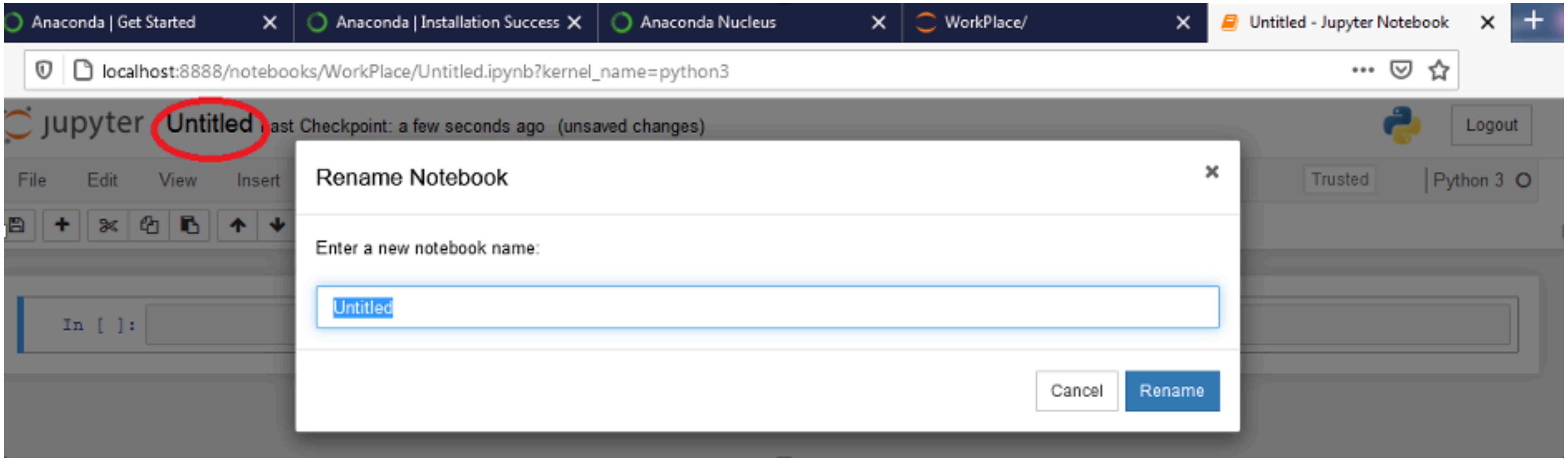


Select items to perform actions on them.

The notebook list is empty.

Installing Anaconda Navigator (Continuing…)

12. It will open a new page in the browser with the Untitled – Jupyter Notebook page. To change the name, click on the Untitled label (on the top left) and rename your file.



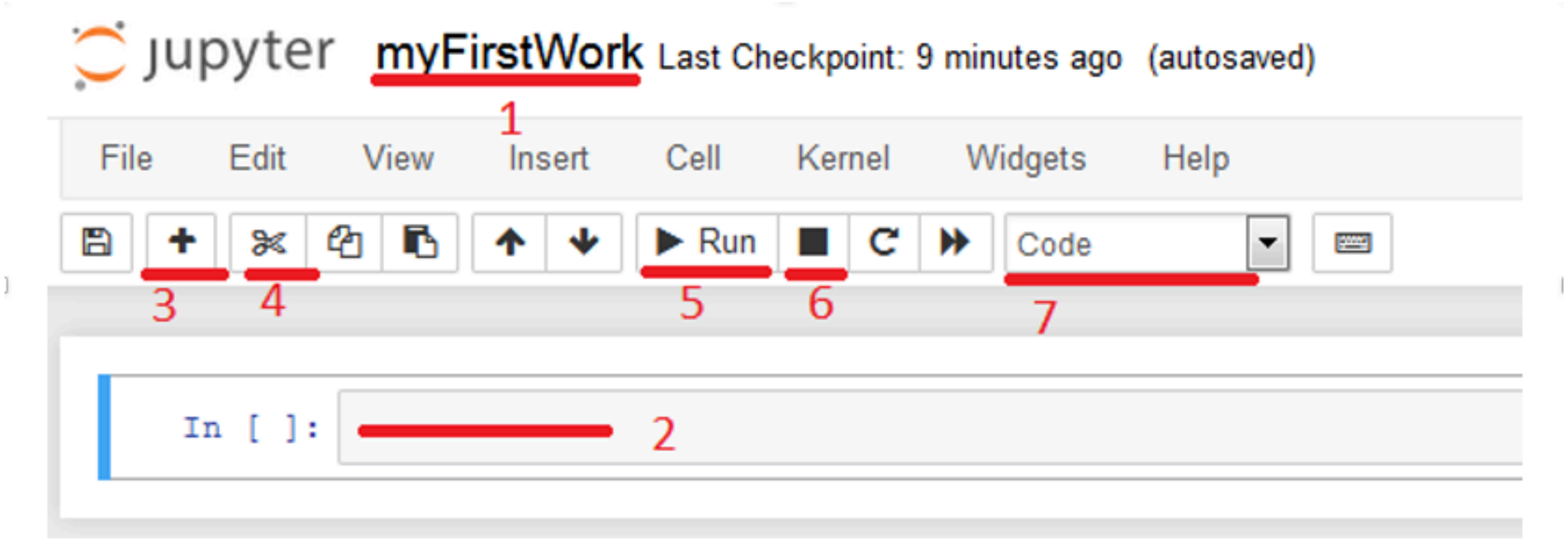
Anaconda | Get Started
Anaconda | Installation Success
Anaconda Nucleus
WorkPlace/
Untitled - Jupyter Notebook
localhost:8888/notebooks/WorkPlace/Untitled.ipynb?kernel_name=python3
jupyter
Untitled
Last Checkpoint: a few seconds ago (unsaved changes)
Logout
File
Edit
View
Insert
Trusted
Python 3
In [ ]:

Rename Notebook

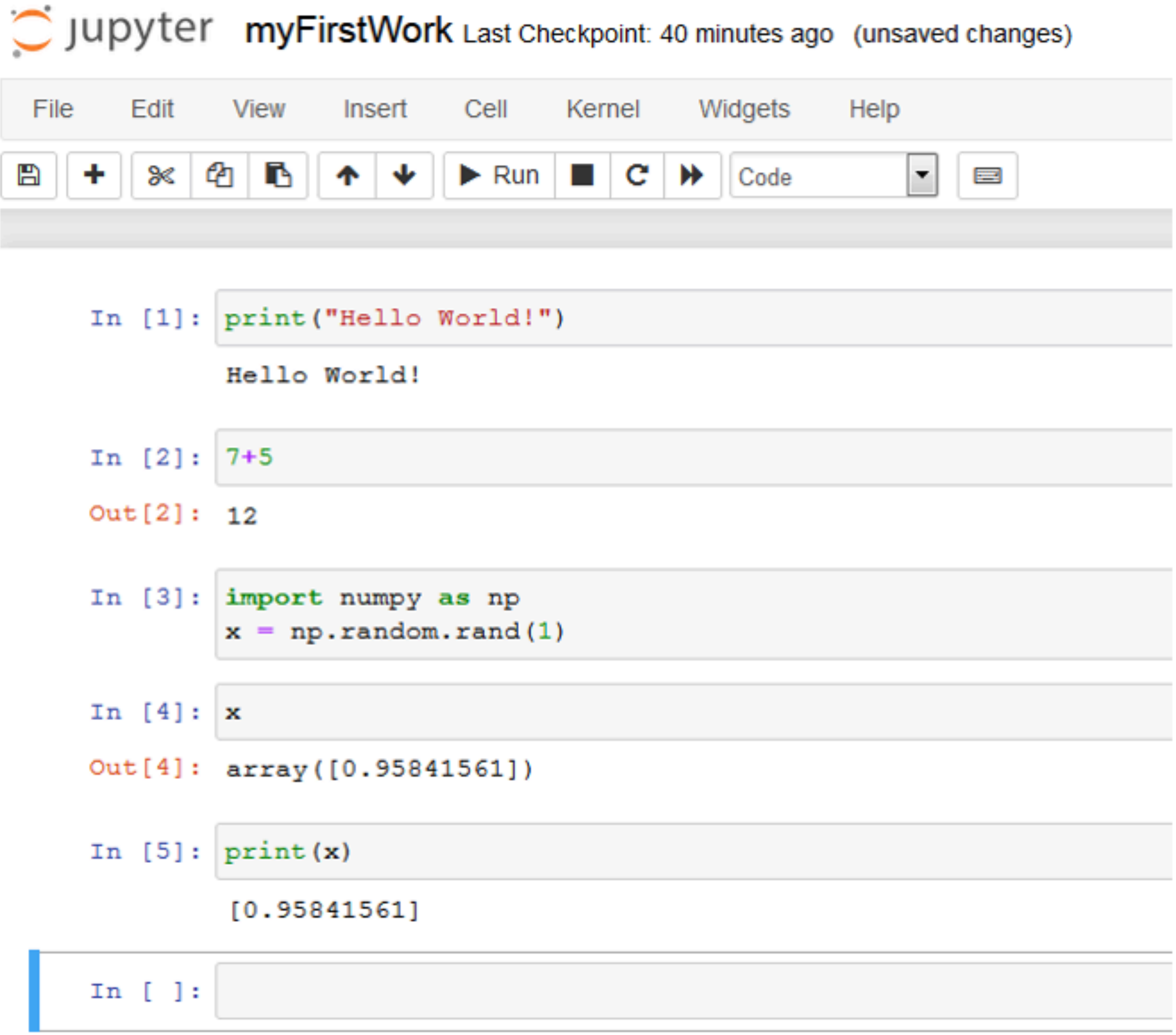
Enter a new notebook name:

