Kailash Parshad

- *TensorFlow and MLflow Demo*

GitHub: - https://github.com/at0m-b0mb/
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- ***Create Conda Environment: -***

```
(base) C:\Users\at0m>conda create -n kailash python=3.10.5 ipykernel
Collecting package metadata (current_repodata.json): failed

CondaError: KeyboardInterrupt

Terminate batch job (Y/N)? C:\ProgramData\Microsoft\Windows\Start Menu\Programs\Ana
conda3 (64-bit)n
Terminate batch job (Y/N)?
Terminate batch job (Y/N)? mn
Terminate batch job (Y/N)? n

(base) C:\Users\at0m>conda create -n kailash python=3.10 ipykernel
Collecting package metadata (current_repodata.json): done
Solving environment: done


==> WARNING: A newer version of conda exists. <==
  current version: 23.7.4
  latest version: 23.9.0
```

- ***Activate the environment and add a newly created environment to the notebook as kernel: -***

```
(base) C:\Users\at0m\Desktop>conda activate kailash

(kailash) C:\Users\at0m\Desktop>python -m ipykernel install --user --name=kailash
Installed kernelspec kailash in C:\Users\at0m\AppData\Roaming\jupyter\kernels\kaila
sh
```

- ***Now installing notebook: -***

```
(kailash) C:\Users\at0m\Desktop>pip install notebook
Collecting notebook
  Obtaining dependency information for notebook from https://files.pythonhosted.org
/packages/29/e0/50b48473fcb99651dd21302da50ae2c49113ccf3dfb901fc6aaa3117e7ed/notebo
ok-7.0.4-py3-none-any.whl.metadata
  Downloading notebook-7.0.4-py3-none-any.whl.metadata (10 kB)
Collecting jupyter-server<3,>=2.4.0 (from notebook)
  Obtaining dependency information for jupyter-server<3,>=2.4.0 from https://files.
pythonhosted.org/packages/96/a2/b432812537beaf22a9dbc0d50cb62471e57ef90df42738675760
fb3dce98/jupyter_server-2.7.3-py3-none-any.whl.metadata
  Downloading jupyter_server-2.7.3-py3-none-any.whl.metadata (8.6 kB)
Collecting jupyterlab-server<3,>=2.22.1 (from notebook)
  Obtaining dependency information for jupyterlab-server<3,>=2.22.1 from https://fi
les.pythonhosted.org/packages/96/cd/cdabe44549d60e0967904f0bdd9e3756b521112317612a3
997eb2fda9181/jupyterlab_server-2.25.0-py3-none-any.whl.metadata
  Downloading jupyterlab_server-2.25.0-py3-none-any.whl.metadata (5.9 kB)
```

- ***Now installing all the dependencies: -***

```
pip install pandas
pip install numpy
pip install scikit-learn
pip install imblearn
pip install matplotlib
pip install mlflow
```

We are using -U so that pip update or downgrade accordingly: -

- MLflow Auto log compatible version 2.3.0 – 2.12.0

```
(base) C:\Users\at0m>pip install -U tensorflow==2.12.0
Defaulting to user installation because normal site-packages is not writeable
Collecting tensorflow==2.12.0
  Downloading tensorflow-2.12.0-cp311-cp311-win_amd64.whl (1.9 kB)
Collecting tensorflow-intel==2.12.0 (from tensorflow==2.12.0)
  Downloading tensorflow_intel-2.12.0-cp311-cp311-win_amd64.whl (272.9 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 18.5/272.9 MB 206.0 kB/s eta 0:20:35
```

- ***Now I will open the Jupiter notebook: -***

Notebook Link: - https://github.com/at0m-b0mb/Mlflow-TensorFlow-Image-Classification-Guide/blob/main/MLFlow%20Tensorflow%20Model%20Kailash.ipynb

```
(kailash) C:\Users\at0m\Desktop\mlflow-main>jupyter notebook
[I 2023-10-07 16:03:01.383 ServerApp] Package notebook took 0.0000s to import
[I 2023-10-07 16:03:01.483 ServerApp] Package jupyter_lsp took 0.1114s to import
[W 2023-10-07 16:03:01.483 ServerApp] A `_jupyter_server_extension_points` function was not fo
und in jupyter_lsp. Instead, a `_jupyter_server_extension_paths` function was found and will b
e used for now. This function name will be deprecated in future releases of Jupyter Server.
[I 2023-10-07 16:03:03.791 ServerApp] Package jupyter_server_terminals took 2.3049s to import
[I 2023-10-07 16:03:03.791 ServerApp] Package jupyterlab took 0.0000s to import
[I 2023-10-07 16:03:04.038 ServerApp] Package notebook_shim took 0.0000s to import
[W 2023-10-07 16:03:04.038 ServerApp] A `_jupyter_server_extension_points` function was not fo
und in notebook_shim. Instead, a `_jupyter_server_extension_paths` function was found and will
 be used for now. This function name will be deprecated in future releases of Jupyter Server.
[I 2023-10-07 16:03:04.038 ServerApp] jupyter_lsp | extension was successfully linked.
[I 2023-10-07 16:03:04.058 ServerApp] jupyter_server_terminals | extension was successfully li
nked.
[I 2023-10-07 16:03:04.070 ServerApp] jupyterlab | extension was successfully linked.
[I 2023-10-07 16:03:04.081 ServerApp] notebook | extension was successfully linked.
[I 2023-10-07 16:03:04.086 ServerApp] Writing Jupyter server cookie secret to C:\Users\at0m\Ap
pData\Roaming\jupyter\runtime\jupyter_cookie_secret
[I 2023-10-07 16:03:04.641 ServerApp] notebook_shim | extension was successfully linked.
[I 2023-10-07 16:03:04.689 ServerApp] notebook_shim | extension was successfully loaded.
[I 2023-10-07 16:03:04.689 ServerApp] jupyter_lsp | extension was successfully loaded.
[I 2023-10-07 16:03:04.689 ServerApp] jupyter_server_terminals | extension was successfully lo
aded.
```

- ***Now run all the functions in the notebook: -***

```
import tensorflow as tf
import mlflow
import numpy as np
import matplotlib.pyplot as plt
```

[1] ✓ 14.0s Python

```
import sys
sys.executable
```

[2] ✓ 0.0s Python

```
'c:\\Users\\at0m\\.conda\\envs\\kailash\\python.exe'
```

```
!python --version
```

