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BITS F464: Machine Learning (1st Sem 2024-25)

ML FRAMEWORKS

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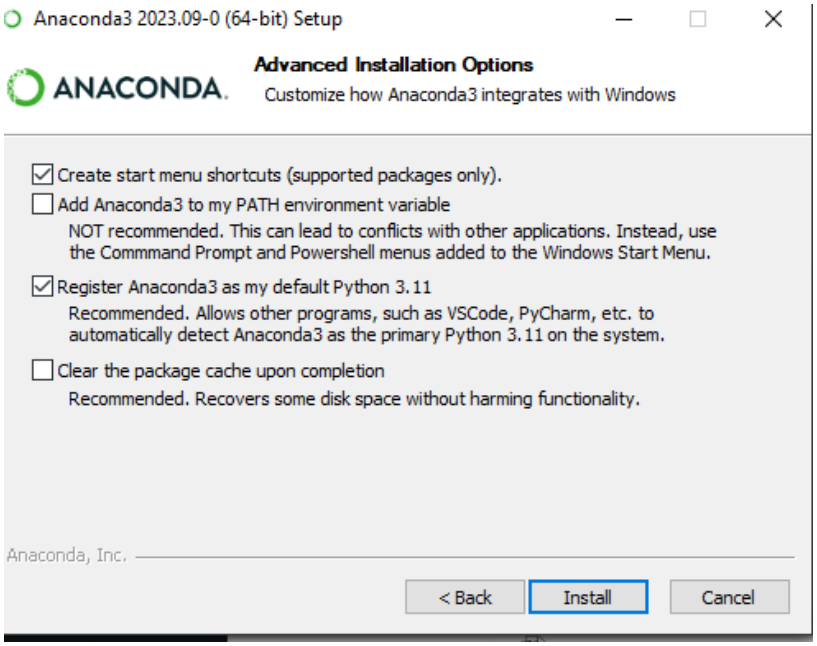
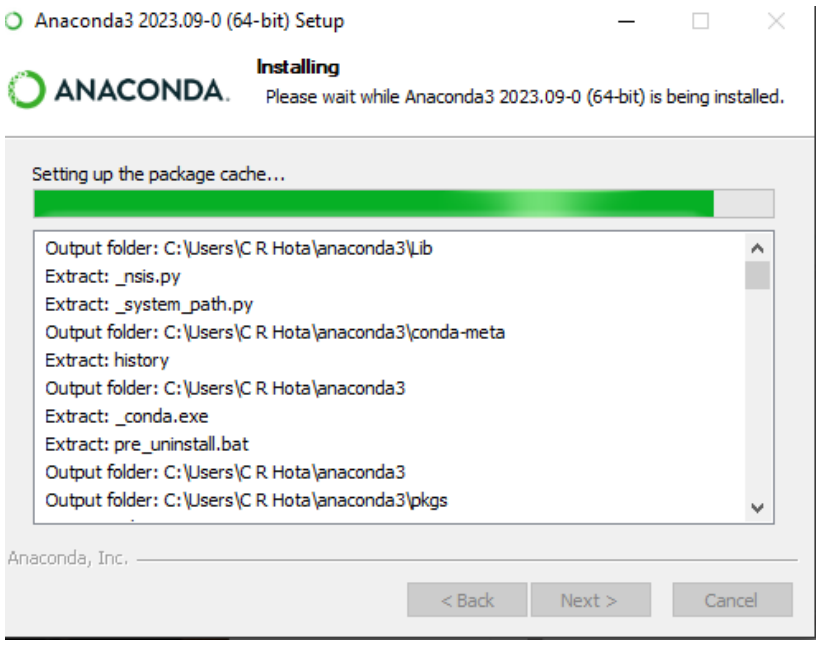
ML Framework: Anaconda