Untitled

Frequently Used buttons

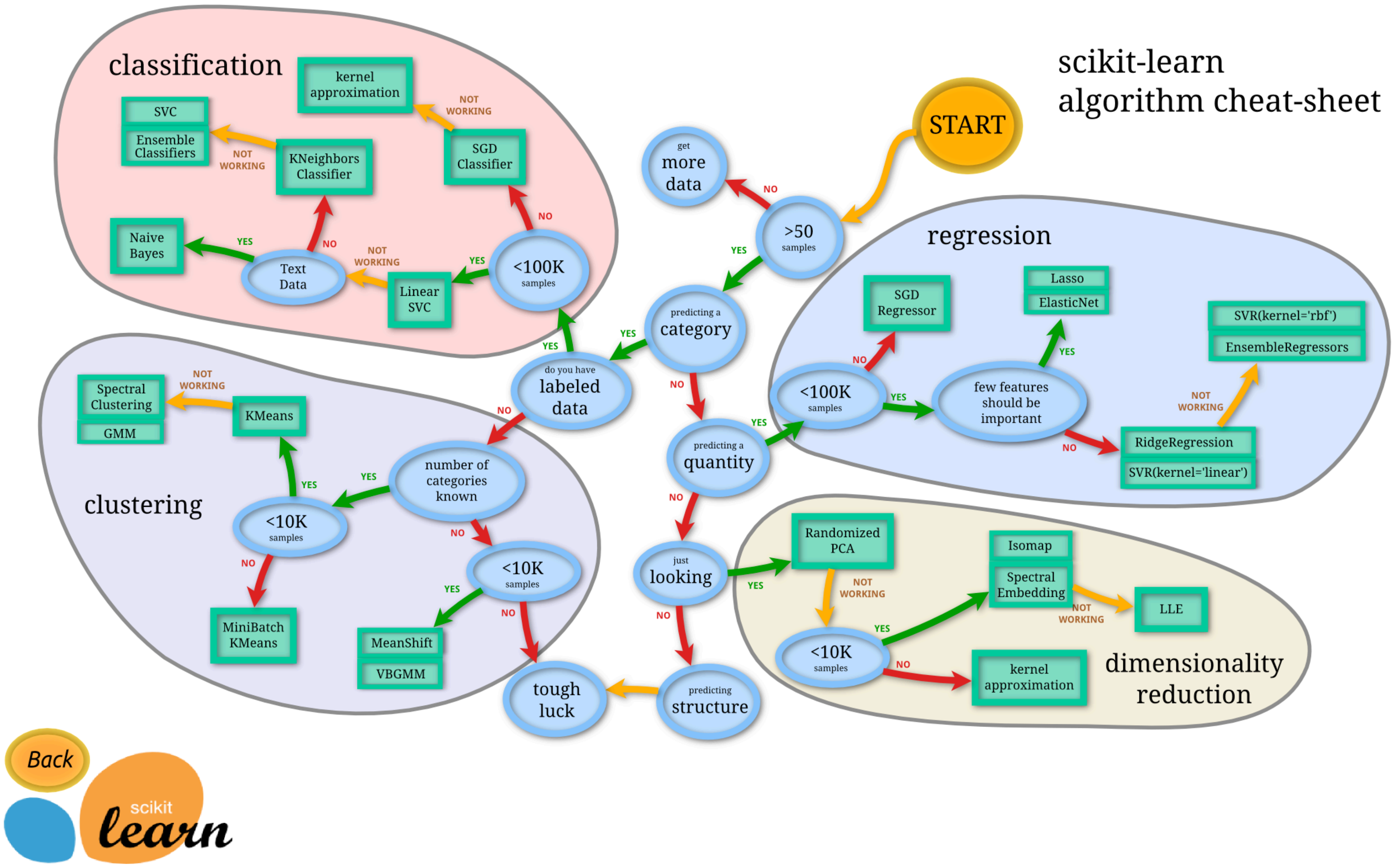


Examples


jupyter
myFirstWork Last Checkpoint: 40 minutes ago (unsaved changes)
File Edit View Insert Cell Kernel Widgets Help
Run
Code

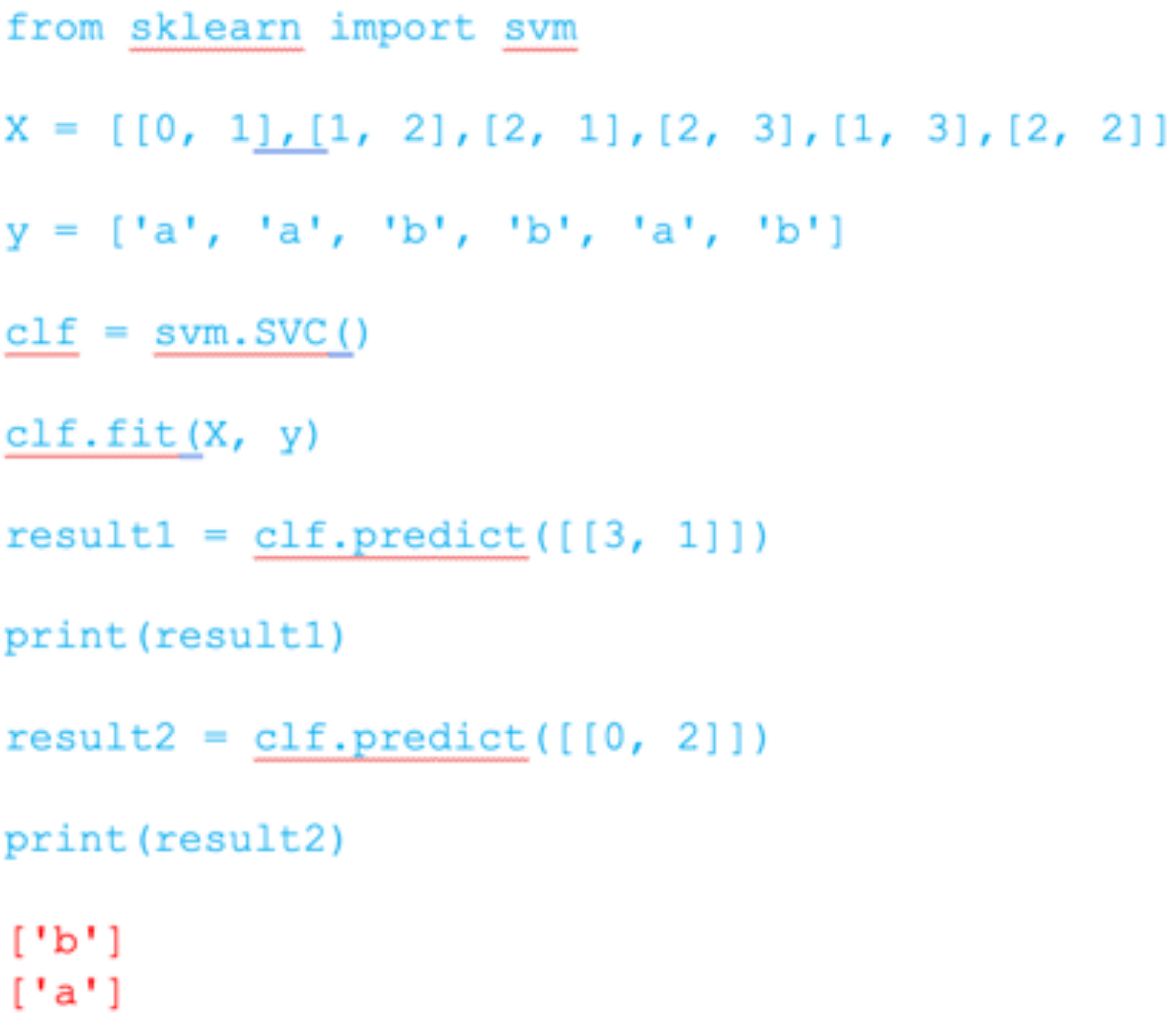
```
In [1]: print("Hello World!")

        Hello World!

In [2]: 7+5

Out[2]: 12

In [3]: import numpy as np
        x = np.random.rand(1)

In [4]: x

Out[4]: array([0.95841561])

In [5]: print(x)

        [0.95841561]

In [ ]:
```