[3] ✓ 0.0s Python

```
Python 3.10.13
```

```
print(tf.__version__)
```

[4] ✓ 0.0s Python

```
2.12.0
```

```
print(mlflow.__version__)
```

[5] ✓ 0.0s Python

```
2.7.1
```

```python
def load_data():
    fashion_mnist = tf.keras.datasets.fashion_mnist
    (train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()

    class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat',
                   'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']

    return train_images, train_labels, test_images, test_labels, class_names
```

[6] ✓ 0.0s Python

```python
train_images, train_labels, test_images, test_labels, class_names= load_data()
```

[7] ✓ 1m 22.3s Python

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-labels-idx1-uby
29515/29515 [==============================] - 0s 2us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-images-idx3-uby
26421880/26421880 [==============================] - 66s 2us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-labels-idx1-ubyt
5148/5148 [==============================] - 0s 0s/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-images-idx3-ubyt
4422102/4422102 [==============================] - 12s 3us/step
```

```python
print(train_images.shape)
#Each Label is between 0-9train_labels
print(test_images.shape)
```

[8] ✓ 0.0s Python

```
(60000, 28, 28)
(10000, 28, 28)
```

```python
def get_val_data(test_images, test_labels):
    test_images_sub_arr = np.array_split(test_images, 2)
    val_images = test_images_sub_arr[0]
    test_images = test_images_sub_arr[1]


    test_labels_sub_arr = np.array_split(test_labels, 2)
    val_labels = test_labels_sub_arr[0]
    test_labels = test_labels_sub_arr[1]

    return val_images, val_labels, test_images, test_labels
```

[9] ✓ 0.0s Python

```python
val_images, val_labels, test_images, test_labels = get_val_data(test_images, test_labels)
```

[10] ✓ 0.0s Python

```python
print(val_images.shape)
print(test_images.shape)

print(val_labels.shape)
print(test_labels.shape)
```

[11] ✓ 0.0s Python

```
(5000, 28, 28)
(5000, 28, 28)
(5000,)
(5000,)
```

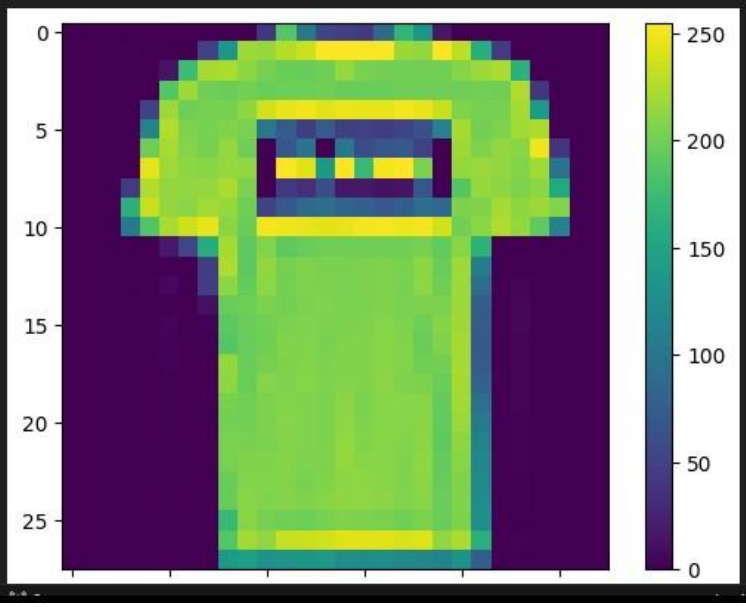
```python
def check_image_pixel_values(single_image):
    plt.figure()
    plt.imshow(single_image)
    plt.colorbar()
    plt.grid(False)
    plt.show()
```

[12] ✓ 0.0s Python

```python
check_image_pixel_values(train_images[1])
```

[13] ✓ 1.2s Python

...



Activate Windows

```python
def image_scaling(img_arr):
    scaled_img = img_arr / 255.0
    return scaled_img
```

[14] ✓ 0.0s Python

```python
scaled_train_images = image_scaling(train_images)
scaled_val_images = image_scaling(val_images)
scaled_test_images = image_scaling(test_images)
```

[15] ✓ 0.3s Python

```python
def verify_data_format(img_arr, img_labels,class_names):
    plt.figure(figsize=(10,10))
    for i in range(25):
        plt.subplot(5,5,i+1)
        plt.xticks([])
        plt.yticks([])
        plt.grid(False)
        plt.imshow(img_arr[i], cmap=plt.cm.binary)
        plt.xlabel(class_names[img_labels[i]])
    plt.show()
```

[16] ✓ 0.0s Python

```
verify_data_format(scaled_train_images, train_labels,class_names)
```

[17] ✓ 1.0s Python

...

```
verify_data_format(scaled_val_images, val_labels,class_names)
```

[18] ✓ 0.9s Python

```
verify_data_format(scaled_test_images, test_labels,class_names)
```

[19] ✓ 1.2s Pythc

- ***<u>Build the Model: -</u>***

```
def tf_model_build():
    model = tf.keras.Sequential([
        tf.keras.layers.Flatten(input_shape=(28, 28)),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(10)
    ])
    return model
```

[28] ✓ 0.0s Python

- ***<u>Compile the Model: -</u>***

```python
def tf_compile_model(model):
    model.compile(optimizer='adam',
                  loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
                  metrics=['accuracy'])
    return model
```

[21] ✓ 0.0s Python

- ***Training the Model: -***

```python
import mlflow
mlflow.tensorflow.autolog(every_n_iter=2)
```

[22] ✓ 0.0s Python

```python
def tf_train_model(scaled_train_images, train_labels, epochs, batch_size, scaled_val_images, val_la
    model.fit(scaled_train_images,
              train_labels,
              epochs=epochs,
              batch_size=batch_size,
              validation_data=(scaled_val_images, val_labels)
             )
    return model
```

[23] ✓ 0.0s Python