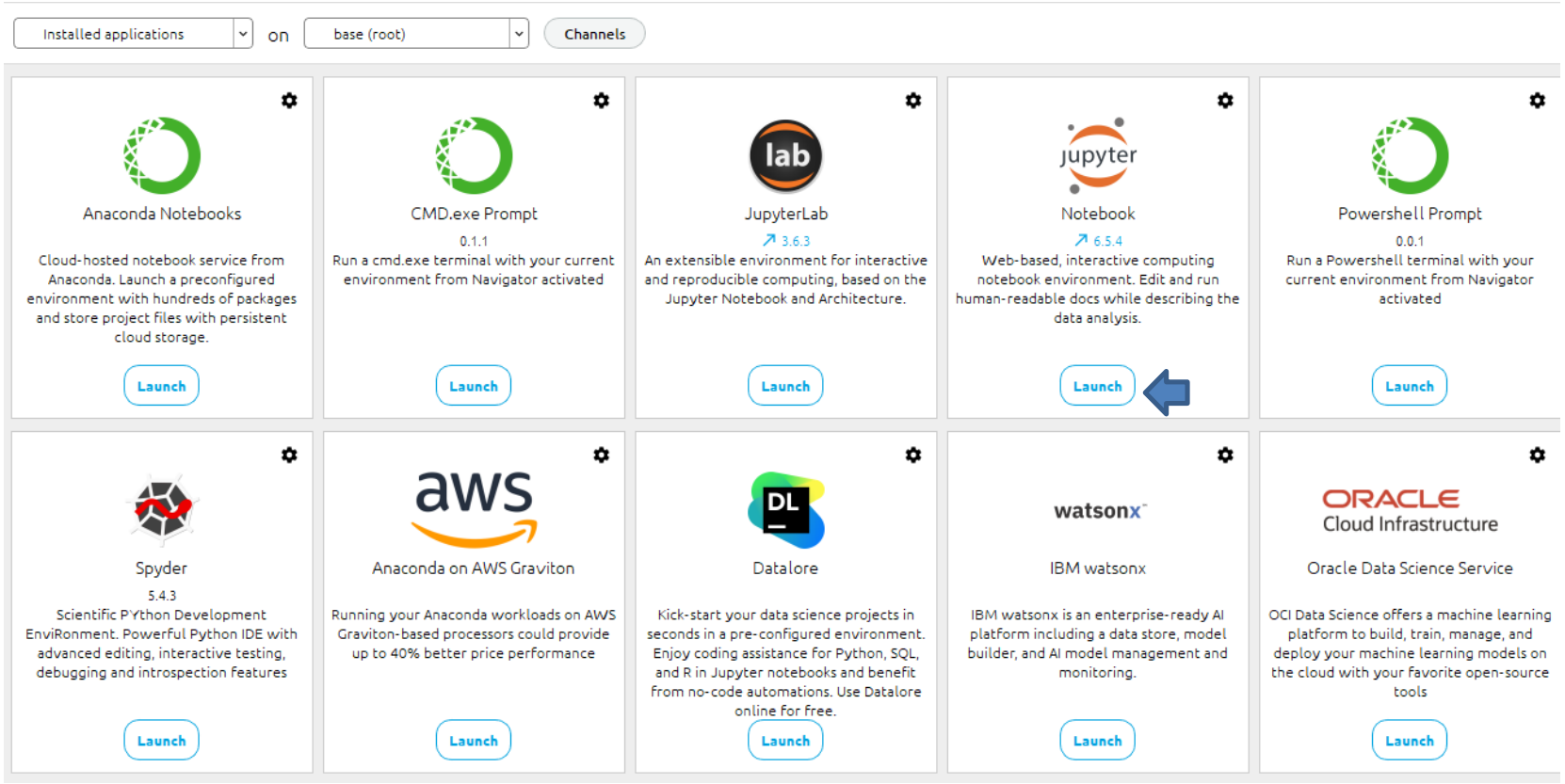
- An ML framework is any tool, interface, or library that lets you develop ML models easily, without understanding the underlying algorithms.
- Anaconda is a distribution of the Python and R programming language for scientific computing suitable for ML.



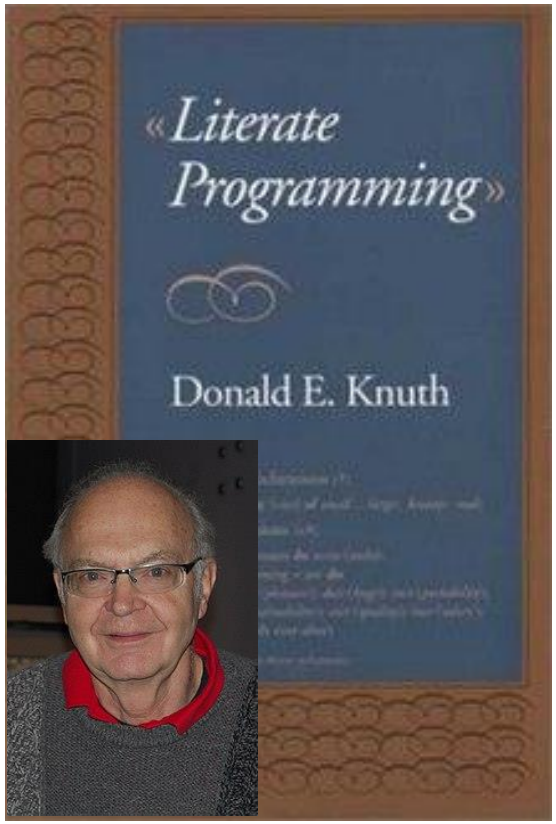


Source: https://www.anaconda.com/definitive-guide-to-ai-platforms

Anaconda Navigator



Notebook: Good Practices of Code Writing



Source: Wiki

- Linear flow of execution.
- Little amount of code.
- Extract reusable code into a package.
- Clean it before storing it in a repository or sharing it with others.
- Develop your code as a story with text, small code fragments and images.