Scikit-learn



Source: https://scikit-learn.org/stable/tutorial/machine_learning_map/index.html

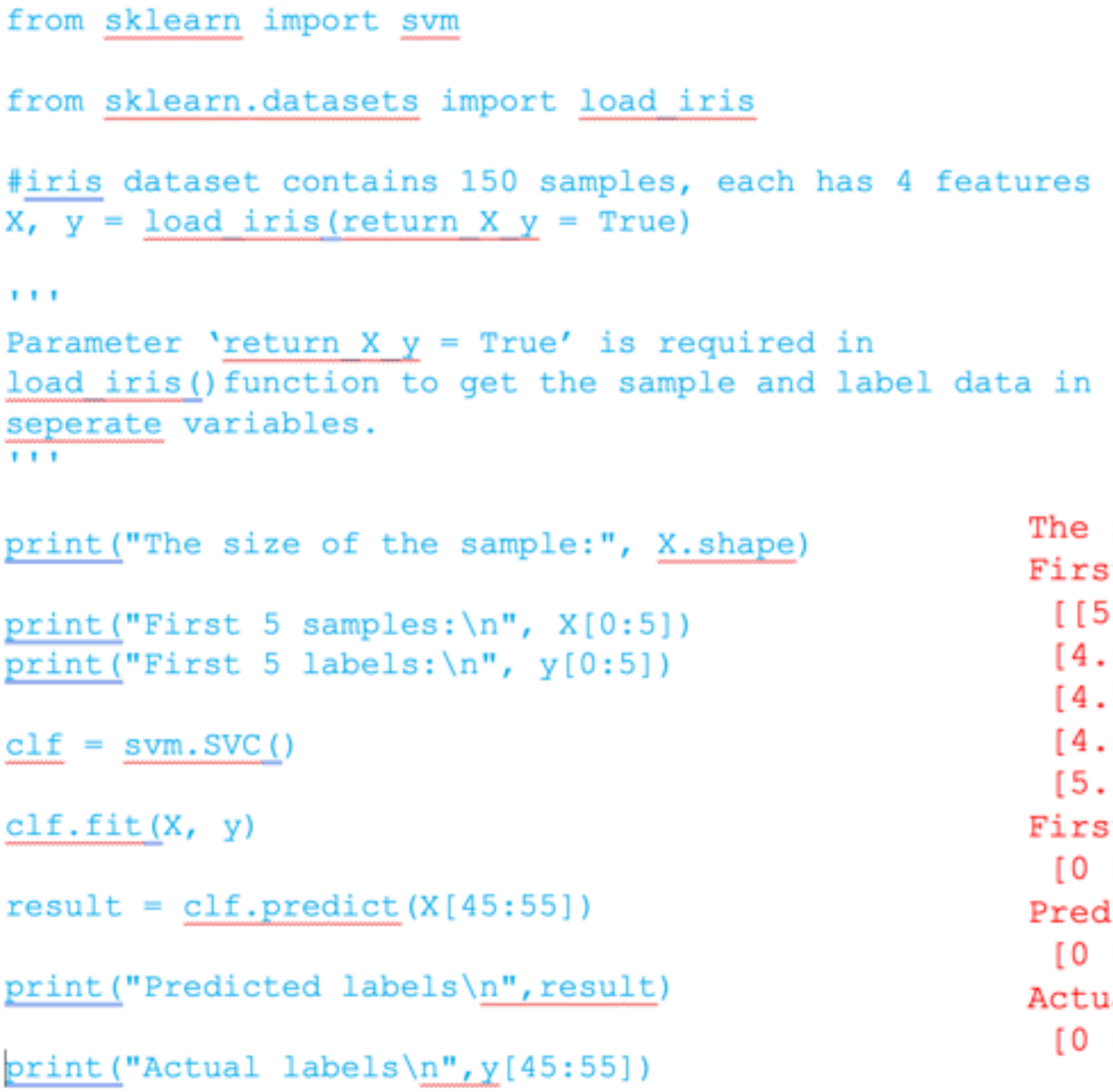
Example 1



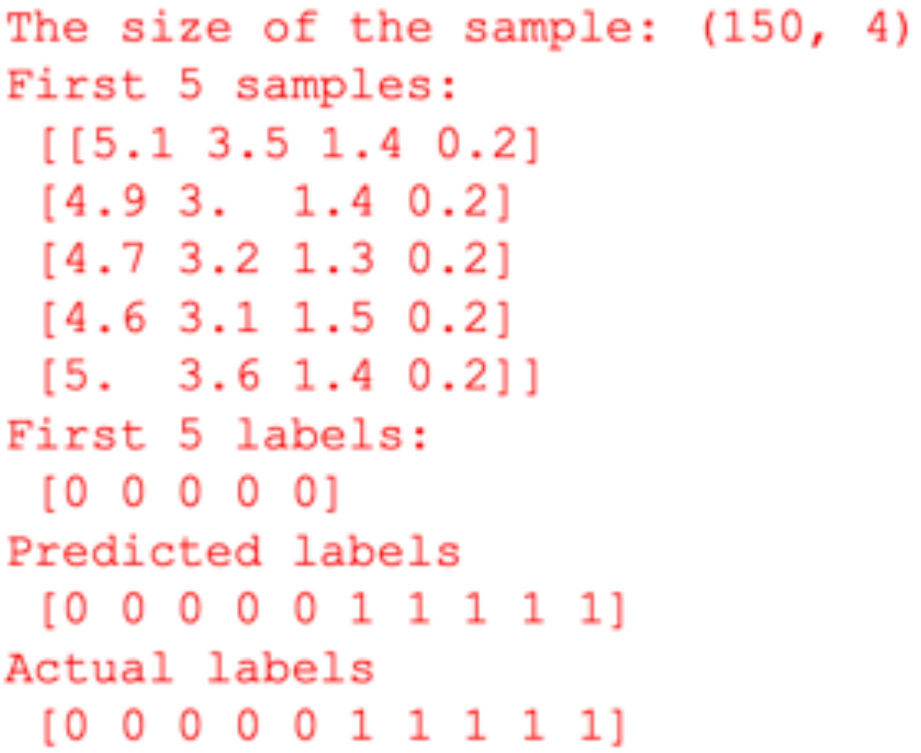
```
from sklearn import svm

X = [[0, 1],[1, 2],[2, 1],[2, 3],[1, 3],[2, 2]]

y = ['a', 'a', 'b', 'b', 'a', 'b']

clf = svm.SVC()

clf.fit(X, y)

result1 = clf.predict([[3, 1]])

print(result1)

result2 = clf.predict([[0, 2]])

print(result2)
```

```
['b']
['a']
```

Example 2



```
from sklearn import svm

from sklearn.datasets import load_iris

#iris dataset contains 150 samples, each has 4 features
X, y = load_iris(return_X_y = True)

'''
Parameter ‘return_X_y = True’ is required in
load_iris()function to get the sample and label data in
seperate variables.
'''

print("The size of the sample:", X.shape)

print("First 5 samples:\n", X[0:5])
print("First 5 labels:\n", y[0:5])

clf = svm.SVC()

clf.fit(X, y)

result = clf.predict(X[45:55])

print("Predicted labels\n",result)

print("Actual labels\n",y[45:55])
```



```
The size of the sample: (150, 4)
First 5 samples:
 [[5.1 3.5 1.4 0.2]
 [4.9 3.  1.4 0.2]
 [4.7 3.2 1.3 0.2]
 [4.6 3.1 1.5 0.2]
 [5.  3.6 1.4 0.2]]
First 5 labels:
 [0 0 0 0 0]
Predicted labels
 [0 0 0 0 0 1 1 1 1 1]
Actual labels
 [0 0 0 0 0 1 1 1 1 1]
```

Data Labeling

Machine Learning ~ Training Framework

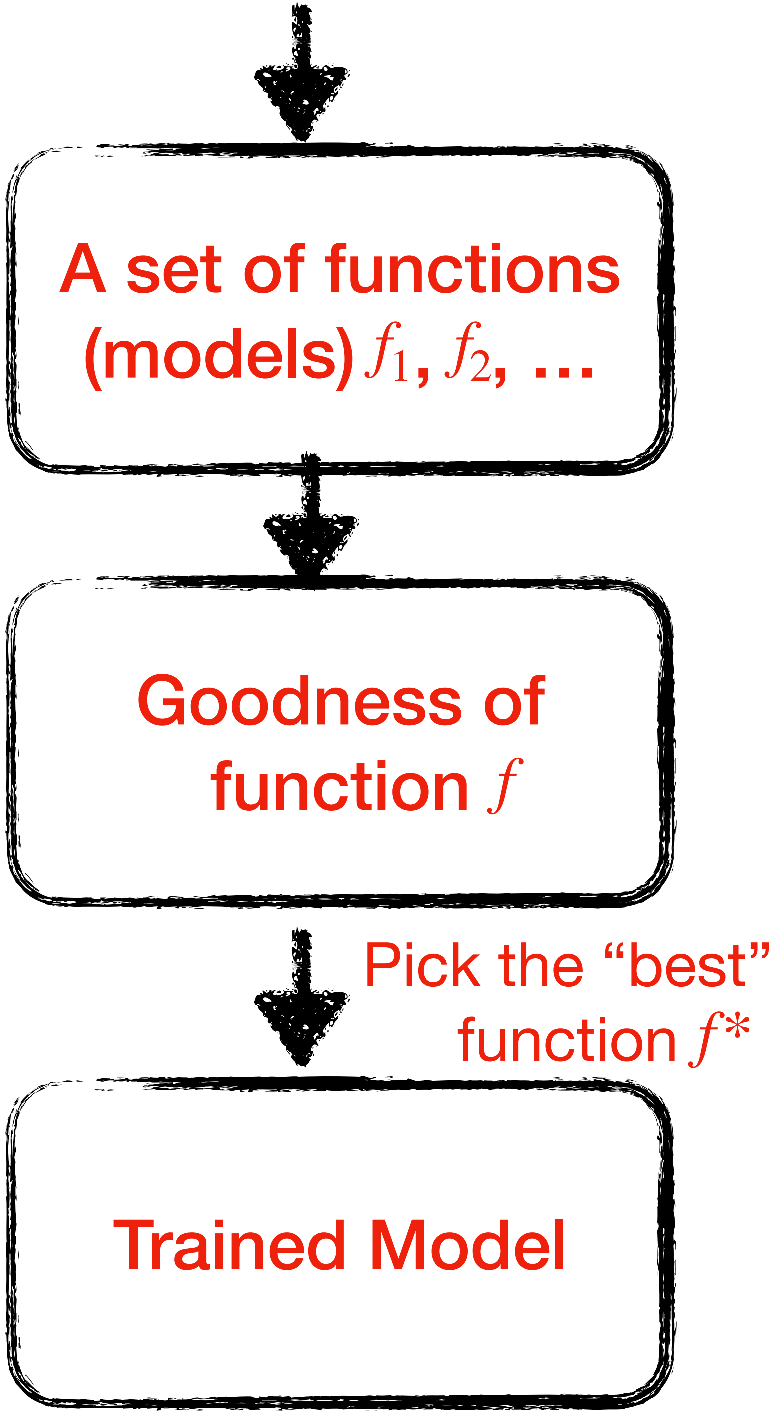
Dog

Monkey

Cat

Cat

Training Data



A set of functions (models) $f_1, f_2, \ldots$

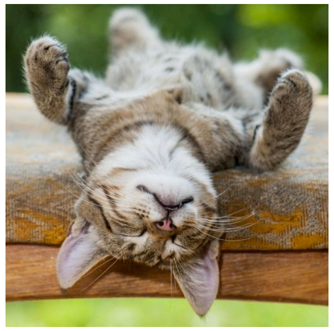
Goodness of function f

Pick the "best" function f^*

Trained Model

Machine Learning ~ Testing Framework

?