```
model = tf_model_build()
model = tf_compile_model(model)

epochs = 10
batch_size = 32
model = tf_train_model(scaled_train_images, train_labels, epochs, batch_size, scaled_val_images, va
```

[37] ✓ 1m 5.8s Python

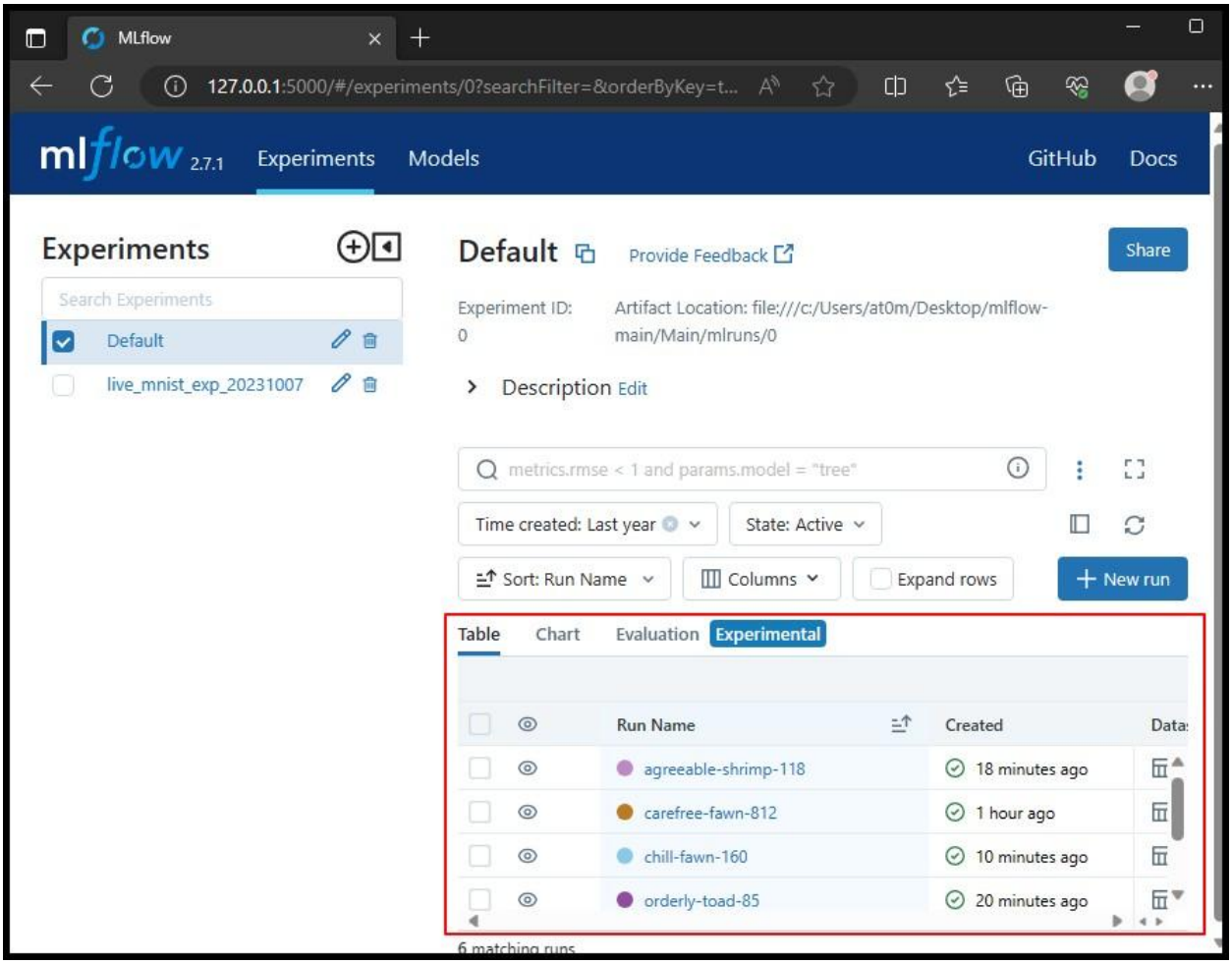
```
2023/10/07 19:26:25 INFO mlflow.utils.autologging_utils: Created MLflow autologging run with ID 'e7077t
Epoch 1/10
1875/1875 [==============================] - 7s 3ms/step - loss: 0.5034 - accuracy: 0.8237 - val_loss:
Epoch 2/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.3757 - accuracy: 0.8643 - val_loss:
Epoch 3/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.3360 - accuracy: 0.8782 - val_loss:
Epoch 4/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.3137 - accuracy: 0.8845 - val_loss:
Epoch 5/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2947 - accuracy: 0.8910 - val_loss:
Epoch 6/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2827 - accuracy: 0.8959 - val_loss:
Epoch 7/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2667 - accuracy: 0.9020 - val_loss:
Epoch 8/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2572 - accuracy: 0.9042 - val_loss:
Epoch 9/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2460 - accuracy: 0.9083 - val_loss:
Epoch 10/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2396 - accuracy: 0.9100 - val_loss:
1/1 [==============================] - 0s 41ms/step
WARNING:absl:Found untraced functions such as _update_step_xla while saving (showing 1 of 1). These fur
INFO:tensorflow:Assets written to: C:\Users\at0m\AppData\Local\Temp\tmp_5q1eg9_\model\data\model\assets
```

Activate Windows

- ***Starting and Looking the data in MLflow: -***