Jupyter Notebook

- An interactive web application for creating and sharing computational documents.

jupyter Untitled Last Checkpoint: 2 minutes ago (autosaved) Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 (ipykernel)

Run Code

In [1]:
```
import pandas as pd
from sklearn.datasets import load_wine

wine_data = load_wine()

wine_df=pd.DataFrame(wine_data.data,columns=wine_data.feature_names)
wine_df["target"] = wine_data.target

wine_df.head()
```

iris, house prices, diabetes, digits…

scikit learn

Out[1]:

alinity_of_ash	magnesium	total_phenols	flavanoids	nonflavanoid_phenols	proanthocyanins	color_intensity	hue	od280/od315_of_diluted_wines	proline	target
15.6	127.0	2.80	3.06	0.28	2.29	5.64	1.04	3.92	1065.0	0
11.2	100.0	2.65	2.76	0.26	1.28	4.38	1.05	3.40	1050.0	0
18.6	101.0	2.80	3.24	0.30	2.81	5.68	1.03	3.17	1185.0	0
16.8	113.0	3.85	3.49	0.24	2.18	7.80	0.86	3.45	1480.0	0
21.0	118.0	2.80	2.69	0.39	1.82	4.32	1.04	2.93	735.0	0

In [ ]:

Scikit-Learn Example Continued…

```
from sklearn.preprocessing import Stand
x = wine_df[wine_data.feature_names].
y = wine_df["target"].copy()
scaler = StandardScaler()
scaler.fit(X)
X_scaled = scaler.transform(X.values)
print(X_scaled[0])        //Other things possi
from sklearn.model_selection import tra
X_train_scaled, X_test_scaled, y_train,
y, train_size=.7, random_state=25)
from sklearn.linear_model import LogisticRegression
logistic_regression = LogisticRegression()
logistic_regression.fit(X_train_scaled, y_train)
log_reg_preds = logistic_regression.predict(X_test_scaled)
```

```
[ 1.51861254 -0.562249
  1.03481896 -0.659563
  1.01300893]
```

```
[3] from sklearn.model_selection import train_test_split

    # Example data
    X = [[1], [2], [3], [4], [5]]
    y = [1, 2, 3, 4, 5]

    # Split data into training and testing sets (without random_state)
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3)

    print("Train:", X_train, y_train)
    print("Test:", X_test, y_test)

    Train: [[5], [1], [4]] [5, 1, 4]
    Test: [[3], [2]] [3, 2]
```

```
    from sklearn.model_selection import train_test_split

    # Example data
    X = [[1], [2], [3], [4], [5]]
    y = [1, 2, 3, 4, 5]

    # Split data into training and testing sets (with random_state)
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,
                                                        random_state=30)

    print("Train:", X_train, y_train)
    print("Test:", X_test, y_test)

    Train: [[3], [1], [5]] [3, 1, 5]
    Test: [[4], [2]] [4, 2]
```

Building the model

Source: https://www.datacamp.com/tutorial/machine-learning-python

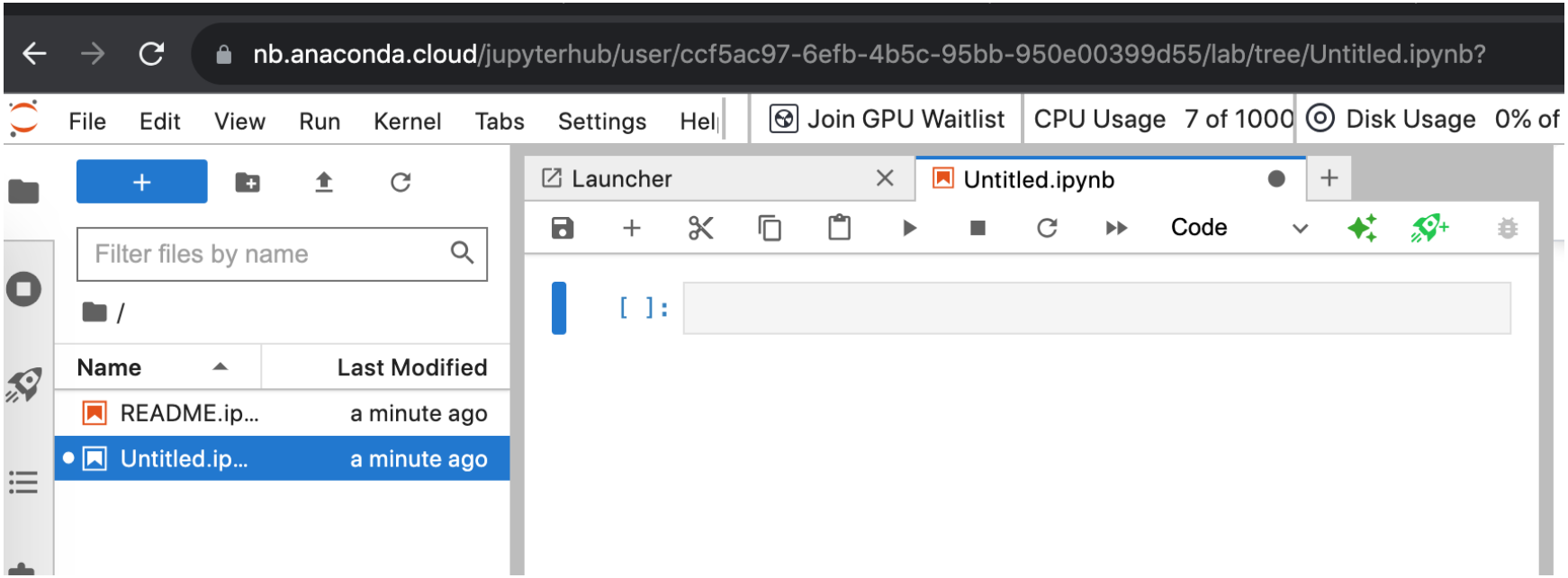
Classification Reports

```
from sklearn.metrics import classification_report
# Store model predictions in a dictionary which makes it's
    easier to iterate through the model and print the results.
```

```
Logistic Regression Results:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        17
           1       1.00      0.92      0.96        25
           2       0.86      1.00      0.92        12

    accuracy                           0.96        54
   macro avg       0.95      0.97      0.96        54
weighted avg       0.97      0.96      0.96        54
```