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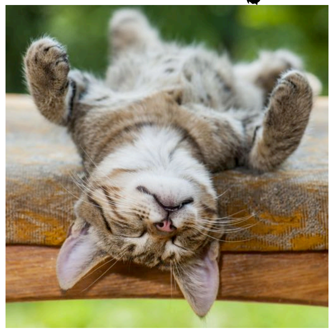
?

“Cat” (95%)

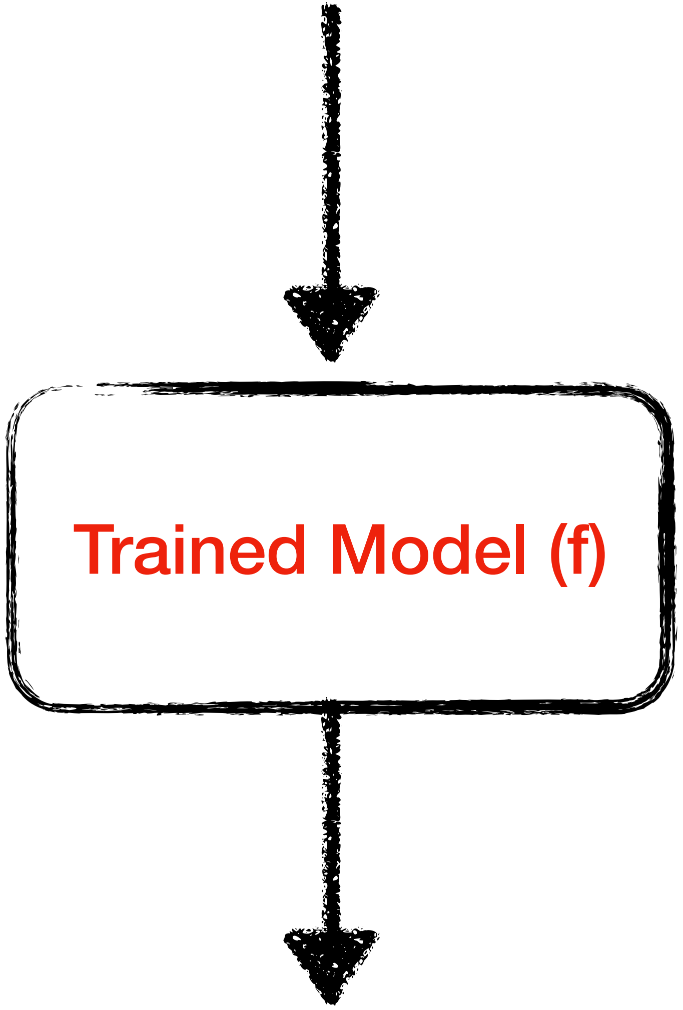


“Cat” (95%)

“Cat” (85%)

“Unknown” (what’s this guy?)

Testing Data



Trained Model (f)

Labels

Training Data

- **Artificial intelligence (AI) is only as good as the data it is trained with**
  - 80% of the time spent on an AI project is wrangling training data, including data labeling
  - Both quality and quantity of training data determine the success of AI

Training Data

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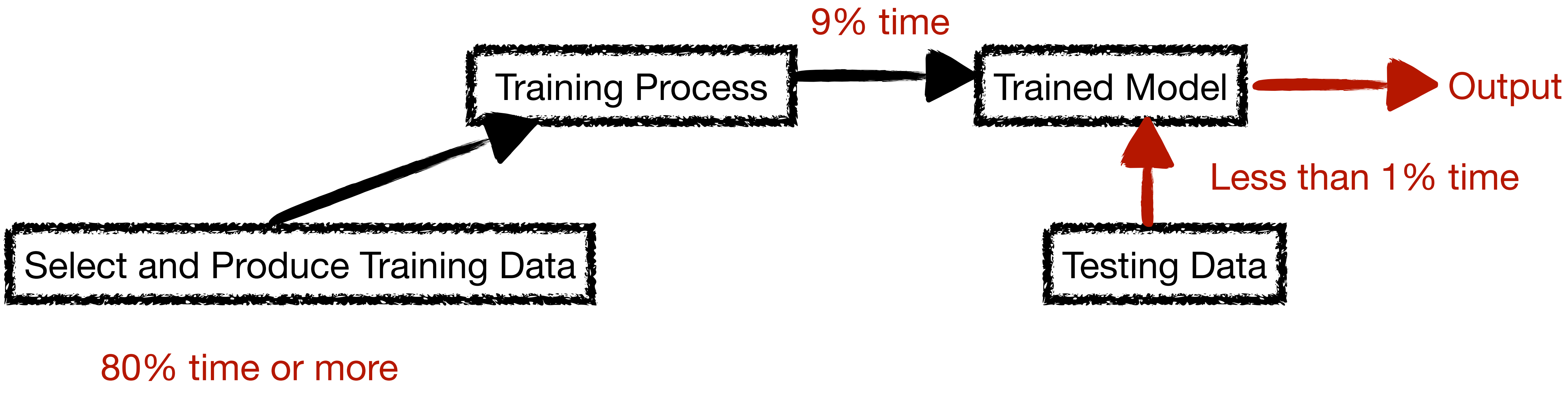


Data Labeling

- **Data Labeling**
  - A central part of the data preprocessing workflow for machine learning
  - Defined as the task of detecting and tagging data with labels
  - Give a machine learning model information about what is shown in order to teach the model from these examples
  - Data labeling structures data to make it meaningful
  - After training, able to find “meaning” in new, relevantly similar data.

Simulating Human Learning

Knowledge

Computer Science

Computer Engineering

Earth Science

Meteorology

Labeling

Simulating Human Learning

Knowledge

Computer Science

Computer Engineering

Earth Science

Meteorology

Become familiar with or an expert in an area

Labeling

Inference

Labeling Example

Twitter 1: I’m gonna be home soon and i don't want to talk about this stuff anymore tonight, k? I've cried enough today.”,,, ← Ham

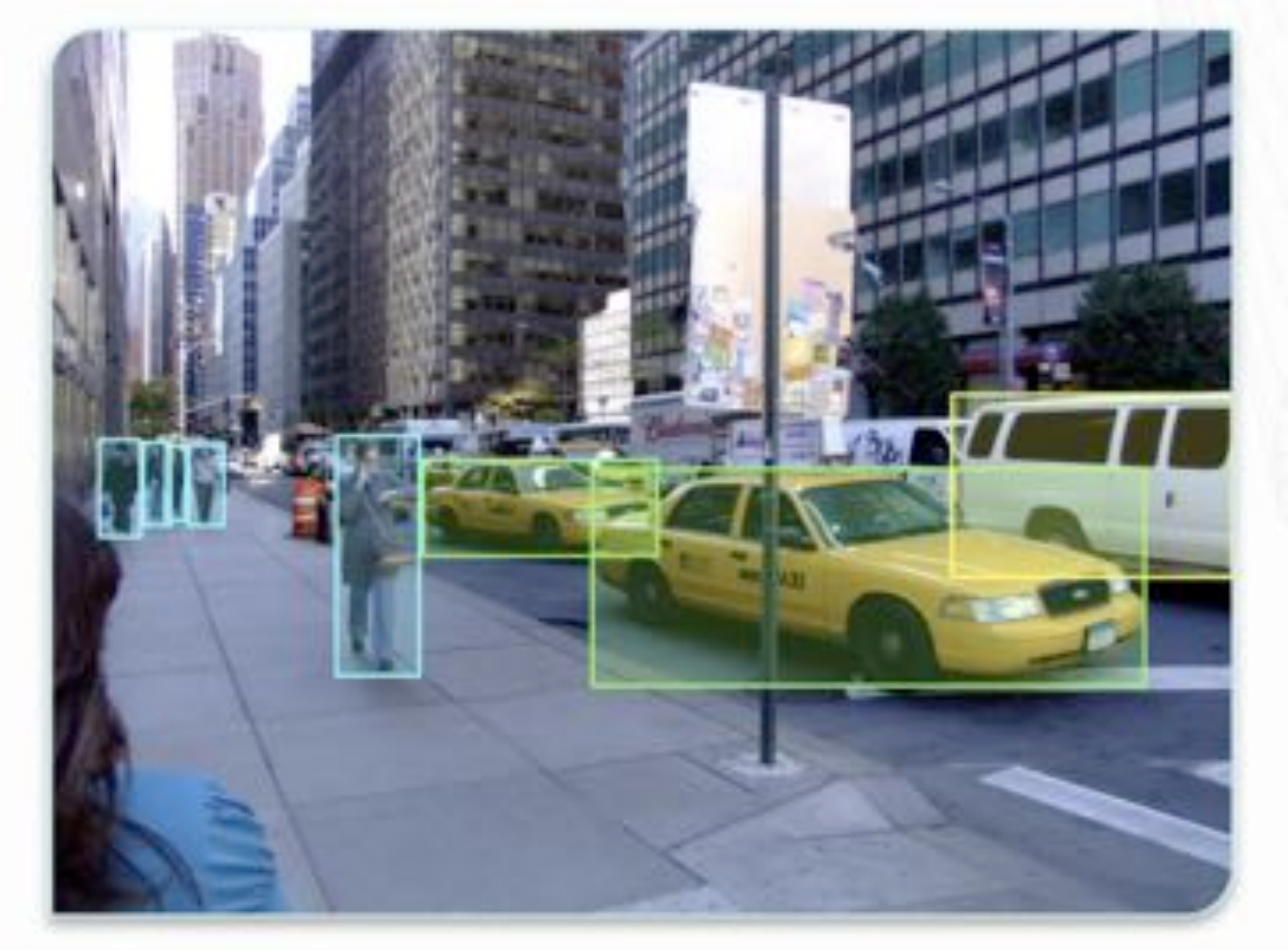
Twitter 2:,Oh k...i'm watching here:),,, ← Ham