```
(base) C:\Users\at0m>conda activate kailash

(kailash) C:\Users\at0m>mlflow ui
Traceback (most recent call last):
  File "C:\Users\at0m\.conda\envs\kailash\lib\runpy.py", line 196, in _run_module_as_main
    return _run_code(code, main_globals, None,
  File "C:\Users\at0m\.conda\envs\kailash\lib\runpy.py", line 86, in _run_code
    exec(code, run_globals)
  File "C:\Users\at0m\.conda\envs\kailash\Scripts\mlflow.exe\__main__.py", line 4, in <module>
    from mlflow.cli import cli
  File "C:\Users\at0m\.conda\envs\kailash\lib\site-packages\mlflow\__init__.py", line 44, in <module>
    from mlflow import (
  File "C:\Users\at0m\.conda\envs\kailash\lib\site-packages\mlflow\data\__init__.py", line 4, in <modul
e>
```


MLflow
127.0.0.1:5000/#/experiments/0?searchFilter=&orderByKey=t...
mlflow 2.7.1
Experiments
Models
GitHub
Docs
Experiments
Search Experiments
Default
live_mnist_exp_20231007
Default
Provide Feedback
Share
Experiment ID: 0
Artifact Location: file:///c:/Users/at0m/Desktop/mlflow-main/Main/mlruns/0
Description Edit
metrics.rmse < 1 and params.model = "tree"
Time created: Last year
State: Active
Sort: Run Name
Columns
Expand rows
New run
Table
Chart
Evaluation
Experimental
Run Name
Created
agreeable-shrimp-118
18 minutes ago
carefree-fawn-812
1 hour ago
chill-fawn-160
10 minutes ago
orderly-toad-85
20 minutes ago
6 matching runs

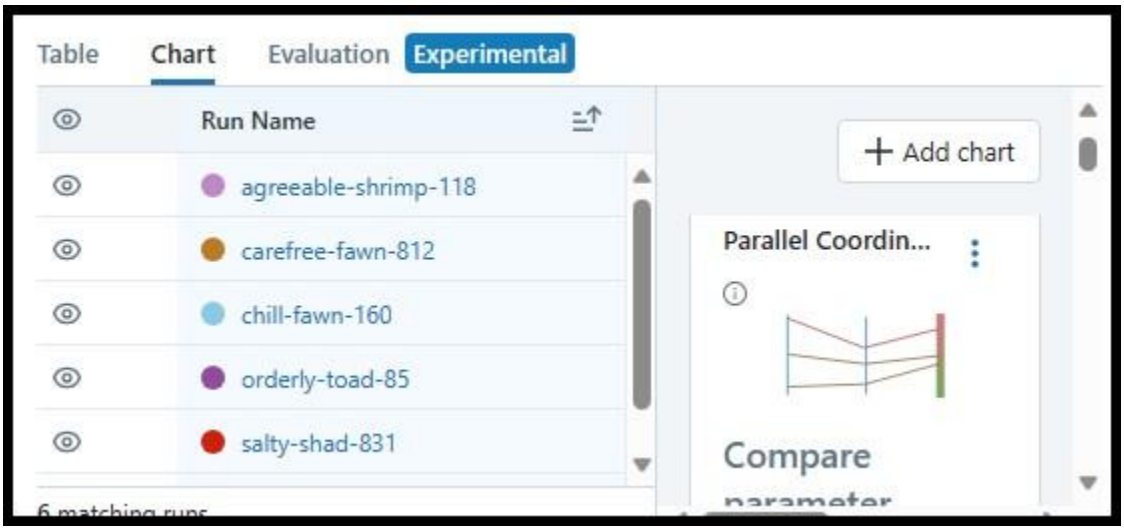
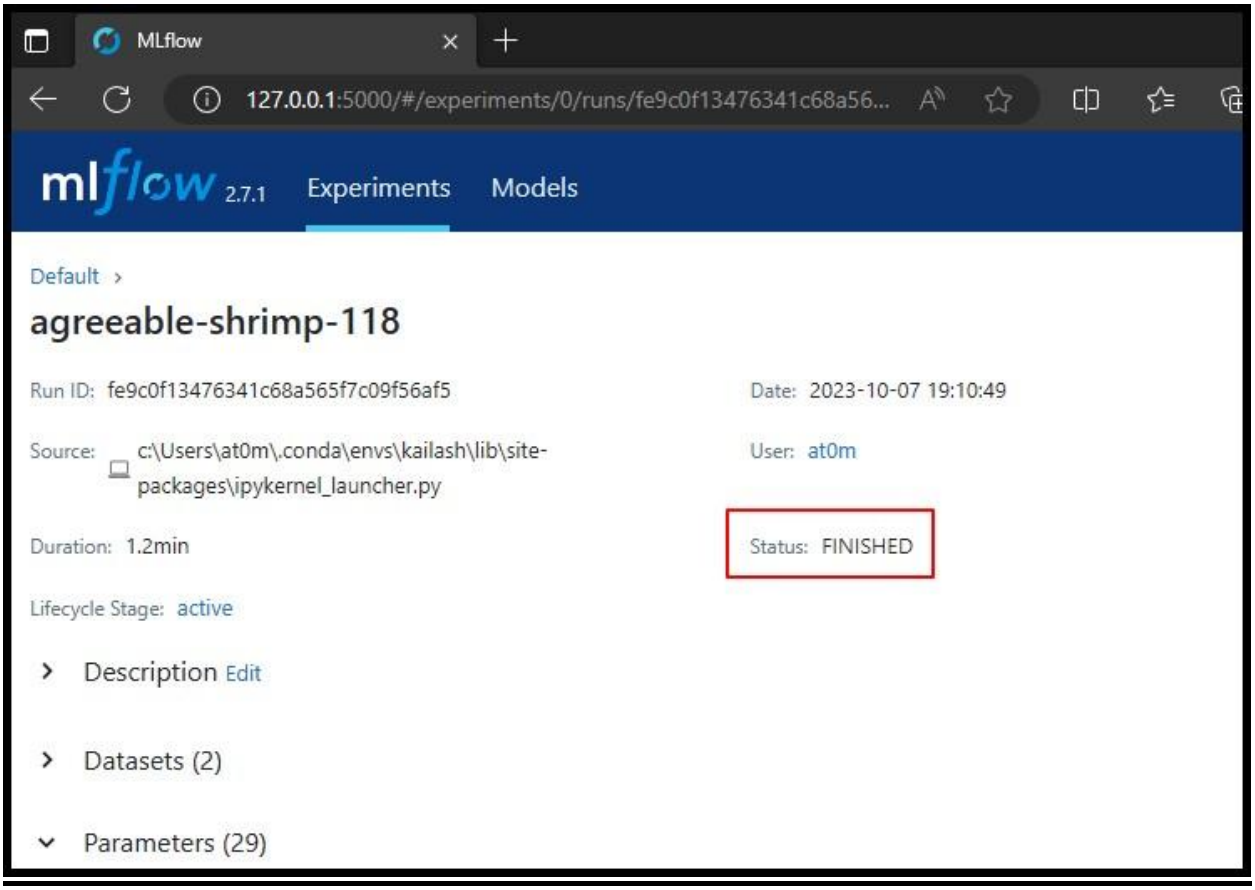
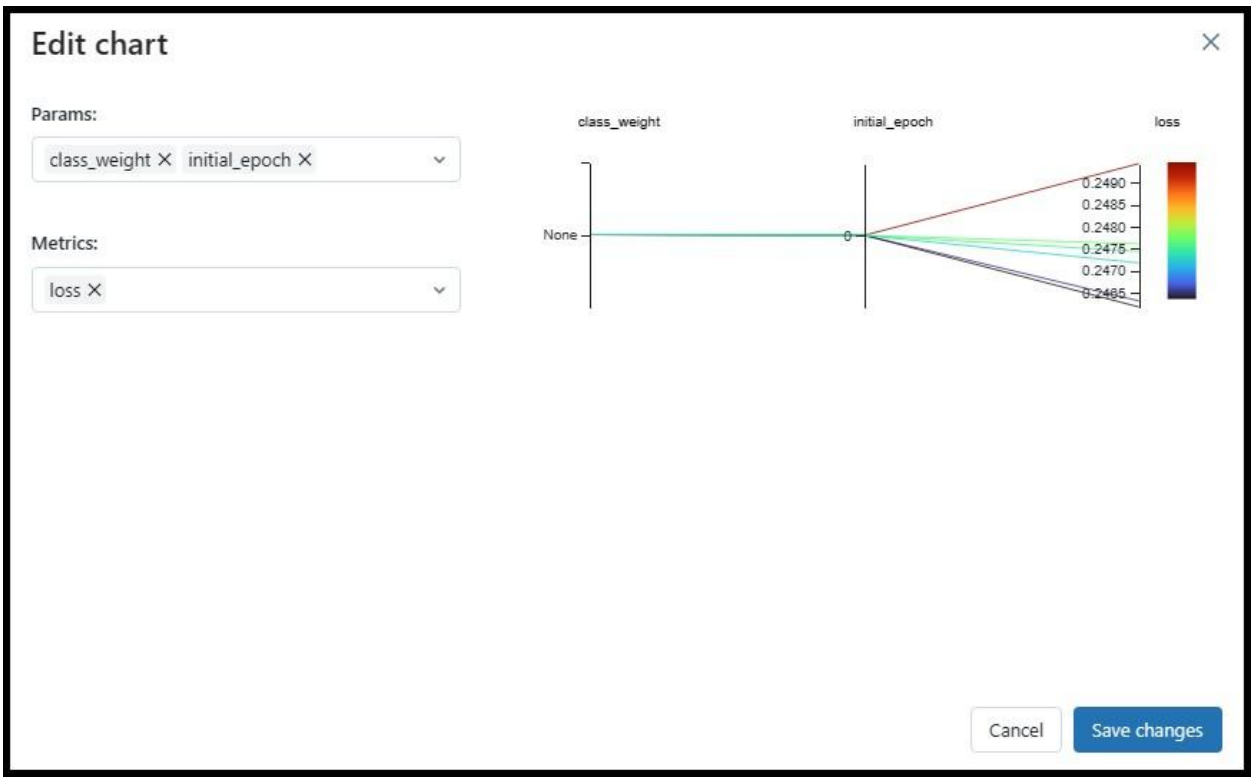


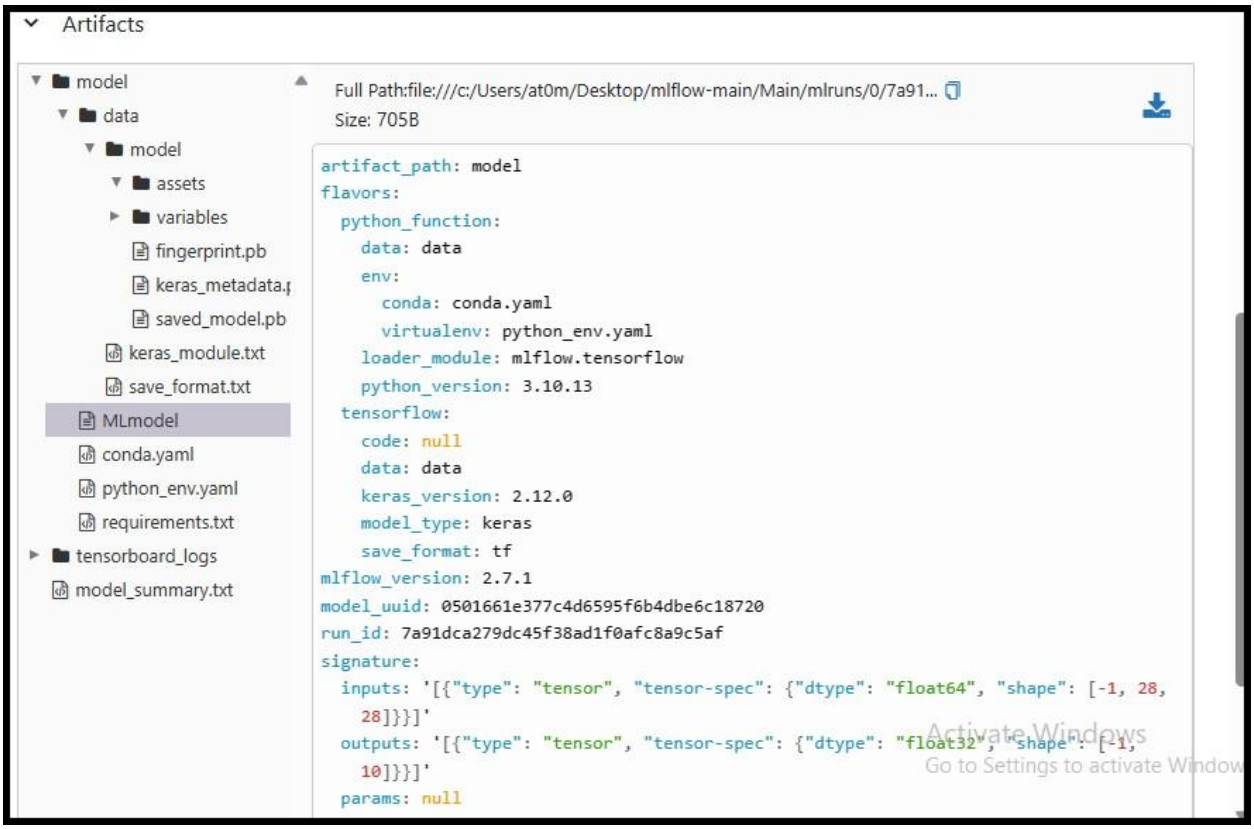
Table
Chart
Evaluation
Experimental
Run Name
agreeable-shrimp-118
carefree-fawn-812
chill-fawn-160
orderly-toad-85
salty-shad-831
Add chart
Parallel Coordin...
Compare

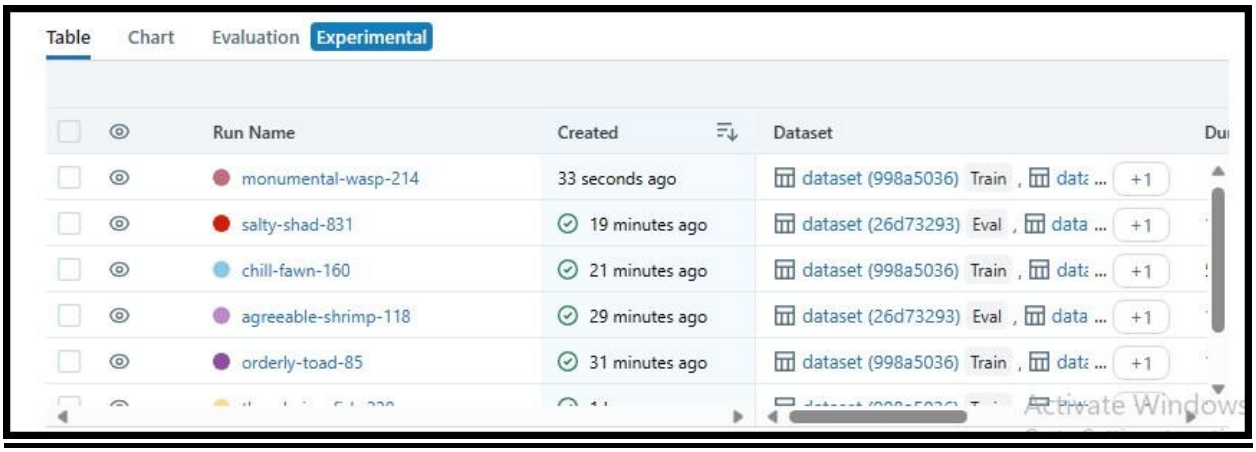