Source: https://www.datacamp.com/tutorial/machine-learning-python

Anaconda Cloud Option



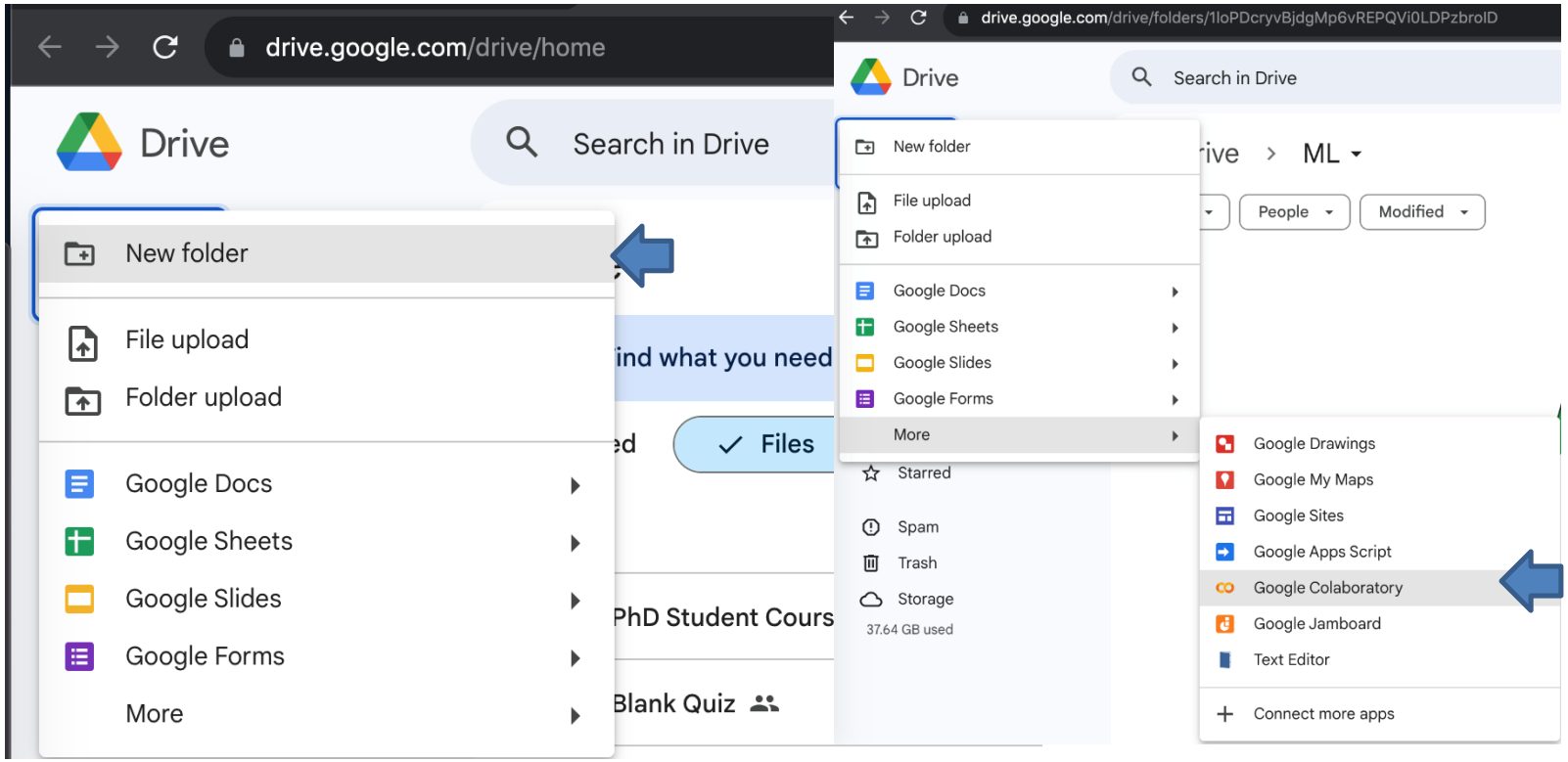
You can install in both the standalone and cloud options, many other packages/ libraries like:

NumPy SciPy Keras TensorFlow PYTORCH NLTK

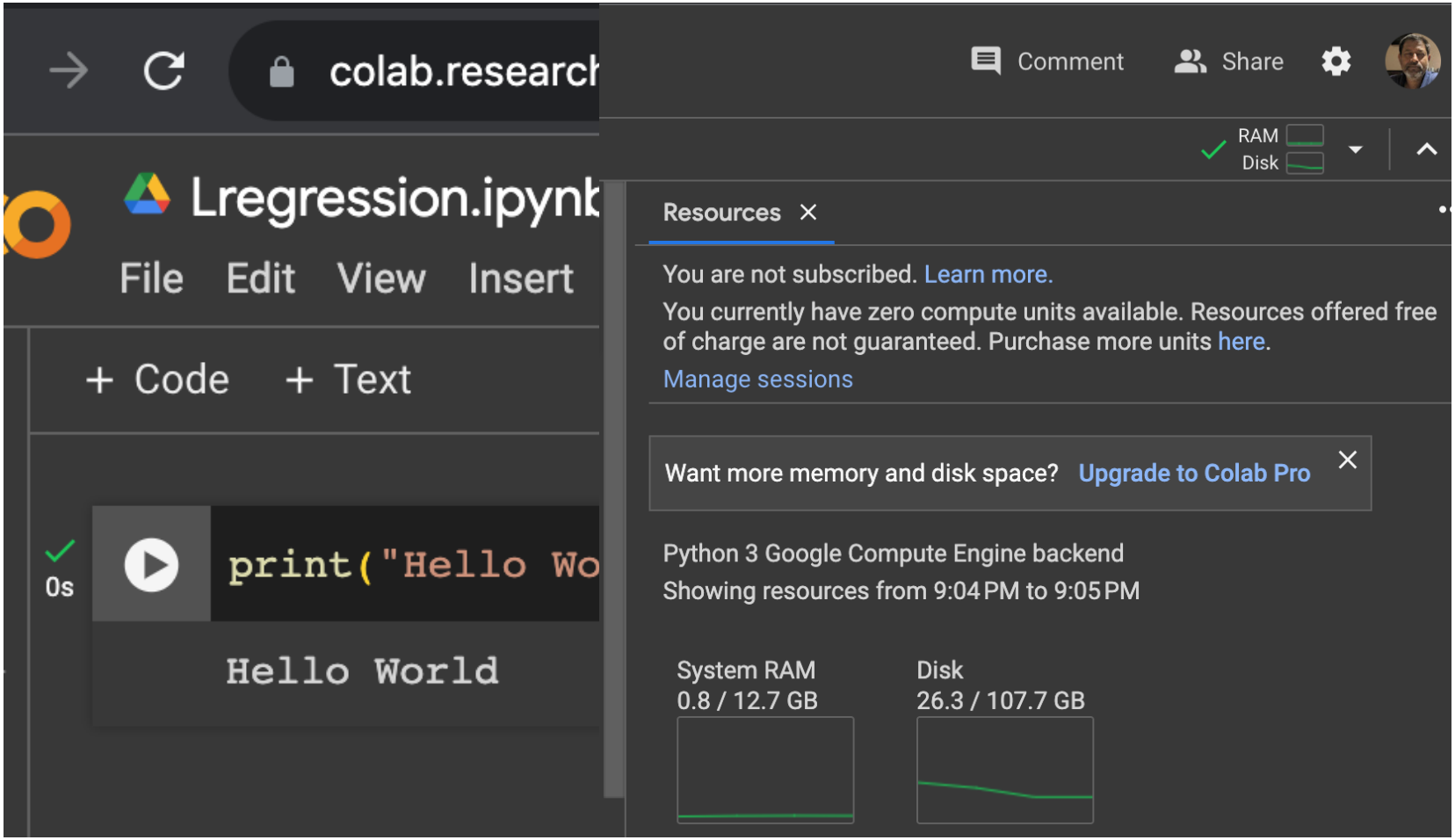
An alternative to Anaconda

- Sharing is allowed in which one?
- More powerful hardware (TPU/ GPU etc. are available in which one?