Tweet 3: ”SIX chances to win CASH! From 100 to 20,000 pounds txt> CSH11 and send to 87575. Cost 150p/day, 6days, 16+ TsandCs apply Reply HL 4 info”,,, ← Spam

Twitter 4,"URGENT! You have won a 1 week FREE membership in our å£100,000 Prize Jackpot! Txt the word: CLAIM to No: 81010 T&C www.dbuk.net LCCLTD POBOX 4403LDNW1A7RW18”,,, ← Spam

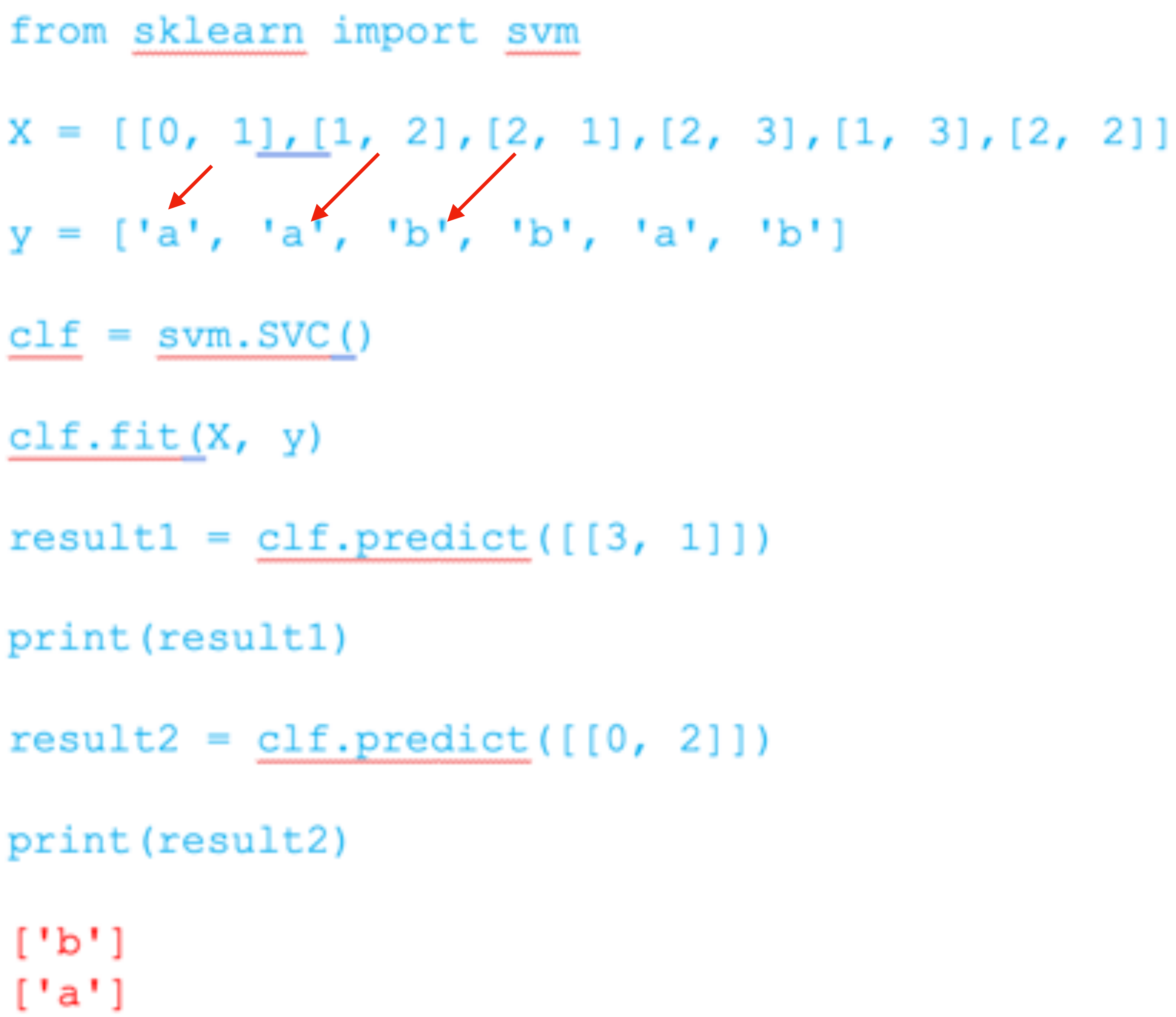
Tweet 5,”XXXMobileMovieClub: To use your credit, click the WAP link in the next txt message or click here>> http://wap. xxxmobilemovieclub.com?n=QJKGIGHJJGCBL",,, ← Spam

Labeling Example



Source: https://labelbox.com/data-labeling-overview

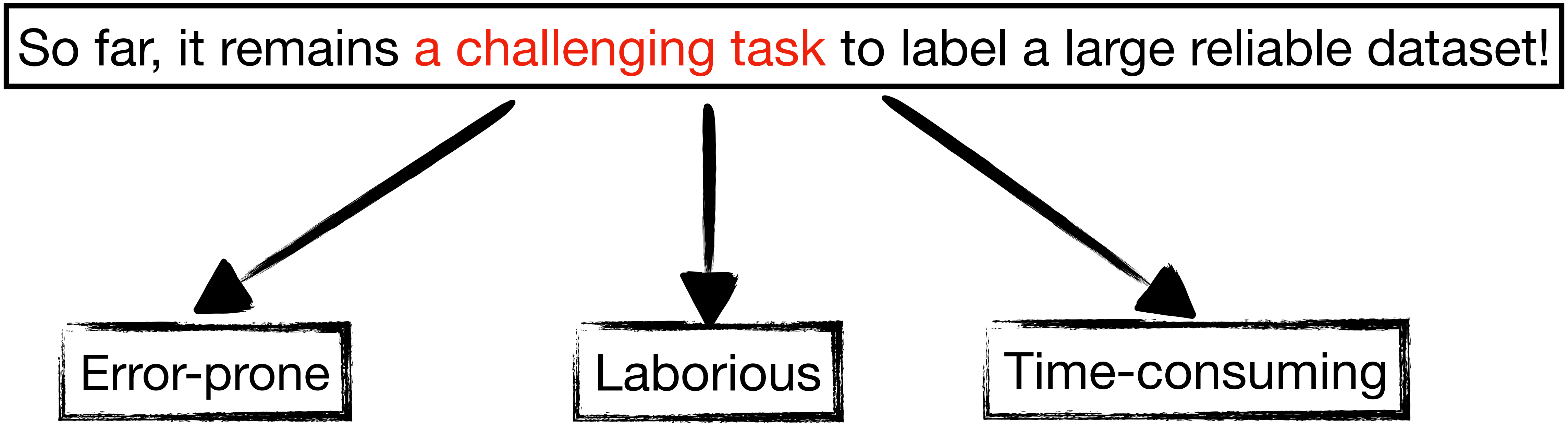
From Previous Coding Practice



Labeling

```
from sklearn import svm

X = [[0, 1],[1, 2],[2, 1],[2, 3],[1, 3],[2, 2]]

y = ['a', 'a', 'b', 'b', 'a', 'b']

clf = svm.SVC()

clf.fit(X, y)

result1 = clf.predict([[3, 1]])

print(result1)

result2 = clf.predict([[0, 2]])

print(result2)
```

```
['b']
['a']
```



So far, it remains a challenging task to label a large reliable dataset!

Error-prone

Laborious

Time-consuming

Tweets Labeling

- **Before labeling, we need to know our task**
  - Detecting the spam and non-spam messages
  - So our label will be spam (indicated as 1) or non-spam (indicated as 0)

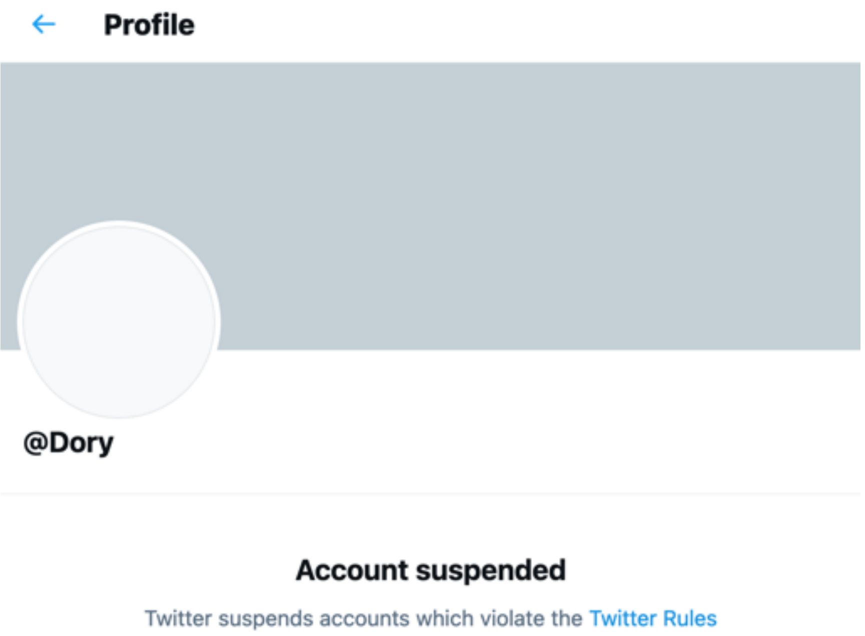
- **A diversified method**
  - Checking suspended account
  - Clustering-based method
  - Rule-based method
  - Manual checking

Checking Suspended Account

- **Suspended Account**

Check suspended account from twitter.