MLflow
127.0.0.1:5000/#/experiments/0/runs/fe9c0f13476341c68a56...
mlflow 2.7.1
Experiments
Models
Default ›
agreeable-shrimp-118
Run ID: fe9c0f13476341c68a565f7c09f56af5
Date: 2023-10-07 19:10:49
Source: c:\Users\at0m\.conda\envs\kailash\lib\site-packages\ipykernel_launcher.py
User: at0m
Duration: 1.2min
Status: FINISHED
Lifecycle Stage: active
Description Edit
Datasets (2)
Parameters (29)

Parameters (29)

Name	Value
batch_size	32
class_weight	None
epochs	10
initial_epoch	0
max_queue_size	10
opt_amsgrad	False
opt_beta_1	0.9
opt_beta_2	0.999
opt_clipnorm	None
opt_clipvalue	None
opt_ema_momentum	0.99


Edit chart
Params:
class_weight
initial_epoch
Metrics:
loss
class_weight
initial_epoch
loss
None
0
0.2490
0.2485
0.2480
0.2475
0.2470
0.2465
Cancel
Save changes


Artifacts
model
data
model
assets
variables
fingerprint.pb
keras_metadata.
saved_model.pb
keras_module.txt
save_format.txt
MLmodel
conda.yaml
python_env.yaml
requirements.txt
tensorboard_logs
model_summary.txt
Full Path:file:///c:/Users/at0m/Desktop/mlflow-main/Main/mlruns/0/7a91...
Size: 705B
artifact_path: model
flavors:
python_function:
data: data
env:
conda: conda.yaml
virtualenv: python_env.yaml
loader_module: mlflow.tensorflow
python_version: 3.10.13
tensorflow:
code: null
data: data
keras_version: 2.12.0
model_type: keras
save_format: tf
mlflow_version: 2.7.1
model_uuid: 0501661e377c4d6595f6b4dbe6c18720
run_id: 7a91dca279dc45f38ad1f0afc8a9c5af
signature:
inputs: '[{"type": "tensor", "tensor-spec": {"dtype": "float64", "shape": [-1, 28, 28]}}]'
outputs: '[{"type": "tensor", "tensor-spec": {"dtype": "float32", "shape": [-1, 10]}}]'
params: null
Activate Windows
Go to Settings to activate Windows.



- ***<u>Evaluate Model in the test Images: -</u>***