Google Colab Continued…



Continued…

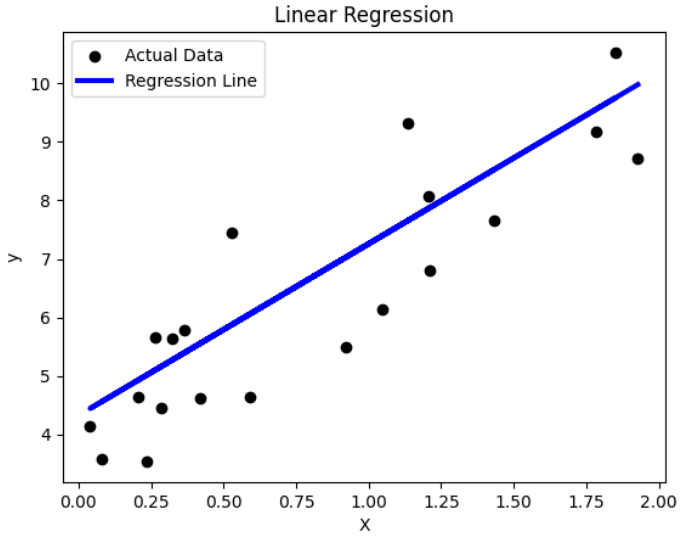

colab.research
Comment
Share
RAM
Disk
Lregression.ipynb
File Edit View Insert
+ Code + Text
Resources
You are not subscribed. Learn more.
You currently have zero compute units available. Resources offered free of charge are not guaranteed. Purchase more units here.
Manage sessions
Want more memory and disk space? Upgrade to Colab Pro
0s
print("Hello Wo
Hello World
Python 3 Google Compute Engine backend
Showing resources from 9:04 PM to 9:05 PM
System RAM
0.8 / 12.7 GB
Disk
26.3 / 107.7 GB

Continued…

```
# Import necessary libraries
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection impor
from sklearn.linear_model import L
from sklearn.metrics import mean_s

# Generate some sample data
np.random.seed(0)
X = 2 * np.random.rand(100, 1)  #
y = 4 + 3 * X + np.random.randn(10

# Split the data into training and
X_train, X_test, y_train, y_test =


# Create a linear regression model
model = LinearRegression()

# Fit the model to the training data
model.fit(X_train, y_train)

# Make predictions using the testing set
y_pred = model.predict(X_test)
```

```
# Print the coefficients
print("Coefficient (slope):", model.coef_[0])
print("Intercept:", model.intercept_)

# Evaluate the model
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)
print("Mean Squared Error:", mse)
print("R^2 Score:", r2)

# Plot the results
plt.scatter(X_test, y_test, color=
plt.plot(X_test, y_pred, color="b
plt.xlabel("X")
plt.ylabel("y")
plt.title("Linear Regression")
plt.legend()
plt.show()
```

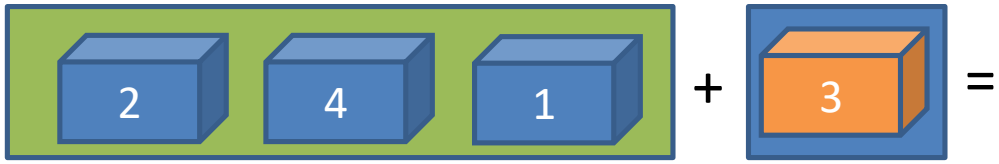
```
Coefficient (slope): [2.93647151]
Intercept: [4.32235853]
Mean Squared Error: 1.0434333815695171
R^2 Score: 0.7424452332071367
```



TensorFlow

Google DeepMind

- Supports distributed ML
- Large-scale ML models in real-world applications (Production environment)
- What is a Tensor?
  - A multi-dimensional array on which mathematical operations can be performed. (Ex: Addition of two tensors)



(Rank 1) (Rank 0)

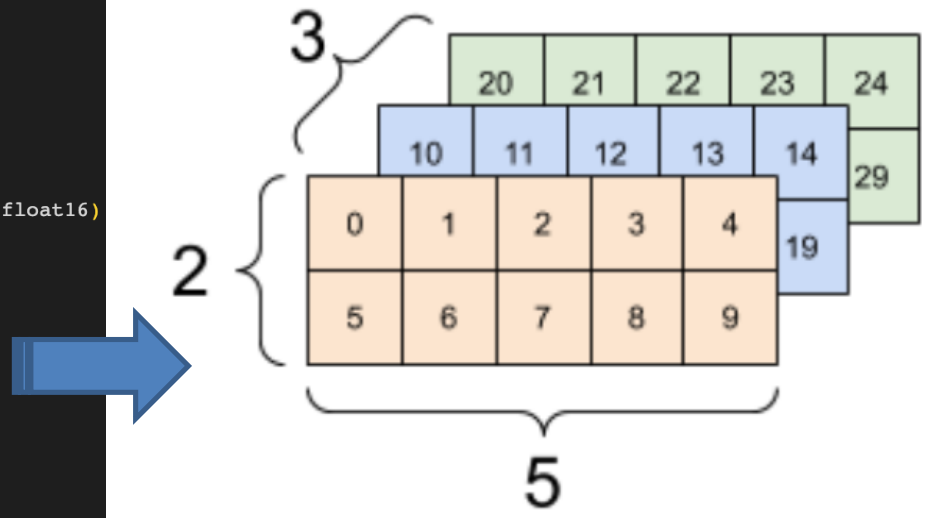
- GPU acceleration for Tensors

$$\left(\begin{pmatrix}1 & 2\\ 3 & 4\end{pmatrix}, \begin{pmatrix}5 & 6\\ 7 & 8\end{pmatrix}, \begin{pmatrix}9 & 10\\ 11 & 12\end{pmatrix}\right) \quad ?$$