Twitter API →



← Profile

@Dory

Account suspended

Twitter suspends accounts which violate the Twitter Rules

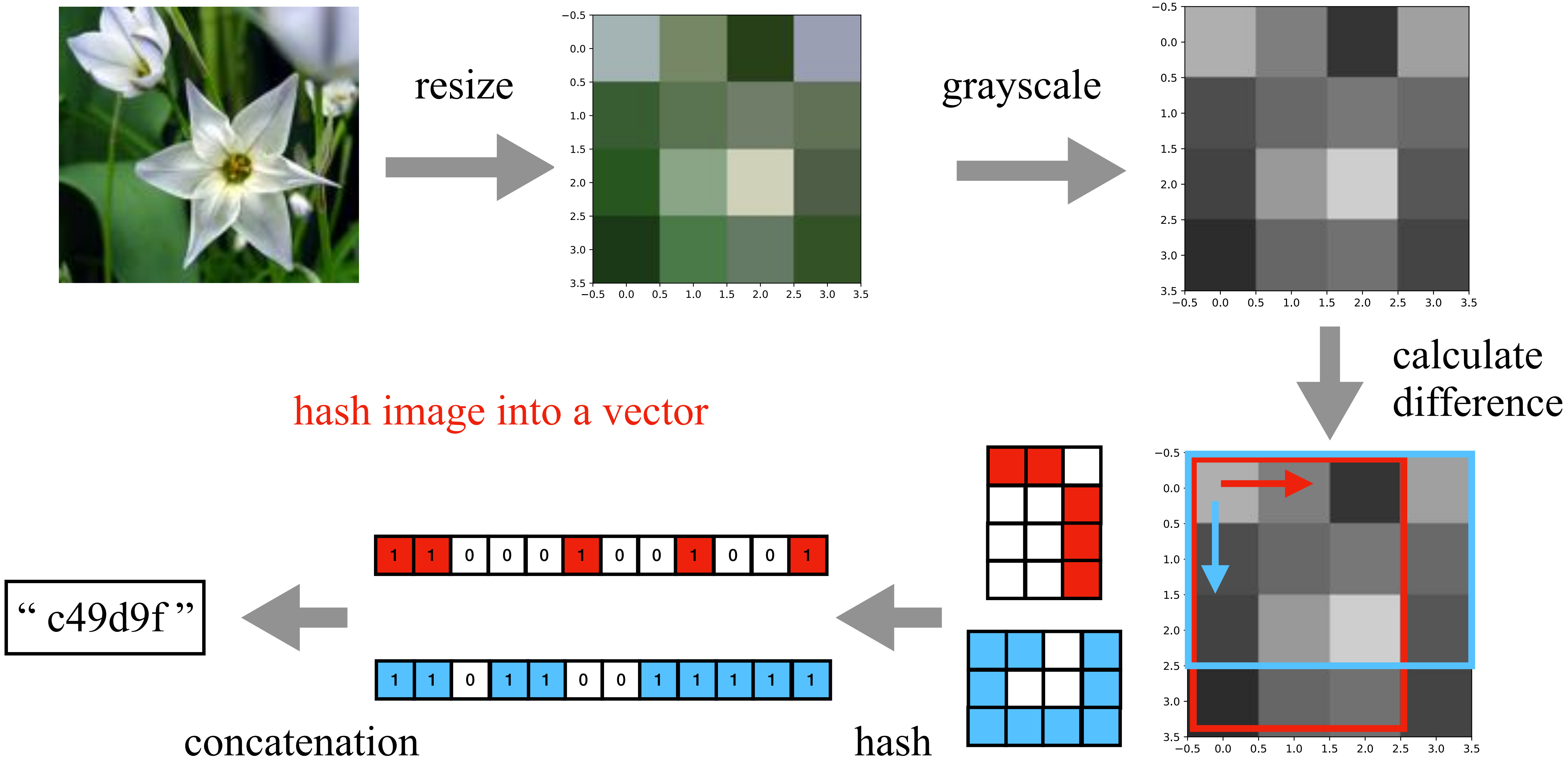
Error Code

50	User not found.
63	User has been suspended.
68	Some actions on this user's Tweet have been disabled by Twitter.
109	The specified user is not found in this list.

Clustering Based Method

- **dHash (1)**

Cluster near-duplicated images from the social network. However, the images in the social network are not in the same size, and usually very large.



resize

grayscale

calculate difference

hash image into a vector

hash

1 1 0 0 0 1 0 0 1 0 0 1

1 1 0 1 1 0 0 1 1 1 1 1

concatenation

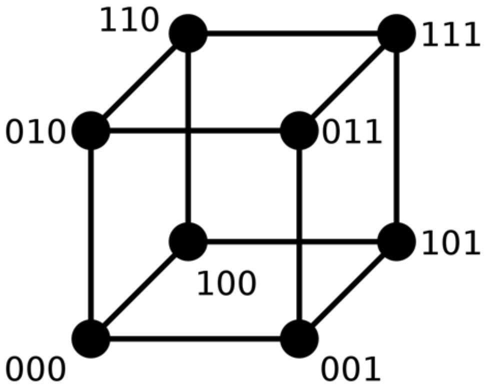
“ c49d9f ”

Clustering Based Method

- **dHash (2)**

Hamming Distance

the number of different bits



d(000, 111) = 3

use hamming distance to compare two image hashs

“ c49d9f ”

“ c49d9f ”

d = 0
same cluster

threshold

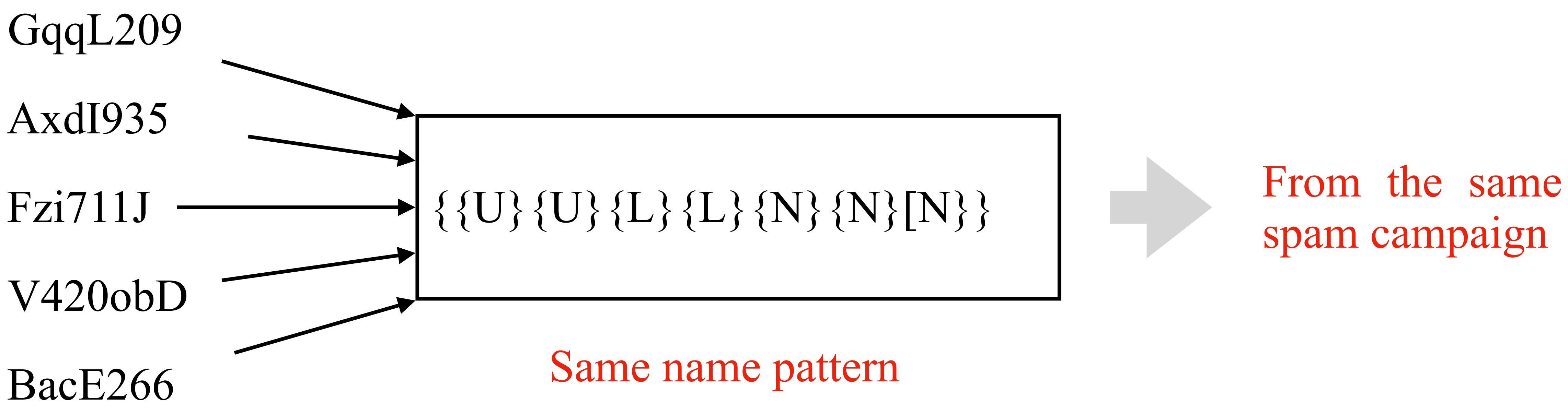
d = 6
not same cluster

“ 88ecd7 ”

Clustering Based Method

- **Automatic Naming Patterns Discovery**

A spam campaign typically registers its accounts with automatic naming patterns which have relatively limited variability.



GqqL209

AxdI935

Fzi711J

V420obD

BacE266

{{U}{U}{L}{L}{N}{N}[N]}

Same name pattern

From the same spam campaign

Clustering Based Method

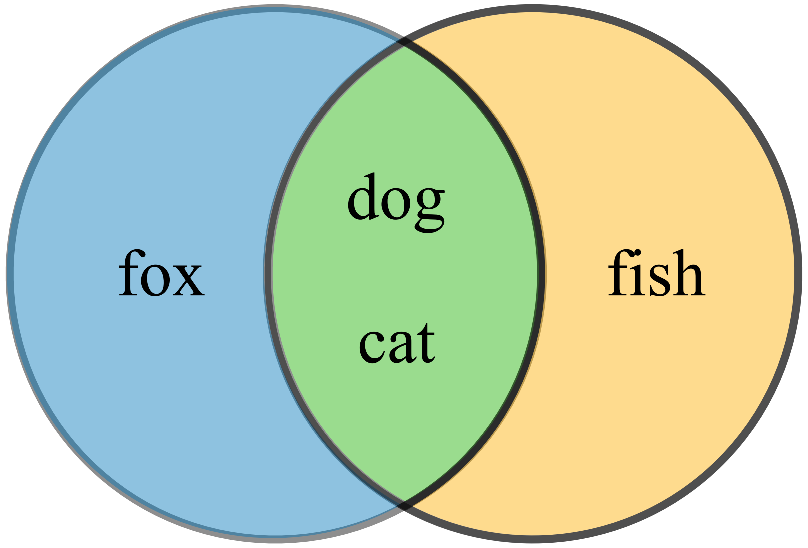
- **minHash (1)**

Cluster near-duplicated content from social networks.

tweet 1: dog, fox, cat

tweet 2: cat, fish, dog

Jaccard similarity



$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{2}{4} = 0.5$$

Clustering Based Method

- **minHash (2)**

Cluster near-duplicated content from social network.