```
train_loss, train_acc = model.evaluate(scaled_train_images,  train_labels, verbose=2)
print('\ntrain accuracy:', train_acc)
```

[25] Python

```
1875/1875 - 3s - loss: 0.2314 - accuracy: 0.9134 - 3s/epoch - 1ms/step

train accuracy: 0.9133999943733215
```

```
val_loss, val_acc = model.evaluate(scaled_val_images,  val_labels, verbose=2)
print('\nval accuracy:', val_acc)
```

[26] Python

```
157/157 - 0s - loss: 0.3414 - accuracy: 0.8760 - 248ms/epoch - 2ms/step

val accuracy: 0.8759999871253967
```

```
test_loss, test_acc = model.evaluate(test_images,  test_labels, verbose=2)
print('\nTest accuracy:', test_acc)
```

[27] Python

```
157/157 - 0s - loss: 74.6896 - accuracy: 0.8432 - 311ms/epoch - 2ms/step

Test accuracy: 0.8432000279426575
```

```
[28]
predictions = model.predict(test_images)
predictions[0]
```
Python

```
...   1/157 [..............................] - ETA: 7s
    157/157 [==============================] - 0s 1ms/step

...  array([ -623.4931  , -1499.3573  ,   945.1065  , -2064.4617  ,
            41.167755, -3514.1626  ,   511.58093 , -4882.0435  ,
         -2092.7468  , -3331.1501  ], dtype=float32)
```

```
[29]
import numpy as np
np.argmax(predictions[0])
#Model is most confident that it's an ankle boot. Let's see if it's correct
```
Python

```
...  2
```

```
[30]
test_labels[0]
```
Python

```
...  2
```

```
[31]
class_names[0]
```
Python

```
...  'T-shirt/top'
```

- ***<u>Experiment Tracking for TensorFlow-based Models: -</u>***

```python
def tf_experiment_tracking(exp_name, run_name, batch_size, epochs, train_loss, train_acc,
                           val_loss, val_acc, test_loss, test_acc, model_signature):
    mlflow.set_experiment(exp_name)
    with mlflow.start_run(run_name=run_name):
        mlflow.log_param("batch_size", batch_size)
        #mlflow.log_param("learning_rate", learning_rate)
        mlflow.log_param("epochs", epochs)
        mlflow.log_metric("train_loss", train_loss)
        mlflow.log_metric("train_accuracy", train_acc)
        mlflow.log_metric("val_loss", val_loss)
        mlflow.log_metric("val_accuracy", val_acc)
        mlflow.log_metric("test_loss", test_loss)
        mlflow.log_metric("test_accuracy", test_acc)
        mlflow.tensorflow.log_model(model, "mnist", signature=model_signature)
    mlflow.end_run()
```

[32] Python