Tensors Continued…

```
import tensorflow as tf
import numpy as np
rank_0_tensor = tf.constant(4)
print(rank_0_tensor)
rank_1_tensor = tf.constant([2.0, 3.0, 4.0])
print(rank_1_tensor)
rank_2_tensor = tf.constant([[1, 2],
                             [3, 4],
                             [5, 6]], dtype=tf.float16)
print(rank_2_tensor)

rank_3_tensor = tf.constant([
  [[0, 1, 2, 3, 4],
   [5, 6, 7, 8, 9]],
  [[10, 11, 12, 13, 14],
   [15, 16, 17, 18, 19]],
  [[20, 21, 22, 23, 24],
   [25, 26, 27, 28, 29]],])

print(rank_3_tensor)
```

```
tf.Tensor(4, shape=(), dtype=int32)
tf.Tensor([2. 3. 4.], shape=(3,), dtype=float32)
tf.Tensor(
[[1. 2.]
 [3. 4.]
 [5. 6.]], shape=(3, 2), dtype=float16)
tf.Tensor(
[[[ 0  1  2  3  4]
  [ 5  6  7  8  9]]

 [[10 11 12 13 14]
  [15 16 17 18 19]]

 [[20 21 22 23 24]
  [25 26 27 28 29]]], shape=(3, 2, 5), dtype=int32)
```



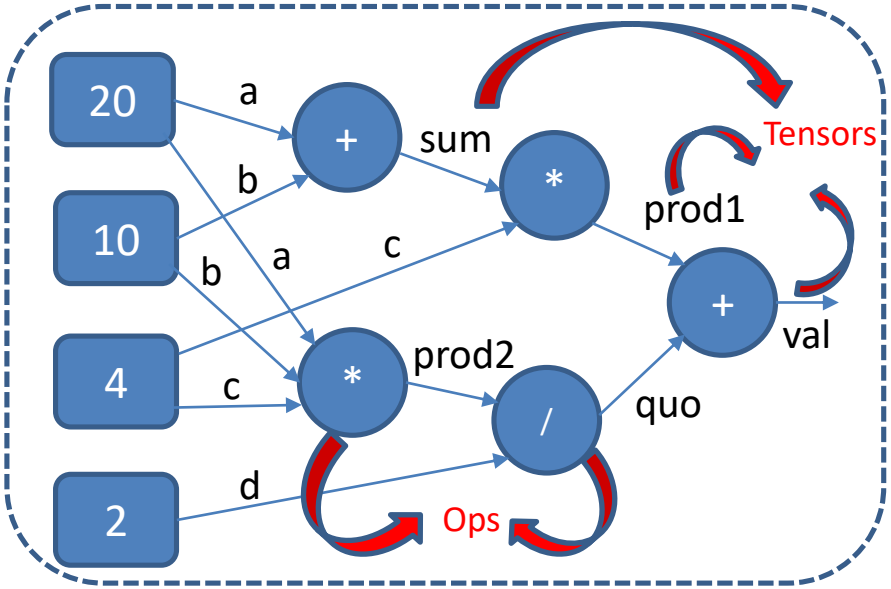
- A Tensor can hold strings too.

```
tensor_of_strings = tf.constant(["BITS Pilani",
                                 "Hyderabad Campus",
                                 "Telangana"])

print(tensor_of_strings)
```

TensorFlow: Computational Graphs

```
import tensorflow as tf
a = 20
b = 10
c = 4
d = 2
sum = a + b
prod1 = sum * c
prod2 = a* b * c
quo = prod2/d
val = prod1 + quo
print(val)
```

```
520.0
```




```
# Load the TensorBoard notebook extension.
%load_ext tensorboard
import tensorboard
```

Insightful visualizations and real-time feedback during the training process.

Tracking: How model training evolves over the time, Debugging: Visualize the computational graph to debug issues related to model architecture.

TensorFlow with Keras

```python
import tensorflow as tf
print("TensorFlow version:", tf.__version__)
mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10)
])
predictions = model(x_train[:1]).numpy()
predictions
tf.nn.softmax(predictions).numpy()
loss_fn = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True)
loss_fn(y_train[:1], predictions).numpy()
model.compile(optimizer='adam',loss=loss_fn,metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)
model.evaluate(x_test,  y_test, verbose=2)
```

```
TensorFlow version: 2.15.0
Epoch 1/5
1875/1875 [==============================] - 7s 3ms/step - loss: 0.3028 - accuracy: 0.9119
Epoch 2/5
1875/1875 [==============================] - 8s 4ms/step - loss: 0.1480 - accuracy: 0.9566
Epoch 3/5
1875/1875 [==============================] - 6s 3ms/step - loss: 0.1115 - accuracy: 0.9665
Epoch 4/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.0908 - accuracy: 0.9724
Epoch 5/5
1875/1875 [==============================] - 7s 3ms/step - loss: 0.0776 - accuracy: 0.9768
313/313 - 1s - loss: 0.0774 - accuracy: 0.9756 - 553ms/epoch - 2ms/step
[0.07737699896097183, 0.975600004196167]
```