Assuming we have N tweets, N-choose-2 comparisons requires:

$$\binom{N}{2} \approx \frac{N^2}{2} \quad \text{comparisons.}$$

A PC can calculate the Jaccard similarity between two sets in 1ms per pair. In twitter, 500 million tweets sent each day.

That means, the total comparison time is

$$\frac{(500 \times 10^6)^2}{2} * \frac{1 \times 10^{-3}}{\text{1 comparision}} = 7{,}927{,}447 \; years$$

Is there a better solution ?

Clustering Based Method

- **minHash (3)**

Assume we have 3 tweets

t1: dog, fox, cat

t2: cat, fish, dog

t3: dog, cat, fox

hash function h1
(dog: 1, cat: 3, fish: 5, fox: 4)

hash function h2
(dog: 6, cat: 4, fish: 1, fox: 3)

	t1	t2	t3
h1	1	1	1
h2	3	1	3

minimum hash value

Sim(t1, t2) = 1/2 = 0.5 1 value in common

Sim(s1, s3) = 2/2 = 1 2 value in common

Clustering 600 million tweets

< 1 hour

Data labeling

- **Rule-Based Method**

Labeling spam tweets:

1) has malicious URL;
2) includes repetitive information;
3) includes deceptive information;
4) has pertinence purpose;
5) includes many meaningless tweets;
6) has relevant information on free or quick money gain;
7) includes adult content;
8) is an automatic tweet from bots/app with the malicious purpose;
9) is from malicious promoters;
10) is friend infiltrators.
11) includes sensitive or offensive contents.

Labeling ham tweets:

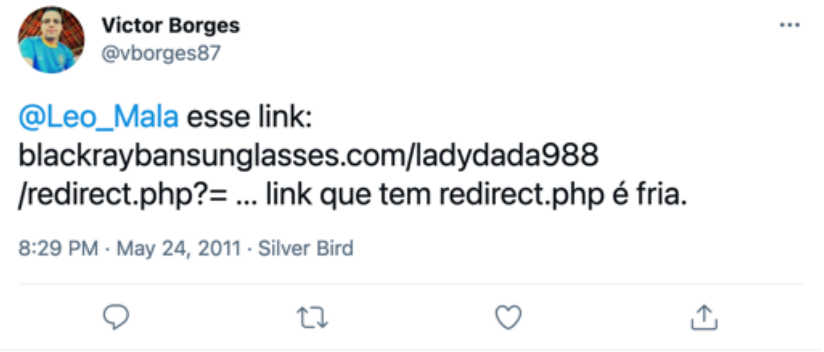
Defining seed accounts:

- governments,
- famous companies,
- organizations,
- well-known persons.

Data labeling

- **Rule-Based Method-Spam Example**

Malicious URL

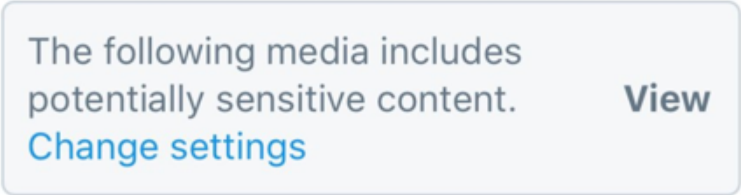


Victor Borges
@vborges87

@Leo_Mala esse link: blackraybansunglasses.com/ladydada988 /redirect.php?= ... link que tem redirect.php é fria.

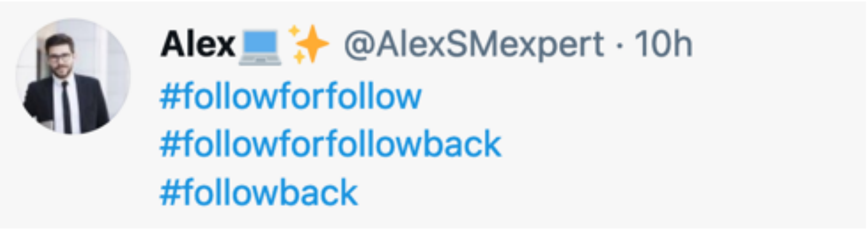
8:29 PM · May 24, 2011 · Silver Bird

Sensitive contents



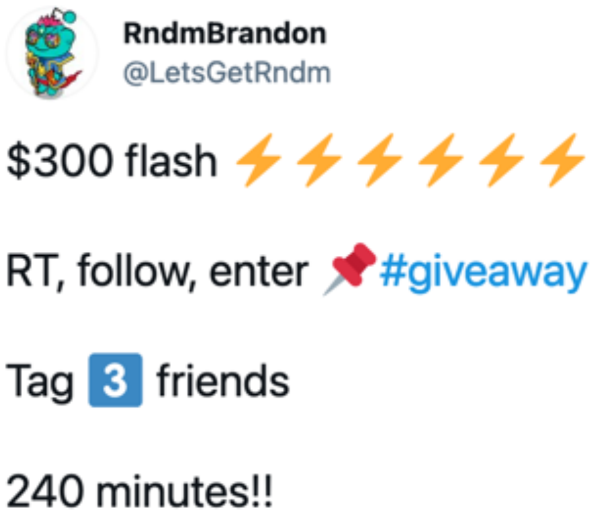
The following media includes potentially sensitive content. View
Change settings

Friend infiltrators



Alex💻✨ @AlexSMexpert · 10h
#followforfollow
#followforfollowback
#followback

Quick money gain



RndmBrandon
@LetsGetRndm

$300 flash ⚡⚡⚡⚡⚡⚡

RT, follow, enter 📌#giveaway

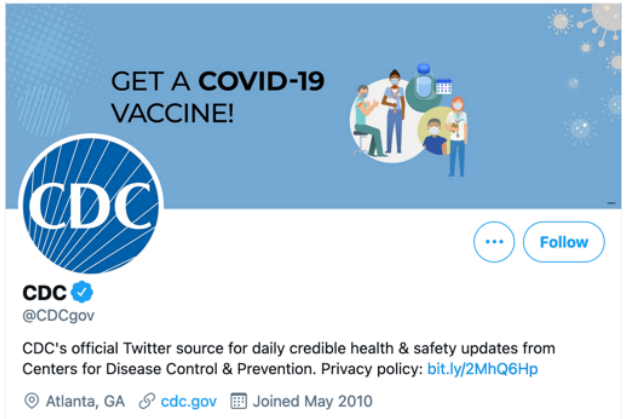
Tag 3 friends

240 minutes!!

Rule-Based Method

- **Ham Example**

Governments

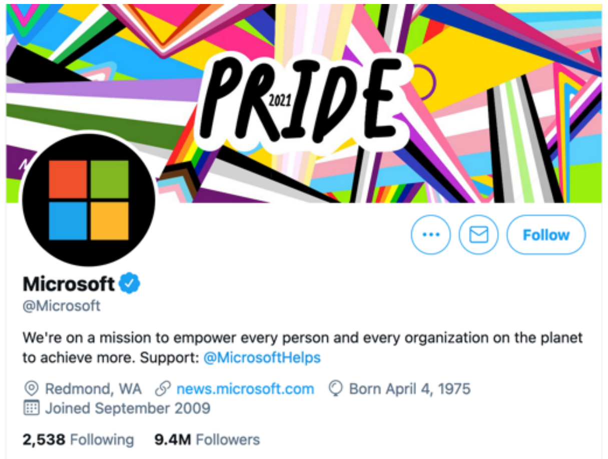


CDC
@CDCgov

CDC's official Twitter source for daily credible health & safety updates from Centers for Disease Control & Prevention. Privacy policy: bit.ly/2MhQ6Hp

Atlanta, GA cdc.gov Joined May 2010

Companies



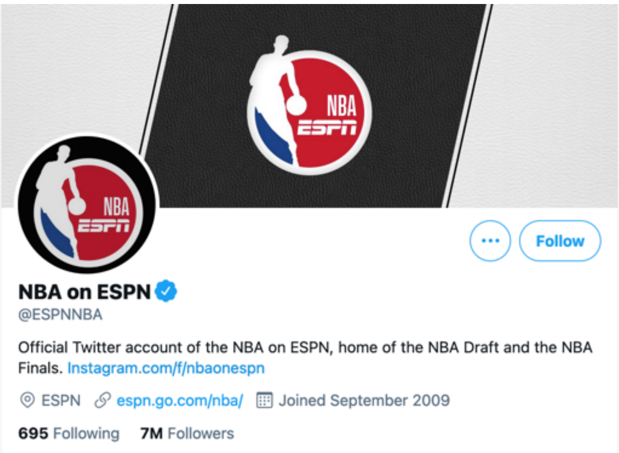
Microsoft
@Microsoft

We're on a mission to empower every person and every organization on the planet to achieve more. Support: @MicrosoftHelps

Redmond, WA news.microsoft.com Born April 4, 1975
Joined September 2009

2,538 Following **9.4M** Followers

Organizations



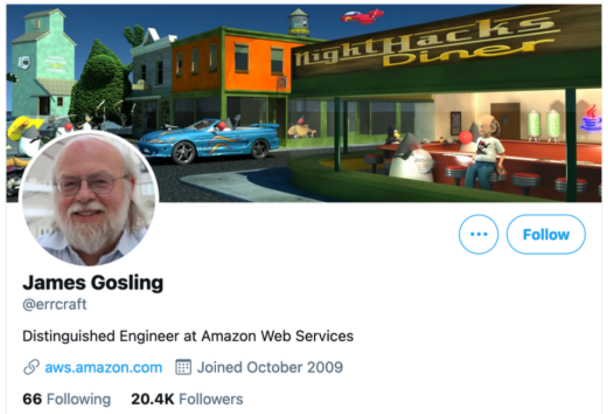
NBA on ESPN
@ESPNNBA

Official Twitter account of the NBA on ESPN, home of the NBA Draft and the NBA Finals. Instagram.com/f/nbaonespn