```python
from mlflow.models.signature import infer_signature
model_signature = infer_signature(scaled_test_images, model.predict(scaled_test_images))
```

[33] Python

```
157/157 [==============================] - 0s 1ms/step
```

```python
from datetime import datetime
exp_timestamp = datetime.now().strftime("%Y%m%d")
exp_name = "live_mnist_exp_" + exp_timestamp
print(exp_name)

run_timestamp = datetime.now().strftime("%Y%m%d--%H%M%S")
run_name = "live_mnist_exp_run_"+ run_timestamp
print(run_name)
```

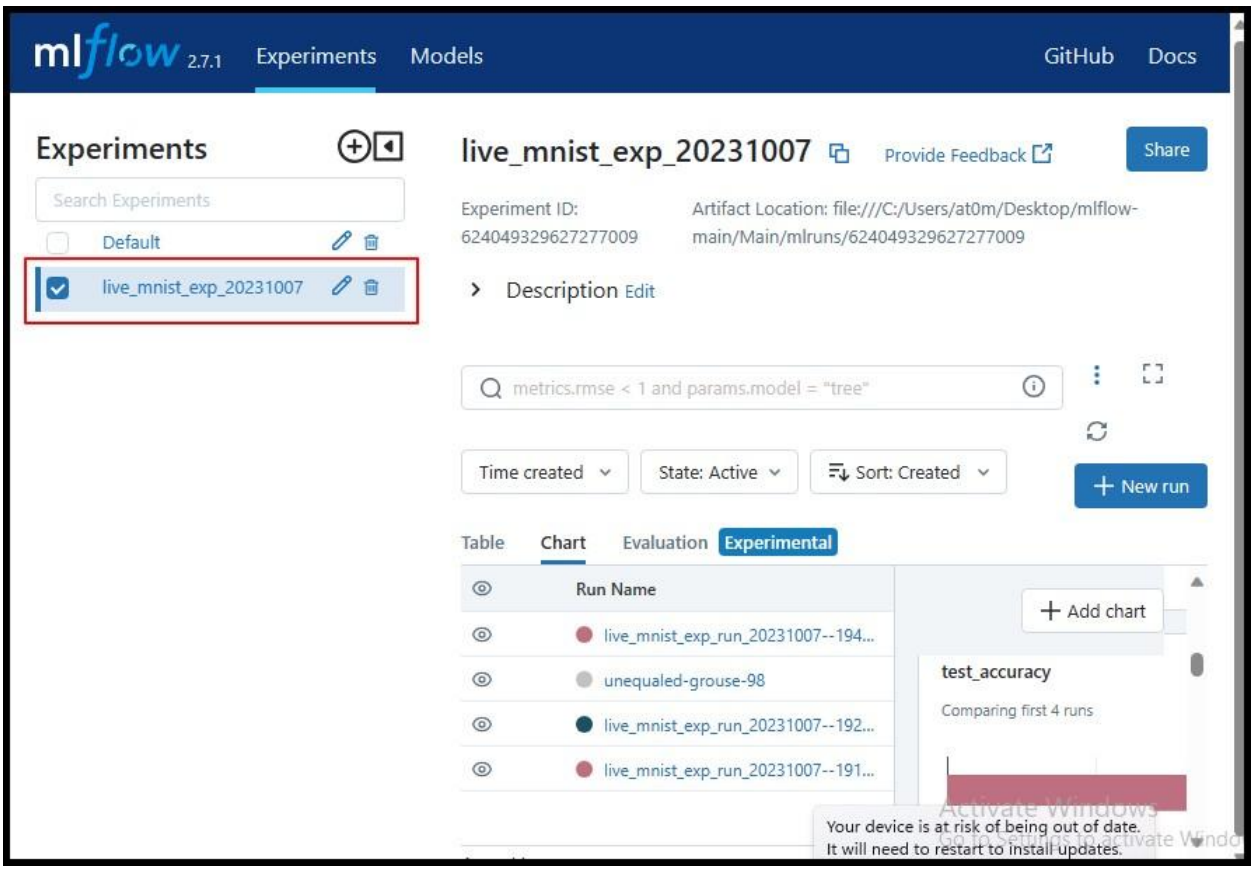
[34] Python

```
live_mnist_exp_20231007
live_mnist_exp_run_20231007--192214
```

```python
tf_experiment_tracking(exp_name, run_name, batch_size, epochs, train_loss, train_acc,
                       val_loss, val_acc, test_loss, test_acc, model_signature)
```

[35] Python