Source: https://www.tensorflow.org/tutorials/

PyTorch

- Dynamic computation graphs, distributed training, mobile deployment, useful for academic and research purposes.

```python
import torch
from torch.autograd import Variable

x_data = Variable(torch.Tensor([[1.0], [2.0], [3.0]]))
y_data = Variable(torch.Tensor([[2.0], [4.0], [6.0]]))

class LinearRegressionModel(torch.nn.Module):

  def __init__(self):
    super(LinearRegressionModel, self).__init__()
    self.linear = torch.nn.Linear(1, 1) # One in and one out
  def forward(self, x):
    y_pred = self.linear(x)
    return y_pred

our_model = LinearRegressionModel()

criterion = torch.nn.MSELoss(size_average = False)
optimizer = torch.optim.SGD(our_model.parameters(), lr = 0.01)

for epoch in range(500):
  # Forward pass: Compute predicted y by passing x to the model
  pred_y = our_model(x_data)

  # Compute and print loss
  loss = criterion(pred_y, y_data)

  # Zero gradients, perform a backward pass,and update the weights.
  optimizer.zero_grad()
  loss.backward()
  optimizer.step()
  print('epoch {}, loss {}'.format(epoch, loss.item()))

new_var = Variable(torch.Tensor([[4.0]]))
pred_y = our_model(new_var)
print("predict (after training)", 4, our_model(new_var).item())
```

```
epoch 0, loss 67.04987335205078
epoch 1, loss 30.550050735473633
epoch 2, loss 14.291292190551758
epoch 3, loss 7.043418884277344
epoch 4, loss 3.807079315185547
epoch 5, loss 2.356700897216797
epoch 6, loss 1.701522707939148
epoch 7, loss 1.4004793167114258
epoch 8, loss 1.2572226524353027
epoch 9, loss 1.1843408346176147
epoch 10, loss 1.1429182291030884
```

...

```
epoch 489, loss 0.0010938026243820786
epoch 490, loss 0.0010780788725242019
epoch 491, loss 0.001062584575265646
epoch 492, loss 0.0010473171714693308
epoch 493, loss 0.0010322668822482228
epoch 494, loss 0.0010174255585297942
epoch 495, loss 0.00100281869526952
epoch 496, loss 0.0009883942548185587
epoch 497, loss 0.0009741996182128787
epoch 498, loss 0.0009601832716725767
epoch 499, loss 0.0009463919559493661
predict (after training) 4 7.964635848999023
```

Source: https://www.geeksforgeeks.org/

Many more…

Apache)

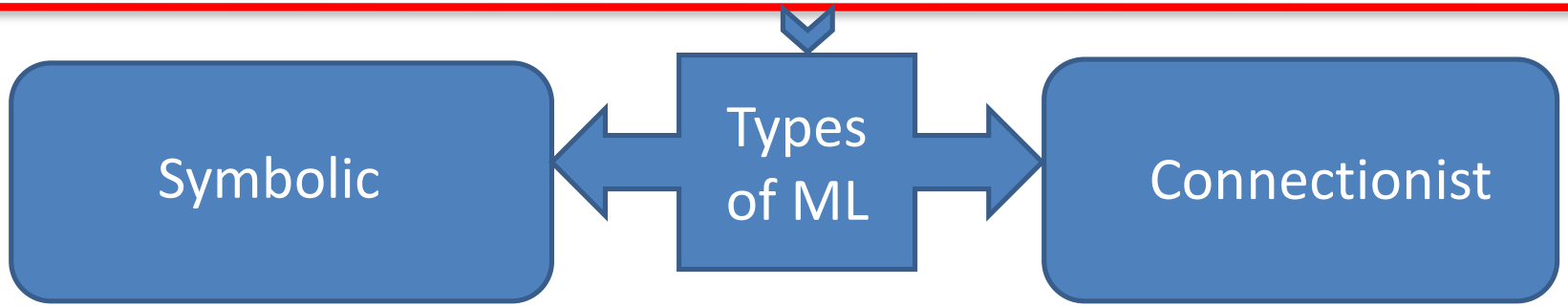
Shogun

Azure ML

Weka 3

- Which framework is best for Machine Learning?
- Type of application, amount of data, Scalability, data processing etc.

What a ML Framework can do for you?



• Knowledge representation: Explicit symbols and Rules.	Distributed manner using layers.
• Learning approach: Manipulation of Symbols.	Weight adjustment.
• Interpretable and transparent: Decisions are well understood by humans.	Highly non-linear rel.
• Training data: Relatively small.	Large amounts of data.

Quiz for you

Q.1 Which approach is better for capturing complex patterns in large datasets?

- Symbolic ML
- Connectionist ML ✓

Q.2 Tensors are data structures used in ML frameworks that might hold:

- A scalar value only.
- A matrix of values with 0 or 1 or 2 or 3, … dimensions ✓
- A string

Q.3 If you have to choose a framework that makes it easier to debug and experiment with models, which one would you?

- TensorFlow - PyTorch ✓ -ScikitLearn

Thank You!