ESPN espn.go.com/nba/ Joined September 2009

695 Following **7M** Followers

People



James Gosling
@errcraft

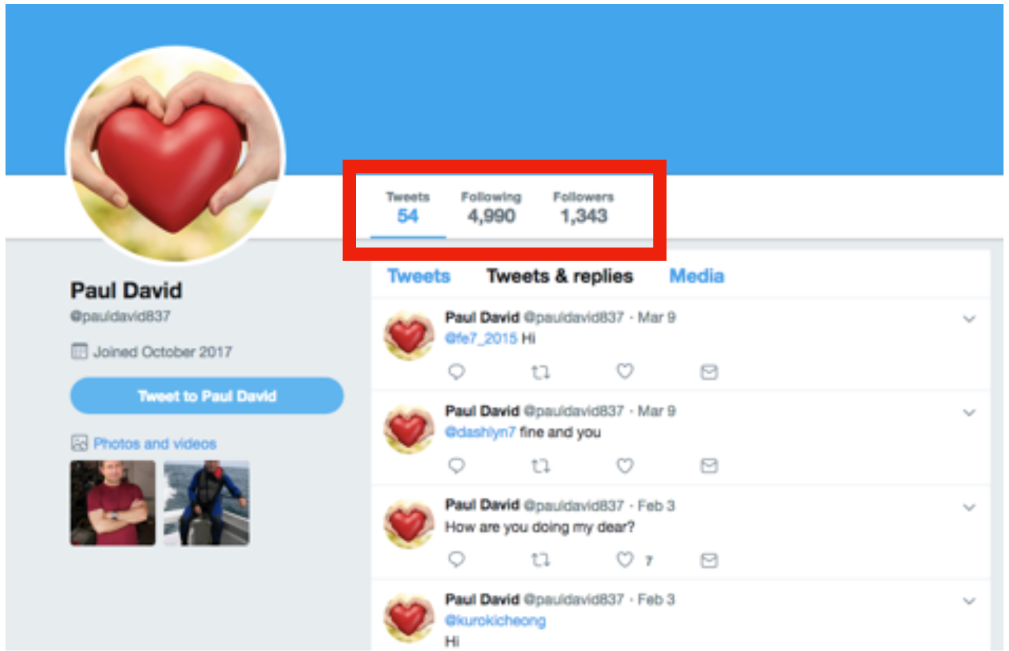
Distinguished Engineer at Amazon Web Services

aws.amazon.com Joined October 2009

66 Following **20.4K** Followers

Data labeling

- **Manual checking**



Paul David
@pauldavid837
Joined October 2017

Paul David @pauldavid837 · Mar 9
@fe7_2015 Hi

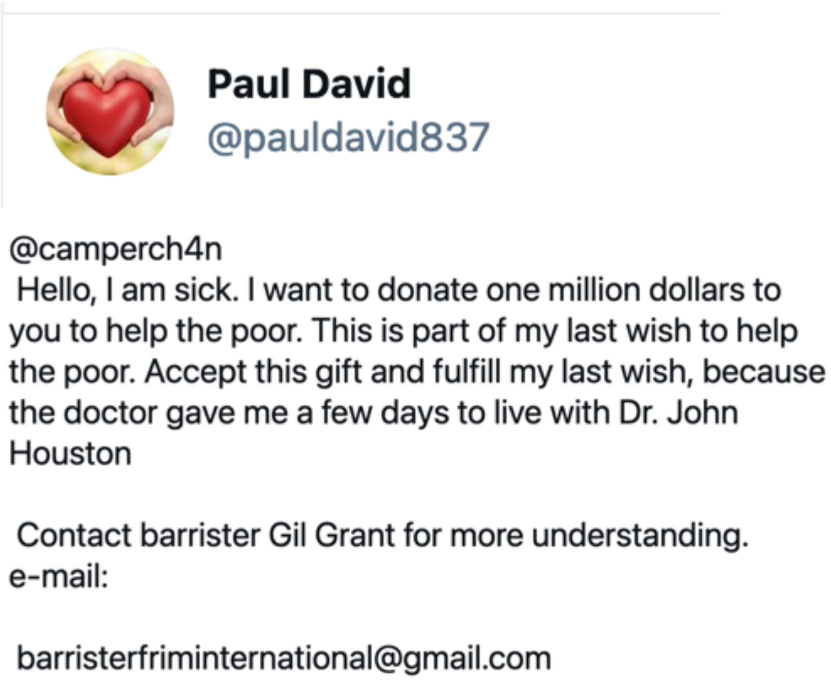
Paul David @pauldavid837 · Mar 9
@dashlyn7 fine and you

Paul David @pauldavid837 · Feb 3
How are you doing my dear?
7

Paul David @pauldavid837 · Feb 3
@kurokicheong
Hi

looks like a normal account!

Mimic Normal User



Paul David
@pauldavid837

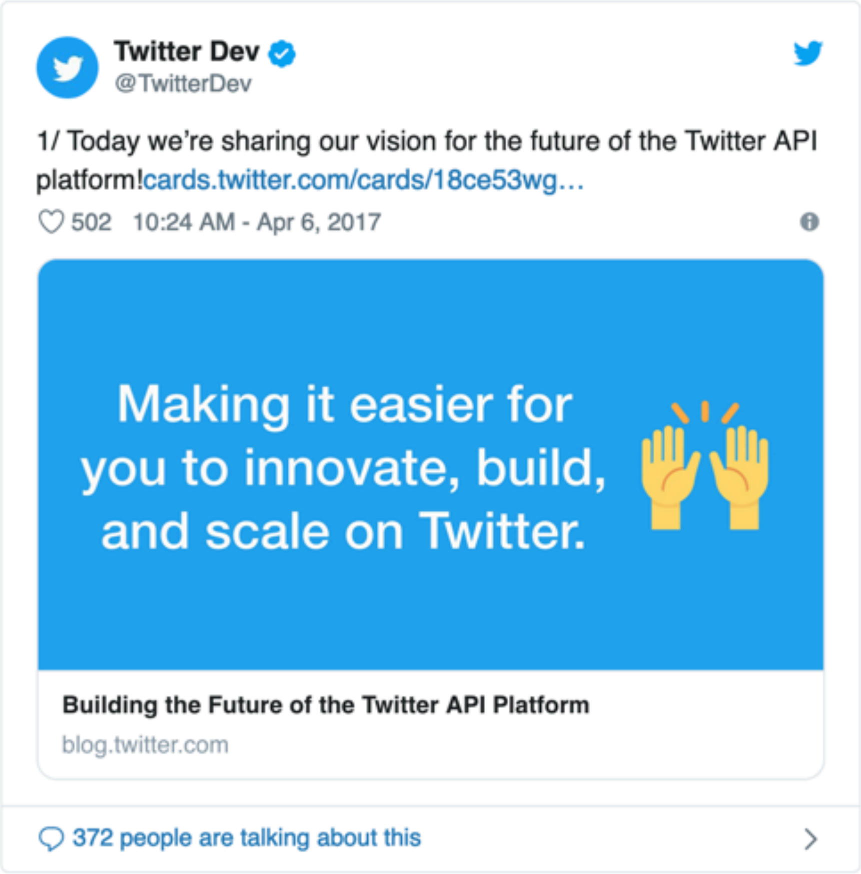
@camperch4n
Hello, I am sick. I want to donate one million dollars to you to help the poor. This is part of my last wish to help the poor. Accept this gift and fulfill my last wish, because the doctor gave me a few days to live with Dr. John Houston

Contact barrister Gil Grant for more understanding.
e-mail:

barristerfriminternational@gmail.com

Fraud

Tweet Data Format



Twitter Dev
@TwitterDev

1/ Today we're sharing our vision for the future of the Twitter API platform!cards.twitter.com/cards/18ce53wg…

♡ 502 10:24 AM - Apr 6, 2017

Making it easier for you to innovate, build, and scale on Twitter.

Building the Future of the Twitter API Platform
blog.twitter.com

372 people are talking about this

Tweet object

Content

Author information

Mentions/Hashtags/URLs

```
  "created_at": "Thu Apr 06 15:24:15 +0000 2017",
  "id_str": "850006245121695744",
  "text": "1\/ Today we\u2019re sharing our vision for the future of
the Twitter API platform!\nhttps:\/\/t.co\/XweGngmxlP",
  "user": {
    "id": 2244994945,
    "name": "Twitter Dev",
    "screen_name": "TwitterDev",
    "location": "Internet",
    "url": "https:\/\/dev.twitter.com\/",
    "description": "Your official source for Twitter Platform news,
updates & events. Need technical help? Visit https:\/\/
twittercommunity.com\/ \u2328\ufe0f #TapIntoTwitter"
  },
  "place": {
  },
  "entities": {
    "hashtags": [
    ],
    "urls": [
      {
        "url": "https:\/\/t.co\/XweGngmxlP",
        "unwound": {
          "url": "https:\/\/cards.twitter.com\/cards\/18ce53wgo4h\/
3xo1c",
          "title": "Building the Future of the Twitter API Platform"
        }
      }
    ],
    "user_mentions": [
    ]
  }
}
```

Tweet JSON object

More Resources

Please check
https://people.cmix.louisiana.edu/yuan/2023_Summer_Tutorial_Courses.html

Q&A

Thank You!