```
WARNING:absl:Found untraced functions such as _update_step_xla while saving (showing 1 of 1). These fur
INFO:tensorflow:Assets written to: C:\Users\at0m\AppData\Local\Temp\tmpd1_fj0h9\model\data\model\assets
INFO:tensorflow:Assets written to: C:\Users\at0m\AppData\Local\Temp\tmpd1_fj0h9\model\data\model\assets
```


mlflow 2.7.1
Experiments
Models
GitHub
Docs
Experiments
Search Experiments
Default
live_mnist_exp_20231007
live_mnist_exp_20231007
Provide Feedback
Share
Experiment ID:
624049329627277009
Artifact Location: file:///C:/Users/at0m/Desktop/mlflow-main/Main/mlruns/624049329627277009
Description Edit
metrics.rmse < 1 and params.model = "tree"
Time created
State: Active
Sort: Created
New run
Table
Chart
Evaluation
Experimental
Run Name
live_mnist_exp_run_20231007--194...
unequaled-grouse-98
live_mnist_exp_run_20231007--192...
live_mnist_exp_run_20231007--191...
Add chart
test_accuracy
Comparing first 4 runs
Your device is at risk of being out of date.
It will need to restart to install updates.

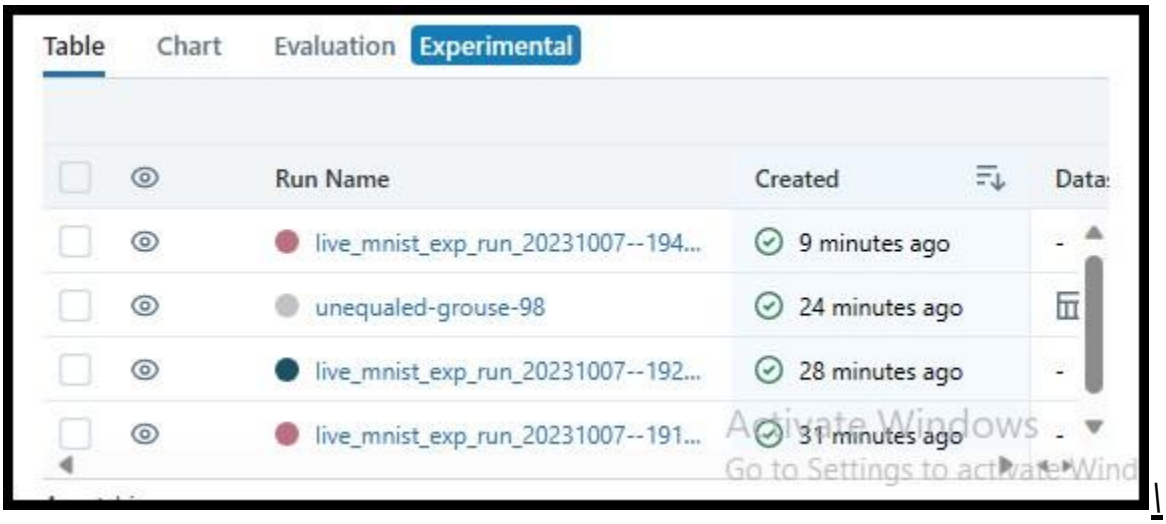
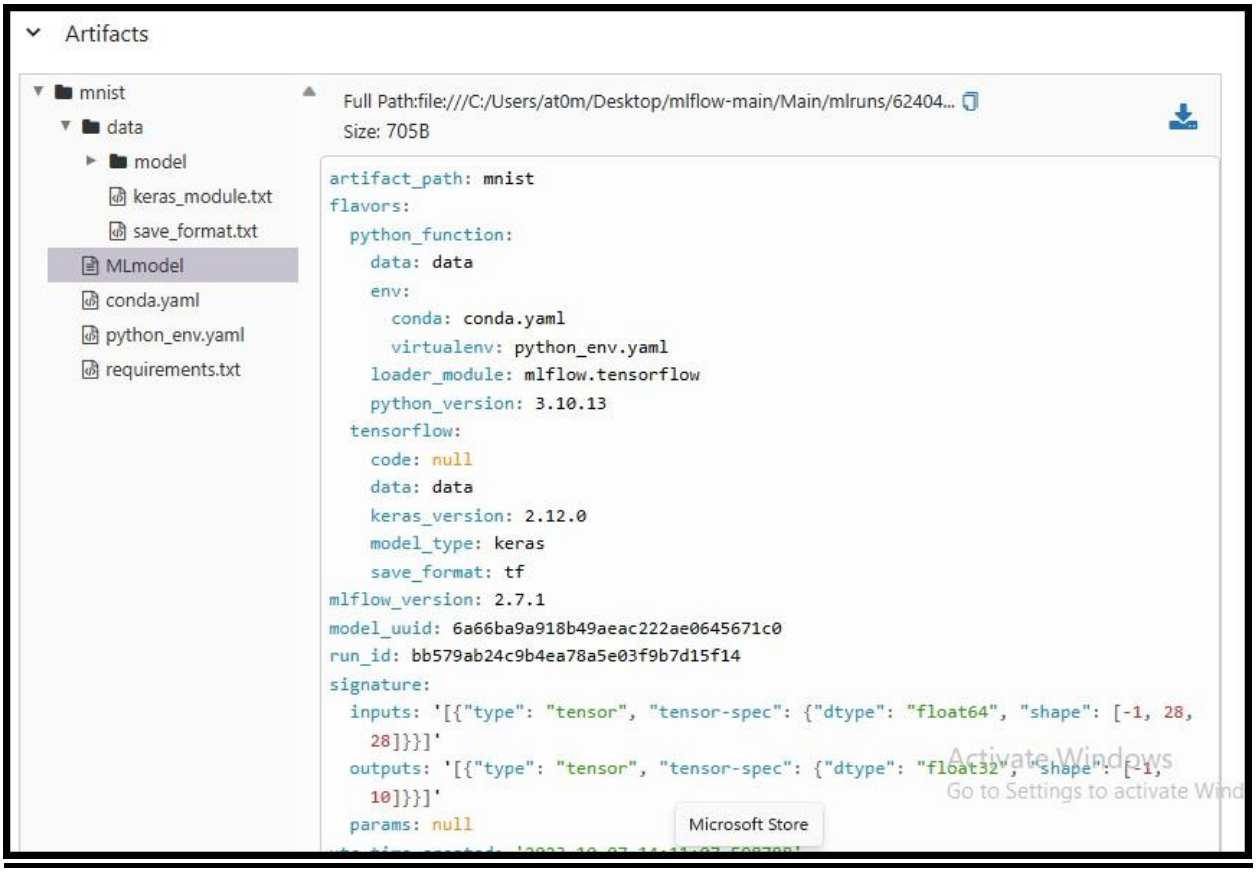


Table
Chart
Evaluation
Experimental
Run Name
Created
Data
live_mnist_exp_run_20231007--194...
9 minutes ago
unequaled-grouse-98
24 minutes ago
live_mnist_exp_run_20231007--192...
28 minutes ago
live_mnist_exp_run_20231007--191...
31 minutes ago



- ***<u>Load the model from MLflow Run and making Predictions: -</u>***

```
predictions[4]
```

Python

```
np.argmax(predictions[5])
```

Python

```
3
```

```
test_labels[5]
```

Python

```
3
```

```
class_names[5]
```

Python

```
'Sandal'
```

```
probability_model = tf.keras.Sequential([model,
                                         tf.keras.layers.Softmax()])
```

Python

```
predictions = probability_model.predict(scaled_test_images)
```

Python

```
157/157 [==============================] - 1s 2ms/step
```

```
predictions[0]
```

Python

```
array([4.9679447e-04, 1.7424519e-07, 9.9035168e-01, 8.3745755e-07,
       4.6180515e-03, 7.8901586e-08, 4.5294818e-03, 4.0465491e-07,
       1.8620020e-06, 5.8993174e-07], dtype=float32)
```

```
np.argmax(predictions[0])
```

Python

```
2
```

Thank you